Accounting for Structural Change: Evidence from Two Centuries of U.S. Data

by

Benjamin N. Dennis
Millennium Challenge Corporation
University of the Pacific

Talan İşcan
Dalhousie University

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DALHOUSIE UNIVERSITY
HALIFAX, NOVA SCOTIA, CANADA
B3H 3J5

Accounting for Structural Change: Evidence from Two Centuries of U.S. Data[*]

Benjamin N. Dennis[†]
Millennium Challenge Corporation,
University of the Pacific

Talan B. İşcan[‡]
Dalhousie University

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Abstract

Historically, the reallocation of labor out of agriculture has been a dominant feature of structural change and economic growth. This paper proposes a framework to decompose this reallocation into components based on three of its key potential drivers: (i) non-homothetic preferences, (ii) sectoral differences in productivity growth rates, and (iii) sectoral differences in factor intensities in production. We then quantify the relative contribution of each of these drivers to U.S. structural change in the last two centuries. Our empirical results show that non-homothetic preferences and differential sectoral productivity growth have been very significant determinants of the labor reallocation process in the U.S. and that, over the last two centuries, their relative contributions have changed in important ways.

Keywords: Long-run structural change; non-homothetic preferences; relative productivity growth; relative capital deepening

JEL Classification: N1; O41

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[†]Benjamin N. Dennis, Economic Analysis, Department of Accountability, Millennium Challenge Corporation, 875 Fifteenth Street, NW, Washington, DC, 20005, USA. *E-mail*: DennisBN@mcc.gov. Tel.: +1.202.521.7220. Fax: +1.202.521.7901.

[‡]*Corresponding author*: Talan İşcan, Department of Economics, Dalhousie University, Halifax, NS, B3H 3J5, Canada. *E-mail*: tiscan@dal.ca. Tel.: +1.902.494.6994. Fax: +1.902.494.6917. *URL*: http://myweb.dal.ca/tiscan/.

1 Introduction

A striking and universal empirical regularity that accompanies modern economic growth is the systematic changes in the share of different sectors in GDP and employment over time, typically referred to as structural change. In recent years, there has been a resurgence of interest on structural change primarily due to its centrality to economic development and its contribution to economic growth.[1] In this paper, we consider three prominent drivers of structural change identified by the recent literature and, using two centuries of data, quantify their relative contribution to structural change in the U.S. They are: (i) non-homothetic preferences, which lead to differential income elasticities of demand across sectors (e.g., Kongsamut et al., 2001), (ii) differences in sectoral productivity growth rates, which lead to a "cost disease" in the slow-productivity-growth sector (e.g., Baumol, 1967, and Ngai and Pissarides, 2007), and (iii) differences in sectoral factor intensities, which lead to differential capital deepening across sectors (e.g., Acemoglu and Guerrieri, 2005).

Historically, the reallocation of labor out of agriculture has been the most dominant and common feature of the structural change process across countries and over time. We therefore direct our overall conceptual and empirical framework towards accounting for the reallocation of labor out of agriculture. Besides, this aspect of structural change in the U.S. is quite dramatic and interesting on its own right: the share of employment in U.S. agriculture dwindled from 75 percent in 1800 to far less than 3 percent in 2000, while the share of agriculture in output declined from 40 percent in 1840 to slightly above 1 percent in 2000; see figure 1.[2]

Our results show that non-homothetic preferences and differential sectoral productivity growth have been very significant determinants of this labor reallocation process in the U.S. However, over the last two centuries, their relative contributions have changed in important ways. We find that at least until the 1960s, the declining share of expenditures

[1]Kuznets (1966) is the classic study on the international patterns of structural change, and Echevarria (1997) is a pioneering study that introduces structural change into the neoclassical model of economic growth.

[2]The famous Kaldor facts have often been documented using twentieth century U.S. data—although there is some uncertainty whether all these facts hold for other industrial countries as well. The same U.S. data have also been extensively used to document the Kuznets facts (see, e.g., Kongsamut et al., 2001)—and these facts are remarkably universal. It is therefore natural to use the U.S. data to examine whether the recent structural change models can in general reconcile these two sets of facts.

on agricultural goods associated with non-homothetic preferences was the primary driver of U.S. structural change. Differential sectoral productivity growth, on the other hand, was a significant driving force of structural change especially in the second half of the twentieth century, and during the nineteenth century it actually retarded the reallocation of labor out of agriculture.

Our accounting of the U.S. structural transformation builds on a unified conceptual framework and takes a long view. One of the contributions of our paper is to systematically document several historical facts that are relevant for the history of structural transformation in the U.S. since 1800. While almost all the facts and trends we draw upon in this paper have been extensively documented by economic historians in various contexts, this is the first time to our knowledge that these data are synthesized with the specific theoretical considerations that we address here, and in a fashion that can provide a unified quantitative explanation of two hundred years of structural change.

Working with two centuries of data also allows us to uncover important empirical trends that differ between the nineteenth and twentieth centuries. These trends have important implications for quantitative theory as they demonstrate the benefits of an encompassing theoretical approach, whereby several drivers of structural change are simultaneously at work but possibly with varying intensities over different stages of economic development.

We organize the rest of the paper as follows. Section 2 summarizes the related literature. Section 3 demonstrates the empirical relevance of the conceptual issues we consider in the paper. Section 4 presents our conceptual framework for structural change accounting. Section 5 presents our quantitative results, and section 6 concludes.

2 Related literature

Our empirical work builds in part on the vast literature on structural change initiated by Simon Kuznets and Hollis Chenery (e.g., Chenery, Robinson and Syrquin, 1986; Feinstein, 1999). However, whereas this earlier literature extensively documented and studied the patterns of structural change across countries, our study is about the key drivers of structural change that emerge over time within a single country. In addition, the conceptual framework and quantitative methodology we use in this paper helps bridge the gap between this earlier literature and the modern approach to economic growth and structural change.

Our framework is also related to recent work that examines structural change in the U.S., e.g., Kongsamut et al. (2001), Caselli and Coleman (2001), and Dennis and İşcan (2007). However, these papers primarily rely on twentieth century data and, as we discuss in detail below, some of the trends identified in these papers do not apply to the nineteenth century. In a conceptually related work, Gollin et al. (2002) provide a model of structural change in the U.K. since 1800 but face the constraint of relatively limited information on relevant variables. For example, they calibrate the growth rate of agricultural productivity to match the trend reallocation of labor out of agriculture. In our analysis, we rely directly on productivity measurements that allow us to examine whether the data are consistent with the implications of our unified conceptual framework for relative prices, productivity and the reallocation of labor out of agriculture, without assuming a unique common trend.

While our conceptual framework builds on the recent advances in multi-sector models with structural change, the list of forces driving structural change we consider here is not exhaustive. One alternative explanation suggests that observed structural change is simply an artifact of increased specialization within each sector (Johnston and Kilby, 1975). For example, much of the home manufacturing and repairs undertaken by farmers in the nineteenth century is now carried out by specialized non-farm firms, thereby giving the impression of labor reallocation out of agriculture. While data limitations do not permit us to present a thorough assessment of these effects of specialization, our data set does allow us to account for the declining significance of home manufacturing on farms, and we find its impact relatively insignificant for the balance of the U.S. structural change. We therefore do not provide a detailed discussion of this issue in the rest of the paper.

Another source of structural change may be diminishing barriers to factor mobility over time. Dennis and İşcan (2007) consider a framework which allows for endogenously determined partial labor mobility and find that, while the contribution of increased labor mobility to structural change was not negligible, it was transitory and relatively small in comparison to other forces that we consider in this paper.[3]

[3]Mas-Colell and Razin (1973) and Caselli and Coleman (2001) also consider exogenous barriers to labor mobility.

3 Data: a first look

We begin our analysis with an overview of the data relevant for the three distinct drivers of structural change, as a way to illustrate the potential significance of the issues raised by the recent structural change models for the long view of structural change in the U.S. First, we consider non-homothetic preferences. In our context, this is closely related to Engel's Law—i.e., the declining share of food in total expenditures as disposable incomes rise. Indeed, during the twentieth century, despite an almost secular rise in per capita food expenditures, the share of food in total expenditures has continuously declined in the U.S.; see figure 2. Since this phenomenon has been repeatedly documented in the empirical literature, we do not elaborate on this issue further.[4]

Second, we consider the role of differences in sectoral productivity growth rates.[5] Figure 3 shows that over time farm and non-farm total factor productivity growth rates have varied substantially both in absolute and relative terms. There are essentially three distinct episodes within which we can examine the productivity growth rate in the farm sector relative to the non-farm sector: 1800–c1900 with faster productivity growth in the non-farm sector, c1900–c1937 with similar productivity growth rates in the farm and non-farm sectors, and c1937–2000 with relatively faster productivity growth rate in the farm sector.[6]

This interpretation of the data in figure 3 is entirely consistent with the historical accounts of relative productivity performance in the U.S. (See, also, our detailed discussion of these issues in appendix A.) For example, all the available evidence suggests that during the nineteenth century the TFP growth rate in the farm sector was significantly below that of the non-farm sector. Despite numerous innovations in farm implements that led to substantial savings of labor through the use of animal power on a variety of farm tasks (McCleland, 1997; Attack, Bateman, and Parker, 2000), the nineteenth century

[4]For instance, Houthaukker (1987) concludes that "of all empirical regularities observed in economic data, Engel's Law is probably the best established."

[5]As we discuss below, the 'differences in sectoral productivity growth' explanation requires an additional condition that corresponds to a non-unitary elasticity of substitution in consumption across goods produced by distinct sectors. Empirically, this condition is satisfied for agriculture and non-agriculture; see Dennis and İşcan (2007).

[6]Economic historians have long recognized the importance of sectoral measures of productivity growth for explaining industrialization and economic development; see Sokoloff (1986) and Williamson (1986).

was still a period of low TFP growth in agriculture. However, sometime in the mid- to late 1930s, farm sector productivity started to outperform the rest of the economy (even manufacturing) by a wide margin. Although the precise causes of this turnaround are still debated, this remarkable structural break in the farm TFP series has been noted by many scholars, and there has been no noticeable slowdown in the farm TFP growth rate in recent decades (Gardner, 2002).[7]

Third, we consider the role of differences in sectoral factor intensities in production. In our conceptual framework, factor shares in each sector are equivalent to the elasticity of output with respect to the factors of production, which we take as a measure of factor intensity in production. Our reading of the literature suggests that, overall, there is considerable uncertainty regarding the relative factor intensity in the farm versus the non-farm sectors. For the nineteenth century, we have relatively detailed estimates of factor shares in agriculture by Gallman (1972) which suggest that the share of capital (including land) had steadily increased from about 22 percent in the 1840s to about 30 percent by 1900. Sokoloff (1986) takes 30 percent as the share of capital in manufacturing, suggesting negligible differences between agriculture and non-agriculture.

For the second half of the twentieth century, we have the estimates of Jorgenson, Gollop, and Fraumeni (1987). Their econometric results show that for the farm sector (Table 7.3) the share of capital in the value of output (net of intermediate inputs) is about 30 percent, and for aggregate output (Table 9.8) it is about 38 percent suggesting lower capital intensity in farming. Gardner (2002, p. 37), on the other hand, compares several estimates of the share of labor in agriculture used for growth accounting purposes, and suggests a much larger share for capital in the farm sector.[8] Finally, we should note that most quantitative analysis in macroeconomics uses 0.33 for the share of physical capital in the non-farm business sector.

Unfortunately, we have no empirical evidence on the relative rates of capital deepening in the farm versus non-farm sectors, which would have helped to settle the issue. We know

[7]See also Jorgenson and Gallop (1992) for a postwar assessment of farm–non-farm relative TFP growth. Due to data limitations, we are unable to formally date these "turning points" through statistical structural break tests.

[8]For the first half of the twentieth century, Kendrick (1961, Table A-10, p. 285) presents estimates of factor shares for the farm and private non-farm sectors, indicating higher capital intensity in the farm sector. However, there is a strong downward trend in his capital share estimates in both sectors.

that capital deepening was pervasive in both agriculture and non-agriculture during the nineteenth century: see McCleland (1997) for agriculture, and Attack, Bateman, and Margo (2005) for non-agriculture. However, we are not in a strong position to conclude anything firm about their relative magnitudes. Hence, in accounting for U.S. structural change, we allow for both identical sectoral capital intensity, and the possibility that the non-farm sector uniformly had a higher capital intensity than the farm sector over the last two centuries.

We should also note that our emphasis on the decline of the agricultural sector (as in Caselli and Coleman, 2001, and Gollin et al., 2002) is not, by any means, meant to downplay the rise of the service sector. However, at least in the U.S., the patterns of structural change associated with the service sector are considerably more complex. In particular, while in the second half of the twentieth century the decline in the share of employment in agriculture coincided with an increase in the employment share of the service sector, in the nineteenth century the decline in the employment and output shares of agriculture mostly translated into a parallel increase in the employment and output share of manufacturing.[9] In fact, after documenting the non-negligible increase in the service sector's share in overall output (from 38 to 47 percent between 1840 and 1900), Gallant and Weiss (1969, Table 2, p. 291 and p. 304) also conclude that this increase in the share of the service sector "is not such a marked change when compared with the structural shifts that occurred within the commodity [agriculture, manufacturing, mining and construction] producing sector" and especially from agriculture to manufacturing.[10] Furthermore, the fact that the reallocation of labor out of agriculture has actually ac-

[9] Fuchs (1968) is the classic study on the growth of the service sector.

