Alternative User Costs, Rates of Return and TFP Growth Rates for the US Nonfinancial Corporate and Noncorporate Business Sectors: 1960-2014

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Abstract

Using the new Bureau of Economic Analysis (BEA) Integrated Macroeconomic Accounts as well as other BEA data, we construct a set of productivity accounts for two key sectors of the US economy: the Corporate Nonfinancial Sector (Sector 1) and the Noncorporate Nonfinancial Sector (Sector 2). Calculating user costs of capital based on, alternatively, ex post and predicted asset price inflation rates, we provide alternative estimates for capital services and Total Factor Productivity growth for the two sectors. Rates of return on assets employed are also reported for both sectors. Finally, the paper compares rates of return on assets employed and TFP growth rates when the land and inventory components are withdrawn from the asset base.

Key Words

User cost of capital, Total Factor Productivity, rate of return on assets, Integrated Macroeconomic Accounts, Bureau of Economic Analysis, ex post and ex ante asset inflation rates, US Nonfinancial Sector, Austrian model of production, balancing rates of return.

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1. Introduction

The US Bureau of Economic Analysis (BEA), in conjunction with the Bureau of Labor Statistics (BLS) and the Board of Governors of the Federal Reserve, have developed a new set of production accounts, the Integrated Macroeconomic Accounts, for two major private sectors of the US economy: the Corporate Nonfinancial Sector (which we will call Sector 1) and the Noncorporate Nonfinancial Sector (which we will call Sector 2). For both sectors we work out the rate of return on assets employed back to 1960 and compute estimates of Total Factor Productivity (TFP) growth. In addition to comparing results across the sectors, we are particularly interested in determining whether rates of return and TFP growth have declined in recent years compared to the long run trends.

Another contribution of the paper is to document what can happen to user costs when ex post asset inflation rates are used in the user cost formula. Dale Jorgenson and his coworkers have advocated the use of ex post inflation rates in a user cost formula and so we call the resulting user costs "Jorgensonian". We show that for many assets, Jorgensonian user costs can be quite volatile and even negative at times which means that they cannot be used in many contexts. We advocate the use of predicted asset inflation rates in the user cost formula and we suggest a very simple moving average method for forming these predicted asset inflation rates, which we implement and compare with their Jorgensonian counterparts. We use Jorgensonian and predicted user costs to construct alternative measures of capital services and TFP growth for our two sectors of the US economy and, somewhat surprisingly, we find that there was little difference in the resulting trend measures of TFP growth, even though there are very large differences in the two sets of user costs.

An additional contribution is the examination of what happens to ex post rates of return on assets employed and on TFP growth as we withdraw assets from the asset base. This research has relevance for existing estimates of rates of return and TFP growth since many productivity studies exclude land and inventories from their asset base. We find that excluding these assets leads to exaggerated estimated rates of return on the remaining assets (as could be expected) but the effects on estimates of TFP growth are more variable. For our Sector 1, we found that excluding land and inventories had little effect on measured TFP growth but in Sector 2, the exclusion of land dramatically lowered measured TFP growth.

Our accounting framework is laid out in the following section and the empirical results for the above measurement exercises follow in the subsequent sections. An Appendix explains how we used the Integrated Macroeconomic Accounts to construct our data set for the two sectors of the US economy.

2. The Accounting Framework, User Costs and Rates of Return on Assets

Following Jorgenson and Griliches (1967), the Total Factor Productivity growth of a firm or industry of a sector is generally measured as an output index divided by an input index. The basic ingredients that go into an index number formula are two price vectors and two quantity vectors that list the output quantities and their prices (or the input quantities and their prices) produced or used for the production unit for the two observations being compared. Compiling prices and quantities for outputs and nondurable inputs for each period or observation is generally straightforward, but determining the flow price for a durable input is not straightforward. In order to accomplish the latter task, we will use a model of production that is due to the economist Hicks (1961) and the accountants Edwards and Bell (1961).[2] Their treatment of capital inputs used in production is explained in the following quotations:

"We must look at the production process during a period of time, with a beginning and an end. It starts, at the commencement of the Period, with an Initial Capital Stock; to this there is applied a Flow Input of labour, and from it there emerges a Flow Output called Consumption; then there is a Closing Stock of Capital left over at the end. If Inputs are the things that are put in, the Outputs are the things that are got out, and the production of the Period is considered in isolation, then the Initial Capital Stock is an Input. A Stock Input to the Flow Input of labour; and further (what is less well recognized in the tradition, but is equally clear when we are strict with translation), the Closing Capital Stock is an Output, a Stock Output to match the Flow Output of Consumption Goods. Both input and output have stock and flow components; capital appears both as input and as output" John R. Hicks (1961; 23).

"The business firm can be viewed as a receptacle into which factors of production, or inputs, flow and out of which outputs flow...The total of the inputs with which the firm can work within the time period specified includes those inherited from the previous period and those acquired during the current period. The total of the outputs of the business firm in the same period includes the amounts of outputs currently sold and the amounts of inputs which are bequeathed to the firm in its succeeding period of activity." Edgar O. Edwards and Philip W. Bell (1961; 71-72).

Hicks and Edwards and Bell obviously had the same model of production in mind: in each accounting period, the business unit combines the capital stocks and goods in process that it has inherited from the previous period with "flow" inputs purchased in the current period (such as labour, materials, services and additional durable inputs) to produce current period "flow" outputs as well as end of the period depreciated capital stock and inventory components which are regarded as outputs from the perspective of the current period (but will be regarded as inputs from the perspective of the next period). The model could be viewed as an Austrian model of production in honour of the Austrian economist Böhm-Bawerk (1891) who viewed production as an activity which used raw materials and labour to further process partly finished goods into finally demanded goods.[3] The beauty of this model is that a complex intertemporal production model with many periods can be reduced to a sequence of single period models.

Using the above one period framework, we can now explain how user costs arise. Consider a production unit which produces quantities q_O of a single output, uses q_I units of an intermediate input, uses q_L units of labour services during say period t and purchases q_K units of a capital stock at the beginning of the period. After using the services of the capital input during period t, the production unit will have $q_K{}^u$ units of used (depreciated) capital on hand at the end of period t. We suppose that the production unit faces the positive prices $P_O{}^t$, $P_I{}^t$, $P_L{}^t$ for its output and variable inputs during period t and it faces the beginning of period t price for units of the capital input equal to $P_K{}^t$ and the price $P_K{}^{t+1u}$ for (used) units of the depreciated capital good at the end of period t. Finally, we assume that the production unit has a one period financial opportunity cost of capital at the beginning of period t (i.e., a beginning of the period nominal interest rate) equal to r^t. We also assume that the period t production possibilities set for this production unit is the set S^t. Using all of these assumptions, the

[2] This model can be traced back in part to Walras (1954; 267-269) and Böhm-Bawerk (1891; 342) and more explicitly to von Neumann (1945; 2).
[3] For more on this Austrian model of production and additional references to the literature, see Diewert (1977; 108-111) (1980; 473) (2010) (2014).

production unit's (competitive) one period profit maximization problem is the following constrained optimization problem:

$$(1)\quad \max_{q_O,q_I,q_L,q_K,q_K^*} \{P_O^t q_O - P_I^t q_I - P_L^t q_L - P_K^t q_K + (1+r^t)^{-1} P_K^{t+1u} q_K^* : (q_O,q_I,q_L,q_K,q_K^u) \in S^t\}.$$

Note that (1) assumes that all outputs and all variable inputs are paid for at the beginning of period t, as is the payment for the initial capital stock, which is an input. The depreciated capital stock q_K^u is an output that is "produced" at the end of period t and its end of period t market value, $P_K^{t+1u} q_K^u$, is discounted by $(1+r^t)$ to account for the opportunity cost of tying up financial capital in the asset over period t.

We make some additional assumptions at this point in order to further simplify the constrained optimization problem defined by (1). First we assume that the capital input depreciates at the constant geometric rate δ per period. The geometric model of depreciation has been advocated by Jorgenson (1989) and his coworkers and it is currently used by the BEA to construct US business sector capital stocks. The geometric model of depreciation implies that the depreciated quantity of end of period capital, q_K^u, is related to the corresponding beginning of the period capital stock, q_K, by the following equation:[4]

$$(2)\quad q_K^u = (1-\delta)q_K$$

where δ is the geometric rate of depreciation and satisfies the inequalities $0 \leq \delta < 1$. Let P_K^{t+1} be the end of period t price of a unit of the capital stock that has the same quality as the beginning of the period unit of the capital stock. Define the *constant quality asset inflation rate* over period t, i^t, by the following equation:

$$(3)\quad 1+ i^t \equiv P_K^{t+1}/P_K^t.$$

Thus i^t is the constant quality inflation rate for the capital stock component from the beginning of period t to the end of period t. We assume that the anticipated end of period t price for the used beginning of the period capital stock is equal to the end of period price for a constant quality unit of the capital stock, i.e., we assume that $P_K^{t+1u} = P_K^{t+1}$ and thus we have the following equation:

$$(4)\quad P_K^{t+1u} = (1+i^t)P_K^t.$$

Our final additional assumption is that all revenues and variable input costs are received and paid for at the end of period t instead of the beginning of period t. With these changes, the producer's constrained optimization problem becomes:

$$(5)\quad \max_{q_O,q_I,q_L,q_K} \{(1+r^t)^{-1}[P_O^t q_O - P_I^t q_I - P_L^t q_L + (1+i^t)(1-\delta)P_K^t q_K] - P_K^t q_K : (q_O,q_I,q_L,q_K) \in S^{t*}\}.$$

The terms involving q_K (the beginning of the period capital stock) in the objective function of (5) simplify to $-f_K^t \equiv -(1+r^t)^{-1}[1+r^t - (1+i^t)(1-\delta)]P_K^t$. Thus f_K^t is the *discounted to the*

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[4] The assumption of equation (2) allows us to replace the initial production possibilities set S^t with a new set S^{t*} which is the feasible set of (q_O^t,q_I,q_L,q_K).

beginning of period t user cost of capital using the geometric model of depreciation.[5] However, instead of discounting end of period cash flows to the beginning of period t, we could anti-discount or appreciate beginning of the period cash flows to the end of period t.[6] This can be accomplished by multiplying the objective function in (5) by $(1+r^t)$. If we do this, we obtain the following one period profit maximization problem:

$$(6)\quad \max_{q_O,q_I,q_L,q_K} \{[P_O^t q_O - P_I^t q_I - P_L^t q_L - u_K^t q_K : (q_O,q_I,q_L,q_K) \in S^{t*}\}$$

where the *end of period user cost of capital* u_K^t is defined as follows:

$$(7)\ u_K^t \equiv [1+r^t - (1+i^t)(1-\delta)]P_K^t = [r^t - i^t + (1+i^t)\delta]P_K^t.$$

This formula for the user cost of capital was obtained by Christensen and Jorgenson (1969; 302) for the geometric model of depreciation. It plays a fundamental role in our analysis.[7]

There are two versions of the user cost formula u_K^t defined by (7) that we will use in this paper:

- An *ex post version* that uses the actual beginning and end of period constant quality asset prices, P_K^t and P_K^{t+1}, in order to define the asset inflation rate as $i^t \equiv (P_K^{t+1}/P_K^t) - 1$.
- An *ex ante version* that uses the actual beginning of period t constant quality asset price, P_K^t, and an anticipated price for the asset at the end of period t, P_K^{t+1*}, in order to define an *anticipated asset inflation rate* as $i^{t*} \equiv (P_K^{t+1*}/P_K^t) - 1$.

Jorgenson (1995) (1996) and his coworkers[8] have endorsed the use of ex post user costs, arguing that producers can perfectly anticipate future asset prices, and so we refer to the user costs defined by (7) when ex post asset inflation rates are used in the formula as *Jorgensonian user costs*. On the other hand, Diewert (1980; 476) (2005a; 492-493) and Hill and Hill (2003)

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[5] This simple discrete time derivation of a user cost (as the net cost of purchasing the durable good at the beginning of the period and selling the depreciated good at an interest rate discounted price at the end of the accounting period) was developed by Diewert (1974; 504), (1980; 472-473), (1992; 194). Simplified user cost formulae (the relationship between the rental price of a durable input to its stock price) date back to Babbage (1835; 287) and to Walras (1954; 268-269). The original version of Walras in French was published in 1874. The early industrial engineer, Church (1901; 907-909) also developed a simplified user cost formula.

[6] Assuming that all of the flow transactions within the accounting period are realized at the end of each period is consistent with traditional accounting treatments of assets at the beginning and end of the accounting period and the cash flows that occur during the period; see Peasnell (1981; 56). The idea of anti-discounting to the end of the period to form *end of period user costs* u_K^t (as opposed to the usual discounted to the *beginning of period user costs* f_K^t) was explicitly suggested by Diewert (2005; 485). Anti-discounting is implicit in the derivation of the user cost of an asset using the geometric model of depreciation that was made by Christensen and Jorgenson (1969; 302).

[7] We have ignored tax complications in deriving (6). Any specific capital taxes (such as property taxes on real estate assets) should be added to the user cost formula for the relevant assets. In our empirical work, we were not able to obtain a breakdown of property taxes into land and structure components and so property tax rates are missing in our user costs that we construct in the following sections of this study. Business income taxes that fall on the gross return to the asset base can be absorbed into the cost of capital, r^t, so that r^t can be interpreted as the before income tax gross return to the asset base used by the production unit. For material on the construction of user costs for more complex systems of business income taxation, see Diewert (1992) and Jorgenson (1996).

[8] See in particular Jorgenson and Griliches (1967) (1972) and Christensen and Jorgenson (1969).

endorsed the ex ante version for most purposes, since these ex ante user costs will tend to be smoother than their ex post counterparts and they will generally be closer to a rental or leasing price for the asset.[9] We will use our sectoral data on the US corporate and noncorporate financial sector to compute capital services aggregates and the resulting rates of TFP growth using both Jorgensonian and smoothed user costs that use predicted asset inflation rates.

We now discuss the issues surrounding the choice for the cost of capital, r^t, in the user cost formula. There are many methods for choosing r^t that have been suggested in the literature but the methods break down into two classes: those that choose exogenous estimates for r^t and those that choose r^t endogenously as the rate of return which will just make the value of inputs used during the period (including capital services) equal to the value of outputs produced during the accounting period. We will use endogenous estimates for the cost of capital in this study.[10]

In order to explain how the cost of capital is determined endogenously, we need to consider the case where the production unit uses N types of capital. Let $P_{Kn}{}^t$ and $P_{Kn}{}^{t+1}$ be the beginning and end of period t prices for a new asset of type n, let $0 \leq \delta_n < 1$ be the associated geometric depreciation rate, let $i_n{}^t \equiv (P_{Kn}{}^{t+1}/P_{Kn}{}^t) - 1$ be the associated period t ex post asset n inflation rate over period t and let r^t be the endogenously determined period t ex post rate of return on the asset base for the production unit. The *ex post end of period t user cost for asset n* is defined as:

$$(8)\ u_{Kn}{}^t \equiv [1+r^t - (1+i_n{}^t)(1-\delta_n)]P_{Kn}{}^t = [r^t - i_n{}^t + (1+i_n{}^t)\delta_n]P_{Kn}{}^t; \qquad n = 1,...,N.$$

The period t technology set for the production unit is now the set of feasible production vectors $(q_O,q_I,q_L,q_{K1},q_{K2},...,q_{KN})$ that belong to a period t production possibilities set S^{t*}. Let $q_O{}^t,q_I{}^t,q_L{}^t$ denote the period t output produced, intermediate input used and labour used for the production unit and let $(q_{K1}{}^t,q_{K2}{}^t,...,q_{KN}{}^t)$ denote the vector of beginning of period t capital stocks used by the production unit during the period. The *ex post rate of return on the period t asset base*, r^t, is defined as the solution to the following (linear) equation which sets the value of period t outputs equal to the value of period t inputs where capital inputs are valued at their ex post user costs:

$$\begin{aligned}(9)\ 0 &= P_O{}^tq_O{}^t - P_I{}^tq_I{}^t - P_L{}^tq_L{}^t - \Sigma_{n=1}{}^N\, u_{Kn}{}^tq_{Kn}{}^t \\ &= P_O{}^tq_O{}^t - P_I{}^tq_I{}^t - P_L{}^tq_L{}^t - \Sigma_{n=1}{}^N\, [1+r^t - (1+i_n{}^t)(1-\delta_n)]P_{Kn}{}^tq_{Kn}{}^t.\end{aligned}$$

The ex post cost of capital method for determining the opportunity cost of capital that is based on solving equation (9) for r^t is due to Jorgenson and Griliches (1967) (1972) and Christensen and Jorgenson (1969). This method has been used frequently in the regulatory context. The method can be applied to both a single enterprise as well as to the economy as a whole. National statistical agencies that have programs that measure the productivity of market sector

[9] Of course, the problem with using ex ante user costs is that there are many methods that could be used to predict asset inflation rates and these different methods could generate very different user costs. For empirical evidence on this point, see Harper, Berndt and Wood (1989), Diewert (2005a) and Schreyer (2012).

[10] The problem with the exogenous method is that it is difficult to determine exactly the appropriate external cost of financial capital. In particular, it is difficult to estimate the risk premium that is associated with investing in a production unit that generates variable ex post rates of return on its asset base over time. Nevertheless, the exogenous method is probably the preferred method from a theoretical point of view. These issues are discussed more fully in Schreyer, Diewert and Harrison (2005) and Schreyer (2009) (2012).

industries generally use this method.[11] From a national income accounting perspective, this method has the great advantage for statistical agencies that it preserves the structure of the *System of National Accounts 1993* (SNA 1993); i.e., the resulting user cost values just sum to the Gross Operating Surplus that was already in SNA 1993. Thus this method can be viewed as a straightforward elaboration of the present system of accounts which does not change its basic structure; it only provides a decomposition of Gross Operating Surplus or Cash Flow into more basic components.[12]

In the following sections of this study, we will calculate these ex post rates of return on assets for our Sectors 1 and 2 and also use the Jorgensonian user costs defined by (8) when we calculate TFP growth rates for our two sectors.

The major disadvantage of using Jorgensonian user costs is their volatility and their tendency to become negative for at least some periods when asset inflation rates for particular assets (such as land) are high. These volatile and sometimes negative user costs do not approximate corresponding asset rental prices (when they exist), which do not exhibit the same volatility. Moreover, if these bouncing user costs are used in production function studies where the underlying technology is estimated using derived supply and demand functions, the resulting estimated parameters are unlikely to be reliable. Finally, if statistical agencies report these volatile user costs in their system of productivity accounts, users are likely to be skeptical of these estimates. Thus there is a need to produce smoother user costs for a variety of reasons.

Our approach to producing smoother user costs will be to use *predicted asset inflation rates*, say i_n^{t*}, in the user cost formula instead of the actual ex post asset inflation rates, i_n^t. The method for calculating these predicted asset inflation rates will be explained more fully in subsequent sections but the predicted rates are basically simple long run geometric averages of past ex post inflation rates. Once the smoothed or ex ante asset inflation rate for asset n in period t, i_n^{t*}, has been defined for n = 1,...,N, the *ex ante or smoothed end of period t user cost for asset n in period t*, u_{Kn}^{t*}, is defined as:

$$(10)\ u_{Kn}^{t*} \equiv [1+r^{t*} - (1+i_n^{t*})(1-\delta_n)]P_{Kn}^t = [r^{t*} - i_n^{t*} + (1+i_n^{t*})\delta_n]P_{Kn}^t; \qquad n = 1,...,N$$

where *the smoothed balancing rate of return for period t*, r^{t*}, is defined as the solution to the following equation (which is linear in r^{t*}):

$$\begin{aligned}(11)\ 0 &= P_O^tq_O^t - P_I^tq_I^t - P_L^tq_L^t - \Sigma_{n=1}^N u_{Kn}^{t*}q_{Kn}^t \\ &= P_O^tq_O^t - P_I^tq_I^t - P_L^tq_L^t - \Sigma_{n=1}^N [1+r^{t*} - (1+i_n^{t*})(1-\delta_n)]P_{Kn}^tq_{Kn}^t.\end{aligned}$$

The smoothed rate of return r^{t*} can be viewed as a planned rate of return on assets that is expected on the beginning of the period value of the capital stock used by the production unit, provided expected asset inflation rates, the i_n^{t*}, are realized.[13] The smoothed user costs

[11] The Bureau of Labor Statistics in the U.S. was the first to introduce an official program to measure Multifactor Productivity or Total Factor Productivity in 1983; see Dean and Harper (2001). Other countries with TFP programs now include Canada, Australia, the UK and New Zealand.

[12] This method for decomposing Gross Operating Surplus into explanatory factors (that are useful when measuring TFP growth), was endorsed in the *System of National Accounts, 2008*; see Schreyer, Diewert and Harrison (2005) for a discussion of the issues.

[13] Period t predicted prices for output, intermediate input and labour, say P_O^{t*}, P_I^{t*} and P_L^{t*}, should be used in equation (11) in order to calculate the period t predicted rate of return, r^{t*}, instead of the actual ex post prices for

defined by (10) will also provide a decomposition of Gross Operating Surplus into meaningful components. As we shall see, the ex ante user costs are considerably smoother than their Jorgensonian counterparts.[14] Note that both of our user cost models use endogenous rates of return. One of the main purposes of this study is to determine whether the choice of user cost formula affects our estimates of TFP growth.

We conclude this section by discussing some of the problems associated with the valuation of investments made by the production unit during period t and with the sales of assets that might have occurred during period t. We discuss these issues in the context of equation (9) but a similar discussion holds for the accounting framework defined by equation (11).

Consider the second equation in (9). Upon noting that $(1+i_n^t)P_{Kn}^t$ is equal to the end of period t price of a new unit of the nth capital stock component, P_{Kn}^{t+1}, (9) can be rewritten as follows:

$$(12)\ 0 = P_O^t q_O^t - P_I^t q_I^t - P_L^t q_L^t - \Sigma_{n=1}^N (1+r^t)P_{Kn}^t q_{Kn}^t + \Sigma_{n=1}^N P_{Kn}^{t+1}(1-\delta_n)q_{Kn}^t.$$

Recall our Austrian one period model of production where the beginning of period t capital stocks are regarded as inputs and the end of period capital stocks are regarded as outputs. The initial value of the capital stock, $\Sigma_{n=1}^N P_{Kn}^t q_{Kn}^t$, is appreciated to end of period values by multiplying this initial capital stock value by $(1+r^t)$ so that the anti-discounted price for input asset n is $(1+r^t)P_{Kn}^t$. Looking at (12), we see that the term $-\Sigma_{n=1}^N (1+r^t)P_{Kn}^t q_{Kn}^t$ is (minus) the cost of the beginning of period t capital stock at end of period prices. The other prices on the right hand side of (12) are also expressed in end of period t prices. The first three terms on the right hand side of (12) correspond to the value of outputs produced during period t, less the value of intermediate and labour inputs used during the period. The final set of terms, $\Sigma_{n=1}^N P_{Kn}^{t+1}(1-\delta_n)q_{Kn}^t$, is the end of period t value of the depreciated beginning of the period capital stock. Thus $(1-\delta_n)q_{Kn}^t$ is the depreciated quantity of the beginning of the period capital stock for asset n that is left over at the end of period t. But this quantity is not the entire end of period t capital stock for asset n: during period t, there may have been investments in asset n. Suppose q_{GIn}^t is the *gross investment* in asset n during period t (and the average price that the statistical agency assigns to this investment is P_{GIn}^t) for n = 1,...,N. Thus the actual end of period t quantity of asset n that the production unit has at its disposal is $q_{Kn}^{t+1} \equiv q_{GIn}^t + (1-\delta_n)q_{Kn}^t$ and according to our accounting conventions, it should be valued at the end of period t asset price P_{Kn}^{t+1}. Hence the terms $\Sigma_{n=1}^N P_{Kn}^{t+1}q_{GIn}^t$ seem to be missing from the right hand side of (12). There is an explanation for this apparent puzzle.

output, intermediate input and labour, P_O^t, P_I^t and P_L^t. However, it is the usual convention in production theory to assume that actual ex post unit value prices for variable outputs and inputs are equal to their predicted counterparts.

[14] There is a problem with interpreting these smoothed user costs as rental prices that might be anticipated at the beginning of the accounting period. When there is a severe recession in the economy in say period t, both r^t defined by solving (9) and r^{t*} defined by solving (11) will become unusually low (or even negative) and it is unlikely that the resulting low (or negative) user costs defined by (10) could be anticipated in practice. This limitation of our analysis should be kept in mind, particularly when looking at the user costs for 2008. This suggests that exogenous estimates for the cost of capital may be a more appropriate strategy for forming user costs that more closely approximate rental prices. If an exogenous r^{t*} is used, then equation (11) will not hold in general and it will be necessary to include pure profits (or losses) as a balancing item in the SNA. However, we do not pursue this line of inquiry in the present study.

Suppose asset n is a reproducible capital stock; i.e., an asset which is produced internally by the production unit or purchased from another producer. In this case, the value of the gross investment in asset n during period t, $P_{GIn}^{t}q_{GIn}^{t}$, will be part of the period t value of output for the production unit; i.e., it should be included as part of $P_O^tq_O^t$. This resolves the puzzle for reproducible capital stock components.[15]

Now suppose asset n is an inventory stock. External purchases of the inventory stock will be part of intermediate input purchases, $P_I^tq_I^t$. Sales of the inventory item will be reflected in the value of gross output, $P_O^tq_O^t$. But at the end of period t, there will be a net change in inventory stocks equal to $q_{Kn}^{t+1} - q_{Kn}^{t}$. Hence it appears that the term $P_{Kn}^{t+1}(q_{Kn}^{t+1}-q_{Kn}^{t})$ is missing on the right hand side of (12). Note that since asset n is an inventory item, we assume $\delta_n \equiv 0$ and so the term $P_{Kn}^{t+1}(1-\delta_n)q_{Kn}^{t} = P_{Kn}^{t+1}q_{Kn}^{t}$ is present on the right hand side of (12) and adding $P_{Kn}^{t+1}(q_{Kn}^{t+1}-q_{Kn}^{t})$ to this term gives us the end of period value of inventory stocks, $P_{Kn}^{t+1}q_{Kn}^{t+1}$, which is the right answer from the perspective of the Austrian approach to production theory. But statistical agencies treat inventory change over a period as part of sectoral output and so the missing term $P_{Kn}^{t+1}(q_{Kn}^{t+1}-q_{Kn}^{t})$ should be included as a part of the value of gross output, $P_O^tq_O^t$.[16] This resolves the puzzle for inventory components of the capital stock.

Suppose asset n is a type of land asset. As was the case for inventory items, we assume that the land depreciation rate is $\delta_n = 0$ and again, we find that the term $P_{Kn}^{t+1}(q_{Kn}^{t+1}-q_{Kn}^{t})$ is missing on the right hand side of (12). This term now represents the value of net purchases of land of type n over period t, $q_{Kn}^{t+1}-q_{Kn}^{t}$, valued at end of period t price for this type of land, P_{Kn}^{t+1}. Statistical agencies typically do not treat land as an output or an intermediate input so in this case, the net quantity of land purchases over period t, valued at end of period land prices, will not appear as part of the gross output (if land was sold during period t) or intermediate input of the sector (if land was purchased during period t). Thus we need to treat these net purchases as an input cost item, so $-P_{Kn}^{t+1}(q_{Kn}^{t+1}-q_{Kn}^{t})$ should be added to the right hand side of (12), but this net cost value is offset by the increase in the value of land holdings at the end of the period, so $+P_{Kn}^{t+1}(q_{Kn}^{t+1}-q_{Kn}^{t})$ should be added to the right hand side of (12). These two entries cancel and so this resolves the puzzle for the land components of the capital stock.[17]

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[15] However, to make the accounting precisely consistent with the Austrian model of production, we require that the price used to value gross investments in asset n during period, P_{GIn}^{t}, be equal to the end of period t imputed value for a unit of the nth capital stock. Setting $P_{Kn}^{t+1} = P_{GIn}^{t}$ will ensure consistency. In our empirical work, we used the BEA end of period price for reproducible units of the capital stock which may be slightly different from the corresponding investment price for the asset.

[16] The BEA in particular *does* include the value of inventory change as part of the gross output of an industry. However, they may not value the change in inventories at end of period prices of the inventory item and so again there may be a slight inconsistency in our empirical work due to this pricing difference. For a more complete treatment of the accounting problems associated with the treatment of inventories in the Austrian model of production, see Diewert (2005b).

[17] Suppose some land is purchased during period t at the price P_{Kn}^{t*} where this purchase price is not equal to the end of period price of land, P_{Kn}^{t+1}. The quantity of new land purchased will be equal to $q_{Kn}^{t+1} - q_{Kn}^{t}$. Then the term $-P_{Kn}^{t*}(q_{Kn}^{t+1}-q_{Kn}^{t})$ should be added to the right hand side of (12) as a purchase of a primary input (a cost item) and at the same time, we should add the term $P_{Kn}^{t+1}(q_{Kn}^{t+1}-q_{Kn}^{t})$ to the right hand side of (12) to value this land purchase at the end of period t price of this type of land (a revenue item). Thus in principle, we should add the term $(P_{Kn}^{t+1}-P_{Kn}^{t*})(q_{Kn}^{t+1}-q_{Kn}^{t})$ to the right hand side of (12). If some land is sold during the period at the price P_{Kn}^{t*}, then $q_{Kn}^{t+1} - q_{Kn}^{t}$ is negative and is equal to minus the quantity sold. In this case, we should still add the term $(P_{Kn}^{t+1}-P_{Kn}^{t*})(q_{Kn}^{t+1}-q_{Kn}^{t})$ to the right hand side of (12) to make the accounting consistent with our

Real monetary balances are not regarded as productive inputs by national income accountants. However, we treat real monetary balances as being necessary for production.[18] Our accounting treatment of real balances is entirely analogous to our treatment of land and, as was the case with land, the accounting decomposition given by (9) or (12) is consistent with our Austrian theory of production.

Equations (9) and (12) provided an accounting treatment of production using ex post asset prices. As mentioned above, it is possible to build a similar accounting treatment of production using ex ante asset prices; i.e., instead of using equation (9) as our starting point for our accounting decomposition, we could have used equation (11). The consistency of equation (11) with the Austrian view of production is similar to our analysis of the consistency of equations (9) and (12) with the Austrian approach to production theory.

We conclude this section with an important observation. Although we do not think that the Jorgensonian ex post user costs are useful in all contexts, we do think that *they are the right user costs to use in the context of finding the ex post rate of return on assets for a production unit*. Ex post rates of return are extremely important indicators of economic efficiency (along with TFP growth rates) and it is important to measure these rates of return accurately to guide the allocation of resources between sectors.[19]

Before we use the data that are described in the Appendix to construct ex post rates of return on assets and TFP growth rates, in the following section we describe the use of our data base to construct estimates for real wages and labour productivity.

3. Real Wages and Labour Productivity Growth in Sectors 1 and 2

In this section, we draw on our data base that is described in the Appendix in order to calculate real wages and labour productivity for the two sectors. We start off using the data for Sector 1, the Nonfinancial Corporate Sector of the US economy.

Table A13 in the Appendix provides the Value Added of Sector 1 in year t, $V_{VA1}{}^t$, and the corresponding year t price index, $P_{VA1}{}^t$. These two series are also listed in Table 1 below. Define the year t real value added of Sector 1 as $Q_{VA1}{}^t \equiv V_{VA1}{}^t/P_{VA1}{}^t$ for t = 1960,...,2014. The price and quantity of employee labour in Sector 1, $P_{E1}{}^t$ and $Q_{E1}{}^t$, are provided in Appendix Table A14. Re-label these series as $P_{L1}{}^t$ and $Q_{L1}{}^t$ and define the value of labour input in Sector 1 for year t as $V_{L1}{}^t \equiv P_{L1}{}^t Q_{L1}{}^t$. The labor series $V_{L1}{}^t$ and $P_{L1}{}^t$ are also listed in Table 1. The value of capital services in Sector 1 for year t, $V_{KS1}{}^t$, can be defined residually by subtracting the value of labour input from value added; i.e., $V_{KS1}{}^t \equiv V_{VA1}{}^t - V_{L1}{}^t$. The shares of labour and capital services in value added are defined as $s_{L1}{}^t \equiv V_{L1}{}^t/V_{VA1}{}^t$ and $s_{KS1}{}^t \equiv V_{KS1}{}^t/V_{VA1}{}^t$. These Sector 1 value added shares along with the value of capital services are also listed in Table 1.

Austrian model of production. In our empirical work, we did not make these adjustments to the accounting identity given by (12); we simply assumed that $P_{Kn}{}^{t*}$ is equal to our end of period price for the asset, $P_{Kn}{}^{t+1}$.

[18] This is consistent with the cash-in-advance, or vending machine model of the demand for money consider by Fischer (1974). For a more extensive discussion of the issues surrounding money in the production function, see Diewert and Fox (2015).

[19] See Harberger (1998) on the importance of the rate of return on assets.

A beginning of year t price index for personal consumption expenditures, P_C^t, for t = 1960-2105 is provided in Table A15 in the Appendix. We convert this beginning of the year t price index into a centered consumer price index for year t, P_C^{t*}, by averaging P_C^t and P_C^{t+1}; i.e., define $P_C^{t*} \equiv (1/2)(P_C^t + P_C^{t+1})$ for t = 1960,...,2014.[20] This series, along with the wage rate index P_{L1}^t, was used to define the *Sector 1 real wage for year t*, defined as follows:

$$(13)\ RW_1^t \equiv P_{L1}^t/P_C^{t*}\,; \qquad t = 1960,...,2014.$$

Finally, *Sector 1 Labour Productivity in year t* (relative to the level in 1960), $ProdL_1^t$, is defined as follows (and is listed in Table 1):

$$(14)\ ProdL_1^t \equiv [Q_{VA1}^t/Q_{L1}^t]/[Q_{VA1}^{1960}/Q_{L1}^{1960}]\,; \qquad t = 1960,...,2014.$$

The price of (value added) output in Sector 1 grew 4.56 fold over the sample period while employee wages grew 13.95 fold. The geometric rates of growth were 3.61% per year for output and 5.00% per year for wages. Real wages grew 2.25 fold over the sample period while labour productivity grew 3.41 fold (the corresponding geometric rates of growth were 1.51% and 2.30% per year). The sample average labour and capital services shares were 68.6% and 31.4% respectively. The upward trend in the capital services share is noticeable in Figure 1 which plots the series s_{L1}^t, s_{KS1}^t, P_{VA1}^t, RW_1^t and $ProdL_1^t$. Note that the capital services share finishes up at 36.7%, well above its long term average of 31.4%. It can be seen that real wages have grown very slowly since 2007. Note also that real wage growth was fairly similar to labour productivity growth until 1982 and then labour productivity grew substantially faster than real wages. Finally, it can be seen that labour productivity in Sector 1 is still growing fairly steadily since 2006 at the geometric average rate of 1.20% per year but this rate is lower than the historical average rate of 1.51% per year.

We turn our attention to Sector 2, the Nonfinancial Noncorporate Sector of the US economy.

Table A13 in the Appendix provides the Value Added of Sector 1 in year t, V_{VA2}^t, and the corresponding year t price index, P_{VA2}^t. These two series are listed in Table 2. Define the year t real value added of Sector 2 as $Q_{VA2}^t \equiv V_{VA2}^t/P_{VA2}^t$ for t = 1960,...,2014. The price, quantity and value of labour in Sector 2, P_{L2}^t, Q_{L2}^t and V_{L2}^t are provided in Appendix Table A14. The labour series V_{L2}^t and P_{L2}^t are also listed in Table 2. The value of capital services in Sector 2 for year t, V_{KS2}^t, can be defined residually by subtracting the value of labour input from value added; i.e., $V_{KS2}^t \equiv V_{VA2}^t - V_{L2}^t$. The shares of labour and capital services in value added for Sector 2 are defined as $s_{L2}^t \equiv V_{L2}^t/V_{VA2}^t$ and $s_{KS2}^t \equiv V_{KS2}^t/V_{VA2}^t$. These Sector 2 value added shares along with the value of capital services are also listed in Table 2.

Again, we use the consumption price series P_C^{t*} along with the Sector 2 wage rate index P_{L2}^t to define the *Sector 2 real wage for year t*, $RW_2^t \equiv P_{L2}^t/P_C^{t*}$ for t = 1960,...,2014. This series also appears in Table 2.

Finally, *Sector 2 Labour Productivity of Sector 1 in year t* (relative to the level in 1960), $ProdL_2^t$, is defined as follows (and listed in Table 2):

[20] This series was normalized to equal 1 in 1960. Note that the Sector 1 wage rate series P_{L1}^t is also normalized to equal 1 in 1960.

(15) $\text{ProdL}_2^{\,t} \equiv [Q_{VA2}^{\,t}/Q_{L2}^{\,t}]/[Q_{VA2}^{\,1960}/Q_{L2}^{\,1960}]$; $t = 1960,\ldots,2014.$

Figure 1: Sector 1 Labour and Capital Shares of Value Added, Output Price, Real Wage and Labour Productivity

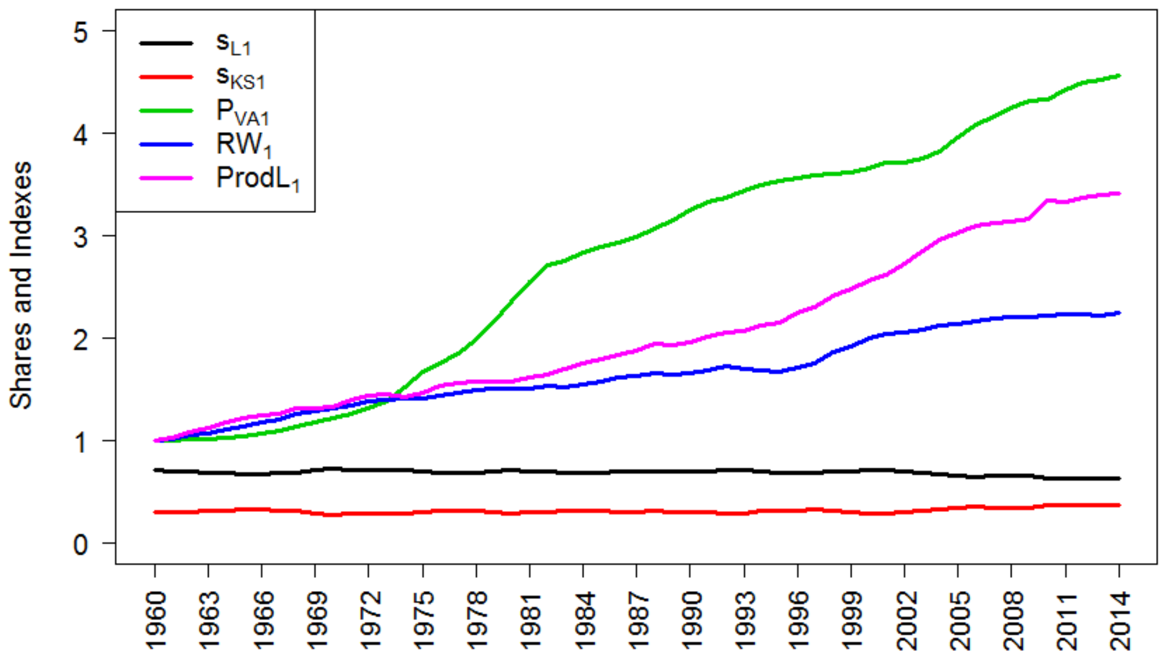


Figure 2: Sector 2 Labour and Capital Shares of Value Added, Output Price, Real Wage and Labour Productivity

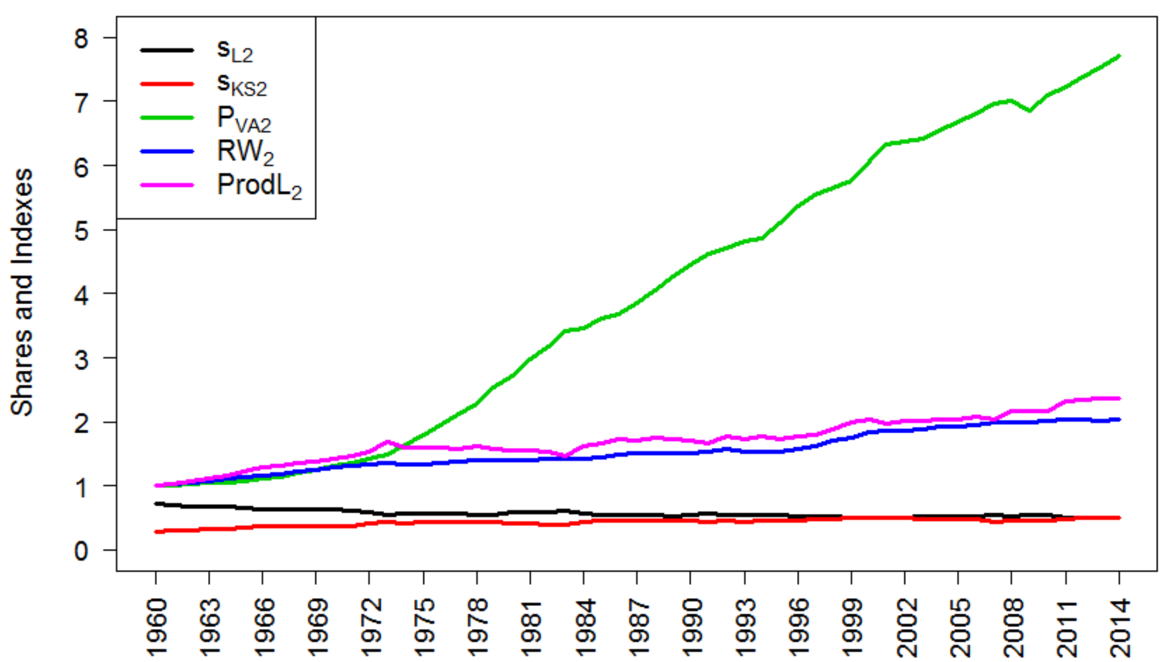


Table 1: Sector 1 Value Added V_{VA1}^t, Value of Labour Input V_{L1}^t, Value of Capital Services V_{KS1}^t, Value Added Shares of Labour and Capital Services, s_{L1}^t and s_{KS1}^t. Price of Labour P_{L1}^t, Real Wage RW_1^t and Labour Productivity $ProdL_1^t$ for Year t