[10] An additional issue for the nineteenth century is the changing composition of output within the service sector. Over this period within the service sector, the relative importance of sectors producing intermediate products has increased from 49 to 56 percent. This mostly reflects the declining share of housing services within final service product (Gallman and Weiss, 1969, Table A-1). In fact, within the non-housing and non-government service output (roughly equivalent to the business nonresidential service sector), the share of final consumption was essentially identical for the two end points 1839 and 1899. It is thus safe to conclude that much of the increase in the service sector share of output during this period is accounted for by a rising share of intermediate service input use by producers of final goods and services, and we conjecture that the observed growth in the intermediate service sector output was of equal importance for agriculture and industry. As well, Gallman's (2000, Table 1.10) estimates show that the "expenditure" share of services has actually declined over the nineteenth century. Another vexing issue is the lack of consistent productivity, price and output estimates for the service sector until about 1920s.

celerated in the twentieth century makes our focus particularly relevant. Thus, for the purposes of accounting for the secular structural change that has taken place in the U.S. since 1800, it is appropriate to focus on the relative decline of agriculture.

4 The conceptual framework

Since we take the striking decline in the employment share of agriculture as the stylized fact to be accounted for in the nineteenth and twentieth century U.S. structural transformation, the conceptual framework we develop below is deliberately specialized. There are two sectors in the model: agriculture produces a consumption good, which is possibly a necessity, and non-agriculture produces a good that can be either consumed or invested in physical capital.[11] We then propose a structural change accounting framework which apportions the reallocation of labor out of agriculture to the three key drivers identified above.

4.1 Production and preferences

Time is continuous. There is no population growth, and the labor force is normalized to one. We denote agriculture by A, and non-agriculture ("manufacturing") by M.

Production.—At time t output Y in each sector is given by

$$Y_{At} = B_A K_{At}^{\beta} (Z_{At} L_{At})^{1-\beta},$$
$$Y_{Mt} = B_M K_{Mt}^{\alpha} (Z_{Mt} L_{Mt})^{1-\alpha}.$$

where, for each sector $i = A, M$, Y_i is output (equivalent of value added in national accounts), $K_i \geq 0$ is the capital stock, $Z_i > 0$ is labor augmenting technology, $L_i \geq 0$ is labor input, and $B_i > 0$ is an efficiency parameter. All labor augmenting technological change is exogenous. We refer to ZL as effective labor. The elasticities of output with respect to capital (α and β) are constant. These technology parameters satisfy $0 < \beta < 1$ and $0 < \alpha < 1$, and throughout we refer to them as capital shares.

[11]To maintain as much parallelism as possible with the previous literature, we model a closed economy.

Resource constraints.—All resources are fully used:

$$K_{At} + K_{Mt} = K_t \quad \text{and} \quad L_{At} + L_{Mt} = 1. \tag{1}$$

Because total employment is normalized to one, in what follows all aggregate variables can be interpreted in per worker terms.

Sectoral specialization.—The non-agricultural good can either be consumed, C_M, or invested in the form of physical capital, $I = \dot{K} + \delta K$, where $0 \leq \delta < 1$ is the depreciation rate. The agricultural good can only be consumed, C_A. Thus, market clearing in product markets implies

$$C_{At} = B_A K_{At}^{\beta} (Z_{At} L_{At})^{1-\beta}, \tag{2}$$

$$I_t = B_M K_{Mt}^{\alpha} (Z_{Mt} L_{Mt})^{1-\alpha} - C_{Mt}. \tag{3}$$

As we discuss below, restricting the production of capital goods to the manufacturing sector also contributes to the changing composition of output and employment shares over time.

Preferences.—Preferences are represented by an additively separable lifetime utility function. Instantaneous utility depends on a composite consumption good C

$$C_t = \left[\eta^{1/\nu} C_{Mt}^{(\nu-1)/\nu} + (1-\eta)^{1/\nu} \left(C_{At} - \gamma_A \right)^{(\nu-1)/\nu} \right]^{\nu/(\nu-1)}. \tag{4}$$

In equation (4), $\gamma_A \geq 0$ represents the subsistence level of food consumption and $\nu > 0$ is the elasticity of substitution between food consumption net of subsistence and non-food consumption.[12] For a non-trivial equilibrium, we require

$$B_A K_{At}^{\beta} (Z_{At} L_{At})^{1-\beta} > \gamma_A. \tag{5}$$

[12] Of course, in practice, there is no "fixed" level of subsistence food consumption independent of height and weight, both of which have evolved with economic growth. See Fogel (2004) for a discussion of these issues.

4.2 Optimality conditions

Production efficiency.—There is perfect factor mobility across sectors, and product markets are competitive. As a result, returns to factors of production are always equalized. This yields the equality of marginal rates of transformation across sectors:

$$\left(\frac{1-\beta}{\beta}\right)\left(\frac{K_A}{Z_A L_A}\right) = \left(\frac{1-\alpha}{\alpha}\right)\left(\frac{K_M}{Z_M L_M}\right). \tag{6}$$

Equation (6) is an intratemporal optimality condition and it determines the sectoral allocation of capital per worker for given values of relative productivity Z_M/Z_A, and capital intensities α and β.

Figure 4 shows some of the configurations of $\kappa_A = K_A/K$ and L_A that are implied by the production efficiency equation. For example, when both the labor augmenting technology and capital shares are identical across sectors ($Z_A = Z_M$, and $\alpha = \beta$), production efficiency requires $L_A = \kappa_A$. The dashed diagonal line in figure 4 shows such points. Given the uncertainty surrounding the precise capital intensities in the farm and non-farm sectors, we also consider the case $\alpha > \beta$ whereby the capital intensity in the non-farm sector exceeds that in the farm sector. In this case, production efficiency requires that the economy operate in the upper half of figure 4, along the solid line (for $\alpha = 0.38$ and $\beta = 0.30$). Of course, the labor augmenting technologies may also differ across sectors. When labor augmenting technology in the non-farm sector exceeds that of the farm sector ($Z_M > Z_A$), then the economy would operate in Region I, above the solid line in figure 4. We use the implications of the production efficiency condition for relative productivity levels in our quantitative analysis below.

Relative prices.—Since there is perfect factor mobility across sectors, there is a unique wage rate and interest rate. We normalize the price of the M good to 1, and let P_A denote the relative price of the A good. We solve for the relative price of the A good using equation (6) and the equilibrium condition that the marginal value product of labor is identical across sectors:

$$P_A = \left(\frac{1-\alpha}{1-\beta}\right)\left(\frac{Z_M}{Z_A}\right)\left(\frac{B_M}{B_A}\right)\frac{[K_M/(Z_M L_M)]^{\alpha}}{[K_A/(Z_A L_A)]^{\beta}}. \tag{7}$$

Consumption demand.—Finally, the equality of the marginal rates of substitution between A and M goods corresponds to

$$\left(\frac{1-\eta}{\eta}\right)\left(\frac{C_{Mt}}{C_{At}-\gamma_A}\right) = P_{At}^{\nu}. \tag{8}$$

4.3 Sectoral allocation of labor

We derive the sectoral allocation of labor when both product and factor markets clear, and when the equilibrium satisfies two optimality conditions—(i) that marginal rates of transformation between agricultural (A) and non-agricultural (M) goods are equalized (i.e., productive efficiency in equation (6)) and (ii) that there is equality of marginal rates of substitution between A and M goods (consumption optimality in equation (8)).

To this end, first define the following ratios:

$$b = \frac{B_M}{B_A}, \quad z_t = \frac{Z_{Mt}}{Z_{At}}, \quad y_A = \frac{Y_A}{L_A}, \quad k_A = \frac{K_A}{Z_A L_A}, \quad k_M = \frac{K_M}{Z_M L_M}.$$

Then, using the market clearing and optimality conditions, we obtain an expression for the employment share of non-agriculture

$$L_{Mt} = \frac{1 - s_A(y_{At})}{1 + p(z_t)\, s_k(k_{At}, k_{Mt})(1 - s_{Mt})}, \tag{9}$$

where the *relative productivity* effect is[13]

$$p(z_t) = \left(\frac{1-\eta}{\eta}\right) b^{1-\nu} z_t^{1-\nu}, \tag{10}$$

the *subsistence consumption* effect is

$$s_A(y_{At}) = \frac{\gamma_A}{y_{At}}, \tag{11}$$

the *capital accumulation* effect is

$$s_{Mt} = \frac{I_t}{Y_{Mt}}, \tag{12}$$

[13] We include the constant terms $\left(\frac{1-\eta}{\eta}\right) b^{1-\nu}$ in the relative productivity effect so that the differential capital deepening effect we discuss below only depends on factor share parameters, and the capital accumulation effect has a simple economic interpretation. This is inconsequential for our quantitative results below.

and the *differential capital deepening* effect is

$$s_k(k_{At}, k_{Mt}) = \left(\frac{1-\beta}{1-\alpha}\right)^{\nu} \left(\frac{k_{Mt}^{\alpha}}{k_{At}^{\beta}}\right)^{1-\nu}. \tag{13}$$

Let us discuss in turn the relevance of each of these for structural change. The relative productivity effect $p(z_t)$ in equation (10) originates from differences in sectoral productivity growth rates (i.e., $\dot{z} \neq 0$). This expression also demonstrates that the influence of the relative productivity effect on structural change depends on the elasticity of substitution between the consumption of agricultural and non-agricultural goods, ν. When this elasticity is unitary, this effect vanishes regardless of the magnitude of the differences between sectoral productivity levels. When $\nu < 1$ (gross complementarity), faster productivity growth in agriculture leads to "cost disease" for non-agriculture with labor moving out of agriculture.

The subsistence consumption effect $s_A(y_A)$ in equation (11) is the ratio of subsistence agricultural consumption to output per agricultural worker in agriculture. As productivity in agriculture increases, C_A tends to increase (since $C_A = Y_A$). However, due to Engel's law, actual output increases proportionately less than income, leading to a reallocation of labor out of agriculture. The capital accumulation effect, s_M in equation (12), is the share of investment in nonagricultural output. In the model, only nonagricultural goods can be converted into physical capital, and this specialization is responsible for the capital accumulation effect.

The capital deepening effect, s_k in equation (13), originates from differential capital intensities ($\alpha \neq \beta$). This expression shows that the influence of the capital deepening effect on structural change also depends on the elasticity of substitution between agricultural and non-agricultural goods, ν. As in the case of the relative productivity effect, this effect vanishes when this elasticity is unitary regardless of the magnitude of the differences between sectoral capital intensities. When $\nu < 1$, the sector that uses the scarce factor (labor) more intensively would tend to employ proportionately *more* labor (and capital) over time. This is similar in principle to the relative productivity effect, with the understanding that, in this case, the sector with lower capital intensity is the relative constraining factor for economic growth and amasses (in relative terms) all the factors of production (Acemoglu and Guerrieri, 2005).

If agriculture is indeed more labor intensive relative to non-agriculture, this tendency would, of course, thwart the secular reallocation of labor out of agriculture that we observe in the data. Therefore, for differential capital deepening effect alone to generate farm out-migration, we need a combination of higher capital share in agriculture ($\beta > \alpha$) and gross complementarity ($\nu < 1$), which would correspond to agriculture becoming more capital intensive relative to non-agriculture over time.

In sum, equation (9) is analogous to level accounting in economic development and it allows us to decompose the employment share of non-agriculture into four different components. It takes as given the agricultural consumption per worker, the investment non-agricultural output ratio, the allocation of capital across sectors, and the output per effective worker in each sector, and links these to the four proximate determinants of sectoral allocation of labor described above. Structural change accounting, as measured by the changing employment shares, immediately follows from this expression.

5 Accounting for U.S. structural change

5.1 Data

We rely on numerous data sources to account for the U.S. structural change in the nineteenth and twentieth centuries. Appendix A provides an extensive discussion of our data sources. Briefly, however, our nineteenth century data set builds on the meticulous work of numerous economic historians affiliated with the NBER, and the twentieth century data come mostly from official sources. Not surprisingly, our desire to use both nineteenth and twentieth century data faces important data constraints. We encounter many instances in which data from different sources using different methodologies need to be parsed (over time). There are also instances in which we have to choose among alternative estimates (covering roughly the same period). In those cases, we consult different sources and historical accounts to determine whether the broader tendencies we detect in our parsed data series coincide with those detected by previous researchers and economic historians. These are discussed extensively in our detailed data appendix (appendix A).[14] When

[14]Mundlak (2005) also uses two centuries of U.S. data in his analysis of technological change in the U.S. agriculture. However, he does not use data on the rest of the economy and his data sources are

we are unwilling to parse two time series, we bracket our estimates based on alternative scenarios. This "sensitivity" analysis is the best we can do given our current knowledge.

Before we move on to our quantitative account of the reallocation of labor out of agriculture, we first discuss whether the restrictions implied by our conceptual framework match the broad tendencies in nineteenth and twentieth century data on relative productivity growth and relative prices.

5.2 Relative productivity

Taking sectoral factor intensities (α and β) and the allocation of labor and capital across agriculture and non-agriculture as data, the production efficiency condition (6) provides a simple way to compute the implied *level* of farm–non-farm productivity (z).

We show the combinations of capital and employment shares of agriculture (L_A, κ_A) since 1840 in figure 4. The solid line shows the theoretical L_A, κ_A combinations when relative productivity is one ($z = 1$), the income share of capital in agriculture (β) is 0.30, and the income share of capital in non-agriculture (α) is 0.38 (see section 3). The actual allocations lie above the solid line for the entire nineteenth century as well as the first half of the twentieth century, cross the solid line in 1950, and remain below it thereafter. Under our parameter restrictions, this suggests that labor augmenting technology in non-agriculture exceeded that of agriculture until about 1950, at which point agriculture overtook non-agriculture.

In table 1, we compare the relative TFP *growth* rate derived by using the production efficiency condition ("implied" series) with those obtained by using growth accounting techniques (as in figure 3).[15] Unfortunately, the years for which we have TFP data for the nineteenth century do not perfectly overlap across the implied and measured estimates. We therefore present a qualitative comparison of the relative TFP growth rates for the

slightly different from those we use.

[15]We computed the implied series by first calculating the implied relative productivity. We solved for the implied z using equation (6) for given values of $L_{At}, \kappa_{At}, \alpha$, and β. These implied productivity levels do not depend on preference parameters. However, they do depend on perfect factor mobility across sectors. The implied relative productivity series should be interpreted with the understanding that, prior to the mid-twentieth century, the quality of the κ_A series is relatively poor. Sectoral productivity estimates based on growth accounting rely on separate estimates of K_A and K_M, and thus are more reliable.

nineteenth century.[16] Overall, we find that for both the nineteenth and twentieth centuries the two estimates point to similar tendencies (except for the period after 1977), although there are some important differences in terms of magnitudes. More important for our purposes, both measures reveal the following chronology of relative TFP growth: a faster TFP growth rate in non-agriculture in the postbellum nineteenth century, an even sectoral performance during the interwar period, and an acceleration of the TFP growth rate in agriculture relative to that of non-agriculture thereafter. In light of the theory, these trends imply that the relative productivity effect was a headwind for the reallocation of labor out of agriculture during the nineteenth century, and a driving force during much of the twentieth century.

5.3 Relative prices

Relative prices provide another simple link between our conceptual framework and data. Equation (7) shows that the change in relative prices depends on two principle forces: relative productivity growth and differential growth in capital per effective worker, with each sector weighted by their respective capital intensity parameter. Leaving the capital deepening effect aside for the moment, equation (7) suggests that a higher non-farm productivity growth rate relative to that of the farm sector would lead to a rise in the price of farm products relative to non-farm goods, and vice versa.

Given our chronology of the relative productivity growth rate, this is indeed what we observe in the nineteenth and twentieth century data. Figure 5 shows farm relative to non-farm prices. Starting from about 1820, prices of farm products increase relative to non-farm products over the course of the nineteenth century and that this secular trend continue until about 1918.[17] Recall that this is precisely the period during which our relative productivity series indicate a faster non-farm productivity growth rate. In the second half of the twentieth century, however, there is a distinct secular decline in the relative price of farm goods, accompanied, as we discussed above, by a relatively faster

[16]See table A.1 in appendix A for the sectoral estimates based on growth accounting techniques.

[17]Appendix A provides a detailed discussion of alternative relative price series, all of which suggest that the relative price of farm goods increased significantly during the nineteenth century. These include historically consistent price series constructed by Hanes (1998).

productivity growth rate in the farm sector.

Given that the relative productivity and price series broadly satisfy our cross-equation restrictions, the task ahead of us is to quantify the contribution of each of these factors (the relative productivity effect, the subsistence consumption effect and the capital accumulation effect) to the U.S. structural transformation experience.

5.4 Quantitative results

The core of our quantitative analysis is to calculate the model-based sectoral allocation of labor (L_M) given in equation (9)—see appendix B for details. Our conceptual framework and discussion above identifies three key drivers of the reallocation of labor out of agriculture in the U.S., and we will progressively introduce each of these drivers to illustrate their relative contribution.

5.4.1 Relative productivity and capital accumulation effects

We begin by considering a baseline scenario in which only the relative productivity and capital accumulation effects drive structural change. We thus turn off the subsistence consumption effect, by setting $\gamma_A = 0$, and the differential capital deepening effect, by setting $\alpha = \beta$. This is a useful starting point because it allows us to examine how far a minimal deviation from the standard neoclassical model would go in accounting for the U.S. structural change.

For this structural change accounting, we need values for two preference parameters: the elasticity of substitution between farm and non-farm goods, ν, which we set equal to 0.1 (gross complementarity), and the weight on the non-farm good in the consumption aggregator, η, which we set equal to 0.85 (to match the long-run expenditure shares).

Figure 6 demonstrates the results of the baseline scenario for the twentieth century. The model-based L_M series incorporating the relative productivity and capital accumulation effects have little hope of matching the data, especially before about 1960, despite an acceleration of the farm productivity growth rate starting in the late 1930s. The results are especially disappointing for the beginning of the century, when relative productivity growth favors the non-farm sector. As a result, during that period, the calibrated series imply on-farm migration which is counterfactual (except for the brief period after the Great Depression). Aside from grossly missing the broader trends in the early part of the century, the combined influences of the relative productivity and capital accumulation effects are also economically small. The best the baseline scenario can account for is about a two percentage points increase in the employment share of non-farm sector relative to an actual change of about 30 percentage points throughout the twentieth century.[18]

Figure 6 also shows that the baseline model is not sensitive to substantial variations in the investment–non-farm output ratio. We consider two examples in which the investment–output ratio is kept constant: a "high" ratio corresponds to the investment–output ratio in the year 2000 when the investment boom in the U.S. reached one of its historic peaks (according to the BEA data), and a "low" ratio, which is taken as half of that peak, but still above the post-WWII mean.[19] While these alternative estimates help bracket the calibrated series, they have no substantial influence on our conclusions.[20]

Inspection of equation (9) suggests why the joint influences of relative productivity and capital accumulation are unlikely to account for the U.S. structural transformation experience even after the 1940s when relative productivity growth favored agriculture. There is a strong upward "trend" in the actual employment share of the non-farm sector. On the right-hand side of equation (9), we have the inverse of the relative productivity term (i.e, $p(z)$) multiplied by one minus the investment–output ratio (with $s_A = 0$ and $s_k = 1$). Although relative productivity growth ($\dot{z}_t/z_t$) favors the farm sector at least in the twentieth century, changes in $p(z)$ do not sufficiently amplify the changes in relative productivity. Alternatively, to have an upward trend on the right-hand-side of equation (9), we need a strong trend in the ratio of investment to non-farm output. But, at least over the twentieth century, this ratio moved very little.

[18]We also calculated the employment share of non-farm sector using the implied relative productivity growth series from section 5.2 by replacing the z obtained by TFP growth accounting. The results were quantitatively similar—with the difference that the model-based series using TFP-based z series exhibit a reallocation of labor into the farm sector in the first two decades of the twentieth century, whereas the implied z series do not exhibit any significant change in employment shares.

[19]Gordon's (2004, Figure 2.9) estimates also show that since 1870 capital–output ratio in the U.S. has been roughly constant.

[20]We do not present the model-based series for the nineteenth century because, as we discussed above, relative productivity growth was much higher in the non-farm sector during much of this century. This alone implies an increasing employment share of farm employment which is counter to the actual record and which therefore widens the gap between the baseline scenario and the data.

In order for the relative productivity effect to account for structural change, we would need a consistent two percent per annum TFP farm–non-farm differential in favor of the farm sector (absent capital accumulation effects) in order to bring the employment share of agriculture in the model from its actual value of 33 percent in 1910 to about 6.2 percent by 2000 (actual is 2.4 percent). As shown above, however, the TFP growth differential was much less than two percent per year during the twentieth century, and typically favored non-agriculture during the nineteenth century.[21]

Overall, we find that the combined relative productivity and capital accumulation effects can account for the U.S. structural change since about the mid-1960s, but do a poor job reconciling with the data prior to that time. We now introduce the subsistence consumption effect into the analysis and examine its quantitative contribution to structural change in the U.S.

5.4.2 Subsistence consumption effect

To incorporate the subsistence consumption effect into the quantitative analysis, we need to calibrate the subsistence consumption parameter γ_A. While our conceptual framework treats this as a constant parameter, there are several potential complications associated with treating γ_A as strictly constant in a study that covers two centuries of rapid physiological, as well as structural change. For example, minimum requirements for caloric intake might have changed over time with the increase in average height and weight of adults. In addition, as incomes and social norms change, preferences that determine the subsistence consumption bundle may also change over time—for instance, more weight on meat and fruits, which are relatively more expensive, and less weight on cereals and potatoes, which are relatively inexpensive. We thus pursue several alternative approaches.

In the first approach, we fix γ_A using a benchmark year estimate of the ratio of subsistence food consumption to per capita food consumption $C_A = Y_A$. (Of course, in practice food consumption is not equal to food production because of spoilage, cooking losses, waste, and other losses.) Specifically, we set $\gamma_A/C_A = 0.95$ for 1919, and let this ratio

[21]Even during the golden years of agricultural productivity growth from 1948 to 2000, this differential was only about 0.7 percent per annum. Furthermore, even if we used relative price inflation to gauge relative TFP trends, the average relative price deflation was 1.6 percent for 1946–2000, significantly below the figures needed to account for U.S. structural change by relative price effects alone.

fluctuate over time with the fluctuations in per capita consumption.[22] Aside from the fact that this approach fixes the subsistence consumption requirements for the entire sample period, it is also only feasible for the twentieth century, because we lack food consumption data for the nineteenth century.

The second approach we pursue makes assumptions about the evolution of γ_A/C_A without necessarily assuming that γ_A remains constant throughout. Thus, annual variations in the values of C_A no longer translate automatically into fluctuations in the γ_A/C_A ratio. This more flexible and indirect approach also allows us to extend the analysis to the nineteenth century. Within this approach we again consider two alternatives: (i) a constant γ_A/C_A ratio at 0.90 from 1800 until 1950, and (ii) a trending γ_A/C_A ratio from 1800 until 1950 with $\gamma_A/C_A(1800) = 0.95$ and $\gamma_A/C_A(1950) = 0.90$. In both cases, after 1950 we let γ_A/C_A vary as in our first approach.

At first blush, assuming an almost constant γ_A/C_A ratio for a period of 150 years appears extreme. However, we base our decision to use flat γ_A/C_A profiles on several observations. First, we construct an index of farm output per worker from 1800 to 2000 using the value of farm output and total employment.[23] Remarkably we find that this index is practically flat from 1800 until about 1950. Although, there is uncertainty about the exact turning point, after about 1960 these data exhibit an upward trend.[24] This suggests that a flat γ_A/C_{At} profile is not inconsistent with the production data at least until the early 1950s.[25]

[22]Specifically, our data in figure 2 panel (a) suggests that real per capita food consumption was particularly low in this year—clearly due to the rising price of food during WWI. So, for that year, we pick a high ratio of the value of subsistence to actual food consumption. We then use the γ_A value corresponding to that benchmark (1,330 in 2000 dollars) and the actual data on per capita consumption expenditures on food to determine the γ_A/C_{At} series.

[23]In particular, we constructed a farm output index (2000=1) by relying on three sources: for 1800–1900 we used Towne and Rasmussen estimates of the value of agricultural output entering gross product as revised by Weiss (1993), for 1900–1929, farm gross private domestic product by Kendrick, and for 1929–2000, farm business GDP by BEA. We also construct a total employment index (2000=1) by relying on for the period Weiss (1992, 1993) for the nineteenth century and the U.S. Department of Commerce for the twentieth century. We then took the ratio of the farm output index and the total employment index. This index is admittedly noisy at the beginning of our sample.

[24]Our per capita consumption data in figure 2a also show a distinct upward trend after the early 1960s. Consumption data before that date are relatively more volatile because they are more heavily influenced by on-farm consumption of food and food transfers during the Great Depression.

[25]A back of the envelope calculation also shows that a flat γ_A/C_A profile is broadly consistent with the available data in more than one way. For instance, from 1800 to 1840, the growth rates of the capital

A relatively flat γ_A/C_A profile is also consistent with the U.S. Department of Agriculture's estimates of total food supply measured in calories per person per day. For instance, Putnam et al. (2002, Figure 1) show that per capita food supply remained practically constant from 1910 (the earliest year for which there is reliable data) until 1965, and has been *increasing* since then.[26]

Figure 7 presents the actual share of employment in non-agriculture, as well as the model-based series calculated using the three alternative approaches to calibrating γ_A/C_A. In all cases, we allow for the relative productivity and capital accumulation effects.[27] First, consider the scenario in which we set $\gamma_A/C_A = 0.95$ for 1919. Compared to the baseline scenario, the model with subsistence consumption yields much more significant reallocation of labor from agriculture to non-agriculture, and it matches the employment share of the non-farm sector closely in 1919 and 1929. More specifically, this extended model matches the long run trend reallocation after 1919 reasonably well. These results are clearly suggestive of the importance of non-homothetic preferences in accounting for the U.S. structural change.