Year	V_{VA1}^t	V_{L1}^t	V_{KS1}^t	s_{L1}^t	s_{KS1}^t	P_{VA1}^t	P_{L1}^t	RW_1^t	$ProdL_1^t$
1960	255.9	180.4	75.5	0.7050	0.2950	1.0000	1.0000	1.0000	1.0000
1961	262.8	184.5	78.3	0.7021	0.2979	1.0030	1.0290	1.0181	1.0301
1962	286.9	199.3	87.6	0.6947	0.3053	1.0095	1.0725	1.0505	1.0781
1963	306.1	210.1	96.0	0.6864	0.3136	1.0145	1.1094	1.0725	1.1231
1964	330.6	225.7	104.9	0.6827	0.3173	1.0239	1.1640	1.1104	1.1739
1965	364.7	245.4	119.3	0.6729	0.3271	1.0419	1.2085	1.1364	1.2152
1966	403.1	272.9	130.2	0.6770	0.3230	1.0723	1.2792	1.1753	1.2422
1967	423.9	291.1	132.8	0.6867	0.3133	1.0962	1.3501	1.2058	1.2643
1968	465.4	320.9	144.5	0.6895	0.3105	1.1302	1.4519	1.2537	1.3134
1969	504.4	356.1	148.3	0.7060	0.2940	1.1779	1.5545	1.2842	1.3178
1970	518.6	374.5	144.1	0.7221	0.2779	1.2216	1.6690	1.3173	1.3337
1971	558.5	396.2	162.3	0.7094	0.2906	1.2657	1.7739	1.3441	1.3927
1972	622.2	439.9	182.3	0.7070	0.2930	1.3108	1.8849	1.3791	1.4339
1973	698.7	495.1	203.6	0.7086	0.2914	1.3876	2.0157	1.4004	1.4452
1974	755.7	542.9	212.8	0.7184	0.2816	1.5239	2.2140	1.4058	1.4256
1975	818.1	569.0	249.1	0.6955	0.3045	1.6735	2.4284	1.4139	1.4708
1976	928.1	640.0	288.1	0.6896	0.3104	1.7549	2.6233	1.4415	1.5282
1977	1052.9	723.3	329.6	0.6870	0.3130	1.8543	2.8320	1.4697	1.5673
1978	1201.4	829.5	371.9	0.6904	0.3096	1.9868	3.0722	1.4886	1.5788
1979	1341.6	942.4	399.2	0.7024	0.2976	2.1497	3.3668	1.5002	1.5718
1980	1452.7	1030.7	422.0	0.7095	0.2905	2.3508	3.7310	1.5079	1.5770
1981	1641.7	1139.8	501.9	0.6943	0.3057	2.5530	4.0746	1.5100	1.6206
1982	1701.4	1183.3	518.1	0.6955	0.3045	2.7049	4.3920	1.5317	1.6459
1983	1817.5	1250.1	567.4	0.6878	0.3122	2.7546	4.5656	1.5253	1.6988
1984	2040.5	1388.2	652.3	0.6803	0.3197	2.8397	4.7838	1.5419	1.7456
1985	2172.9	1490.1	682.8	0.6858	0.3142	2.8900	5.0489	1.5719	1.7959
1986	2260.7	1578.2	682.5	0.6981	0.3019	2.9303	5.3247	1.6154	1.8349
1987	2425.7	1685.5	740.2	0.6949	0.3051	2.9859	5.5326	1.6337	1.8799
1988	2640.7	1825.3	815.4	0.6912	0.3088	3.0624	5.8270	1.6549	1.9406
1989	2772.6	1934.8	837.8	0.6978	0.3022	3.1554	6.0175	1.6431	1.9265
1990	2897.7	2037.5	860.2	0.7031	0.2969	3.2507	6.3362	1.6568	1.9542
1991	2946.1	2071.1	875.0	0.7030	0.2970	3.3222	6.6568	1.6788	2.0093
1992	3074.6	2188.7	885.9	0.7119	0.2881	3.3645	6.9976	1.7209	2.0597
1993	3216.0	2271.0	945.0	0.7062	0.2938	3.4346	7.1064	1.6915	2.0656
1994	3465.8	2398.7	1067.1	0.6921	0.3079	3.4868	7.2530	1.6773	2.1188
1995	3682.7	2524.6	1158.1	0.6855	0.3145	3.5344	7.3930	1.6759	2.1510
1996	3924.4	2667.7	1256.7	0.6798	0.3202	3.5578	7.6890	1.7111	2.2413
1997	4219.5	2862.6	1356.9	0.6784	0.3216	3.5860	7.9603	1.7545	2.3067
1998	4470.8	3093.8	1377.0	0.6920	0.3080	3.5955	8.4875	1.8610	2.4048
1999	4745.3	3310.0	1435.3	0.6975	0.3025	3.6193	8.8505	1.9151	2.4714
2000	5063.1	3597.3	1465.8	0.7105	0.2895	3.6610	9.4524	2.0011	2.5618
2001	5026.2	3584.6	1441.6	0.7132	0.2868	3.7132	9.8280	2.0421	2.6163
2002	5066.0	3542.0	1524.0	0.6992	0.3008	3.7109	10.0373	2.0525	2.7272
2003	5228.7	3595.7	1633.0	0.6877	0.3123	3.7486	10.4012	2.0878	2.8444
2004	5577.0	3762.8	1814.2	0.6747	0.3253	3.8262	10.8273	2.1235	2.9567
2005	5958.9	3930.3	2028.6	0.6596	0.3404	3.9577	11.2147	2.1357	3.0287
2006	6377.9	4129.3	2248.6	0.6474	0.3526	4.0789	11.6165	2.1598	3.1010
2007	6571.4	4305.3	2266.1	0.6552	0.3448	4.1610	12.0778	2.1894	3.1233
2008	6624.1	4358.0	2266.1	0.6579	0.3421	4.2492	12.4226	2.1993	3.1326
2009	6253.9	4088.4	2165.5	0.6537	0.3463	4.3182	12.6545	2.2109	3.1601
2010	6605.7	4158.7	2447.0	0.6296	0.3704	4.3216	12.8807	2.2228	3.3375
2011	6921.7	4363.4	2558.3	0.6304	0.3696	4.4176	13.1669	2.2282	3.3331
2012	7321.5	4593.3	2728.2	0.6274	0.3726	4.4916	13.4816	2.2322	3.3727
2013	7591.9	4747.4	2844.5	0.6253	0.3747	4.5205	13.6248	2.2228	3.3978
2014	7895.8	4995.8	2900.0	0.6327	0.3673	4.5568	13.9548	2.2503	3.4121

Table 2: Sector 2 Value Added V_{VA2}^t, Value of Labour Input V_{L2}^t, Value of Capital Services V_{KS2}^t, Value Added Shares of Labour and Capital Services, s_{L2}^t and s_{KS2}^t. Price of Labour P_{L2}^t, Real Wage RW_2^t and Labour Productivity $ProdL_2^t$ for Year t

Year	V_{VA2}^t	V_{L2}^t	V_{KS2}^t	s_{L2}^t	s_{KS2}^t	P_{VA2}^t	P_{L2}^t	RW_2^t	$ProdL_2^t$
1960	107.4	76.6	30.8	0.7135	0.2865	1.0000	1.0000	1.0000	1.0000
1961	110.2	76.8	33.4	0.6967	0.3033	1.0161	1.0297	1.0187	1.0378
1962	114.2	78.4	35.8	0.6864	0.3136	1.0306	1.0720	1.0500	1.0811
1963	117.1	79.2	37.9	0.6767	0.3233	1.0424	1.1087	1.0719	1.1216
1964	123.0	82.9	40.1	0.6737	0.3263	1.0599	1.1635	1.1100	1.1626
1965	130.0	84.7	45.3	0.6512	0.3488	1.0810	1.2053	1.1334	1.2216
1966	138.5	87.5	51.0	0.6318	0.3682	1.1142	1.2675	1.1646	1.2848
1967	142.1	89.4	52.7	0.6291	0.3709	1.1494	1.3281	1.1862	1.3104
1968	149.8	93.5	56.3	0.6241	0.3759	1.2014	1.4232	1.2289	1.3543
1969	157.8	99.1	58.7	0.6279	0.3721	1.2540	1.5223	1.2577	1.3795
1970	163.4	102.8	60.6	0.6294	0.3706	1.3032	1.6246	1.2823	1.4131
1971	173.1	106.8	66.3	0.6172	0.3828	1.3646	1.7248	1.3069	1.4613
1972	191.2	113.2	78.0	0.5919	0.4081	1.4302	1.8305	1.3393	1.5429
1973	223.5	124.1	99.4	0.5553	0.4447	1.4928	1.9487	1.3539	1.6773
1974	235.2	135.6	99.6	0.5763	0.4237	1.6334	2.1193	1.3456	1.6064
1975	252.0	144.1	107.9	0.5718	0.4282	1.8018	2.3053	1.3423	1.5966
1976	275.6	155.4	120.2	0.5638	0.4362	1.9586	2.4811	1.3634	1.6031
1977	300.7	170.1	130.6	0.5655	0.4345	2.1231	2.6649	1.3830	1.5835
1978	340.7	189.5	151.2	0.5562	0.4438	2.2748	2.8772	1.3941	1.6224
1979	380.3	211.6	168.7	0.5565	0.4435	2.5432	3.1382	1.3983	1.5821
1980	399.8	233.2	166.6	0.5832	0.4168	2.7131	3.4595	1.3982	1.5599
1981	435.5	253.4	182.1	0.5819	0.4181	2.9761	3.7703	1.3972	1.5534
1982	454.5	272.6	181.9	0.5998	0.4002	3.1681	4.0618	1.4166	1.5252
1983	480.7	290.0	190.7	0.6032	0.3968	3.4070	4.2399	1.4165	1.4720
1984	556.3	314.0	242.3	0.5644	0.4356	3.4506	4.4382	1.4305	1.6259
1985	600.4	330.0	270.4	0.5497	0.4503	3.6182	4.6619	1.4514	1.6725
1986	636.3	346.1	290.2	0.5439	0.4561	3.6821	4.8851	1.4821	1.7404
1987	667.5	365.3	302.2	0.5472	0.4528	3.8627	5.0870	1.5021	1.7171
1988	727.1	390.9	336.2	0.5376	0.4624	4.0499	5.3541	1.5206	1.7546
1989	774.1	413.1	361.0	0.5337	0.4663	4.2668	5.5205	1.5074	1.7298
1990	807.5	437.7	369.8	0.5420	0.4580	4.4449	5.7961	1.5155	1.7165
1991	815.0	458.3	356.7	0.5623	0.4377	4.6295	6.0487	1.5254	1.6579
1992	869.8	471.9	397.9	0.5425	0.4575	4.7022	6.3684	1.5661	1.7813
1993	903.5	501.4	402.1	0.5550	0.4450	4.8129	6.4767	1.5417	1.7301
1994	951.2	522.6	428.6	0.5494	0.4506	4.8685	6.6155	1.5299	1.7648
1995	992.0	541.2	450.8	0.5456	0.4544	5.0990	6.7770	1.5363	1.7381
1996	1069.5	566.7	502.8	0.5299	0.4701	5.3611	7.0498	1.5688	1.7707
1997	1136.9	601.8	535.1	0.5294	0.4706	5.5402	7.3528	1.6206	1.7889
1998	1229.4	637.3	592.1	0.5184	0.4816	5.6619	7.7929	1.7087	1.8943
1999	1312.3	662.7	649.6	0.5050	0.4950	5.7664	8.1347	1.7602	1.9933
2000	1420.7	712.9	707.8	0.5018	0.4982	6.0680	8.6602	1.8334	2.0293
2001	1637.1	830.6	806.5	0.5073	0.4927	6.3365	8.9251	1.8545	1.9809
2002	1707.0	861.7	845.3	0.5048	0.4952	6.3650	9.0834	1.8575	2.0170
2003	1800.5	934.1	866.4	0.5188	0.4812	6.4184	9.3894	1.8847	2.0118
2004	1953.7	1023.3	930.4	0.5238	0.4762	6.5464	9.7942	1.9209	2.0381
2005	2088.6	1102.8	985.8	0.5280	0.4720	6.6842	10.1199	1.9272	2.0460
2006	2293.1	1210.0	1083.1	0.5277	0.4723	6.8051	10.5245	1.9567	2.0912
2007	2356.3	1303.0	1053.3	0.5530	0.4470	6.9719	10.9629	1.9872	2.0289
2008	2474.5	1315.8	1158.7	0.5317	0.4683	6.9994	11.2585	1.9932	2.1583
2009	2321.0	1271.1	1049.9	0.5477	0.4523	6.8638	11.4066	1.9929	2.1651
2010	2395.5	1291.9	1103.6	0.5393	0.4607	7.0960	11.6811	2.0158	2.1779
2011	2592.9	1324.2	1268.7	0.5107	0.4893	7.2228	11.9747	2.0264	2.3162
2012	2742.3	1386.7	1355.6	0.5057	0.4943	7.3719	12.2744	2.0323	2.3493
2013	2839.8	1410.8	1429.0	0.4968	0.5032	7.5334	12.3977	2.0226	2.3635
2014	2966.3	1470.3	1496.0	0.4957	0.5043	7.7110	12.6666	2.0426	2.3645

The price of (value added) output in Sector 2 grew 7.71 fold over the sample period (much higher than the Sector 1 price growth of 4.56 fold) while wages grew 12.67 fold. The geometric rates of growth were 3.61% per year for real value added, 3.86% per year for the value added deflator and 4.81% per year for wages. Real wages grew 2.04 fold over the sample period while labour productivity grew 2.36 fold, much lower than the 3.41 fold of labour productivity in Sector 1. The long run average geometric rates of growth of real wages and labour productivity for Sector 2 were 1.33% and 1.61% per year while the corresponding growth rates for Sector 1 were 1.51% and 2.30% per year. Thus real wage growth and labour productivity growth in Sector 2 were substantially below their Sector 1 counterparts. The sample average labour and capital services shares in Sector 2 were 56.7% and 43.3% (68.6% and 31.4% in Sector 1). It can be seen that Sector 2 is much more capital intensive than Sector 1. The upward trend in the capital services share is very noticeable in Figure 2, which plots the series $s_{L2}{}^{t}$, $s_{KS2}{}^{t}$, $P_{VA2}{}^{t}$, $RW_2{}^{t}$ and $ProdL_2{}^{t}$. Note that the capital services share finishes up at 50.4%, well above its long term average of 43.3%. It can be seen that real wages have grown very slowly since 2001. Note also that real wage growth stagnated after 2007 while labour productivity continued to grow. *It can be seen that the structure of production is entirely different in the noncorporate nonfinancial sector as compared to the corporate nonfinancial sector*.

In the following section, we will calculate price and quantity indexes for the capital stocks used in both sectors as well as the corresponding real and nominal capital output ratios for the two sectors.

4. Capital stocks and Capital Output Ratios for Sectors 1 and 2

In the Appendix, we constructed price and quantity indexes for nine capital stocks that are used as inputs into Sector 1. In this section, we denote the beginning of year t price, quantity and value of capital stock component i used by Sector 1 in year t as $P_{K1,i}{}^{t}$, $Q_{K1,i}{}^{t}$ and $V_{K1,i}{}^{t}$ for i = 1,...,9 and t = 1960,...,2015. In Table 3, we indicate where these series are located in the Appendix.

Table 3: Capital Stock Components for Sector 1 and their Location in the Appendix

$V_{K1,1}$	Equipment; see V_{EQ1}, P_{EQ1} and Q_{EQ1} in Tables A5 and A6
$V_{K1,2}$	Intellectual Property Products; see V_{IP1}, P_{IP1} and Q_{IP1} in Tables A5 and A6
$V_{K1,3}$	Nonresidential Structures; see V_{SN1}, P_{SN1} and Q_{SN1} in Tables A5 and A6
$V_{K1,4}$	Residential Structures; see V_{SR1}, P_{SR1} and Q_{SR1} in Tables A5 and A6
$V_{K1,5}$	Residential Land; see V_{LR1} and Q_{LR1} in Table A9
$V_{K1,6}$	Farm Land; see Q_{LF1} and $P_{LF1} = P_{LF}$ in Table A2
$V_{K1,7}$	Commercial Land; see V_{LN1} and Q_{LN1} in Table A9
$V_{K1,8}$	Inventory Stocks; see V_{I1} and Q_{I1} in Table A15
$V_{K1,9}$	Currency and Deposit Holdings; see V_{M1} and Q_{M1} in Table A15

We constructed chained Fisher capital stock price and quantity indexes for Sector 1 using the price and quantity information for each of the nine assets. Denote the resulting period t price and quantity indexes as $P_{K1}{}^{t}$ and $Q_{K1}{}^{t}$ for t = 1960,...,2015. Define the Sector 1 capital stock value at the beginning of year t as $V_{K1}{}^{t} \equiv P_{K1}{}^{t}Q_{K1}{}^{t}$. Now define the year t nominal and real capital output ratios as $V_{K/O,1}{}^{t} \equiv V_{K1}{}^{t}/V_{VA1}{}^{t}$ and $Q_{K/O,1}{}^{t} \equiv Q_{K1}{}^{t}/Q_{VA1}{}^{t}$. $V_{K1}{}^{t}$, $Q_{K1}{}^{t}$, $P_{K1}{}^{t}$, $V_{K/O,1}{}^{t}$ and $Q_{K/O,1}{}^{t}$ are listed in Table 4.

Table 4: Capital Stock Values, Prices and Quantities and Nominal and Real Capital Output Ratios for Sectors 1 and 2

Year	V_{K1}^t	Q_{K1}^t	P_{K1}^t	$V_{K/O,1}^t$	$Q_{K/O,1}^t$	V_{K2}^t	Q_{K2}^t	P_{K2}^t	$V_{K/O,2}^t$	$Q_{K/O,2}^t$
1960	633.4	633.4	1.0000	2.4752	2.4752	368.9	368.9	1.0000	3.4345	3.4345
1961	641.2	650.0	0.9865	2.4399	2.4807	373.3	371.4	1.0049	3.3872	3.4248
1962	662.5	668.8	0.9906	2.3092	2.3533	385.6	376.4	1.0244	3.3762	3.3969
1963	689.9	691.8	0.9972	2.2539	2.2930	402.2	382.0	1.0530	3.4348	3.4002
1964	712.8	713.3	0.9993	2.1561	2.2090	411.5	384.3	1.0707	3.3455	3.3116
1965	750.5	739.3	1.0151	2.0579	2.1122	422.5	389.6	1.0844	3.2499	3.2397
1966	804.3	773.4	1.0400	1.9953	2.0572	445.9	399.5	1.1162	3.2197	3.2139
1967	874.7	816.8	1.0709	2.0634	2.1124	472.1	407.0	1.1601	3.3222	3.2916
1968	944.1	858.8	1.0994	2.0286	2.0855	500.5	412.4	1.2136	3.3409	3.3074
1969	1028.6	895.4	1.1487	2.0393	2.0909	548.1	422.7	1.2967	3.4733	3.3591
1970	1131.9	931.5	1.2152	2.1826	2.1942	614.3	436.1	1.4086	3.7596	3.4784
1971	1233.1	961.7	1.2823	2.2079	2.1794	675.1	445.3	1.5161	3.8998	3.5101
1972	1342.0	989.3	1.3565	2.1569	2.0841	746.7	459.5	1.6249	3.9052	3.4373
1973	1462.6	1020.1	1.4338	2.0933	2.0259	838.5	476.2	1.7609	3.7515	3.1803
1974	1663.0	1056.7	1.5738	2.2006	2.1309	1005.7	495.0	2.0320	4.2761	3.4374
1975	2016.4	1109.2	1.8180	2.4647	2.2689	1183.2	500.6	2.3634	4.6952	3.5795
1976	2216.9	1130.3	1.9613	2.3886	2.1373	1342.6	506.9	2.6486	4.8716	3.6025
1977	2449.5	1166.5	2.0999	2.3264	2.0544	1497.6	509.0	2.9422	4.9803	3.5939
1978	2725.9	1206.9	2.2587	2.2689	1.9958	1705.4	515.1	3.3106	5.0057	3.4396
1979	3098.1	1249.0	2.4806	2.3093	2.0013	2007.9	527.2	3.8085	5.2798	3.5257
1980	3569.1	1296.1	2.7537	2.4569	2.0974	2296.6	538.1	4.2683	5.7445	3.6514
1981	4058.3	1331.1	3.0488	2.4720	2.0700	2488.8	544.4	4.5719	5.7149	3.7201
1982	4528.4	1377.0	3.2886	2.6616	2.1892	2647.9	554.8	4.7728	5.8260	3.8671
1983	4779.9	1405.0	3.4020	2.6299	2.1295	2736.8	565.4	4.8408	5.6934	4.0070
1984	4966.4	1436.6	3.4570	2.4339	1.9993	2866.2	570.4	5.0250	5.1523	3.5380
1985	5280.1	1493.8	3.5346	2.4300	1.9868	2962.8	582.3	5.0879	4.9347	3.5092
1986	5540.5	1546.5	3.5826	2.4508	2.0046	3134.5	597.4	5.2473	4.9262	3.4568
1987	5742.8	1584.8	3.6237	2.3675	1.9508	3314.2	603.7	5.4899	4.9651	3.4934
1988	6041.1	1614.4	3.7420	2.2877	1.8722	3522.6	609.2	5.7828	4.8448	3.3930
1989	6434.3	1643.3	3.9156	2.3207	1.8701	3777.3	616.6	6.1259	4.8796	3.3988
1990	6749.5	1674.7	4.0303	2.3293	1.8787	4005.2	622.3	6.4360	4.9600	3.4255
1991	7057.4	1707.1	4.1343	2.3955	1.9250	4108.2	627.4	6.5480	5.0407	3.5639
1992	7229.2	1732.9	4.1716	2.3513	1.8963	4206.9	626.7	6.7131	4.8367	3.3879
1993	7421.0	1754.3	4.2302	2.3075	1.8735	4256.2	625.6	6.8033	4.7108	3.3327
1994	7775.5	1793.9	4.3345	2.2435	1.8047	4388.0	626.2	7.0077	4.6132	3.2049
1995	8173.3	1842.8	4.4353	2.2194	1.7686	4487.7	629.3	7.1314	4.5239	3.2346
1996	8648.2	1895.7	4.5619	2.2037	1.7187	4688.9	635.2	7.3817	4.3842	3.1841
1997	9059.0	1956.6	4.6299	2.1469	1.6629	4897.0	647.3	7.5658	4.3073	3.1541
1998	9577.5	2032.2	4.7129	2.1422	1.6343	5191.2	658.6	7.8816	4.2225	3.0334
1999	10131.9	2110.4	4.8009	2.1352	1.6096	5607.1	669.6	8.3735	4.2727	2.9424
2000	10861.3	2200.2	4.9366	2.1452	1.5909	6082.2	682.9	8.9060	4.2811	2.9169
2001	11758.9	2291.5	5.1316	2.3395	1.6929	6733.2	701.0	9.6050	4.1129	2.7133
2002	12238.7	2324.1	5.2661	2.4159	1.7024	7256.3	709.3	10.230	4.2509	2.6448
2003	12832.2	2348.3	5.4645	2.4542	1.6836	7847.9	710.4	11.048	4.3588	2.5323
2004	13575.4	2393.6	5.6715	2.4342	1.6422	8495.9	715.8	11.869	4.3486	2.3986
2005	14835.3	2432.0	6.1000	2.4896	1.6153	9558.0	726.9	13.149	4.5763	2.3262
2006	16327.0	2484.1	6.5727	2.5599	1.5887	10742.6	737.0	14.577	4.6847	2.1870
2007	17248.2	2519.9	6.8447	2.6247	1.5956	11334.8	750.9	15.094	4.8104	2.2219
2008	17652.5	2538.6	6.9537	2.6649	1.6284	11138.3	764.9	14.561	4.5012	2.1637
2009	17527.8	2561.5	6.8429	2.8027	1.7687	10275.4	775.7	13.247	4.4272	2.2938
2010	17154.9	2583.4	6.6405	2.5970	1.6901	9937.9	772.2	12.869	4.1486	2.2876
2011	17460.2	2620.2	6.6637	2.5225	1.6723	9464.8	773.8	12.232	3.6503	2.1555
2012	18064.0	2648.8	6.8197	2.4673	1.6250	9539.9	779.4	12.240	3.4788	2.0953
2013	18919.5	2688.7	7.0367	2.4921	1.6010	10491.4	788.3	13.309	3.6944	2.0912
2014	19908.8	2754.4	7.2281	2.5215	1.5896	11284.8	797.0	14.160	3.8043	2.0717
2015	20661.5	2806.7	7.3615			11960.3	810.2	14.762		

It can be seen that the Sector 1 aggregate capital stock price P_{K1}^t increased 7.36 fold over the sample period. The average geometric growth rates for the price and quantity of the Sector 1 capital stock were 3.70% per year and 2.74% per year respectively. The real capital output ratio, $Q_{K/O,1}{}^t$, declined more or less steadily from 2.47 in 1960 to 1.59 in 2014. The nominal capital output ratio, $V_{K/O,1}{}^t$, did not decline nearly as much due to increasing land prices.[21] The nominal capital output ratio started at 2.47 and ended up at 2.52 with many fluctuations in between ($V_{K/O,1}{}^t$ had a low of 2.00 in 1966 and a high of 2.80 in 2009).