There are, however, some important discrepancies between the data and the model-based series. In particular, the model makes the prediction of an unrealistically high employment share in the non-farm sector at the turn of the twentieth century. Given that this approach fixes γ_A, these high values of L_M in 1900 and 1909 are largely due to the *slightly* higher per capita food consumption (hence lower γ_A/C_A ratio) in those years relative to that of 1919. Our emphasis on slightly is warranted, because in the model even minor variations in the γ_A/C_A series have a substantial effect on the sectoral allocation of labor.

When we consider the alternative and more flexible approaches to measuring γ_A/C_A

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stock and total employment were practically identical (see Mundlak (2005, Figure 1 for capital, and Weiss's employment data). This fact and standard growth accounting for agriculture suggest that the decline in the share of employment in agriculture should be roughly identical to the TFP growth rate in agriculture. Indeed, during this period, the annual TFP growth in agriculture was about two percent which was slightly less than the annualized decline in the farm share of employment (2.4 percent).

[26]Gollin et al. (2002) model preferences for food consumption with an upper bound. Once the economy reaches this upper bound, all productivity gains in agriculture lead to proportional reallocation of labor out of this sector. Such a specification is also broadly consistent with a fairly flat per capita food consumption over time.

[27]For the nineteenth century, we set I/Y_M equal to its value in 2000. We experimented with alternative (and plausible) values of I/Y_M, and the results were not sensitive to the specific values of this ratio.

ratio, the model-based L_M series coincide with the actual data remarkably well (figure 7, series labeled by + and ×; note that these series coincide after 1950 by construction). Overall, the case in which we allow γ_A/C_A ratio to increase gently from 0.95 in 1800 to 0.90 in 1950 accounts for the U.S. structural change experience considerably better than the other two cases. We thus find that the subsistence consumption effect is the dominant driving force of structural change in the U.S. from the beginning of the nineteenth century well into the mid-twentieth century. This complements the baseline scenario, whereby relative productivity and capital accumulation effects jointly provided a good accounting of U.S. structural change beginning in the mid-1960s.

5.4.3 Capital deepening effect

The third driver of structural change in our conceptual framework is the capital deepening effect. This effect is only present when $\alpha \neq \beta$. As we discussed in section 3, there is no agreement on the parameter estimates of the sectoral capital intensities, α and β, but those that find sharp differences typically suggest a larger capital intensity in non-agriculture. To make the contrast between the previous scenarios as sharp as possible, we use the estimates of Jorgenson et al. (1986) and set the share of capital in agriculture at 0.30 and the share in non-agriculture at 0.38.

To incorporate the capital deepening effect into the quantitative analysis, we also need data on the sectoral capital stock per effective worker, k_A, k_M. Since there are no estimates available for k_A, k_M, we calculate the s_k series from the data using equation (7), which links s_k to information on relative prices, factor shares, and relative productivity levels, b and z.

Figure 8 shows the model-based L_M when we consider both $\alpha = \beta$ and $\alpha > \beta$, the latter of which incorporates all three key theoretical drivers of structural change. Because the results when the subsistence consumption effect operates through the gently upward sloping γ_A/C_A profile from 1800 until 1950 (i.e., $\gamma_A/C_A(1800) = 0.95$ and $\gamma_A/C_A(1950) = 0.90$) provide a better fit for the nineteenth century, we present this scenario. The model-based series with $\alpha = \beta$ (no capital deepening) are practically indistinguishable from the model-based L_M with the capital deepening effect. From a quantitative perspective, therefore, the relative productivity and subsistence consumption effects combined account for the bulk of U.S. structural transformation in the last two centuries.

There are also two theoretical reasons to doubt the strength of the capital deepening effect as an important driver of structural change in the U.S. First, the quantitative simulations in Acemoglu and Guerrieri (2005, Figures 1 and 2) demonstrate that structural change driven by differential capital deepening alone is painstakingly slow: under their baseline parameter values, even at the early stages of transformation, reallocating 20 percent of the labor force across sectors takes about 1,000 years! This speed of labor reallocation is clearly too slow for differential capital deepening to quantitatively account for U.S. structural change in the last two centuries.

Second, and more important for our context, in terms of changes over time in the sectoral shares of employment and the capital stock, the capital deepening effect favors the *less* capital intensive sector. Recall that capital is the only reproducible factor of production in the model. So, when $\nu < 1$, the sector that uses labor (the non-reproducible factor) more intensively would tend to employ proportionately more labor over time.

Since the results in figure 8 are based on relatively lower capital intensity in agriculture, this theoretical result would lead us to conclude that the capital deepening effect would have actually slowed the reallocation of labor out of agriculture—a result only marginally noticeable in our results. Given that U.S. structural transformation has been rapid and unequivocally geared toward the reallocation of labor out of agriculture, we conclude that capital deepening has been a relatively insignificant factor in this historical episode.

6 Concluding remarks

The structural transformation of the U.S. economy from an agricultural to an industrial base was a rapid and striking event. Surprisingly, very few attempts have been made to quantitatively account for this phenomenon. Recent developments in the theory of 'non-balanced' growth provide important insights into how to potentially account for this process within a unified framework. In this paper, we ask whether these insights are sufficient to explain the massive structural change in the U.S. over the last two centuries. We find that a combination of relative productivity growth and subsistence consumption effects accounts for much of the U.S. structural transformation in the last two centuries.

Appendix

A Data on the U.S. structural change

Aligning theoretical concepts with available data is especially challenging for long-run sectoral data. Our theoretical setup distinguishes sectors by the differentiated products they produce. So, ideally, our sectoral data, say, on agricultural employment (or hours worked) should pertain to those engaged in agricultural production. Similarly, data on agricultural value added should ideally correspond to value added in the production of agricultural goods. Both the nineteenth and twentieth century data we have are far from this ideal state. Instead, we have data on agricultural employment (or labor force) corresponding to those residing on farms, or declare their primary source of employment as farm employment. Clearly, such farm workers may have off-farm jobs. Also, many farm workers do not directly engage in agricultural production: land improvements, fencing, and home manufacturing generate incomes for the farm households, but do not constitute part of the agricultural value added.

In our empirical work, we use the raw farm employment data, without making an attempt to distinguish between employment strictly related to agriculture and on-farm non-agricultural employment. For the nineteenth century, we include land improvements and home manufacturing in agricultural value added, because a non-negligible portion of farm employment was directed towards these activities, especially towards land improvement. (However, relative to total agricultural value added both land improvements and on-farm home manufacturing had shrunk significantly by mid-nineteenth century.) However, to calculate agricultural labor productivity growth in a fashion that is consistent across the two centuries, we exclusively use agricultural production as the appropriate output measure.

A.1 The nineteenth century data

Output

- 1839–1899: Value added by the commodity sector, 1839–1899 ("variant A"), from Gallman (1960), and value added by the service sector, Gallman and Weiss (1969).

The total commodity sector is agriculture, mining, manufacturing and construction ("variant A"). There are no comparable estimates that cover earlier episodes as such estimates usually rely on questionable and unverifiable assumptions about both sectoral productivity levels and productivity growth rates (Weiss, 1992, Note to Table 1.2).

Labor

- 1800–1860: Total and farm labor force (10 years and older), Weiss (1992).

- 1870–1900: Total and farm labor force (10 years and older), Weiss (1993) and unpublished spreadsheets of Weiss, which revises the farm employment data used in Weiss (1993).

Manufacturing employment estimates are from Lebergott (1964, Table A.1).

Capital stock

- 1840–1900: Depreciable capital stock estimates at current and constant (1860) prices, from Gallman (1986).

We calculated the U.S. total fixed capital stock as the sum of domestic capital and equipment both given in Gallman (1986, Table 4.A.1, "Variant A"). Unfortunately, Gallman does not present capital stock estimates by sector directly. However, his Table 4.8 contains the ratios of capital stock to value added by sector. Gallman (in notes to Table 4.8) states that the ratios for each sector are based on the value added by sector calculated in Gallman (1960). We therefore use these agricultural value added estimates and the capital stock to value added ratio to calculate the agricultural capital stock. (This measure of capital stock naturally excludes the capitalized value of improvements to farmland, livestock, and inventories.)

Kendrick (1961, Tables A-XVI and B-III) also gives estimates of capital stock in the domestic private economy by sector. However, his capital stock estimates for the domestic economy are decade averages for 1869-1878 and 1879-1888, so they are not directly comparable with those based on Gallman (1986). In any case, the ratio of farm capital (net of cropland value, but inclusive of livestock) to domestic capital (net of land, farm and forest and excluding inventories) generally yield slightly larger ratios for farm capital compared to those we used in our analysis.

Factor shares

- Farm: Gallman (1972, Table 5) gives the following for labor shares in agricultural income (in percent): 1840=78.7, 1850=74.6, 1860=70.4, 1870=75.6, 1880=76.7, 1890=70.4, and 1900=71.0. Mundlak (2005, Figure 4) sets the share of labor at 40 percent for the entire nineteenth century, but provides no explanation for his choice.

- Nonfarm: Sokoloff's (1986) TFP estimates are based a capital share of 30 percent in manufacturing output (net of intermediate inputs).

Labor productivity in agriculture

- 1800–1900: Net farm output (net of intermediate inputs), which includes farm shelter but excludes improvements to land and home manufactures, from Weiss (1993) and unpublished spreadsheets on employment by Weiss.

Weiss (1993) revises the gross farm output estimates of Towne and Rasmussen (1960, Table 1) by correcting several entries in the livestock and crop output series. We converted the net output series in current prices into net output in 1840 prices using the implicit price index given in Towne and Rasmussen.

Manufacturing labor productivity

- 1820–1860: Sokoloff (1986).
- 1860–70: Annualized growth rate of a three-year centered-moving-average of the manufacturing production index (from 1861–71) of Frickey (1947, Table 6) minus the 1860–70 annualized growth rate of manufacturing employment from Lebergott (1964, Table A.1). Frickey and Lebergott's data yield 2.3% for 1870–80, 2.1% for 1880–90, 1.2% for 1890–1900.
- 1870–1900: output per person engaged in manufacturing, from Kendrick (1961, Table D-I).

Agricultural TFP

- 1800–1840: Gallman (1972, Table 7).
- 1840–1900: Craig and Weiss (2000, Table 3), who correct for changes in agricultural hours worked (both estimates include improvements to land as agricultural output).

Alternative agricultural TFP growth estimates by Gallman (1972) from 1800 to 1860, and by Kendrick (1961, Table B-I, ”net output”) from 1870 to 1900 are slightly higher for overlapping decades. However, none of these studies take into account changes in hours worked, which Craig and Weiss argue have increased at least after 1840. Moreover, Gallman's (1972, pp. 201–204) estimates are based on 1840 factor shares, and linear extrapolations of land and capital inputs between 1800 and 1840 and 1805 and 1840, respectively. Mundlak (2005, Figure 1) reports his own estimates of TFP growth in agriculture, but assumes constant capital stock and output growth rates for 1800–1840, and constant capital-output ratio for 1840–1900. Mundlak's estimates are uniformly lower than those reported by Gallman, and Craig and Weiss; see Sources to Table A.1.

Manufacturing TFP

- 1820–1860: The most widely cited estimates for manufacturing are from Sokoloff (1986) who provides a range of labor productivity and total factor productivity (TFP) growth estimates based on 13 manufacturing sectors from 1820 to 1860 (for certain years, data are missing for several sectors), and we take them as representative.

- 1860–1870: There are no data available for this period, so we used the GDP per capita growth rate (0.4 percent per annum) to proxy for manufacturing TFP growth rate from Gallman (2000, Table 1.6). Manufacturing labor productivity estimates based on Frickey (1947, Table 6) for manufacturing output index and Lebergott (1964, Table A.1) manufacturing employment also indicate an essentially flat productivity during this period.
- 1870–1900: Kendrick (1961, Table D-I).

Discussion of productivity estimates

Table A.1 summarizes the labor and total factor productivity estimates we rely upon. Here we provide a brief discussion.

Non-farm productivity estimates for the mid-nineteenth century are limited. Sokoloff (1986, p. 700) compares his estimates, which we use, with earlier studies, and concludes that evidence from cotton textiles in Massachusetts reveal generally lower estimates, but textile industry estimates in Davis and Stettler (1966) are higher. Sokoloff's labor productivity estimates are also consistent with those based on censuses of manufacturing from 1850 to 1870 (e.g., Atack, Bateman and Margo 2005), which essentially imply significant labor productivity growth between 1850 and 1860, followed by very little or no growth from 1860 to 1870, and robust growth afterwards. Our conclusion that, over the nineteenth century, TFP growth rate in the non-agricultural sector exceeded that of agricultural sector is also consistent with Kendrick's (1961, Tables B-I and D-I) estimates for agriculture and manufacturing for the period from 1870 to 1900. Finally, for 1840–1900 Gallman (2000, Table 1.7) estimates TFP growth for the total economy as 0.71 percent per annum, which is considerably higher than that of agriculture (0.46) reported by Craig and Weiss.

We checked the representatives of these estimates using Kendrick's (1961, Table D-I) estimates of manufacturing labor productivity after 1869. Kendrick's manufacturing labor productivity estimates are comparable with those based on Frickey and Lebergott, except for the period 1870–80 (0.7 versus 2.3 percent, respectively). Kendrick's data for the rest of the period show that manufacturing labor and TFP productivity growth was higher than farm labor and TFP growth (see his Table B-I for farm (net output), Table D-I for manufacturing, and Table A-XXIII for non-farm private sector TFP indexes). Atack et al. (2000, pp. 261–62) attribute three-fourths of the increase between 1840 and 1910 in the productivity of farm labor (engaged in land intensive production) to mechanization. They argue that livestock productivity growth was very low (as mechanization in dairy production only emerged in the twentieth century). Weiss's estimates are consistent with these observations. The balance of these estimates therefore suggest that labor and total factor productivity growth in agriculture lagged behind manufacturing throughout the period from early 1800's to 1900, a conclusion also shared by Williamson and Lindert (1980, pp. 170–72).

Prices

- 1800–1890: Wholesale price indexes for all commodities (series E52) and farm products (E53) from the U.S. Department of Commerce (1975, Warren and Pearson series).
- 1860–1990: Wholesale price indexes for all commodities other than farm products, and farm products, both from Hanes (1998, reprinted in Sutch and Carter, series Cc126 and 127, respectively). Hanes constructed his 1890–1990 series by extending the Warren and Pearson indexes using identical aggregation methods and products.
- 1869–1913: Consumer price index from Perez and Siegler (2003).

The wholesale prices in the Warren and Pearson indexes primarily relate to New York City. In this series, there is a gentle upward trend in the relative price series, favoring farm products, especially after about 1820.

One shortcoming of the non-agricultural prices cited above is that they refer to industrial commodities or manufactured products only. To see whether the relative price indices with a more comprehensive coverage of goods and *services*, we also consulted several other sources—though, these data tend to be sparser. The best estimates available are those recently synthesized by Perez and Seigler (2003) and Balke and Gordon (1989). We find that these price indices with a more comprehensive coverage of goods and services exhibit trends similar to those present in the prices of the more narrowly defined goods. For instance, the CPI-like index constructed by Perez and Siegler (2003), and the GNP deflator constructed by Balke and Gordon (1989) are highly correlated over their overlapping sample from 1869 to 1913 (correlation 0.96) and both exhibit a substantial decreases, which are consistent with the non-farm commodity price indices.

Gallman (1960) also reports implicit price deflators for final goods from 1839 to 1900. His data suggest that over the entire period, the implicit price index for agricultural goods was essentially flat (despite a transitory surge during the Civil War). Towne and Rasmussen's (1960) implicit agricultural price index estimates from 1809 to 1900 also show no increase in agricultural prices. Weiss's (1993 and unpublished spreadsheets) revised estimates of Towne and Rasmussen data exhibit the same tendency. Gallman's implicit price index for manufacturing goods, however, declined by about 0.7 percent per annum. This declining manufacturing implicit price index was reflected in the dramatic decline in the prices of both semi-durables and durables (Gallman, 2000, p. 33 and p. 41). Further, Brady's (1966) price indices suggest that whereas from 1834 to 1899 prices of producer durable goods (as measured by machine-shop products) or consumer durables (such as stoves) declined (anywhere from 2.6 to 0.5) percent per annum, most perishable consumer goods prices (butter, wheat, and processed or fresh meat) either increased or were stable. We also calculated the relative price of farm goods (implied by Weiss's estimates) to a measure of non-farm goods (based on the un-weighted average of shoes, stoves and machine-shop products from Brady) and found an overwhelming upward trend over the period 1810 to 1900. Atack, Bateman and Parker's (2000, p. 280) thus summarize the existing evidence from that period: "farm terms of trade, defined as the ratio of farm prices to all prices, generally improved."

A.2 The twentieth century data

Output

- 1900–1929: Gross private domestic product, farm and non-farm, 1929 prices, from U.S. Department of Commerce (1975, series F126 and F127). These are essentially Kendrick's (1961, Table AIII) estimates.
- 1929–2000: Gross value added by the business sector, farm and non-farm, current prices, from Bureau of Economic Analysis (http://www.bea.gov/bea, Table 1.3.5) Non-farm business sector excludes output of governments of all levels and government enterprises, output of household workers, nonprofit institutions, gross housing product of owner-occupied dwellings, and the rental value of nonprofit institutional real estate. The two series were very similar at the break year (1929) and the remaining overlapping years (until 1960).

Since the business sector data excludes output at all levels of government, we also considered GDP excluding housing value added (only available after 1929). These series have essentially the same trend, with the exception of the WWII period.

Labor

- 1900–1947: Farm employment and total employment (14 years old and over), U.S. Department of Commerce (1975, series D5 and D6). According to this series employment share of farm sector in 1900 is about 41 percent, which is significantly larger than the 36 percent based on Weiss (1993 and unpublished worksheets). The main difference between the two series is the age cutoff for employment (14 years old for Department of Commerce and 10 years old for Weiss). Since for 1910 the employment share of agriculture for 10 years old and older (Tostlebe, 1957, Table 4, who corrects the census figures for known underreporting problems), and for 14 years old and older are virtually identical (31 and 32.6 percent, respectively), and since these differences remain minor thereafter, in the final series shown in Figure 1, we used Weiss's data until 1900, and Department of Commerce numbers after 1910.
- 1948–2000: Agricultural employment and total employment (16 years old and over), U.S. Department of Commerce, Bureau of Labor Statistics (http://bls.org/, Table 1: Employment status of the civilian noninstitutional population, 1940 to date).[28]

[28]Mundlak (2005, Figure 1) reports Gardner (2002, Figures 8.1 and 8.2) for his twentieth century labor

Capital

- 1900–1953: Farm capital stock (net of cropland value, inventories, livestock and workstock), and nonresidential real capital stock, equipment, and structures (1929 prices) in the private domestic economy, Kendrick (1961, Tables A-XVI for non-farm and Table B-III for farm). Inventories are excluded from both farm and total capital stock estimates for consistency with the 1947–2000 period estimates. Including workstock in both the farm and total capital stock estimates does not affect the results materially, especially during the later periods. These are available for the following key years: 1899, 1909, 1919, 1929, 1937, 1948, and 1953, but we did not use the last two observations. Kendrick (Table A-XV) includes annual capital stock data, 1889–1953, for the farm and private non-farm, nonresidential sectors, but these are not separated by fixed physical assets and land and real estate. Moreover, Kendrick's (1961: 354–356) annual farm capital stock data are essentially interpolations using Tostlebe's (1957) estimates, which are in turn based on census data.

- 1947–2000: Current-cost net stock of private fixed assets by industry, farm and non-farm, excluding real estate and rental and leasing (in current dollars, year end estimates), Bureau of Economic Analysis (http://www.bea.gov/, Table 3.1ES). (These data do not include livestock and work stock.) We also computed the capital stock in the farm and non-farm sectors using current-cost net stock of private fixed assets, equipment and software, and structures by type which starts in 1929 (BEA, Table 2.1). To compute farm equipment and structures we added agricultural machinery and farm structures. To compute non-farm structures, we added nonresidential equipment and software and nonresidential structures. These series are consistently below those obtained from the industry side, but the overall trends are identical.

Gross investment

- 1900–1930: Gross domestic private investment (from Kendrick 1961, Table A-IIa) minus net non-farm private residential investment (derived from annual capital stock estimates in Kendrick, Table A-XVI), both in 1929 prices.

- 1929–2000: Gross domestic private nonresidential fixed investment, current prices, Bureau of Economic Analysis (http://www.bea.gov/, Table 5.2.5).

Unfortunately, gross investment divided by private (or business sector) non-farm output series from Kendrick and the Bureau of Economic Analysis (BEA) are significantly different and difficult to reconcile. We, therefore, bracket our estimates using three alternative

series. Figure 8.1 in Gardner shows real agricultural GDP and agricultural output. Figure 8.2 in Gardner shows real farm GDP per person measured either by farm employment or farm population, but Gardner does not explicitly state his data sources on farm employment and population.

series: (i) investment-output ratio based on parsed Kendrick-BEA data, (ii) investment-output ratio set equal to its value in 2000 (about 0.16), which represents a “high” value , and (iii) investment-output ratio set equal to half its value in 2000 (about 0.08), which represents a “low” value.

Factor shares

- 1900–1953: Factor shares in the farm and non-farm private domestic economy, Kendrick (1961, Table A-10). Although, Kendrick’s numbers for the farm sector are broadly consistent with those reported by Gallman (1972, Table 5) for earlier periods, Kendrick’s non-farm sector capital shares are slightly below those typically used in modern studies.

- 1948–1979: Average value shares of capital and labor input, Jorgenson, Gollop, and Fraumeni (1987), Table 7.3 for agricultural production, and Table 9.8 for aggregate output.

Farm and non-farm labor productivity

- 1900–1966: Farm and non-farm output per man-hour in the private economy (1958 = 100), U.S. Department of Commerce (1975, series D683–688, columns 684, 686).

- 1947–2000: Non-farm business sector output per hour (1992=100), Bureau of Labor Statistics (http://www.bls.gov/data/home.htm, series PRS85006093).

- 1948–2000: Farm output per unit of farm labor (1996=100), U.S. Department of Agriculture, Economic Research Service (http://www.ers.usda.gov.) See Ball et al. (1997) for a detailed description of output and inputs.

Farm TFP

- 1900–1953: Farm (net output based) TFP, 1929=100, from Kendrick (1961, Table B-I).

- 1948–2000: U.S. Department of Agriculture, Economic Research Service, http://www.ers.usda.gov. These are updated series based on the basic methodology discussed in Ball et al. (1997).

Non-farm TFP

- 1900–1956: Private domestic non-farm economy TFP, 1929=100, from Kendrick (1961, Table A-XXIII).

- 1948–2000: Private non-farm business sector multifactor productivity, Bureau of Labor Statistics, Historical SIC measures 1948–2002 (http://www.bls.gov/mfp/historicalsic.htm).

Discussion of productivity estimates We compared the Kendrick and ERS farm and Kendrick and BLS non-farm TFP growth rates during the period 1948–1953. Non-farm TFP growth rates were very similar, but the farm TFP growth rates were not, with Kendrick's data exhibiting a much faster TFP growth rate.

Consumption expenditures

- 1900–1929: Personal consumption expenditures and consumption expenditures on food, in current and in 1987 constant prices, from Lebergott (1996, Tables A1 and A2).

- 1929–2000: Price indexes for personal consumption expenditures by type of product (2000=100), and personal consumption expenditures and consumption expenditures on food, in current prices, from Bureau of Economic Analysis (http://bea.org/, NIPA Tables 2.4.4 and 2.4.5).

We parsed these series by deflating the Lebergott series using the ratio of real personal expenditures in 1929, which is a common observation.

Population

- 1900–1999: mid-year population estimates, from Population Estimates Program, U.S. Census Bureau (http://www.census.gov/popest/archieves/pre-1980/).

- 2000: mid-year population estimates, from Population Estimates Program, U.S. Census Bureau (http://www.census.gov/popest/estimates/).

National population data for the years 1900 to 1949 exclude the population residing in Alaska and Hawaii. National population data for the years 1940 to 1979 cover the resident population plus Armed Forces overseas. National population data for all other years cover only the resident population.

Prices

- 1913–1954: Wholesale price index for industrial commodities (series E23), and the wholesale price index for farm goods, (E25), from the U.S. Department of Commerce (1975).

- 1955–2000: Producer price index for total industrial commodities and producer price index for farm products, from the *Economic Report of the President, 2002*, Table B–67.
- 1913–2000: CPI all items, all urban consumers, city average, (1982-84=100), from the Bureau of Labor Statistics (http://www.bls.gov/cpi/).

All series are constructed by the Bureau of Labor Statistics.

B Solution method

Our quantitative analysis proceed as follows.

Step 1: Set the parameter values $\nu, \eta, \alpha, \beta, \gamma_A$.

Step 2: Solve the productive efficiency condition (6) for the level of relative productivity, z, in year 2000 using data on $L_{A,2000}$ and $\kappa_{A,2000}$. Call this the calibrated value of z, z^{c}_{2000}.

Step 3: Solve equation (9) for the ratio of efficiency parameters, b, using $L_{M,2000}$, $s_{M,2000}$, and z^{c}_{2000} (from Step 1). Label this calibrated value of b as b^{c}.

Step 4: Use z^{c}_{2000} to re-scale the Z_{Mt}/Z_{At} series estimated by TFP growth accounting. Call these z-series, z^{c}_t.

Step 5: Use equation (7) to compute k^{α}_M/k^{β}_A.

Step 6: Solve equation (9), for L_{Mt} using b^{c}, $p(z^{\mathrm{c}}_t)$, and data on I_t/Y_{Mt} and γ_A/C_{At}. We call these model-based L_{Mt}.

Our method ensures that model-based L_M equals actual L_M in 2000.