We turn our attention to the capital stocks used in Sector 2. In the Appendix, we describe the construction of price and quantity indexes for fourteen capital stocks that are used as inputs into Sector 2.[22] In this section, we denote the beginning of year t price, quantity and value of capital stock component i used by Sector 2 in year t as $P_{K2,i}{}^t$, $Q_{K2,i}{}^t$ and $V_{K2,i}{}^t$ for i = 1,...,14 and t = 1960,...,2015. In Table 5, we indicate where these series are located in the Appendix.

Table 5: Capital Stock Components for Sector 2 and their Location in the Appendix

$V_{K2,1}$	Equipment held by Sole Proprietors; see V_{EQ2a} and P_{EQ2a} in Tables A7 and A8
$V_{K2,2}$	Equipment held by Partners; see V_{EQ2b} and P_{EQ2b} in Tables A7 and A8
$V_{K2,3}$	Equipment held by Cooperatives; see V_{EQ2c} and P_{EQ2c} in Tables A7 and A8
$V_{K2,4}$	Intellectual Property Products held by Sole Proprietors; see V_{IP2a} and P_{IP2a} in Tables A7 and A8
$V_{K2,5}$	Intellectual Property Products held by Partners; see V_{IP2b} and P_{IP2b} in Tables A7 and A8
$V_{K2,6}$	Nonresidential Structures held by Sole Proprietors; see V_{SN2a} and P_{SN2a} in Tables A7 and A8
$V_{K2,7}$	Nonresidential Structures held by Partners; see V_{SN2b} and P_{SN2b} in Tables A7 and A8
$V_{K2,8}$	Nonresidential Structures held by Cooperatives; see V_{SN2c} and P_{SN2c} in Tables A7 and A8
$V_{K2,9}$	Residential Structures; see V_{SR2}, P_{SR2} and Q_{SR2} in Tables A7 and A8
$V_{K2,10}$	Residential Land; see V_{LR2} and Q_{LR2} in Table A9
$V_{K2,11}$	Farm Land; see Q_{LF2} and $P_{LF2} = P_{LF}$ in Table A2
$V_{K2,12}$	Commercial Land; see V_{LN2} and Q_{LN2} in Table A9
$V_{K2,13}$	Inventory Stocks; see V_{I2} and Q_{I2} in Table A15
$V_{K2,14}$	Currency and Deposit Holdings; see V_{M2} and Q_{M2} in Table A15

We constructed chained Fisher capital stock price and quantity indexes for Sector 2 using the price and quantity information for each of the fourteen assets. Denote the resulting beginning of period t price and quantity indexes as $P_{K2}{}^t$ and $Q_{K2}{}^t$ for t = 1960,...,2015. Define the Sector 2 capital stock value at the beginning of year t as $V_{K2}{}^t \equiv P_{K2}{}^t Q_{K2}{}^t$. Now define the year t nominal and real capital output ratios for Sector 2 as $V_{K/O,2}{}^t \equiv V_{K2}{}^t/V_{VA2}{}^t$ and $Q_{K/O,2}{}^t \equiv Q_{K2}{}^t/Q_{VA2}{}^t$. $V_{K2}{}^t$, $Q_{K2}{}^t$, $P_{K2}{}^t$, $V_{K/O,2}{}^t$ and $Q_{K/O,2}{}^t$ are listed in Table 4 above.

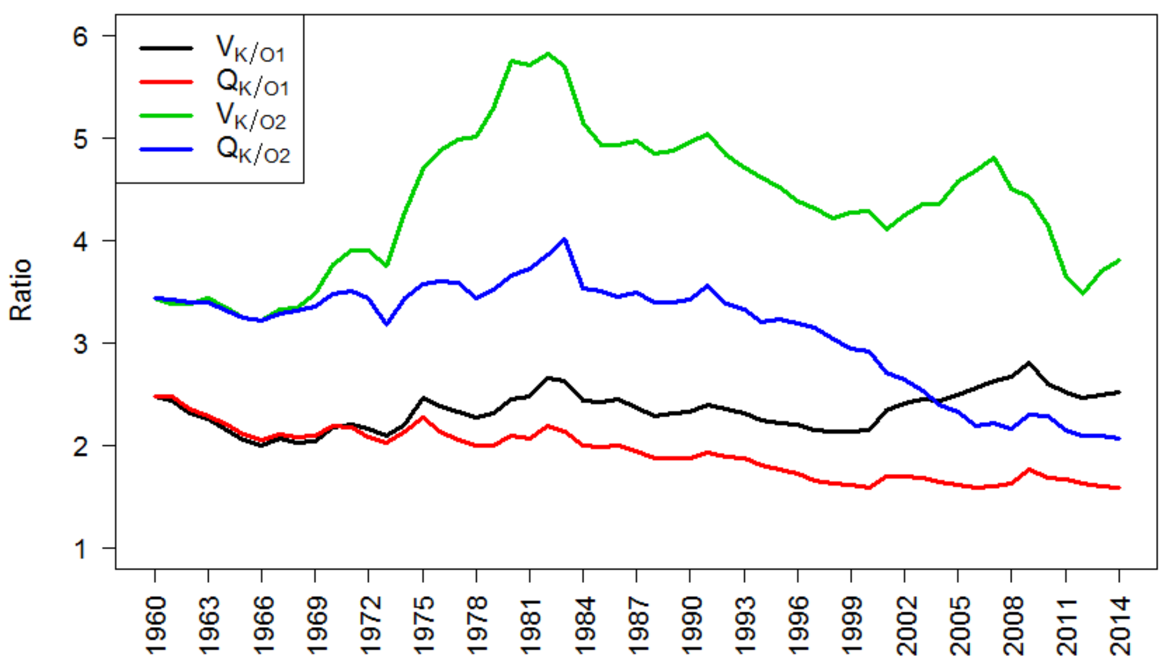
[21] We constructed chained Fisher land price and quantity indexes for Sector 1 and then compared the value of land to value added and the quantity of land to the quantity of output. The nominal land to output ratio went from 36.7% in 1960 to a peak of 51.2% in 2006, declined to 22.0% in 2012 and finished up in 2014 at 30.4%. The corresponding real land to output ratio declined steadily from 36.7% in 1960 to 9.8% in 2014. The inclusion or exclusion of land from the productive asset base does make a significant difference to capital output ratios.

[22] The BEA Fixed Asset Tables are organized somewhat differently for the Nonfinancial Noncorporate Sector as compared to Sector 1, with a decomposition of Sector 2 into subsectors. This led us to organize the capital stock data for Sector 2 into 14 components rather than 9 components.

Viewing Table 4, it can be seen that the Sector 2 aggregate capital stock price P_{K2}^{t} increased 14.76 fold over the sample period whereas the Sector 1 capital stock price increased only 7.36 fold. The average geometric growth rates for the price and quantity of the Sector 2 capital stock were 5.02% per year (3.70% per year for Sector 1) and 1.44% per year (2.74% per year for Sector 1) respectively. This large difference in growth rates between sectors is explained by the relatively very large land component in the Sector 2 capital stock.[23] The price of land tends to grow more rapidly and the quantity less rapidly than other assets. The real capital output ratio for Sector 2, $Q_{K/O,2}^{t}$, increased (erratically) from 3.43 in 1960 to 4.01 in 1983 and then declined to 2.07 in 2014. The corresponding nominal capital output ratio, $V_{K/O,2}^{t}$, did not decline nearly as much, due to increasing land prices. The nominal capital output ratio started at 3.43 and remained roughly constant until 1969 and then increased rapidly to hit a peak of 5.83 in 1982 and then fell to 3.48 in 2012 and increased a little to end up at 3.80 in 2014. It can be seen that the real and nominal capital output ratios are in general, much larger in Sector 2 than in Sector 1.

The nominal and real capital output ratios for Sectors 1 and 2 are plotted in Figure 3.

Figure 3: Nominal and Real Capital Output Ratios for Sectors 1 and 2



The overall decline in the real capital output ratios from 1983 is visible in Figure 3. The much higher capital output ratios for Sector 2 over Sector 1 are also apparent.

[23] The average share of residential land in Sector 2 value of the capital stock is 28.2%, farm land is 16.4% and commercial (nonresidential and nonfarm) land is 7.1%. Thus the overall average land share in the total value of Sector 2 assets is 51.6% and for reproducible assets is 48.4%. The average land share of asset value in Sector 1 is only 14.4% and the corresponding reproducible asset share is 85.6%.

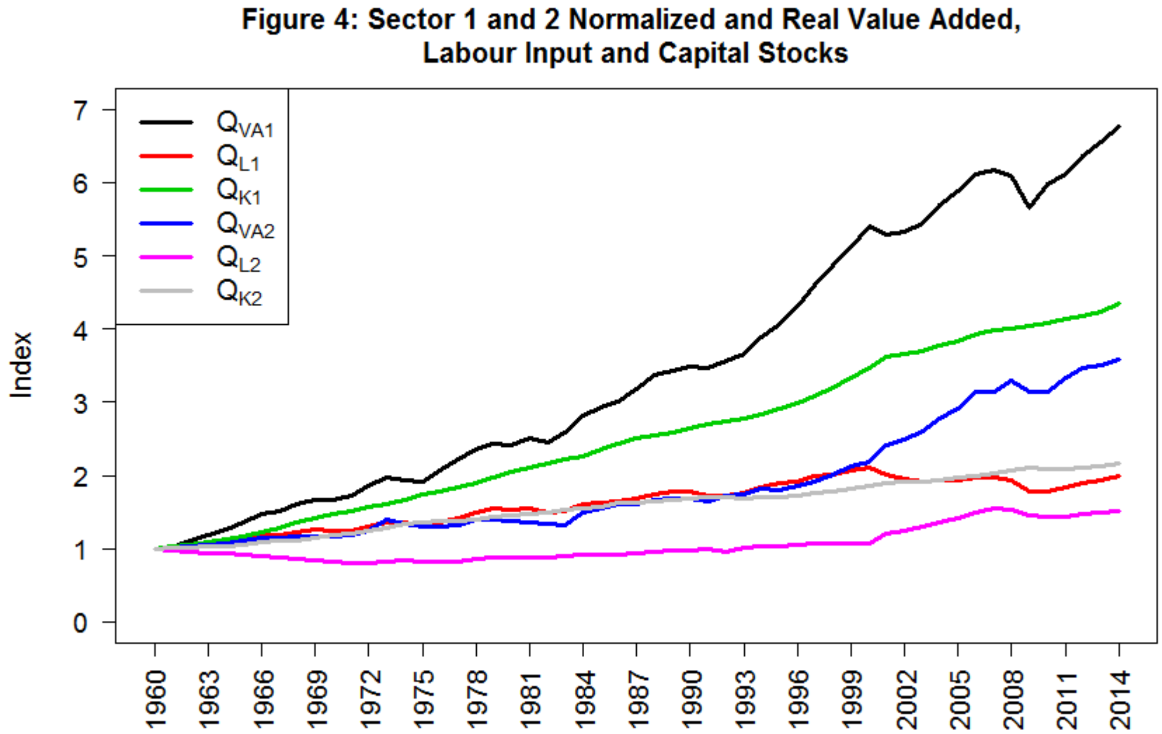


Figure 4 plots real value added, labour input and beginning of the period capital stocks for Sectors 1 and 2, except that each series is divided by its starting 1960 value. Thus real value added in Sectors 1 and 2 grew 6.77 fold and 3.58 fold respectively, labour input grew 1.98 fold in Sector 1 and 1.51 fold in Sector 2 and capital stocks grew 4.35 fold in Sector 1 and only 2.16 fold for Sector 2. Note that labour input in Sector 2 did not recover to its starting value in 1960 until 1993 after which it grew fairly rapidly until 2007 when it levelled off.

In the following section, we turn our attention to deriving the alternative balancing rates of return on assets, and the resulting user costs, for our two sectors that were discussed in Section 2.

5. Balancing Rates of Return and Alternative User Costs for Sectors 1 and 2

Denote the beginning of the year t asset prices for Sector 1 by $P_{K1,n}{}^t$ for n = 1,...,9; see Table 3 for where these prices can be found in the Appendix. The year t inflation rate for asset n, $i_{1,n}{}^t$, is defined as follows:

$$(16)\ i_{1,n}{}^t \equiv (P_{K1,n}{}^{t+1}/P_{K1,n}{}^t) - 1\ ; \qquad n = 1,...,9\ ;\ t = 1960,...,2014.$$

Denote the depreciation rate for asset n in year t used in Sector 1 by $\delta_{1,n}{}^t$. Define the depreciation rates for assets n = 5,...,9 to be 0 for all years t. The nonzero depreciation rates for assets n = 1,2,3,4 used in Sector 1 are listed in Table A10 in the Appendix.

Recall equation (9) in Section 2 which defined the ex post rate of return on assets for year t, r^t. For Sector 1, we will use the following counterpart to (9) to define the year t *ex post rate of return on assets for Sector 1*, $r_1{}^t$:

(17) $V_{VA1}^{t} - V_{L1}^{t} - \Sigma_{n=1}^{9} [1+r_1^{t} - (1+i_{1,n}^{t})(1-\delta_{1,n}^{t})]P_{K1,n}^{t}Q_{K1,n}^{t} = 0$; t = 1960,...,2014

where Sector 1 value added and the value of labour input in year t, V_{VA1}^{t} and V_{L1}^{t}, are listed in Table 1 above. The Sector 1 ex post rates of return on assets (the r_1^{t} which solve (17) for year t data) are listed in Table 6.
Recall that the personal consumption deflator for the beginning of year t was defined in Section 3 as P_C^{t} for t = 1960,...,2014. Define the corresponding year t *consumption inflation rate*, i_C^{t}, by (18) and the corresponding year t *ex post real rate of return on assets* for Sector 1, R_1^{t}, by (19):

(18) $i_C^{t} \equiv (P_C^{t+1}/P_C^{t}) - 1$; t = 1960 ...,2014;
(19) $R_1^{t} \equiv [(1+r_1^{t})/(1+i_C^{t})] - 1$; t = 1960 ...,2014.

The personal consumption deflator inflation rates i_C^{t} and the Sector 1 ex post real rates of return R_1^{t} are also listed in Table 6.

We also calculated a balancing rate of return for Sector 1 for each year t, r_1^{t*}, using a modification of equation (11) in section 3 above. In order to calculate this alternative rate of return on assets, we need to form *expected or predicted asset inflation rates*, $i_{1,n}^{t*}$, for each asset n. We formed predicted rates as follows. For the first 6 years in our sample, we used the actual geometric average growth rate of the asset prices, starting at the beginning of 1960 and ending at the beginning of 1965. Thus we defined $i_{1,n}^{t*}$ as follows for the first 6 years in our sample:

(20) $i_{1,n}^{t*} \equiv (P_{K1,n}^{1965}/P_{K1,n}^{1960})^{1/5} - 1$; n = 1,...,9; t = 1960,...,1965.

For the years 1966-1985 we defined the $i_{1,n}^{t*}$ as geometric average growth rates of the asset price from the beginning of 1960 to the beginning of year t as follows for n = 1,...,9:

(21) $i_{1,n}^{1966*} \equiv (P_{K1,n}^{1966}/P_{K1,n}^{1960})^{1/6} - 1,$
$i_{1,n}^{1967*} \equiv (P_{K1,n}^{1967}/P_{K1,n}^{1960})^{1/7} - 1,$
...
$i_{1,n}^{1985*} \equiv (P_{K1,n}^{1985}/P_{K1,n}^{1960})^{1/25} - 1.$

For t greater than 1985, we simply used the geometric average growth rate of the asset price over the 25 years prior to year t; i.e., define $i_{1,n}^{t*}$ for t ≥ 1985 as follows:[24]

(22) $i_{1,n}^{t*} \equiv (P_{K1,n}^{t}/P_{K1,n}^{t-25})^{1/25} - 1$; n = 1,...,9; t = 1985,...,2014.

Recall equation (11) in Section 2 which decomposed value added into labour and capital service components using predicted asset inflation rates, which we now denote by $i_{1,n}^{t*}$, and a predicted or expected balancing nominal rate of return on assets for year t, which we now

[24] It may be that the length of our moving average process is too long or that better methods for predicting asset prices one year hence could be devised. However, our goal is to obtain user costs that could approximate one year rental prices for assets used in production (when they exist). Since observed rental prices are relatively smooth, our suggested method for generating predicted asset prices does lead to relatively smooth user costs as will be seen later.

denote by r_1^{t*}. For Sector 1, we will use the following counterpart to (11) to define the year t *predicted balancing rate of return on assets for Sector 1*, r_1^{t*}:

$$(23)\ V_{VA1}{}^{t} - V_{L1}{}^{t} - \Sigma_{n=1}^{9} [1+r_1^{t*} - (1+i_{1,n}{}^{t*})(1-\delta_{1,n}{}^{t})]P_{K1,n}{}^{t}Q_{K1,n}{}^{t} = 0\ ; \qquad t = 1960,...,2014$$

where Sector 1 value added and the value of labour input in year t, $V_{VA1}{}^{t}$ and $V_{L1}{}^{t}$, are listed in Table 1 above and the nonzero depreciation rates for assets n = 1,2,3,4 used in Sector 1 are listed in Table A10 in the Appendix. The Sector 1 predicted rates of return on assets (the r_1^{t*} which solve (23) for year t data) are listed in Table 6. The corresponding year t *predicted real rate of return on assets* for Sector 1, R_1^{t*}, is defined by (24) and also listed in Table 6:

$$(24)\ R_1^{t*} \equiv [(1+r_1^{t*})/(1+i_C{}^{t})] - 1\ ; \qquad t = 1960\ ...,2014.$$

The mean nominal rate of return r_1^{t} over the sample period in Sector 1 was 11.25% (minimum rate was 3.21% in 2009 and the maximum was 21.97% in 1974) while the mean real ex post rate of return on assets R_1^{t} was 7.57% (minimum was 1.99% in 2009; maximum was 11.83% in 1965). These ex post real rates have been above average for the last three years at 9.73%, 9.82% and 8.68%. The mean nominal predicted rate of return r_1^{t*} over the sample period in Sector 1 was 10.04% (minimum rate was 6.96% in 2001 and the maximum was 12.56% in 1978) while the mean expected real rate of return on assets R_1^{t*} was 6.44% (minimum was -0.94% in 1974; maximum was 9.77% in 1965).[25]

These rates of return and the personal consumption deflator inflation rates are plotted in Figure 5. The most important series is R_1^{t}, the before income tax realized real rate of return on assets used in the Corporate Nonfinancial Sector.[26] This real rate has remained above 5% except for the 10 years 1960, 1982-83, 1985, 1990-93 and 2008-09, and has remained below 11% except for the 3 years 1965 and 2004-05. There is no indication of a real rate of return slowdown that shows up in our data. However, the 2008 financial crisis certainly drove down ex post realized rates of return temporarily in 2008 and 2009.