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Table 1: Growth Rate of Ratio of Nonfarm to Farm TFP
(annualized compound growth rate, percent)

Period	Implied	Measured	Period	Implied	Measured
1820–1830	—	+	1900–1909	−0.18	1.99
1830–1840	—	(+)	1909–1919	−2.37	1.62
1840–1850	0.25	+	1919–1929	0.64	0.80
1850–1860	1.77	+	1929–1937	0.15	0.89
1860–1870	−2.96	(−)	1937–1947	−0.93	−0.55
1870–1890	0.98	+/(−)	1947–1957	−5.32	1.09
1880–1890	3.92	+	1957–1967	−5.81	−0.29
1890–1900	0.02	+	1967–1977	−3.07	−0.86
			1977–1987	0.46	−2.01
			1987–2000	1.18	−1.00

Notes: Implied relative TFP growth rates are based on the production efficiency condition, sectoral labor and capital stock shares, and sectoral factor intensities as discussed in the text and given by equation (6). For the non-farm sector, we used a constant share of capital, $\alpha = 0.3$, throughout. For the farm sector, we used the following share of capital (β) parameters: 1840=0.22, 1850=0.25, 1860=0.30, 1870=0.24, 1880=0.23, 1890=.30, 1900=0.29, and thereafter 0.30. For the nineteenth century, since the periods for which we have farm and non-farm TFP growth rates do no overlap, using data in Table A.1, we indicated the likely sign of measured relative TFP growth rates (likely signs assigned using average labor productivity growth rates are given in parentheses, when either they are different in sign from the likely relative TFP growth estimates or relative TFP growth estimates are not available for the period). Measured relative TFP growth rates are based on farm and non-farm TFP estimates. The numbers are the annualized compound growth rates in percent. A positive number means faster TFP growth rate in the non-farm sector. Measured series are non-farm minus farm TFP growth rate.
Sources: For measured series, see the sources to figure 3, and for implied series, see the sources to figure 4.

Table A.1: Productivity Growth by Industry, Nineteenth Century U.S.
(annualized growth rate, percent)

Period	Q_A	N_A	Q_A/N_A	Q_M/N_M	TFP_A	TFP_M	GDPP	TFP
1800-1810	3.02	2.90	0.12	–		–	–	
1810-1820	3.03	2.96	0.06	–	} 0.60	–	1.1	}0.55
1820-1830	3.17	2.76	0.40	3.94		3.03	0.8	
1830-1840	3.62	2.77	0.83	}0.68		}0.97	1.3	
1840-1850	2.13	2.37	−0.23		} −0.14		1.9	
1850-1860	3.64	2.53	1.08	3.21		2.44	1.6	
1860-1870	1.92	0.12	1.80	0.82	1.47	–	0.4	
1870-1880	4.36	2.68	1.63	0.76		0.87	2.3	}0.71
1880-1890	1.93	1.28	0.65	2.24	} 0.52	1.96	1.7	
1890-1900	2.45	1.08	1.36	1.25		1.12	1.1	

Notes and Sources: Annualized growth rates (g) are computed using the compound growth rate formula: $x_t = x_0(1+g)^t$, and are expressed in percent.
$\mathbf{Q_A}$: Farm net output ("narrow") which includes farm shelter but excludes improvements to land and home manufactures from unpublished data underlying Weiss (1993, Table 4).
$\mathbf{N_A}$: Farm employment from Table **??**.
$\mathbf{Q_A/N_A}$: Farm labor productivity (equivalent to y_A in the text).
$\mathbf{Q_M/N_M}$: Manufacturing labor productivity. 1820–1832, 1832–1850, and 1850–1860 are from Sokoloff (1986, Table 13.4) based on weighted averages of net output in 13 manufacturing industries, and is the mid-point of the (Northern) firm and aggregate level estimates of Sokoloff's "variant B", 1861–71 are annualized growth rate of three year centered moving average of manufacturing production index of Frickey (1947, Table 6) minus 1860–70 annualized growth rate of manufacturing employment from Lebergott (1964, Table A.1), and from 1870 to 1900 are from Kendrick (1961, Table D-I, "output per person engaged").
$\mathbf{TFP_A}$: Farm total factor productivity (TFP). 1800–1840 are from Gallman (1972, Table 7), and 1840–1860, 1860–1870, and 1870–1900 are from Craig and Weiss (2000, Table 3), who account for increases in average hours worked by farm workers. Both Gallman and Craig and Weiss use agricultural output figures that include improvements to land and maintenance. Gallman (1972) also provides decennial estimates based on extrapolation of agricultural capital stock and land from 1800 to 1840: 1800–1810=−0.31, 1810–1820=0.36, 1820–1830=1.11, and 1830–1840=1.40. Kendrick's (1961, Table B-I, "net output") TFP indexes imply the following farm TFP growth: 1870–1880= 1.46, 1880–1890=0.54, and 1890–1900=1.05. Mundlak (2005, Table 2), after accounting for factor biased technological change, reports the following TFP growth rates in agriculture: 1800–1840=0.19, 1840–1880=0.56, and 1880–1900= [0.15–0.56].
$\mathbf{TFP_M}$: Manufacturing TFP. 1820–1832, 1832–1850, and 1850–1860 are from Sokoloff (1986, Table 13.9) based on "variant B" weighted averages of net output in 13 manufacturing industries, and is the mid-point of the firm and aggregate level estimates (1820-30 is 1820-32). 1870–1900 are from Kendrick (1961, D-I). 1860–1870 growth rate is approximated by 0.4 percent per annum based on Gallman (2000, Table 1.6) GDP per capita growth rate.
GDPP: Gross domestic product per capita from Gallman (2000, Table 1.6).
TFP: Aggregate TFP. 1800–1840 and 1840–1900 are from Gallman (2000, Table 1.7). Most years (e.g., 1869, 1879) are reported by the census year (e.g., 1870, 1880).

Table A.2: Summary of Variable Descriptions and Data Sources

Variable	Description	Source
Output	Gross value added by the business sector, farm and non-farm.	Gallman (1960), Gallman and Weiss (1969), U.S. Department of Commerce (1975), and BEA.
Consumption	Private consumption expenditures, food and all items	Lebergott (1996), and BEA.
Employment	Farm and non-farm employment, 10 years and older (1800–1900), 14 years old and older (1910–1947), 16 years old and older (1948–2000).	Weiss (1992 and unpublished worksheets), and BLS.
Capital stock	Farm capital stock (net of cropland value, inventories, livestock and workstock), and private domestic economy, nonresidential stock of equipment, software, and structures.	Gallman (1986), Kendrick (1961), and BEA.
Gross investment	Gross domestic private nonresidential fixed investment. No data for the nineteenth century.	Kendrick (1961) and BEA.
Farm TFP	Farm total factor productivity.	Gallman (1972), Craig and Weiss (2000); 1900–1947, Kendrick (1961, Table B-I), and 1948–2000, U.S. Department of Agriculture, ERS.
Nonfarm TFP	Manufacturing TFP for 1820–1890, and private non-farm business sector TFP for the twentieth century.	Sokoloff (1986); 1860–1870, Gallman (2000); 1870–1900, Kendrick (1961, Table D-I); 1900–1947, Kendrick (1961, Table A-XXIII); 1948–2000, BLS.
Prices	Wholesale price indexes for farm products and all commodities other than farm products.	1800–1860, Warren and Pearson series; 1860–1941, Hanes (1998); 1941–2000, Bureau of Labor Statistics.
Factor shares	Share of labor in total agricultural income and in non-farm income	1840–1890 (farm only): Gallman (1972); 1948–1979: Jorgenson et al. (1987).

Note: See appendix A for more precise variable definitions, and details.

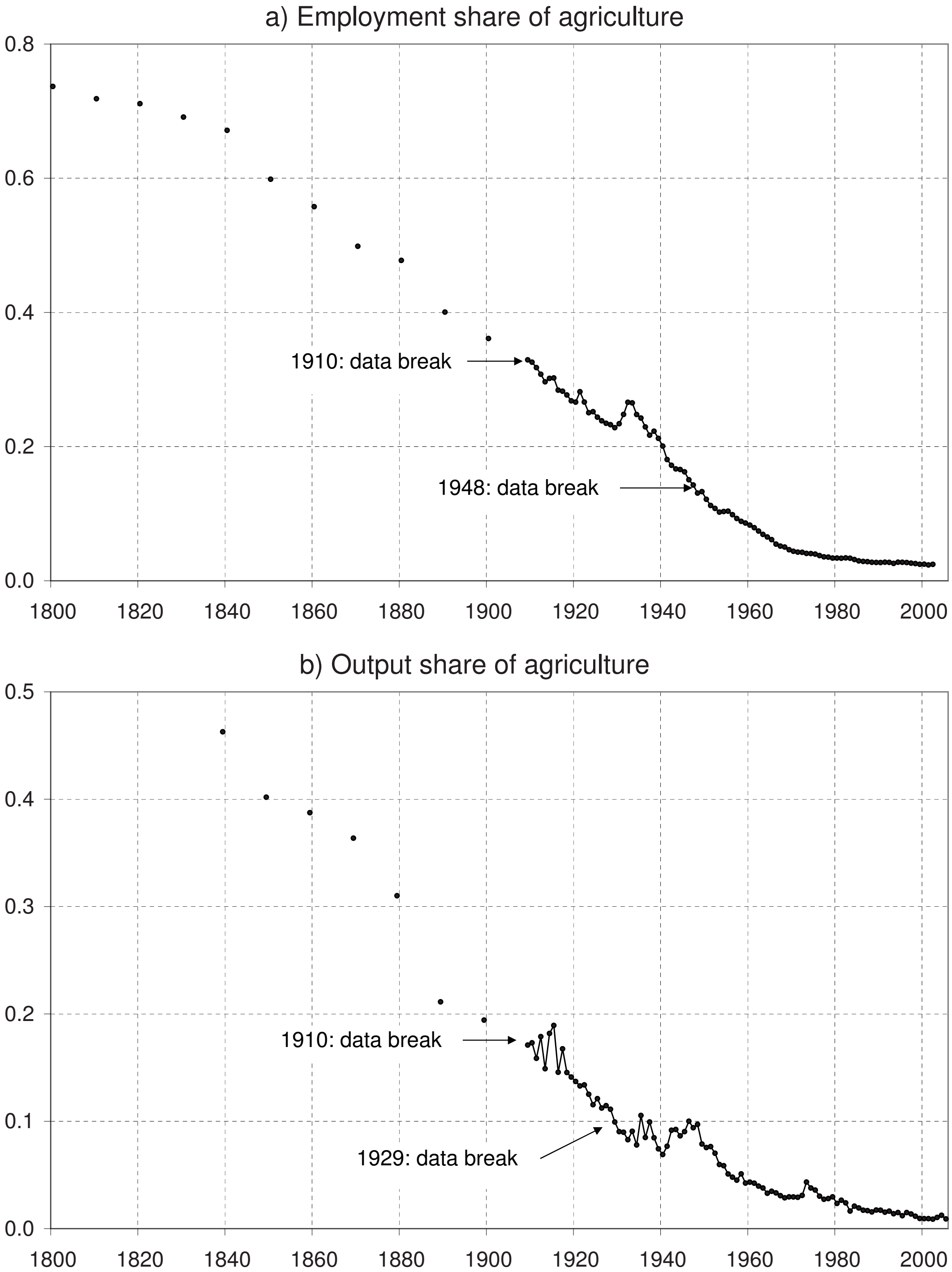

Figure 1: Two centuries of U.S. structural transformation

Sources: Employment share: 1800–1900, Weiss (1992 and unpublished worksheets); 1910–1947, U.S. Department of Commerce (1975, series D5 and D6), and 1948–2000, U.S. Department of Commerce (various issues), and BLS (series LNU02000000). Output share: 1839–1899, Gallman (1960) and Gallman and Weiss (1969); 1910–1929, U.S. Department of Commerce (1975, series F126 and F127); and 1929–2000, Bureau of Economic Analysis (Table 1.3.5). See also appendix A.