[25] Note that our expected real rate of return on Sector 1 assets has been fairly stable over the period 1982-2014. R_1^{t*} ranged between 4.62% (1990) and 9.33% (1997) over this period.

[26] The average corporate income tax paid by the nonfinancial corporate sector on assets during our sample period as a percentage of the asset base is 1.98% per year; see the series $V_{TI1}{}^{t}$ in Appendix Table A3.

Table 6: Sector 1 Nominal and Real Ex Post Rates of Return on Assets, r_1^t and R_1^t, Predicted Nominal and Real Rates of Return on Assets, r_1^{t*} and R_1^{t*} and the Personal Consumption Deflator Inflation rate i_C^t for t = 1960-2014

Year	r_1^t	R_1^t	r_1^{t*}	R_1^{t*}	i_C^t
1960	0.06221	0.04658	0.07862	0.06275	0.01494
1961	0.08185	0.07479	0.08056	0.07350	0.00657
1962	0.09385	0.07922	0.09036	0.07577	0.01356
1963	0.09575	0.08189	0.09677	0.08289	0.01282
1964	0.11589	0.10057	0.10372	0.08856	0.01392
1965	0.13517	0.11832	0.11421	0.09766	0.01508
1966	0.14139	0.10622	0.11940	0.08491	0.03179
1967	0.12723	0.09898	0.11168	0.08383	0.02570
1968	0.14483	0.09778	0.11344	0.06768	0.04286
1969	0.14778	0.09592	0.10697	0.05694	0.04733
1970	0.12743	0.07770	0.09364	0.04540	0.04615
1971	0.13499	0.09399	0.10092	0.06116	0.03747
1972	0.13896	0.10179	0.10824	0.07208	0.03373
1973	0.18054	0.10140	0.11272	0.03813	0.07185
1974	0.21968	0.09375	0.10469	-0.00937	0.11514
1975	0.14378	0.07057	0.10899	0.03801	0.06839
1976	0.14385	0.08806	0.11775	0.06323	0.05128
1977	0.15231	0.08094	0.12309	0.05352	0.06603
1978	0.17530	0.09247	0.12556	0.04623	0.07582
1979	0.17809	0.07268	0.11990	0.01970	0.09826
1980	0.16368	0.05180	0.11203	0.00511	0.10637
1981	0.14144	0.06054	0.11902	0.03971	0.07628
1982	0.09045	0.03863	0.11120	0.05839	0.04989
1983	0.07854	0.03885	0.11533	0.07429	0.03820
1984	0.09637	0.05941	0.12551	0.08756	0.03489
1985	0.08499	0.04763	0.12172	0.08310	0.03566
1986	0.07588	0.05781	0.10539	0.08682	0.01709
1987	0.10137	0.06152	0.10839	0.06828	0.03755
1988	0.11995	0.07502	0.11255	0.06791	0.04179
1989	0.09847	0.05771	0.10617	0.06513	0.03853
1990	0.09156	0.03976	0.09822	0.04610	0.04982
1991	0.07187	0.04629	0.09224	0.06617	0.02445
1992	0.07501	0.04730	0.08817	0.06011	0.02646
1993	0.08919	0.04760	0.08947	0.04787	0.03970
1994	0.09660	0.07587	0.09614	0.07541	0.01927
1995	0.10467	0.08190	0.09571	0.07312	0.02105
1996	0.09519	0.07763	0.09616	0.07859	0.01629
1997	0.10135	0.09794	0.09667	0.09327	0.00311
1998	0.09585	0.08791	0.08947	0.08157	0.00731
1999	0.10187	0.08102	0.08674	0.06618	0.01929
2000	0.10532	0.07847	0.07939	0.05316	0.02490
2001	0.08194	0.06815	0.06964	0.05601	0.01291
2002	0.09623	0.07547	0.07348	0.05315	0.01930
2003	0.10074	0.08108	0.07884	0.05957	0.01819
2004	0.14446	0.11254	0.08640	0.05610	0.02869
2005	0.15074	0.11619	0.09296	0.06015	0.03095
2006	0.11690	0.09733	0.09770	0.07847	0.01784
2007	0.08600	0.05094	0.09211	0.05686	0.03336
2008	0.04872	0.03351	0.08693	0.07117	0.01472
2009	0.03210	0.01992	0.07963	0.06688	0.01195
2010	0.08064	0.06690	0.09472	0.08080	0.01288
2011	0.10320	0.07462	0.09636	0.06796	0.02660
2012	0.11663	0.09731	0.10072	0.08167	0.01761
2013	0.11163	0.09822	0.10108	0.08780	0.01221
2014	0.09900	0.08679	0.09725	0.08506	0.01123
Mean	0.11254	0.07569	0.10045	0.06440	0.03427

We turn our attention to Sector 2. Denote the beginning of the year t asset prices for Sector 2 by $P_{K2,n}{}^{t}$ for n = 1,...,14; see Table 5 for where these prices can be found in the Appendix. The year t inflation rate for asset n in Sector 2, $i_{2,n}{}^{t}$, is defined as follows:

$$(25)\ i_{2,n}{}^{t} \equiv (P_{K2,n}{}^{t+1}/P_{K2,n}{}^{t}) - 1\ ; \qquad n = 1,...,14\ ;\ t = 1960,...,2014.$$

Denote the depreciation rate for asset n in year t used in Sector 2 by $\delta_{2,n}{}^{t}$. Define the depreciation rates for assets n = 10,...,14 to be 0 for all years t. The nonzero depreciation rates for assets n = 1,...,9 used in Sector 2 are listed in Table A11 in the Appendix.

Again recall equation (9) in Section 2 which defined the ex post rate of return on assets for year t, r^{t}. For Sector 2, we will use the following counterpart to equation (9) to define the year t *ex post rate of return on assets for Sector 2*, $r_2{}^{t}$:

$$(26)\ V_{VA2}{}^{t} - V_{L2}{}^{t} - \Sigma_{n=1}{}^{14}\,[1+r_2{}^{t} - (1+i_{2,n}{}^{t})(1-\delta_{2,n}{}^{t})]P_{K2,n}{}^{t}Q_{K2,n}{}^{t} = 0\ ; \qquad t = 1960,...,2014$$

where Sector 2 value added and the value of labour input in year t, $V_{VA2}{}^{t}$ and $V_{L2}{}^{t}$, are listed in Table 2. The Sector 2 ex post rates of return on assets (the $r_2{}^{t}$ which solve (26) for year t data) are listed in Table 7 below. The year t *ex post real rate of return on assets* for Sector 2, $R_2{}^{t}$, is defined by (27):

$$(27)\ R_2{}^{t} \equiv [(1+r_2{}^{t})/(1+i_C{}^{t})] - 1\ ; \qquad t = 1960\ ...,2014.$$

We also calculated a balancing rate of return for Sector 2 for each year t, $r_2{}^{t*}$, using a modification of equation (11) in Section 3. In order to calculate this alternative rate of return on assets, we need to form *expected or predicted asset inflation rates*, $i_{2,n}{}^{t*}$, for each asset n. We formed Sector 2 predicted asset inflation rates using exactly the same method that we used to form Sector 1 predicted inflation rates.

Recall equation (11) in Section 2 which decomposed value added into labour and capital service components using predicted asset inflation rates, which we now denote by $i_{2,n}{}^{t*}$, and a predicted or expected balancing nominal rate of return on assets for year t, which we now denote by $r_2{}^{t*}$. For Sector 2, we will use the following counterpart to (11) to define the year t *predicted balancing rate of return on assets for Sector 2*, $r_2{}^{t*}$:

$$(28)\ V_{VA2}{}^{t} - V_{L2}{}^{t} - \Sigma_{n=1}{}^{14}\,[1+r_2{}^{t*} - (1+i_{2,n}{}^{t*})(1-\delta_{2,n}{}^{t})]P_{K2,n}{}^{t}Q_{K2,n}{}^{t} = 0\ ; \qquad t = 1960,...,2014$$

where Sector 2 value added and the value of labour input in year t, $V_{VA2}{}^{t}$ and $V_{L2}{}^{t}$, are listed in Table 2 above and the nonzero depreciation rates for assets n = 1,..,9 used in Sector 2 are listed in Table A11 in the Appendix. The Sector 2 predicted rates of return on assets (the $r_2{}^{t*}$ which solve (28) for year t data) are listed in Table 7 below. The corresponding year t *predicted real rate of return on assets* for Sector 2, $R_2{}^{t*}$, is defined by (29) and also listed in Table 7:

$$(29)\ R_2{}^{t*} \equiv [(1+r_2{}^{t*})/(1+i_C{}^{t})] - 1\ ; \qquad t = 1960\ ...,2014.$$

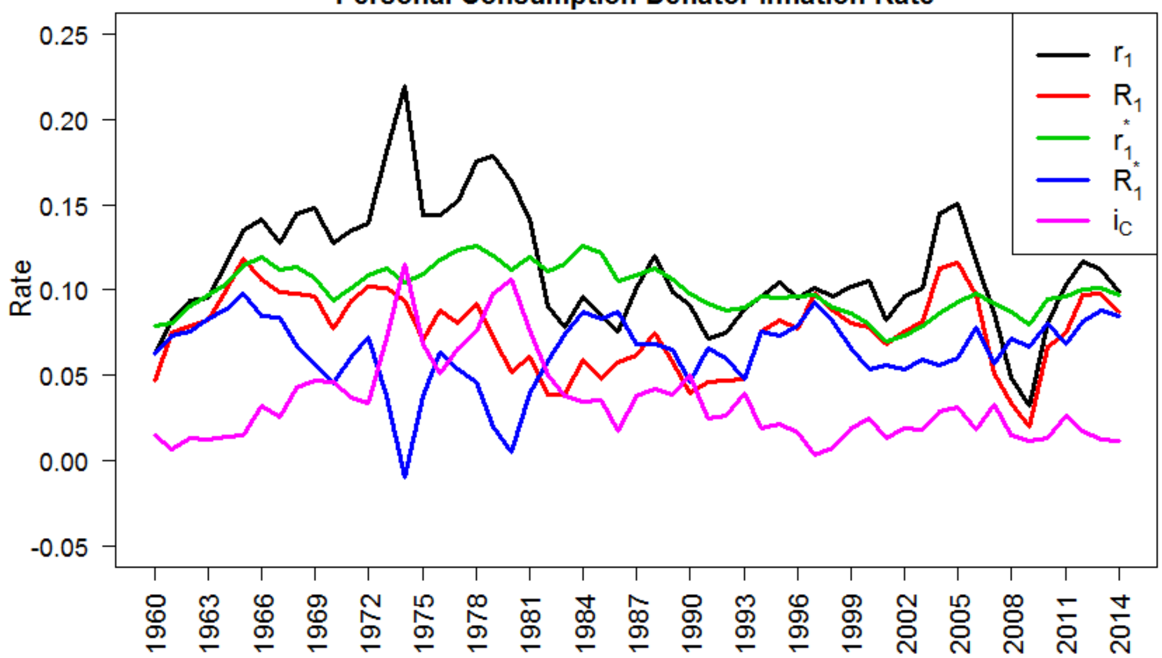
Table 7: Sector 2 Nominal and Real Ex Post Rates of Return on Assets, r_2^t and R_2^t, and Predicted Nominal and Real Rates of Return on Assets, r_2^{t*} and R_2^{t*} for t = 1960-2014

Year	r_2^t	R_2^t	r_2^{t*}	R_2^{t*}
1960	0.06042	0.04481	0.07122	0.05545
1961	0.08105	0.07400	0.07749	0.07045
1962	0.09362	0.07899	0.08184	0.06737
1963	0.08421	0.07049	0.08337	0.06966
1964	0.08289	0.06802	0.08685	0.07193
1965	0.10896	0.09249	0.09667	0.08038
1966	0.12502	0.09036	0.10562	0.07156
1967	0.12889	0.10061	0.10560	0.07789
1968	0.15147	0.10414	0.10908	0.06350
1969	0.16365	0.11107	0.10790	0.05783
1970	0.14618	0.09562	0.10523	0.05647
1971	0.14178	0.10054	0.10895	0.06890
1972	0.16097	0.12308	0.11825	0.08175
1973	0.24596	0.16244	0.13599	0.05984
1974	0.23287	0.10558	0.12540	0.00920
1975	0.18564	0.10975	0.12574	0.05369
1976	0.17560	0.11826	0.13016	0.07504
1977	0.18790	0.11433	0.13161	0.06152
1978	0.21497	0.12935	0.13675	0.05664
1979	0.18052	0.07490	0.13723	0.03548
1980	0.11949	0.01186	0.12739	0.01900
1981	0.09143	0.01407	0.12564	0.04586
1982	0.05761	0.00735	0.11801	0.06488
1983	0.08353	0.04366	0.11585	0.07479
1984	0.07267	0.03651	0.12989	0.09180
1985	0.09803	0.06022	0.13364	0.09460
1986	0.11424	0.09552	0.11922	0.10042
1987	0.12049	0.07995	0.11765	0.07721
1988	0.13053	0.08517	0.12117	0.07619
1989	0.12235	0.08071	0.11848	0.07699
1990	0.08631	0.03476	0.11128	0.05854
1991	0.08890	0.06291	0.10150	0.07521
1992	0.08520	0.05722	0.10703	0.07849
1993	0.10148	0.05942	0.10195	0.05987
1994	0.09211	0.07146	0.10072	0.07990
1995	0.11190	0.08898	0.09927	0.07661
1996	0.10889	0.09111	0.10534	0.08762
1997	0.12780	0.12430	0.10637	0.10294
1998	0.15340	0.14504	0.11213	0.10406
1999	0.15676	0.13486	0.11512	0.09402
2000	0.17223	0.14375	0.11712	0.08998
2001	0.16288	0.14806	0.12284	0.10853
2002	0.17542	0.15316	0.12094	0.09971
2003	0.16423	0.14344	0.11674	0.09679
2004	0.19680	0.16343	0.11690	0.08576
2005	0.19156	0.15578	0.11336	0.07994
2006	0.11664	0.09707	0.11540	0.09585
2007	0.03799	0.00448	0.10722	0.07148
2008	−0.00700	−0.02140	0.11416	0.09800
2009	0.05154	0.03913	0.10460	0.09155
2010	0.03800	0.02480	0.11074	0.09662
2011	0.10934	0.08060	0.12861	0.09937
2012	0.20376	0.18293	0.13526	0.11561
2013	0.17549	0.16131	0.13278	0.11912
2014	0.15135	0.13856	0.13023	0.11768
Mean	0.12756	0.09034	0.11347	0.07727

The mean nominal ex post rate of return r_2^t over the sample period in Sector 2 was 12.76% (minimum rate was −0.70% in 2008 and the maximum was 24.60% in 1973) while the mean real ex post rate of return on assets R_2^t was 9.03% (minimum was −2.14% in 2008; maximum was 18.29% in 2012). Note that the average real rate of return in Sector 2 was a very high 9.03% per year which is considerably above the average real rate of return on assets used in Sector 1, which was 7.57% per year. This result was somewhat surprising. The Sector 2 ex post real rates have been above average for the last 3 years at 18.29%, 16.13% and 13.86%. These are very high real rates of return. The corresponding Sector 1 ex post real rates were only 9.73%, 9.82% and 8.68%.[27] The mean *nominal predicted* rate of return r_1^{t*} over the sample period in Sector 2 was 11.35% (minimum rate was 7.12% in 1960 and the maximum was 13.72% in 1979) while the mean expected *real predicted* rate of return on assets R_1^{t*} was 7.73% (minimum was 0.92% in 1974; maximum was 11.91% in 2013).

These rates of return are plotted in Figure 6. The most important series is R_2^t, the before income tax realized real rate of return on assets used in the Noncorporate Nonfinancial Sector.[28] This series has fluctuated considerably during the sample period, driven by large fluctuations in the price of land. There does not appear to be a long run decline in the real rate of return on assets in Sector 2. The predicted nominal rate of return series r_2^{t*} is much smoother than the corresponding realized return series r_2^t and so the use of the r_2^{t*} series in our user costs will lead to much smoother user costs for this sector.

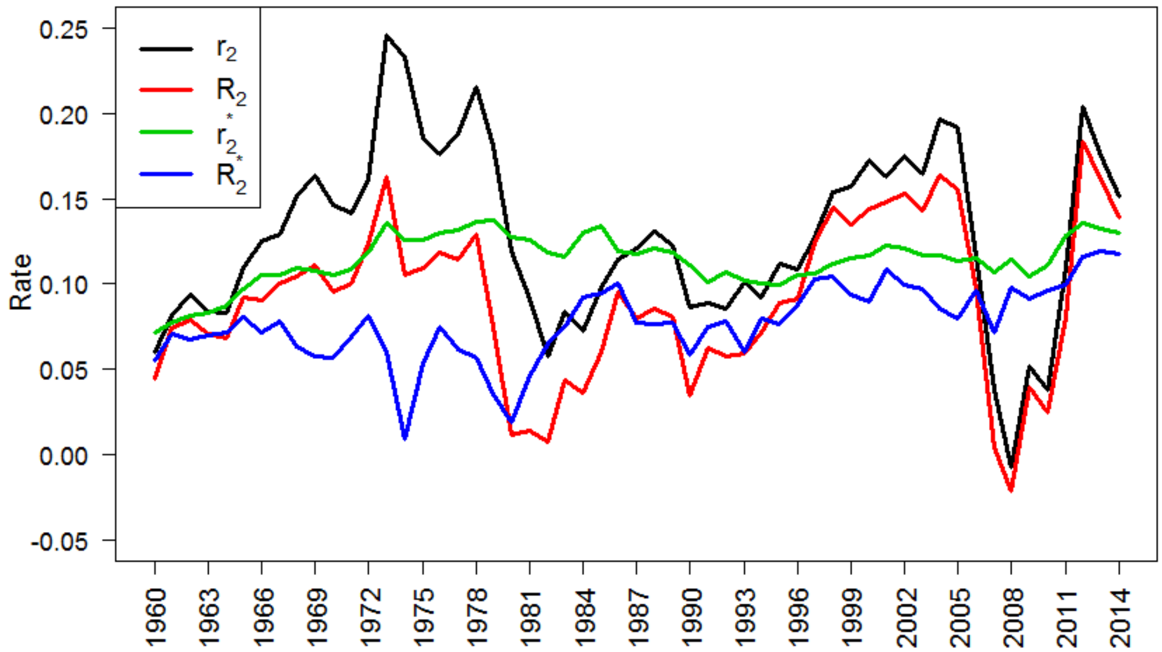
Figure 5: Sector 1 Nominal and Real Rates of Return, Predicted Nominal and Real Rates of Return, and Personal Consumption Deflator Inflation Rate



[27] The reason why nominal and real ex post rates of return on assets are much higher in Sector 2 compared to Sector 1 can be explained by the fact that production in Sector 2 is highly land intensive and land inflation rates are much higher than inflation rates for other assets.

[28] The average business income tax paid by the nonfinancial noncorporate sector on assets during our sample period as a percentage of the asset base is only 0.15% per year; see the series V_{TI2}^t in Appendix Table A3. This income tax rate for Sector 2 seems to be too low to be true!

Figure 6: Sector 2 Nominal and Real Rates of Return, Predicted Nominal and Real Rates of Return



We turn our attention to the calculation of user costs for Sector 1. Recall equations (16) and (17) above. The *year t Jorgensonian user cost for asset n used in Sector 1*, $u_{1,n}{}^t$, is defined as follows:

(30) $u_{1,n}{}^t \equiv [1+r_1{}^t - (1+i_{1,n}{}^t)(1-\delta_{1,n}{}^t)]P_{K1,n}{}^t$; $\quad$ n = 1,...,9; t = 1960,...,2014

where the $i_{1,n}{}^t$ are the ex post asset inflation rates defined by (16) and the $r_1{}^t$ are the Sector 1 balancing nominal rates of return defined by equations (17). These Jorgensonian user costs are listed in Table 8.

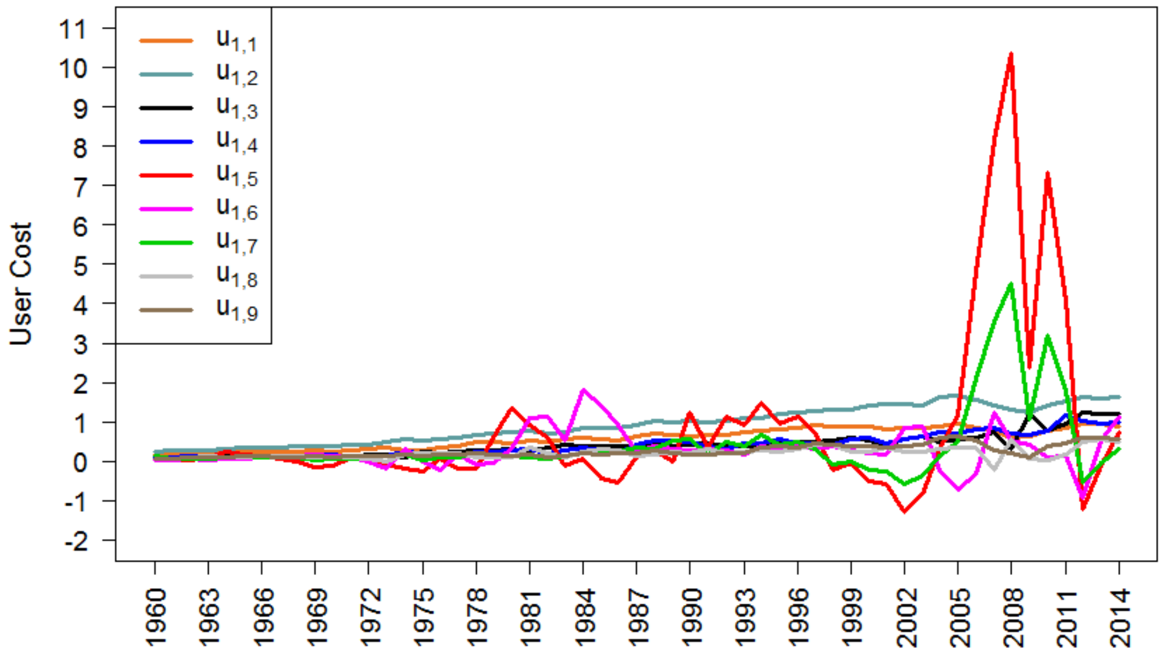
It can be seen that there are numerous negative Jorgensonian user costs for assets 5-8 (residential land, farm land, commercial land and inventory stocks). It can also be seen that these user costs are in general quite volatile; see Figure 7. Thus while Jorgensonian user costs are the "right" user costs to use when computing ex post rates of return on assets, they are not good approximations to rental prices for these assets.[29]

[29] Thus the use of Jorgensonian user costs is not recommended in econometric studies where cost functions are estimated or where production functions are estimated using inverse factor demand equations as additional estimating equations.

Table 8: Jorgensonian User Costs for Sector 1

Year	$u_{1,1}^t$	$u_{1,2}^t$	$u_{1,3}^t$	$u_{1,4}^t$	$u_{1,5}^t$	$u_{1,6}^t$	$u_{1,7}^t$	$u_{1,8}^t$	$u_{1,9}^t$
1960	0.1750	0.2459	0.1036	0.0844	0.0476	0.0358	0.1453	0.0618	0.0473
1961	0.2028	0.2737	0.1064	0.0927	0.0619	0.0311	0.0553	0.0789	0.0764
1962	0.2064	0.2899	0.1191	0.1261	0.0316	0.0535	0.0727	0.0840	0.0820
1963	0.2122	0.2909	0.1214	0.1333	0.0982	0.0355	0.0767	0.1184	0.0859
1964	0.2289	0.3126	0.1222	0.1051	0.2280	0.0638	0.0869	0.1166	0.1069
1965	0.2548	0.3408	0.1397	0.1373	0.1823	0.0610	0.0964	0.0988	0.1277
1966	0.2454	0.3575	0.1471	0.1247	0.1383	0.0958	0.0959	0.1299	0.1183
1967	0.2330	0.3336	0.1293	0.1222	0.0464	0.0830	0.1256	0.1363	0.1131
1968	0.2537	0.3673	0.1316	0.1145	–0.0165	0.1414	0.1061	0.1279	0.1165
1969	0.2698	0.3731	0.1384	0.1715	–0.1365	0.1816	0.0299	0.1058	0.1197
1970	0.2449	0.3713	0.1142	0.1698	-0.0975	0.1456	0.0611	0.1099	0.1014
1971	0.2817	0.4181	0.1156	0.0940	0.1099	0.0934	0.0708	0.1072	0.1273
1972	0.3004	0.4357	0.1630	0.1324	0.1082	–0.0004	0.0539	0.0681	0.1425
1973	0.3504	0.4789	0.1661	0.1528	–0.0634	–0.1827	0.1476	–0.0008	0.1521
1974	0.2824	0.5491	0.1134	0.2528	–0.1706	0.2997	0.1727	0.1592	0.1569
1975	0.2687	0.5280	0.2267	0.1937	–0.2458	–0.0250	0.0279	0.2057	0.1261
1976	0.3594	0.5669	0.2237	0.1988	0.0690	–0.2165	0.0825	0.1900	0.1655
1977	0.3988	0.6158	0.2463	0.0886	–0.1910	0.1746	0.1126	0.1916	0.1621
1978	0.4743	0.6700	0.2698	0.2440	–0.1848	–0.0889	0.1979	0.0870	0.1993
1979	0.4907	0.7107	0.2755	0.2485	0.6154	–0.0384	0.1812	0.0879	0.1720
1980	0.4541	0.7300	0.3008	0.2682	1.3582	0.3242	0.1500	0.1108	0.1357
1981	0.5396	0.7590	0.2441	0.3163	0.9032	1.0925	0.0979	0.3412	0.1706
1982	0.5078	0.7177	0.3508	0.2073	0.5899	1.1189	0.0714	0.2112	0.1143
1983	0.5545	0.7390	0.4227	0.2848	–0.1299	0.5337	0.1492	0.1123	0.1194
1984	0.6100	0.8485	0.3803	0.3397	0.0506	1.8028	0.2138	0.2425	0.1889
1985	0.5710	0.8625	0.3993	0.2849	–0.4352	1.4173	0.2448	0.2999	0.1568
1986	0.5404	0.8619	0.3923	0.1984	–0.5554	0.9307	0.2320	0.2933	0.1936
1987	0.6431	0.9025	0.4018	0.4296	0.0874	0.2379	0.3635	0.1477	0.2138
1988	0.7018	1.0168	0.4266	0.5262	0.2746	0.3832	0.3109	0.1591	0.2716
1989	0.6660	0.9907	0.3866	0.5145	0.0044	0.3025	0.5159	0.2490	0.2170
1990	0.6465	1.0093	0.4149	0.4755	1.2466	0.2646	0.5452	0.2187	0.1569
1991	0.6562	0.9792	0.4617	0.3926	0.3662	0.3143	0.1601	0.2962	0.1872
1992	0.6862	1.0171	0.3721	0.3278	1.1197	0.2609	0.4897	0.2100	0.1963
1993	0.7472	1.1005	0.3721	0.4600	0.9056	0.1598	0.3960	0.2415	0.2054
1994	0.7754	1.1058	0.4098	0.4495	1.4986	0.3957	0.6554	0.2622	0.3337
1995	0.8203	1.1965	0.4978	0.5648	0.9468	0.3104	0.4141	0.2493	0.3678
1996	0.8455	1.2390	0.4963	0.4590	1.1230	0.3726	0.4911	0.3210	0.3543
1997	0.9041	1.2885	0.4841	0.4599	0.7293	0.3212	0.3190	0.4083	0.4484
1998	0.8849	1.3063	0.5169	0.4027	-0.2033	0.3840	–0.0889	0.4327	0.4054
1999	0.8814	1.3242	0.5844	0.5500	-0.0356	0.2777	–0.0156	0.2512	0.3808
2000	0.8751	1.4250	0.5319	0.5929	-0.5109	0.2103	–0.2234	0.2580	0.3780
2001	0.8092	1.4503	0.4056	0.4631	-0.5896	0.1629	–0.2579	0.3554	0.3325
2002	0.8406	1.4560	0.5482	0.5664	-1.3008	0.8472	–0.5688	0.2450	0.3754
2003	0.8351	1.4085	0.6438	0.6407	-0.8349	0.8655	–0.3651	0.2377	0.4106
2004	0.8988	1.6378	0.4990	0.7396	0.3132	–0.2187	0.1370	0.3192	0.5863
2005	0.9644	1.6488	0.5476	0.6996	1.1549	–0.7134	0.5051	0.3582	0.6240
2006	0.8380	1.5553	0.6132	0.8040	4.7836	–0.3142	2.0920	0.3489	0.5321
2007	0.7852	1.4221	0.7279	0.8547	8.1384	1.2308	3.5591	–0.2134	0.2878
2008	0.5912	1.3152	0.2985	0.7091	10.3629	0.5368	4.5319	0.5665	0.1921
2009	0.6227	1.2398	1.2007	0.6816	2.3949	0.4362	1.0473	0.0733	0.1155
2010	0.7606	1.4258	0.7884	0.7836	7.3387	0.0869	3.2094	0.0354	0.3931
2011	0.8414	1.5385	0.9551	1.1627	4.0821	0.1264	1.7852	0.1869	0.4501
2012	0.9659	1.6423	1.2448	1.0248	–1.2067	–0.9477	–0.5277	0.4861	0.5973
2013	0.9513	1.6000	1.1917	0.9591	–0.1068	0.5177	–0.0467	0.5573	0.6102
2014	0.8932	1.6212	1.1972	0.9784	0.7525	1.1182	0.3291	0.4872	0.5453

Figure 7: Jorgensonian User Costs for Sector 1



Recall equations (20)-(23) above. The *year t predicted user cost for asset n used in Sector 1*, $u_{1,n}{}^{t*}$, is defined as follows:

(31) $u_{1,n}{}^{t*} \equiv [1+r_1{}^{t*} - (1+i_{1,n}{}^{t*})(1-\delta_{1,n}{}^{t})]P_{K1,n}{}^{t}$; n = 1,...,9; t = 1960,...,2014

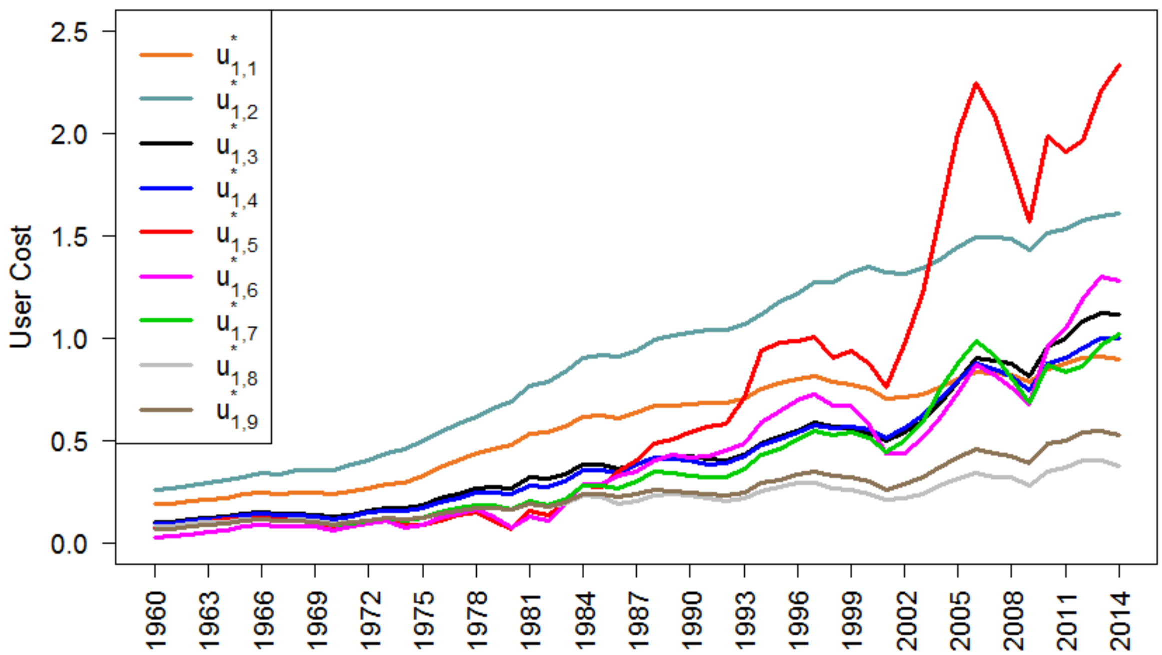
where the $i_{1,n}{}^{t*}$ are the predicted asset inflation rates defined by (20)-(22) and the $r_1{}^{t*}$ are the predicted Sector 1 balancing nominal rates of return defined by equations (23). These predicted user costs are listed in Table 9.

The predicted user costs are much smoother than the Jorgensonian user costs and the negative user costs have been eliminated. Thus in what follows, we will sometimes refer to these predicted user costs as *smoothed user costs*. These user costs are suitable for production or cost function econometric studies. They are also more suitable for statistical agencies to use when computing capital services aggregates for publication. These user costs may be viewed in Figure 8. It can be seen that the user costs for residential, farm and commercial land ($u_{1,5}{}^{t*}$, $u_{1,6}{}^{t*}$ and $u_{1,7}{}^{t*}$) have been quite volatile for the last 20 years in our sample period but the remaining user cost series are fairly smooth.

Table 9: Predicted User Costs for Sector 1

Year	$u_{1,1}^{t*}$	$u_{1,2}^{t*}$	$u_{1,3}^{t*}$	$u_{1,4}^{t*}$	$u_{1,5}^{t*}$	$u_{1,6}^{t*}$	$u_{1,7}^{t*}$	$u_{1,8}^{t*}$	$u_{1,9}^{t*}$
1960	0.1926	0.2627	0.1041	0.0966	0.0768	0.0289	0.0804	0.0805	0.0663
1961	0.1942	0.2691	0.1047	0.0987	0.0799	0.0316	0.0755	0.0825	0.0692
1962	0.2044	0.2815	0.1148	0.1100	0.0917	0.0438	0.0863	0.0926	0.0797
1963	0.2127	0.2941	0.1214	0.1158	0.1046	0.0530	0.0938	0.1000	0.0874
1964	0.2218	0.3055	0.1286	0.1213	0.1130	0.0648	0.1019	0.1048	0.0958
1965	0.2367	0.3246	0.1424	0.1364	0.1134	0.0822	0.1149	0.1150	0.1083
1966	0.2452	0.3390	0.1479	0.1421	0.1210	0.0880	0.1180	0.1181	0.1151
1967	0.2401	0.3375	0.1403	0.1345	0.1128	0.0794	0.1087	0.1103	0.1071
1968	0.2471	0.3525	0.1442	0.1384	0.1129	0.0853	0.1119	0.1129	0.1104
1969	0.2461	0.3588	0.1396	0.1333	0.1037	0.0799	0.1052	0.1065	0.1040
1970	0.2371	0.3576	0.1265	0.1195	0.0774	0.0633	0.0879	0.0923	0.0889
1971	0.2523	0.3815	0.1393	0.1321	0.0824	0.0816	0.0982	0.1014	0.0997
1972	0.2692	0.4067	0.1543	0.1471	0.0997	0.0984	0.1108	0.1114	0.1119
1973	0.2847	0.4350	0.1699	0.1598	0.1132	0.1087	0.1212	0.1198	0.1211
1974	0.2922	0.4602	0.1690	0.1549	0.0907	0.0773	0.1112	0.1130	0.1130
1975	0.3294	0.5029	0.1881	0.1711	0.0872	0.0921	0.1232	0.1240	0.1240
1976	0.3672	0.5432	0.2157	0.1969	0.1091	0.1222	0.1479	0.1434	0.1444
1977	0.4041	0.5813	0.2424	0.2188	0.1375	0.1412	0.1695	0.1580	0.1603
1978	0.4382	0.6187	0.2655	0.2433	0.1483	0.1633	0.1868	0.1686	0.1727
1979	0.4581	0.6539	0.2724	0.2460	0.1061	0.1322	0.1815	0.1685	0.1695
1980	0.4781	0.6885	0.2691	0.2419	0.0666	0.0731	0.1660	0.1615	0.1610
1981	0.5348	0.7633	0.3188	0.2823	0.1581	0.1300	0.2031	0.1902	0.1888
1982	0.5422	0.7875	0.3148	0.2729	0.1338	0.1072	0.1831	0.1759	0.1775
1983	0.5701	0.8335	0.3349	0.3038	0.1904	0.1831	0.2149	0.1936	0.1984
1984	0.6147	0.9014	0.3821	0.3550	0.2835	0.2856	0.2795	0.2309	0.2385
1985	0.6200	0.9188	0.3816	0.3549	0.2770	0.2854	0.2779	0.2265	0.2364
1986	0.6060	0.9117	0.3634	0.3441	0.3500	0.3286	0.2663	0.1938	0.2229
1987	0.6334	0.9407	0.3845	0.3813	0.4041	0.3477	0.3027	0.2045	0.2395
1988	0.6687	0.9930	0.4187	0.4206	0.4859	0.4035	0.3524	0.2302	0.2624
1989	0.6710	1.0123	0.4193	0.4128	0.5052	0.4288	0.3428	0.2386	0.2545
1990	0.6780	1.0243	0.4240	0.4015	0.5378	0.4180	0.3252	0.2297	0.2455
1991	0.6822	1.0405	0.4138	0.3865	0.5712	0.4250	0.3199	0.2156	0.2370
1992	0.6844	1.0379	0.4058	0.3877	0.5833	0.4484	0.3237	0.2053	0.2306
1993	0.7068	1.0669	0.4307	0.4274	0.7127	0.4885	0.3596	0.2158	0.2486
1994	0.7531	1.1192	0.4883	0.4796	0.9369	0.5919	0.4339	0.2540	0.2933
1995	0.7812	1.1766	0.5198	0.5090	0.9801	0.6456	0.4616	0.2713	0.3106
1996	0.8038	1.2199	0.5508	0.5384	0.9824	0.7012	0.5048	0.2917	0.3339
1997	0.8160	1.2720	0.5861	0.5733	1.0047	0.7224	0.5456	0.2951	0.3523
1998	0.7869	1.2754	0.5704	0.5580	0.9028	0.6736	0.5275	0.2699	0.3290
1999	0.7747	1.3181	0.5624	0.5674	0.9409	0.6697	0.5425	0.2608	0.3245
2000	0.7518	1.3513	0.5371	0.5521	0.8735	0.5722	0.5138	0.2416	0.2991
2001	0.7078	1.3197	0.4997	0.5128	0.7628	0.4395	0.4434	0.2097	0.2616
2002	0.7107	1.3152	0.5384	0.5607	0.9716	0.4383	0.5020	0.2164	0.2845
2003	0.7253	1.3404	0.5923	0.6202	1.2157	0.5135	0.5907	0.2418	0.3203
2004	0.7591	1.3849	0.6765	0.7019	1.5875	0.6101	0.7434	0.2789	0.3691
2005	0.8020	1.4414	0.7894	0.7885	2.0012	0.7341	0.8752	0.3115	0.4159
2006	0.8370	1.4929	0.9007	0.8728	2.2479	0.8685	0.9831	0.3405	0.4582
2007	0.8309	1.4925	0.8896	0.8478	2.0897	0.8205	0.9139	0.3204	0.4372
2008	0.8180	1.4889	0.8754	0.8129	1.8485	0.7569	0.8084	0.3217	0.4210
2009	0.7869	1.4336	0.8116	0.7477	1.5675	0.6775	0.6855	0.2820	0.3909
2010	0.8498	1.5105	0.9550	0.8788	1.9874	0.9572	0.8691	0.3469	0.4849
2011	0.8748	1.5367	1.0015	0.9053	1.9109	1.0469	0.8357	0.3716	0.5027
2012	0.9052	1.5771	1.0810	0.9540	1.9657	1.1925	0.8596	0.4029	0.5398
2013	0.9091	1.5974	1.1204	0.9971	2.2011	1.3035	0.9626	0.4029	0.5480
2014	0.8990	1.6057	1.1139	1.0017	2.3348	1.2800	1.0211	0.3764	0.5297

Figure 8: Predicted User Costs for Sector 1



We turn our attention to the calculation of user costs for Sector 2. Recall equation (26) above. The *year t Jorgensonian user cost for asset n used in Sector 2*, $u_{2,n}{}^t$, is defined as follows:

(32) $u_{2,n}{}^t \equiv [1+r_2{}^t - (1+i_{2,n}{}^t)(1-\delta_{2,n}{}^t)]P_{K2,n}{}^t$; $\qquad$ n = 1,...,14; t = 1960,...,2014

where the $i_{2,n}{}^t$ are the ex post asset inflation rates defined by (25) and the $r_2{}^t$ are the Sector 2 balancing nominal rates of return defined by equations (26). These Jorgensonian user costs are listed in Table 10.