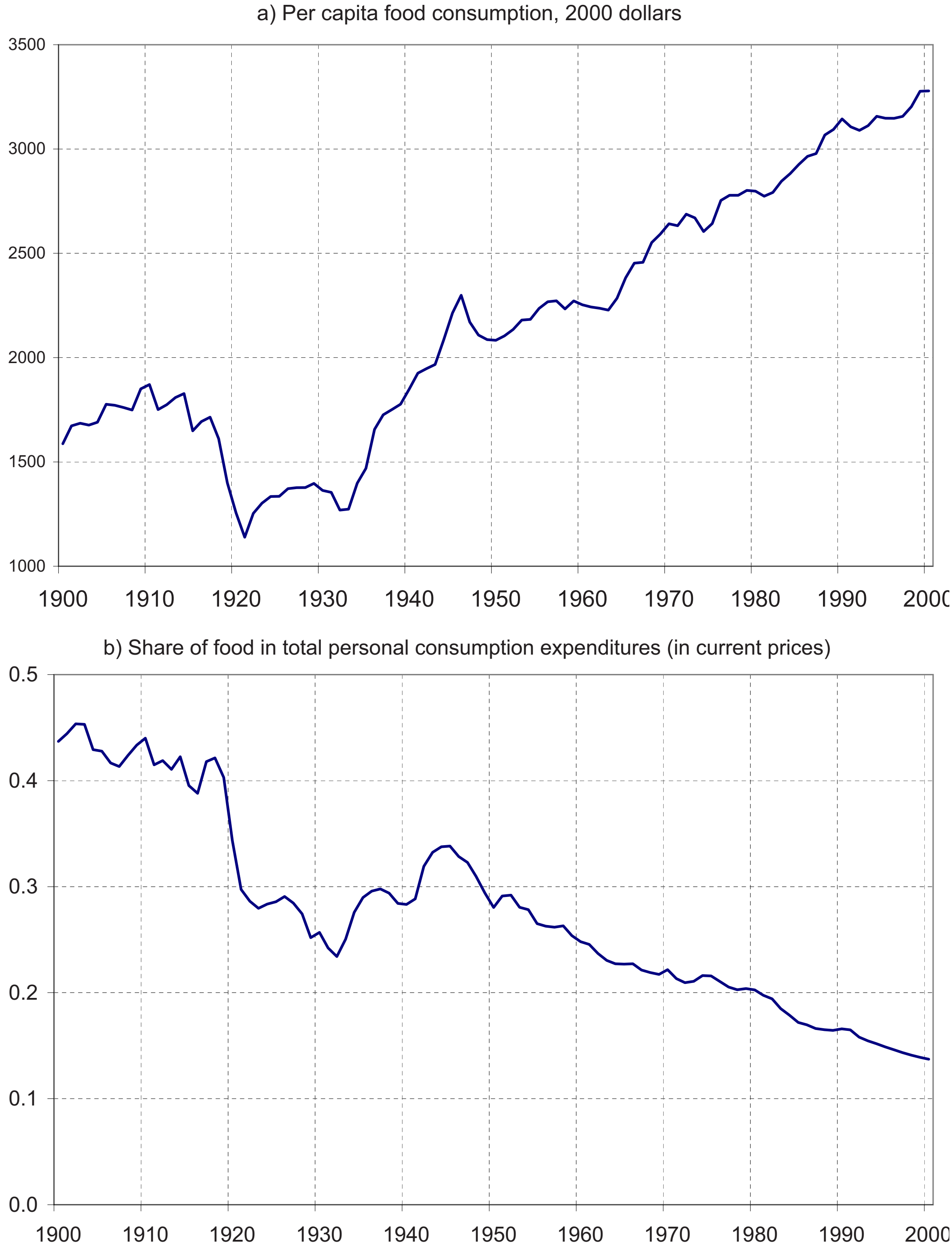

Figure 2: Consumption expenditures on food

Source: Lebergott (1996) and Bureau of Economic Analysis.

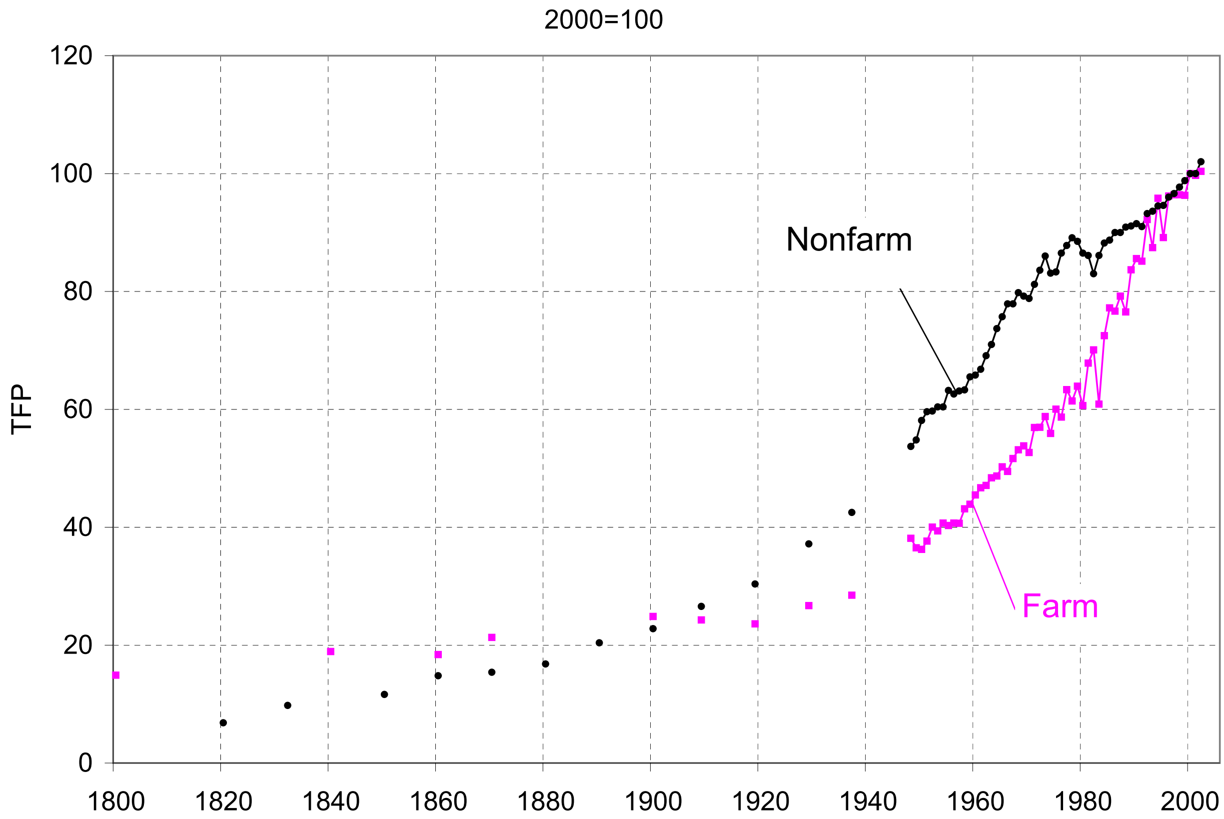

Figure 3: Farm and non-farm TFP

Sources: Farm: 1800–140, Gallman (1972); 1840–1900, Craig and Weiss (2000); 1900–1947, Kendrick (1961, Table B-I), and 1948–2000, U.S. Department of Agriculture, Economic Research Service. Nonfarm: 1820–1860, Sokoloff (1986); 1860–1870, Gallman (2000); 1870–1900, Kendrick (1961, Table D-I); 1900–1947, Kendrick (1961, Table A-XXIII); 1948–2000, Bureau of Labor Statistics. See also appendix A.

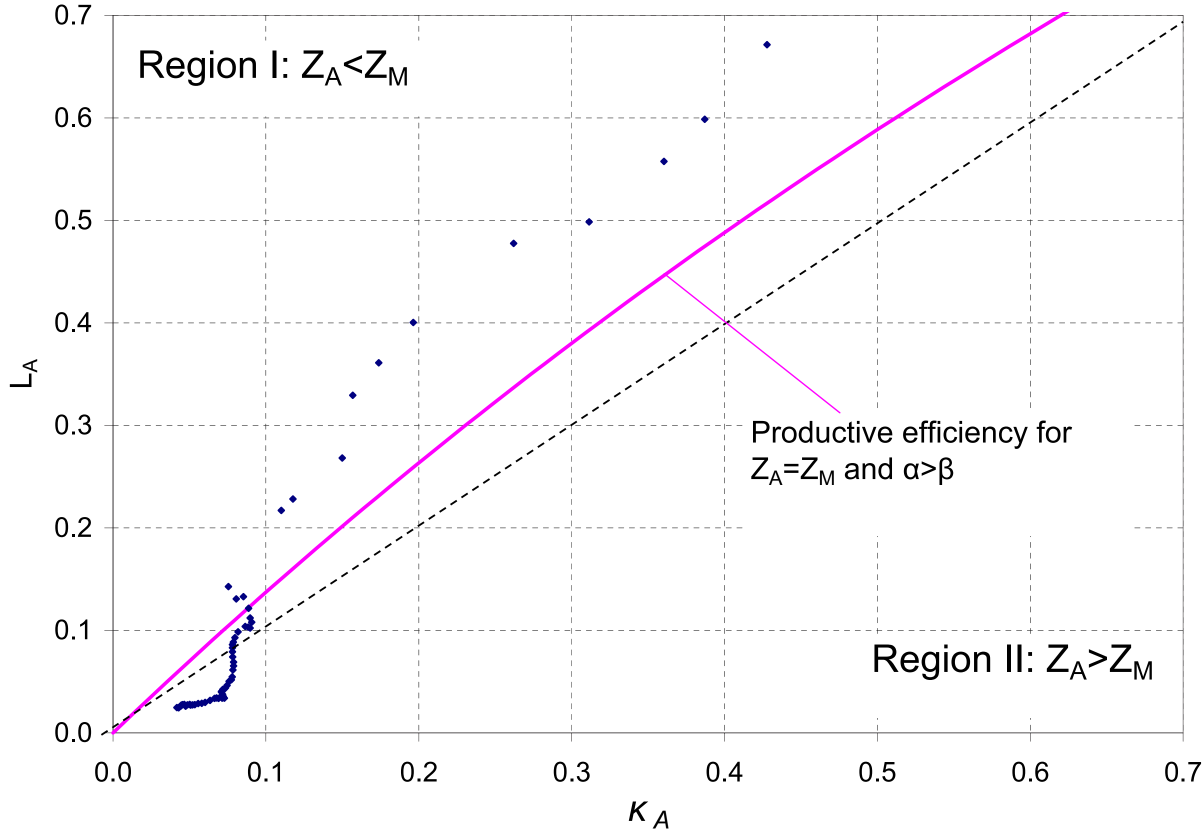

Figure 4: Production efficiency and shares of capital and labor in agriculture, U.S. (1840–2000)

Sources: For labor shares see figure 1. For capital shares: 1840–1890, Gallman (1986); 1900–1937, Kendrick (1961); and 1947–2000, BEA. See also appendix A.

Notes: L_A is employment share of agriculture, and κ_A is capital stock share of agriculture. Diamonds are actual allocations from 1840 to 2000. The solid curve corresponds to those allocations implied by the theory when relative productivity, z is one, income share of capital in agriculture, β is 0.30, and the income share of capital in non-agriculture, α is 0.38.

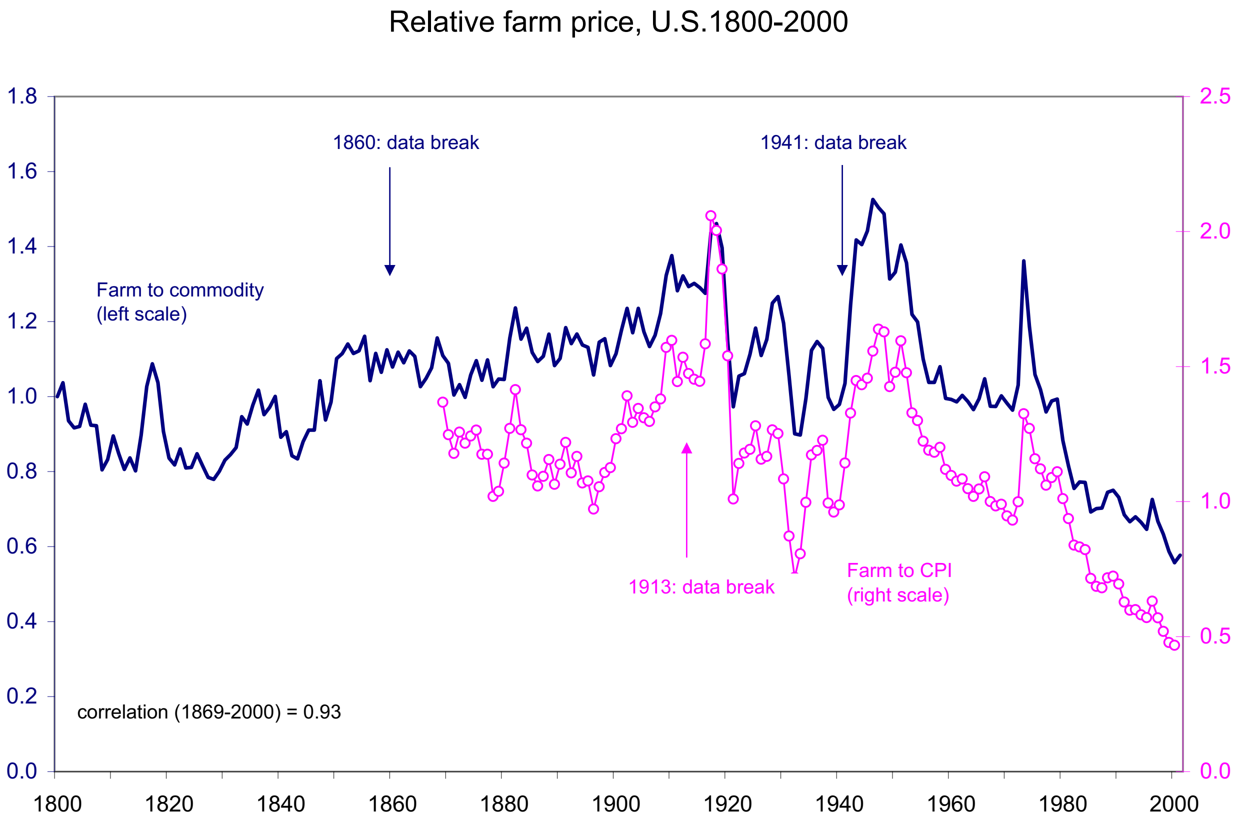

Figure 5: Ratio of farm to non-farm prices, U.S. (1800–2000)

Sources: Farm divided by commodity prices; 1800–1860: Warren-Pearson; 1860–1941: Hanes (1998); 1941–2000: BLS. Farm divided by CPI; 1869–1913: Perez and Siegler (2003) and Hanes; 1913–2000: BLS.

Notes: Farm divided by commodity prices 1800 = 1, and farm divided by CPI 1967 = 1.

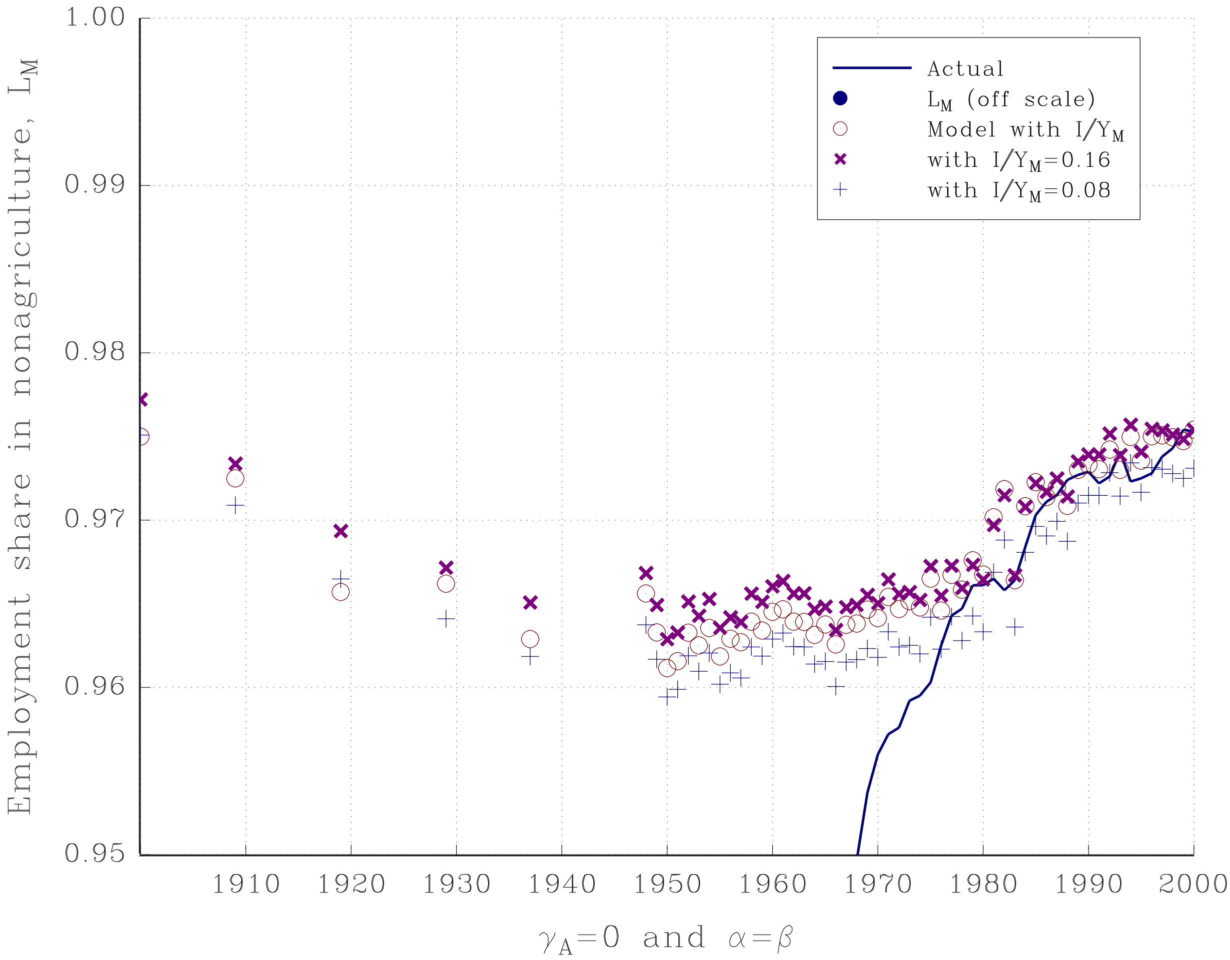

Figure 6: Employment share of non-farm sector: baseline model

Source: For actual series (solid line), see sources to figure 1.
Notes: The calibrated series are computed using the relative productivity values (b and z) calibrated to match L_M in 2000 and using the measured relative productivity growth, as discussed in the text. The parameter values are $\nu = 0.1$ and $\eta = 0.85$. Circles (O) cover the period 1900–2000 and are based on Kendrick's (1961) and BEA's I/Y_M series (which are not directly comparable). The figure also shows two alternative calibrated series using "high" value for $I/Y_M = 0.162$ (×; its value in 2000) and a "low" value for $I/Y_M = 0.081$ (+).

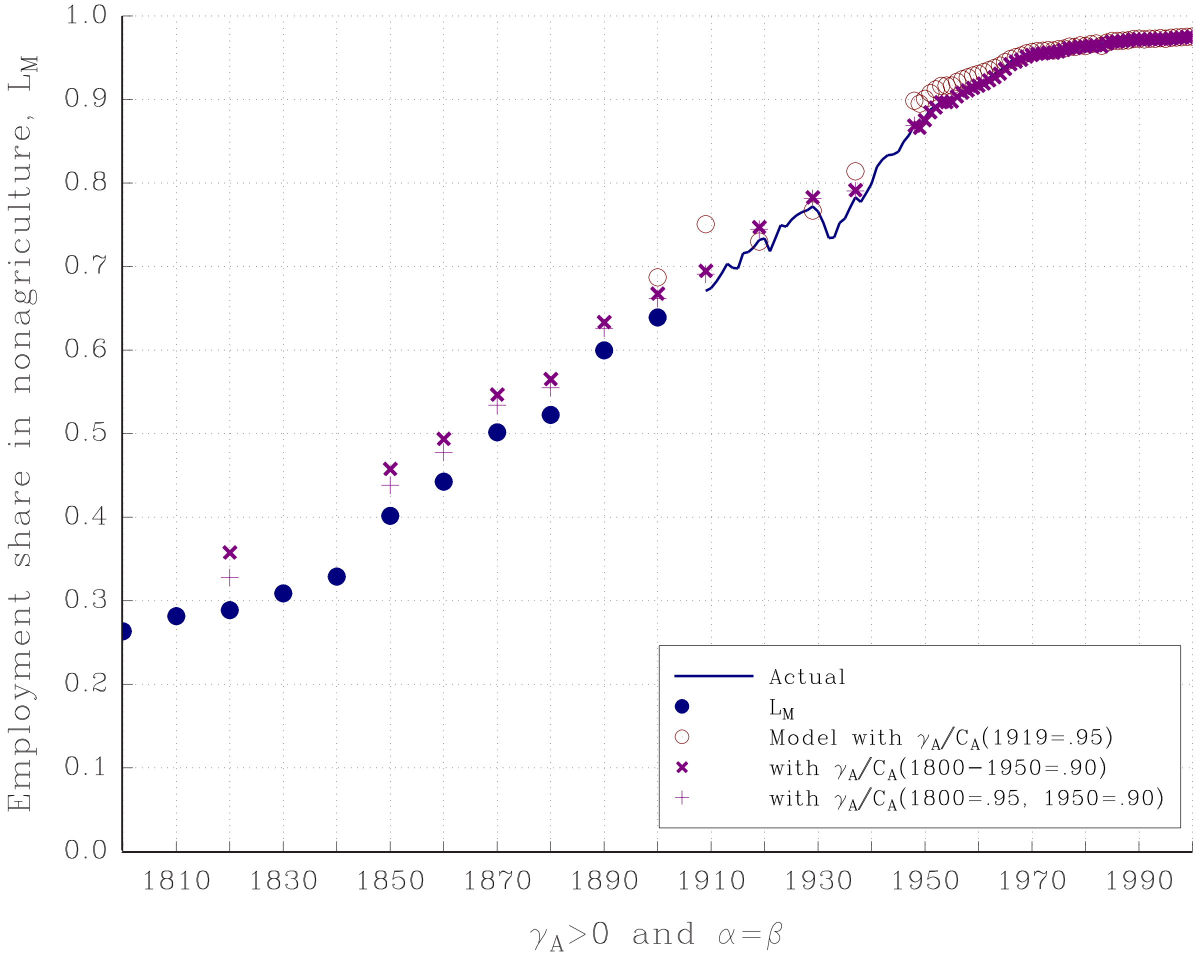

Figure 7: Employment share of non-farm sector: the extended model

Source: For actual series, see sources to figure 1.

Notes: See text for details. Other parameter values are $\nu = 0.1$ and $\eta = 0.85$.

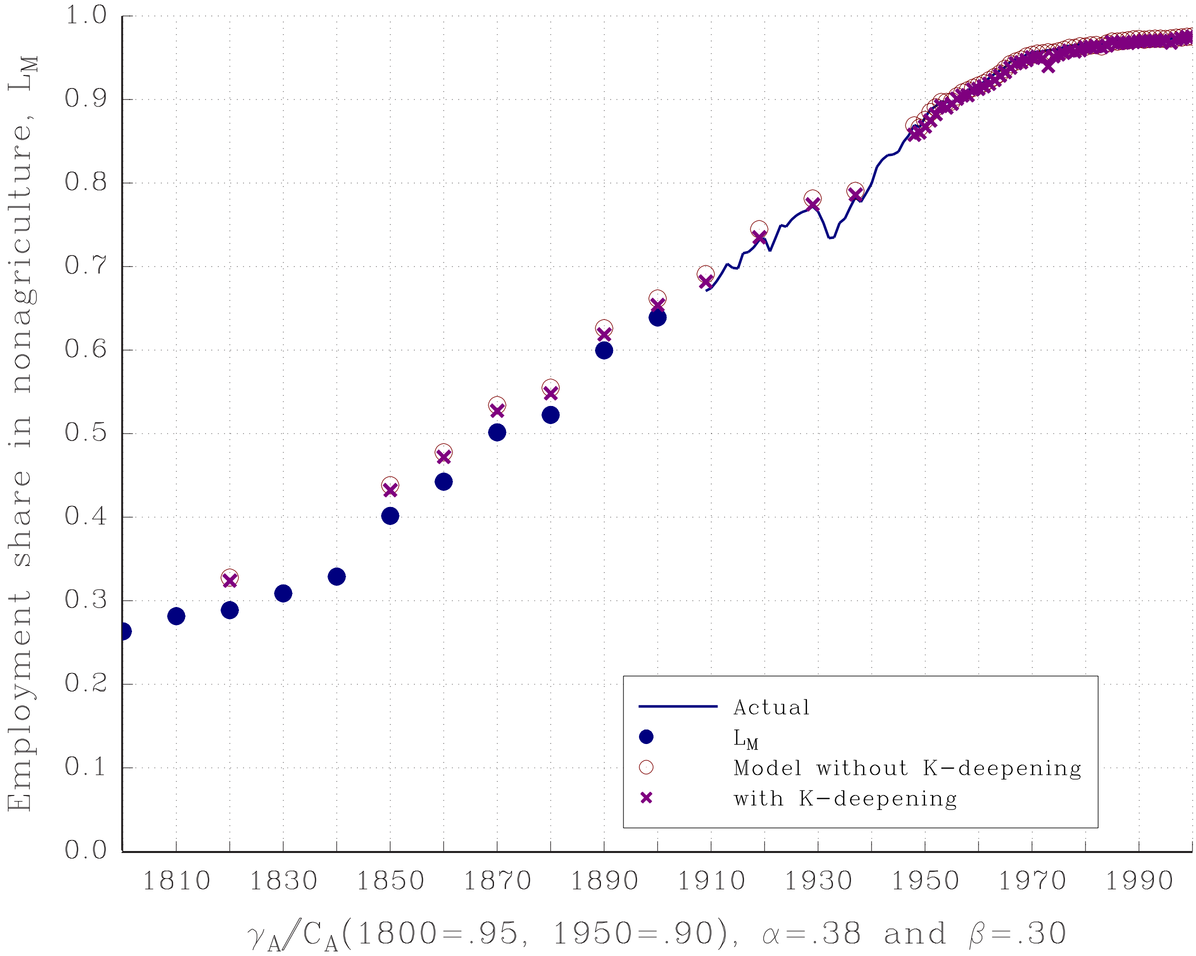

Figure 8: Employment share of non-farm sector: full model

Source: For actual series, see sources to figure 1.

Notes: See text for details. Other parameter values are $\nu = 0.1$ and $\eta = 0.85$.