Table 10, Part 1: Jorgensonian User Costs for Sector 2

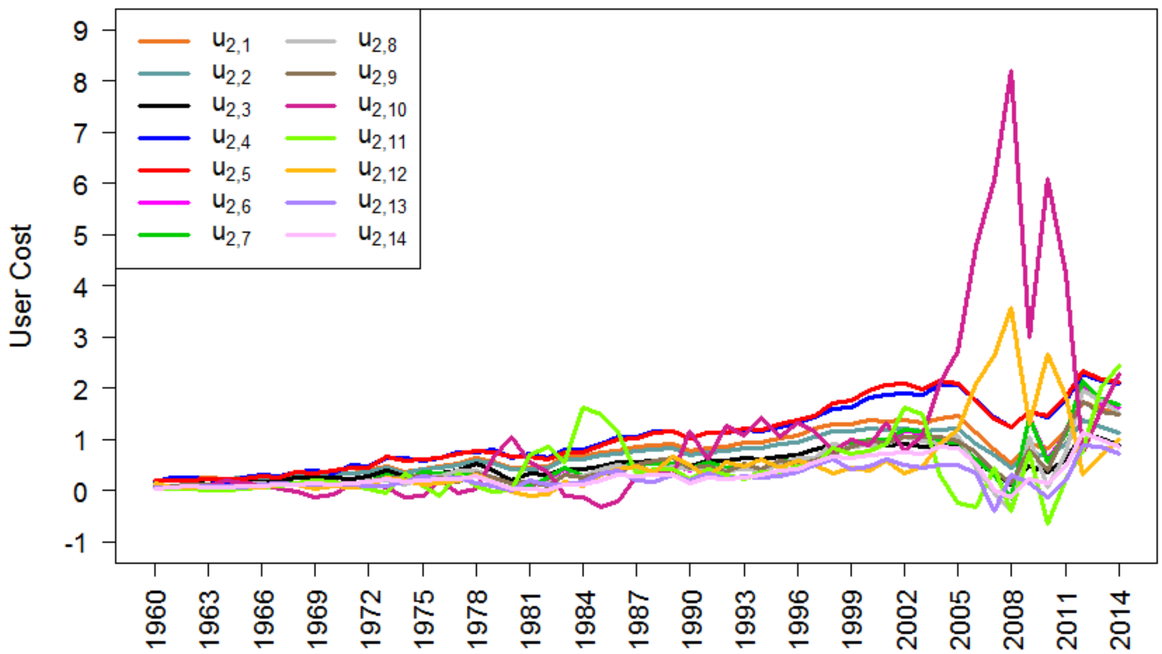
Year	$u_{2,1}{}^t$	$u_{2,2}{}^t$	$u_{2,3}{}^t$	$u_{2,4}{}^t$	$u_{2,5}{}^t$	$u_{2,6}{}^t$	$u_{2,7}{}^t$
1960	0.2124	0.2098	0.1609	0.1673	0.1973	0.1040	0.1040
1961	0.2439	0.2317	0.2235	0.2501	0.2072	0.0951	0.1019
1962	0.2492	0.2385	0.1883	0.2483	0.2062	0.1052	0.1059
1963	0.2478	0.2328	0.2263	0.2308	0.2187	0.1019	0.1000
1964	0.2446	0.2409	0.1507	0.1803	0.2373	0.0757	0.0816
1965	0.2714	0.2630	0.2354	0.2522	0.2383	0.1169	0.1150
1966	0.2802	0.2674	0.1787	0.3138	0.2892	0.1213	0.1248
1967	0.2887	0.2807	0.2139	0.2739	0.2558	0.1397	0.1406
1968	0.3185	0.3022	0.2473	0.3580	0.3794	0.1327	0.1368
1969	0.3369	0.3274	0.2627	0.3955	0.3421	0.1593	0.1583
1970	0.3217	0.3161	0.2566	0.3483	0.3967	0.1453	0.1451
1971	0.3448	0.3284	0.2451	0.5014	0.4604	0.1114	0.1160
1972	0.3865	0.3713	0.2798	0.4838	0.4594	0.1823	0.1882
1973	0.4810	0.4634	0.3945	0.6430	0.6660	0.3178	0.3159
1974	0.3595	0.3324	0.2778	0.6370	0.5939	0.2058	0.1964
1975	0.4345	0.4147	0.2017	0.5874	0.6120	0.3694	0.3704
1976	0.4773	0.4560	0.3296	0.6369	0.6326	0.3285	0.3299
1977	0.5403	0.5108	0.3868	0.7431	0.7188	0.2982	0.3051
1978	0.6315	0.5829	0.5206	0.7425	0.7811	0.3686	0.3778
1979	0.5591	0.5299	0.3961	0.8144	0.7587	0.2598	0.2726
1980	0.4638	0.4181	0.1947	0.6426	0.6580	0.1377	0.1465
1981	0.4535	0.4307	0.3485	0.7259	0.6759	0.1019	0.0925
1982	0.4853	0.4575	0.3266	0.6347	0.6065	0.2221	0.2465
1983	0.6749	0.6170	0.4224	0.8039	0.7484	0.4200	0.4513
1984	0.6738	0.6057	0.4188	0.7932	0.7552	0.2677	0.2816
1985	0.7578	0.6876	0.4897	0.9163	0.8991	0.4128	0.4244
1986	0.7911	0.7230	0.5536	1.0430	0.9948	0.4805	0.4917
1987	0.8644	0.7797	0.5476	1.0470	1.0143	0.5016	0.5101
1988	0.8879	0.8044	0.5853	1.1600	1.1411	0.5331	0.5385
1989	0.9160	0.8220	0.4973	1.1706	1.1531	0.5287	0.5322
1990	0.7827	0.6976	0.4771	1.0312	1.0319	0.4037	0.4100
1991	0.8455	0.7619	0.5872	1.1279	1.1313	0.5675	0.5645
1992	0.8568	0.7661	0.5767	1.1317	1.1423	0.4398	0.4462
1993	0.9512	0.8407	0.6414	1.1950	1.2304	0.4713	0.4762
1994	0.9353	0.8231	0.6163	1.1535	1.1818	0.3867	0.3923
1995	1.0352	0.9106	0.6645	1.2534	1.2956	0.5950	0.5945
1996	1.0935	0.9520	0.7069	1.3245	1.3723	0.5960	0.6002
1997	1.2105	1.0606	0.8058	1.4349	1.4766	0.6430	0.6528
1998	1.3015	1.1662	0.9021	1.6135	1.6982	0.8152	0.8212
1999	1.3084	1.1686	0.8716	1.6279	1.7686	0.8995	0.9038
2000	1.3737	1.2166	0.9127	1.8070	1.9649	0.9973	1.0062
2001	1.3417	1.1950	0.8928	1.8756	2.0760	0.9874	0.9987
2002	1.3838	1.2188	0.9115	1.9137	2.0855	1.1759	1.1784
2003	1.3255	1.1559	0.8505	1.8713	1.9760	1.1471	1.1514
2004	1.4046	1.1857	0.8813	2.0636	2.1473	0.9775	0.9765
2005	1.4535	1.2112	0.8732	2.0663	2.1022	0.9323	0.9336
2006	1.1301	0.9283	0.5597	1.7681	1.7662	0.6166	0.6213
2007	0.8175	0.6929	0.3364	1.4341	1.4041	0.3015	0.3095
2008	0.5356	0.4577	0.1241	1.2412	1.2346	–0.1477	–0.1601
2009	0.9278	0.7582	0.4840	1.5386	1.5567	1.4379	1.4307
2010	0.8383	0.6665	0.3727	1.4281	1.4512	0.6142	0.5656
2011	1.1575	0.9295	0.6253	1.7733	1.8159	1.1182	1.1097
2012	1.7246	1.3721	1.1146	2.2870	2.3288	2.0982	2.1492
2013	1.5943	1.2490	1.0143	2.1388	2.1749	1.7112	1.7807
2014	1.4816	1.1475	0.8982	2.0984	2.1240	1.6190	1.6900

Table 10, Part 2: Jorgensonian User Costs for Sector 2

Year	$u_{2,8}{}^t$	$u_{2,9}{}^t$	$u_{2,10}{}^t$	$u_{2,11}{}^t$	$u_{2,12}{}^t$	$u_{2,13}{}^t$	$u_{2,14}{}^t$
1960	0.1217	0.0837	0.0458	0.0341	0.1435	0.0600	0.0455
1961	0.1043	0.1051	0.0611	0.0303	0.0546	0.0781	0.0756
1962	0.0892	0.1208	0.0313	0.0533	0.0725	0.0838	0.0818
1963	0.0826	0.1266	0.0855	0.0225	0.0657	0.1067	0.0739
1964	0.0868	0.0709	0.1914	0.0242	0.0550	0.0839	0.0723
1965	0.1199	0.1153	0.1559	0.0276	0.0705	0.0728	0.0998
1966	0.1393	0.1110	0.1226	0.0731	0.0791	0.1131	0.1006
1967	0.0862	0.1305	0.0480	0.0855	0.1274	0.1380	0.1149
1968	0.1497	0.1260	–0.0096	0.1520	0.1134	0.1348	0.1241
1969	0.1560	0.1914	-0.1174	0.2083	0.0480	0.1226	0.1386
1970	0.1129	0.1868	-0.0691	0.1784	0.0851	0.1307	0.1248
1971	0.1097	0.1170	0.1222	0.1058	0.0802	0.1149	0.1361
1972	0.2009	0.1684	0.1509	0.0431	0.0869	0.0943	0.1723
1973	0.1999	0.2641	0.0743	–0.0352	0.2557	0.0833	0.2437
1974	0.1306	0.2695	–0.1369	0.3373	0.1965	0.1793	0.1766
1975	0.2629	0.2815	–0.1085	0.1077	0.1127	0.2765	0.1962
1976	0.2895	0.2632	0.1959	–0.1006	0.1553	0.2450	0.2222
1977	0.4029	0.1766	–0.0308	0.3309	0.2029	0.2553	0.2290
1978	0.3829	0.3483	0.0286	0.1049	0.3094	0.1612	0.2788
1979	0.2589	0.2661	0.6313	–0.0241	0.1888	0.0931	0.1773
1980	0.1629	0.1472	1.0467	0.0190	–0.0038	0.0048	0.0311
1981	0.1730	0.1634	0.5608	0.7067	–0.0971	0.2071	0.0397
1982	0.1419	0.0898	0.3629	0.8657	–0.0715	0.1219	0.0218
1983	0.3180	0.3020	–0.0952	0.5700	0.1726	0.1260	0.1341
1984	0.2891	0.2585	–0.1300	1.6292	0.0979	0.1748	0.1161
1985	0.4228	0.3449	–0.3269	1.4985	0.3120	0.3376	0.1983
1986	0.5053	0.3579	–0.1930	1.1357	0.4369	0.4021	0.3199
1987	0.4299	0.5159	0.2924	0.3301	0.4690	0.2004	0.2778
1988	0.4017	0.5759	0.3985	0.4368	0.3713	0.1897	0.3083
1989	0.4774	0.6324	0.3112	0.4290	0.6612	0.3225	0.3034
1990	0.4309	0.4597	1.1726	0.2356	0.5128	0.2022	0.1372
1991	0.4647	0.4650	0.6072	0.4123	0.2655	0.3507	0.2544
1992	0.4086	0.3797	1.2705	0.3206	0.5556	0.2419	0.2375
1993	0.4127	0.5283	1.0875	0.2339	0.4756	0.2803	0.2564
1994	0.3872	0.4332	1.4303	0.3669	0.6255	0.2478	0.3143
1995	0.5142	0.5960	1.0565	0.3583	0.4620	0.2728	0.3996
1996	0.6349	0.5351	1.3398	0.4687	0.5859	0.3667	0.4158
1997	0.6523	0.5877	1.1580	0.5146	0.5064	0.4966	0.5691
1998	0.9083	0.7127	0.7822	0.8290	0.3421	0.6207	0.6688
1999	0.8606	0.8670	1.0054	0.7216	0.4397	0.4239	0.6339
2000	0.8931	0.9763	0.8899	0.7881	0.3892	0.4731	0.6925
2001	0.9245	0.9547	1.3249	0.9185	0.5794	0.6222	0.7225
2002	1.0581	1.0577	0.7723	1.6341	0.3377	0.4992	0.7618
2003	0.9824	1.0502	1.0698	1.5033	0.4679	0.4456	0.7264
2004	0.9173	1.0535	2.0854	0.3149	0.9120	0.4955	0.8514
2005	1.0783	0.9696	2.7238	–0.2283	1.1912	0.5024	0.8367
2006	0.4536	0.7576	4.7723	–0.3180	2.0870	0.3479	0.5307
2007	–0.0483	0.4027	6.0585	0.4442	2.6495	–0.3955	0.0253
2008	–0.4059	0.1573	8.1947	–0.3861	3.5837	0.3250	–0.1227
2009	1.0566	0.8185	2.9867	0.7635	1.3061	0.1506	0.2270
2010	0.0602	0.3882	6.1010	–0.6353	2.6681	–0.1365	0.1457
2011	0.7581	1.1986	4.2297	0.2382	1.8497	0.2134	0.4861
2012	1.9615	1.7471	0.7474	0.7923	0.3269	0.8852	1.1228
2013	1.7757	1.5553	1.5696	2.0023	0.6864	0.8529	1.0022
2014	1.5263	1.4799	2.2857	2.4439	0.9996	0.7274	0.8705

Again, the Jorgensonian user costs are volatile and there are numerous negative user costs in assets, 6-7 (nonresidential structures held by proprietors, partners and coops) and 10-14 (residential land, farm land, commercial land, inventory stocks and monetary stocks). These user costs are plotted in Figure 9. It can be seen at a glance that these user costs are not suitable approximations to asset rental prices.

Figure 9: Jorgensonian User Costs for Sector 2



Recall equation (28) above. The *year t predicted user cost for asset n used in Sector 2*, $u_{2,n}{}^{t*}$, is defined as follows:

(33) $u_{2,n}{}^{t*} \equiv [1+r_2{}^{t*} - (1+i_{2,n}{}^{t*})(1-\delta_{2,n}{}^{t})]P_{K2,n}{}^{t}$; n = 1,...,14; t = 1960,...,2014

where the $i_{2,n}{}^{t*}$ are the predicted asset inflation rates for Sector 2 defined by counterparts to definitions (20)-(22) and the $r_2{}^{t*}$ are the predicted Sector 2 balancing nominal rates of return defined by equations (28). These predicted user costs are listed in Table 11.

Table 11, Part 1: Predicted User Costs for Sector 2

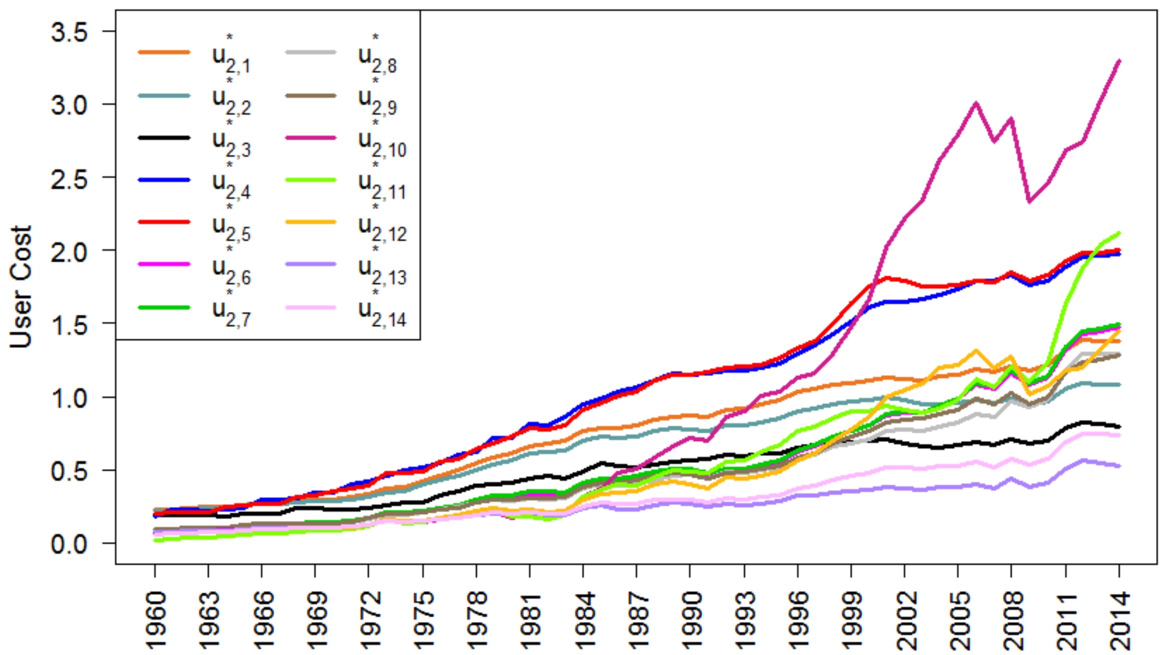
Year	$u_{2,1}^{t*}$	$u_{2,2}^{t*}$	$u_{2,3}^{t*}$	$u_{2,4}^{t*}$	$u_{2,5}^{t*}$	$u_{2,6}^{t*}$	$u_{2,7}^{t*}$
1960	0.2268	0.2187	0.1892	0.1771	0.2018	0.0877	0.0907
1961	0.2345	0.2246	0.1926	0.2266	0.2063	0.0921	0.0951
1962	0.2403	0.2291	0.1910	0.2252	0.2062	0.0965	0.0989
1963	0.2452	0.2362	0.1897	0.2237	0.2063	0.1011	0.1004
1964	0.2496	0.2436	0.1855	0.2259	0.2444	0.1046	0.1082
1965	0.2627	0.2540	0.1966	0.2417	0.2575	0.1197	0.1199
1966	0.2754	0.2676	0.2038	0.2944	0.2676	0.1308	0.1316
1967	0.2799	0.2685	0.1973	0.2966	0.2715	0.1297	0.1339
1968	0.2879	0.2768	0.2423	0.3046	0.3173	0.1367	0.1377
1969	0.2949	0.2860	0.2366	0.3496	0.3211	0.1377	0.1397
1970	0.2989	0.2909	0.2303	0.3496	0.3590	0.1398	0.1399
1971	0.3140	0.2989	0.2309	0.4018	0.3722	0.1488	0.1528
1972	0.3335	0.3203	0.2400	0.4232	0.3973	0.1698	0.1716
1973	0.3707	0.3491	0.2595	0.4637	0.4799	0.2081	0.2105
1974	0.3798	0.3572	0.2796	0.5014	0.4749	0.2026	0.2062
1975	0.4215	0.3984	0.2816	0.5194	0.4926	0.2194	0.2229
1976	0.4568	0.4289	0.3251	0.5453	0.5600	0.2395	0.2417
1977	0.4953	0.4592	0.3584	0.6026	0.5713	0.2567	0.2610
1978	0.5425	0.5015	0.3940	0.6250	0.6393	0.2898	0.2948
1979	0.5855	0.5409	0.4006	0.7178	0.6830	0.3153	0.3240
1980	0.6100	0.5648	0.4073	0.7171	0.7265	0.3117	0.3213
1981	0.6607	0.6100	0.4452	0.8189	0.7875	0.3387	0.3511
1982	0.6800	0.6270	0.4584	0.8074	0.7799	0.3391	0.3512
1983	0.6985	0.6350	0.4390	0.8599	0.8060	0.3380	0.3487
1984	0.7627	0.6957	0.4913	0.9457	0.9073	0.4034	0.4123
1985	0.7889	0.7245	0.5436	0.9867	0.9550	0.4341	0.4432
1986	0.7848	0.7148	0.5245	1.0377	1.0048	0.4380	0.4450
1987	0.8051	0.7303	0.5160	1.0648	1.0339	0.4500	0.4561
1988	0.8440	0.7651	0.5345	1.1143	1.1089	0.4880	0.4928
1989	0.8671	0.7814	0.5578	1.1623	1.1493	0.5015	0.5059
1990	0.8740	0.7800	0.5622	1.1482	1.1497	0.5038	0.5091
1991	0.8654	0.7698	0.5739	1.1587	1.1658	0.4715	0.4760
1992	0.9139	0.8040	0.6034	1.1762	1.2005	0.5068	0.5108
1993	0.9219	0.8082	0.5934	1.1828	1.2067	0.5066	0.5110
1994	0.9497	0.8286	0.6135	1.1945	1.2196	0.5285	0.5329
1995	0.9792	0.8533	0.6147	1.2255	1.2637	0.5590	0.5634
1996	1.0310	0.8973	0.6488	1.2940	1.3323	0.6242	0.6286
1997	1.0546	0.9158	0.6749	1.3488	1.3803	0.6631	0.6686
1998	1.0797	0.9467	0.6888	1.4247	1.4929	0.7241	0.7287
1999	1.0937	0.9647	0.6873	1.5179	1.6397	0.7627	0.7657
2000	1.1083	0.9806	0.6975	1.6107	1.7549	0.8039	0.8077
2001	1.1311	0.9919	0.7126	1.6469	1.8121	0.8740	0.8773
2002	1.1247	0.9735	0.6796	1.6445	1.7939	0.8935	0.8961
2003	1.1131	0.9470	0.6587	1.6641	1.7576	0.8947	0.8954
2004	1.1358	0.9524	0.6551	1.6953	1.7564	0.9341	0.9360
2005	1.1525	0.9562	0.6663	1.7385	1.7611	0.9840	0.9876
2006	1.1838	0.9737	0.6889	1.7957	1.7944	1.0863	1.0919
2007	1.1683	0.9536	0.6723	1.7951	1.7787	1.0576	1.0685
2008	1.2074	0.9843	0.7137	1.8307	1.8493	1.1615	1.1742
2009	1.1740	0.9423	0.6812	1.7667	1.7933	1.0842	1.0967
2010	1.2126	0.9703	0.7039	1.7912	1.8265	1.1290	1.1424
2011	1.3238	1.0549	0.7885	1.8896	1.9292	1.3214	1.3419
2012	1.3875	1.0961	0.8288	1.9540	1.9832	1.4245	1.4506
2013	1.3807	1.0866	0.8122	1.9629	1.9873	1.4443	1.4695
2014	1.3774	1.0813	0.7953	1.9733	2.0024	1.4736	1.4984

Table 11, Part 2: Predicted User Costs for Sector 2

Year	$u_{2,8}^{t*}$	$u_{2,9}^{t*}$	$u_{2,10}^{t*}$	$u_{2,11}^{t*}$	$u_{2,12}^{t*}$	$u_{2,13}^{t*}$	$u_{2,14}^{t*}$
1960	0.0898	0.0921	0.0694	0.0215	0.0730	0.0731	0.0589
1961	0.0924	0.0987	0.0768	0.0285	0.0726	0.0794	0.0661
1962	0.0962	0.1034	0.0829	0.0347	0.0783	0.0840	0.0710
1963	0.1000	0.1049	0.0898	0.0379	0.0810	0.0864	0.0735
1964	0.1059	0.1067	0.0943	0.0445	0.0856	0.0881	0.0781
1965	0.1181	0.1209	0.0957	0.0598	0.0976	0.0976	0.0897
1966	0.1275	0.1302	0.1077	0.0689	0.1038	0.1040	0.1002
1967	0.1281	0.1305	0.1069	0.0704	0.1022	0.1039	0.1003
1968	0.1327	0.1361	0.1084	0.0784	0.1071	0.1084	0.1055
1969	0.1335	0.1373	0.1048	0.0815	0.1063	0.1075	0.1051
1970	0.1332	0.1373	0.0950	0.0835	0.1027	0.1052	0.1034
1971	0.1422	0.1482	0.0969	0.0962	0.1093	0.1106	0.1102
1972	0.1612	0.1677	0.1192	0.1182	0.1258	0.1233	0.1255
1973	0.1944	0.2009	0.1622	0.1611	0.1596	0.1498	0.1537
1974	0.1908	0.1964	0.1435	0.1362	0.1486	0.1444	0.1440
1975	0.2086	0.2082	0.1422	0.1452	0.1571	0.1524	0.1520
1976	0.2315	0.2275	0.1587	0.1675	0.1764	0.1649	0.1666
1977	0.2490	0.2441	0.1759	0.1786	0.1911	0.1732	0.1763
1978	0.2745	0.2772	0.2086	0.2180	0.2183	0.1896	0.1951
1979	0.2952	0.3002	0.2189	0.2332	0.2354	0.2051	0.2069
1980	0.2899	0.2958	0.1749	0.1792	0.2194	0.1983	0.1973
1981	0.3054	0.3107	0.2034	0.1810	0.2289	0.2080	0.2062
1982	0.2971	0.3034	0.1808	0.1598	0.2127	0.1944	0.1967
1983	0.3043	0.3126	0.1940	0.1869	0.2174	0.1951	0.1999
1984	0.3702	0.3785	0.3170	0.3178	0.3009	0.2434	0.2520
1985	0.3979	0.4099	0.3760	0.3596	0.3393	0.2610	0.2743
1986	0.3926	0.4074	0.4806	0.4026	0.3402	0.2331	0.2684
1987	0.4018	0.4278	0.5034	0.3923	0.3539	0.2301	0.2705
1988	0.4327	0.4633	0.5870	0.4472	0.4017	0.2551	0.2923
1989	0.4595	0.4764	0.6635	0.4940	0.4178	0.2765	0.2991
1990	0.4685	0.4653	0.7221	0.4900	0.4058	0.2706	0.2946
1991	0.4428	0.4361	0.7023	0.4783	0.3773	0.2452	0.2736
1992	0.4841	0.4767	0.8627	0.5588	0.4459	0.2645	0.3069
1993	0.4748	0.4867	0.8974	0.5638	0.4404	0.2552	0.3004
1994	0.4963	0.5051	1.0066	0.6212	0.4644	0.2687	0.3131
1995	0.5216	0.5295	1.0342	0.6692	0.4853	0.2829	0.3263
1996	0.5828	0.5865	1.1277	0.7657	0.5684	0.3223	0.3751
1997	0.6059	0.6174	1.1621	0.7934	0.6144	0.3275	0.3966
1998	0.6576	0.6789	1.2908	0.8488	0.6972	0.3439	0.4327
1999	0.6837	0.7243	1.4792	0.8993	0.7780	0.3501	0.4554
2000	0.7111	0.7623	1.6635	0.8981	0.8593	0.3629	0.4764
2001	0.7663	0.8263	2.0211	0.9362	0.9937	0.3851	0.5179
2002	0.7727	0.8479	2.2142	0.9100	1.0454	0.3688	0.5161
2003	0.7684	0.8512	2.3527	0.8942	1.0880	0.3660	0.5088
2004	0.7992	0.8856	2.6203	0.9211	1.1951	0.3816	0.5236
2005	0.8267	0.9105	2.7853	0.9765	1.2181	0.3836	0.5222
2006	0.8782	0.9838	3.0100	1.1231	1.3163	0.4061	0.5532
2007	0.8630	0.9484	2.7442	1.0681	1.2001	0.3777	0.5198
2008	0.9656	1.0248	2.9082	1.2080	1.2718	0.4397	0.5748
2009	0.9338	0.9439	2.3278	1.0979	1.0180	0.3814	0.5341
2010	0.9737	0.9982	2.4524	1.2286	1.0725	0.4115	0.5778
2011	1.1827	1.1648	2.6857	1.6342	1.1745	0.5110	0.6921
2012	1.2913	1.2349	2.7404	1.8823	1.1984	0.5611	0.7482
2013	1.2981	1.2584	3.0332	2.0404	1.3265	0.5496	0.7426
2014	1.2924	1.2819	3.3008	2.1152	1.4435	0.5278	0.7346

It can be seen that the predicted user costs for Sector 2 are all positive; see Figure 10 for plots of the above predicted user costs. It can be seen that all of the predicted user cost series have fairly smooth trends, with the exception of assets 10, 11 and 12 (residential land, farm land and commercial land).

Figure 10: Predicted User Costs for Sector 2



We conclude that our rather simple method for forming predicted asset inflation rates does lead to relatively smooth (and reasonable) user costs that could be published by statistical agencies for general use by economic analysts as well as for the construction of capital services aggregates. In the following section, we will compute capital services aggregates (and the resulting measures of Total Factor Productivity) using both Jorgensonian and predicted user costs to determine if the alternative user costs affect aggregate capital services growth for our two sectors.

6. Jorgensonian and Predicted Measures of Capital Services and Total Factor Productivity Growth

We will use the Törnqvist formula to aggregate capital services and to aggregate all inputs, including labour services.[30] Our methodology for measuring Total Factor Productivity growth follows the methodology proposed by Diewert and Morrison (1986) and Kohli (1990). This methodology measures TFP growth over two periods as an implicit Törnqvist quantity index defined over gross outputs and intermediate inputs divided by a direct Törnqvist quantity index of primary inputs.[31] Since we have only one value added output in our BEA data base for each sector, our output index going from year t to year t+1 is simply $Q_{VA1}{}^{t+1}/Q_{VA1}{}^{t}$ for

[30] This formula was attributed to Törnqvist (1936) by Jorgenson and Griliches (1972; 83) as a discrete time approximation to the continuous time Divisia indexes that Jorgenson and Griliches (1967) (1972) advocated for aggregating inputs and outputs in productivity studies. The formula does not explicitly appear in Törnqvist (1936) but it is explicit in a follow up paper co-authored by Törnqvist; see Törnqvist and Törnqvist (1937). The formula was derived in an instructive manner by Theil (1967; 136-137) and so it is also known as the Törnqvist-Theil formula. Jorgenson and Nishimizu (1982) called the index the translog index. Diewert (1976; 118-129), Diewert and Morrison (1986) and Kohli (1990) related Törnqvist price and quantity indexes to various translog functional forms for cost, revenue and production functions.

[31] See Diewert (2014b) for a detailed explanation of the methodology and an application to US data. The land data used in this earlier study was of lower quality than the land data used in the current study.

Sector 1 and $Q_{VA2}^{t+1}/Q_{VA2}^{t}$ for Sector 2. However, we will use the Törnqvist quantity index to aggregate inputs.

Let $p^t \equiv [p_1^t,...,p_N^t]$ and $q^t \equiv [q_1^t,...,q_N^t]$ denote a generic price and quantity vector for year t. Then the logarithm of the *Törnqvist chain link quantity index* Q_T going from year t to t+1 is defined as follows:

$$(34)\ \ln Q_T(p^t,p^{t+1},q^t,q^{t+1}) \equiv \Sigma_{n=1}^{N} (1/2)(s_n^t + s_n^{t+1})\ln (q_n^{t+1}/q_n^t)$$

where the cost share of input n in year t is defined as $s_n^t \equiv p_n^t q_n^t/p^t \cdot q^t$ for n = 1,...,N. Note that this index can be used to aggregate quantities as long as they are all positive even though some prices may be negative.

The Törnqvist quantity index was used to aggregate the nine types of capital services used by Sector 1. Denote the aggregate *chained Törnqvist quantity index of Jorgensonian capital services* and of *predicted capital services* for Sector 1 for year t by Q_{KJ1}^t and Q_{KP1}^t respectively.[32] Denote the corresponding implicit price indexes by P_{KJ1}^t and P_{KP1}^t. These series are listed in Table 12 and the quantity series are plotted in Figure 11. The Törnqvist quantity index was also used to aggregate the nine types of capital services and the one type of labour used by Sector 1. Denote the chained index for year t using Jorgensonian and predicted user costs by Q_{XJ1}^t and Q_{XP1}^t respectively.[33] These series, along with the labour input series Q_{L1}^t (normalized to equal 1 in 1960) are also listed in Table 12 and plotted in Figure 11. Finally, the *year t levels of Jorgensonian and Predicted TFP* are defined as follows (and listed in Table 12):

$$(35)\ TFP_{J1}^t \equiv [Q_{VA1}^t/Q_{VA1}^{1960}]/\ Q_{XJ1}^t/Q_{XJ1}^{1960}]\ ; \qquad t = 1960,...,2014;$$
$$(36)\ TFP_{P1}^t \equiv [Q_{VA1}^t/Q_{VA1}^{1960}]/\ Q_{XP1}^t/Q_{XP1}^{1960}]\ ; \qquad t = 1960,...,2014.$$

[32] These series are normalized to equal one in 1960 when they are listed in Table 12. The input price and quantity series that are used in the index number formula for Q_{KJ1}^t and Q_{KP1}^t are the $u_{1,n}^t$ and $u_{1,n}^{t*}$ listed in Tables 8 and 10 respectively and the corresponding quantity series $Q_{K1,n}^t$ are described in Table 3.

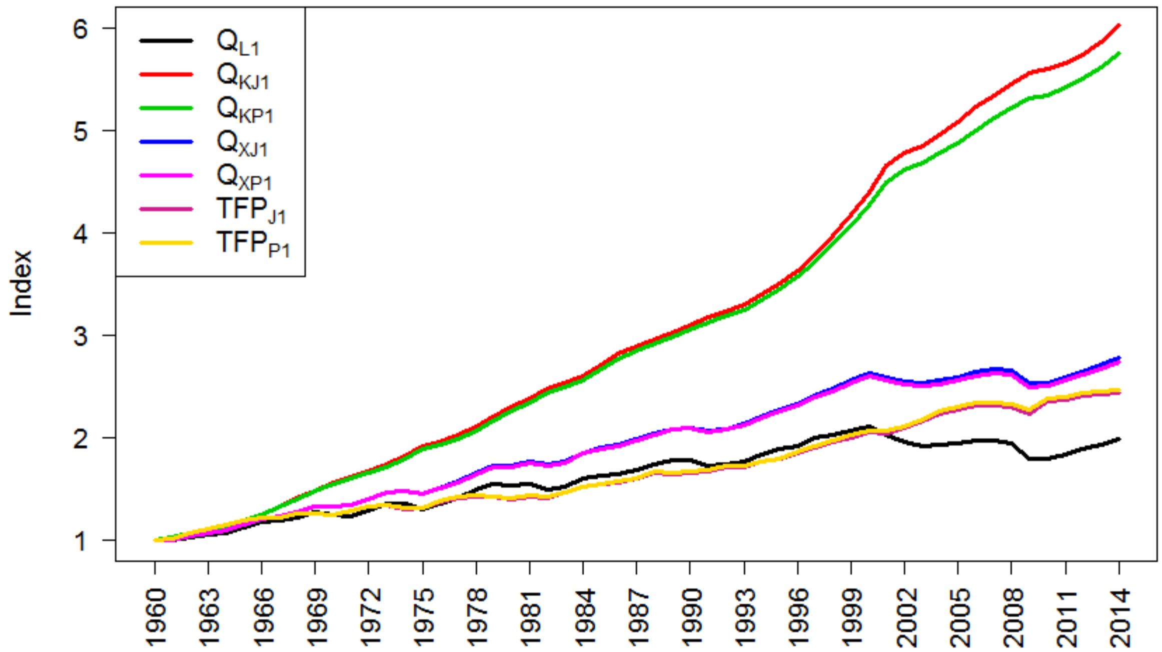
[33] These series were also normalized to equal one in 1960. The price and value of labour input for Sector 1 in year t, P_{L1}^t and V_{L1}^t, are listed in Table 1. Define the quantity of labour used in Sector 1 in year t as $Q_{L1}^t \equiv V_{L1}^t/P_{L1}^t$. Thus we added P_{L1}^t and Q_{L1}^t to our user costs and capital stock quantities to form the overall chained Törnqvist input quantity indexes.

Table 12: Sector 1 Normalized Labour Input Q_{L1}^{t}, Jorgensonian and Predicted Capital Services Inputs Q_{KJ1}^{t} and Q_{JP1}^{t} and Total Factor Productivity Levels TFP_{J1}^{t} and TFP_{P1}^{t}, Price of Labour P_{L1}^{t} and Jorgensonian and Predicted Prices of Capital Services P_{KJ1}^{t} and P_{KP1}^{t}

Year	Q_{L1}^{t}	Q_{KJ1}^{t}	Q_{KP1}^{t}	Q_{XJ1}^{t}	Q_{XP1}^{t}	TFP_{J1}^{t}	TFP_{P1}^{t}	P_{L1}^{t}	P_{KJ1}^{t}	P_{KP1}^{t}
1960	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1961	0.9939	1.0303	1.0308	1.0046	1.0047	1.0192	1.0191	1.0290	1.0066	1.0061
1962	1.0301	1.0621	1.0621	1.0395	1.0395	1.0684	1.0684	1.0725	1.0924	1.0924
1963	1.0498	1.1009	1.1005	1.0649	1.0648	1.1072	1.1073	1.1094	1.1550	1.1554
1964	1.0749	1.1409	1.1394	1.0945	1.0941	1.1528	1.1533	1.1640	1.2178	1.2194
1965	1.1257	1.1883	1.1860	1.1442	1.1435	1.1955	1.1962	1.2085	1.3297	1.3323
1966	1.1826	1.2516	1.2481	1.2030	1.2020	1.2211	1.2222	1.2792	1.3779	1.3817
1967	1.1952	1.3329	1.3279	1.2363	1.2349	1.2223	1.2237	1.3501	1.3197	1.3246
1968	1.2252	1.4091	1.4027	1.2795	1.2777	1.2576	1.2594	1.4519	1.3583	1.3644
1969	1.2699	1.4810	1.4731	1.3318	1.3296	1.2565	1.2586	1.5545	1.3263	1.3334
1970	1.2438	1.5547	1.5457	1.3306	1.3282	1.2467	1.2490	1.6690	1.2276	1.2348
1971	1.2381	1.6146	1.6049	1.3406	1.3380	1.2863	1.2887	1.7739	1.3314	1.3395
1972	1.2937	1.6679	1.6563	1.3961	1.3930	1.3287	1.3316	1.8849	1.4477	1.4578
1973	1.3615	1.7362	1.7169	1.4646	1.4596	1.3435	1.3481	2.0157	1.5532	1.5707
1974	1.3593	1.8173	1.7929	1.4821	1.4761	1.3075	1.3128	2.2140	1.5510	1.5720
1975	1.2989	1.9149	1.8833	1.4574	1.4502	1.3107	1.3173	2.4284	1.7230	1.7519
1976	1.3524	1.9554	1.9262	1.5084	1.5016	1.3701	1.3763	2.6233	1.9515	1.9811
1977	1.4158	2.0232	1.9898	1.5734	1.5655	1.4102	1.4173	2.8320	2.1577	2.1940
1978	1.4967	2.1045	2.0687	1.6550	1.6464	1.4278	1.4353	3.0722	2.3406	2.3812
1979	1.5516	2.1985	2.1577	1.7197	1.7100	1.4182	1.4262	3.3668	2.4050	2.4505
1980	1.5313	2.3017	2.2592	1.7270	1.7172	1.3984	1.4063	3.7310	2.4283	2.4741
1981	1.5506	2.3803	2.3387	1.7597	1.7504	1.4281	1.4357	4.0746	2.7928	2.8424
1982	1.4935	2.4763	2.4308	1.7352	1.7255	1.4166	1.4246	4.3920	2.7712	2.8230
1983	1.5178	2.5375	2.4920	1.7679	1.7583	1.4584	1.4664	4.5657	2.9617	3.0157
1984	1.6086	2.5994	2.5559	1.8537	1.8443	1.5149	1.5226	4.7838	3.3237	3.3803
1985	1.6360	2.7105	2.6656	1.9002	1.8907	1.5462	1.5540	5.0489	3.3366	3.3927
1986	1.6430	2.8144	2.7706	1.9280	1.9190	1.5637	1.5710	5.3247	3.2119	3.2628
1987	1.6887	2.8951	2.8518	1.9822	1.9733	1.6016	1.6088	5.5326	3.3864	3.4379
1988	1.7364	2.9580	2.9145	2.0342	2.0252	1.6565	1.6639	5.8270	3.6511	3.7056
1989	1.7823	3.0229	2.9785	2.0852	2.0760	1.6467	1.6540	6.0175	3.6709	3.7257
1990	1.7825	3.0965	3.0513	2.1004	2.0912	1.6584	1.6658	6.3362	3.6794	3.7339
1991	1.7246	3.1742	3.1276	2.0674	2.0583	1.6762	1.6837	6.6568	3.6511	3.7056
1992	1.7338	3.2360	3.1896	2.0869	2.0779	1.7112	1.7186	6.9976	3.6261	3.6788
1993	1.7715	3.2986	3.2508	2.1308	2.1215	1.7173	1.7248	7.1064	3.7945	3.8503
1994	1.8333	3.3891	3.3391	2.2003	2.1905	1.7653	1.7732	7.2530	4.1703	4.2328
1995	1.8929	3.4987	3.4457	2.2718	2.2614	1.7923	1.8005	7.3930	4.3843	4.4517
1996	1.9232	3.6292	3.5713	2.3234	2.3122	1.8552	1.8642	7.6891	4.5865	4.6608
1997	1.9934	3.7814	3.7155	2.4122	2.3994	1.9062	1.9163	7.9603	4.7528	4.8370
1998	2.0206	3.9735	3.8896	2.4730	2.4570	1.9649	1.9777	8.4875	4.5900	4.6890
1999	2.0731	4.1724	4.0707	2.5553	2.5362	2.0051	2.0202	8.8505	4.5563	4.6701
2000	2.1096	4.4015	4.2773	2.6281	2.6054	2.0564	2.0743	9.4524	4.4109	4.5389
2001	2.0218	4.6490	4.4974	2.5903	2.5645	2.0421	2.0626	9.8281	4.1072	4.2456
2002	1.9561	4.7759	4.6178	2.5507	2.5250	2.0915	2.1128	10.0374	4.2265	4.3712
2003	1.9163	4.8504	4.6840	2.5266	2.5001	2.1574	2.1802	10.4012	4.4592	4.6177
2004	1.9264	4.9636	4.7751	2.5544	2.5246	2.2299	2.2562	10.8273	4.8411	5.0321
2005	1.9427	5.0787	4.8690	2.5884	2.5552	2.2731	2.3026	11.2147	5.2905	5.5184
2006	1.9705	5.2278	4.9980	2.6388	2.6025	2.3156	2.3478	11.6165	5.6970	5.9590
2007	1.9760	5.3432	5.1221	2.6638	2.6297	2.3168	2.3469	12.0778	5.6173	5.8598
2008	1.9446	5.4489	5.2231	2.6539	2.6197	2.2955	2.3254	12.4226	5.5084	5.7466
2009	1.7909	5.5572	5.3134	2.5314	2.4967	2.2357	2.2668	12.6545	5.1613	5.3981
2010	1.7897	5.5942	5.3434	2.5364	2.5007	2.3549	2.3886	12.8807	5.7936	6.0655
2011	1.8370	5.6555	5.4165	2.5889	2.5549	2.3651	2.3965	13.1669	5.9915	6.2558
2012	1.8886	5.7433	5.4995	2.6495	2.6146	2.4042	2.4363	13.4816	6.2917	6.5706
2013	1.9315	5.8658	5.6086	2.7083	2.6711	2.4233	2.4570	13.6248	6.4229	6.7174
2014	1.9845	6.0259	5.7537	2.7824	2.7429	2.4335	2.4686	13.9548	6.3743	6.6758

The quantity and TFP series from Table 12 are plotted in Figure 11.

Figure 11: Sector 1 Indexes of Labour Quantity, and Alternative Capital Services, Aggregate Input and TFP Estimates



It can be seen that labour input into the Corporate Nonfinancial Sector grew fairly steadily to a 2.11 fold increase in 2000 but then growth levelled off and fell to a 1.79 fold increase over 1960 in 2009 and 2010. Labour input has since increased to finish off at a 1.98 fold increase over 1960 in 2014. We note that the price of labour has increased steadily (even through the Great Recession period) to end up increasing 13.95 fold over the sample period. The geometric average rate of growth of $Q_{L1}{}^{t}$ was 1.28% per year and the geometric average rate of growth of $P_{L1}{}^{t}$ over the sample period was 5.00% per year.

The quantity of Jorgensonian capital services increased 6.02 fold over the sample period while the quantity of predicted capital services increased only 5.75 fold. The geometric average rates of growth for these two measures of capital services were 3.38% and 3.29% per year. This difference is surprisingly small considering how different the two sets of user costs were. The price index of Jorgensonian capital services increased 6.37 fold over the sample period while the price index of predicted capital services increased 6.68 fold. The geometric average rates of growth for these two measures of capital services prices were 3.49% and 3.58% per year. One reason why there is so little difference between the two measures of capital services is that land as a share of total capital services in Sector 1 is relatively small.[34]

Sector 1 Jorgensonian input $Q_{XJ1}{}^{t}$ increased 2.78 fold over the sample period while the quantity of predicted capital services $Q_{XP1}{}^{t}$ increased 2.74 fold.[35] The geometric average rates of growth for these two input measures were 1.91% and 1.89% per year. This is a very small difference in growth rates. Sector 1 real value added $Q_{VA1}{}^{t}$ grew 6.77 fold over the sample period (geometric average rate of growth was 3.61% per year). Jorgensonian TFP in Sector 1,

[34] Using Jorgensonian user costs, we find that the sample average input cost shares of labour, land services and reproducible capital stock services in Sector 1 were 68.6%, 2.1% and 29.3%. The sample average cost shares of residential, farm and commercial land (assets 5, 6 and 7) were only 0.05%, 0.17% and 1.85%.

[35] Note that $Q_{XJ1}{}^{t}$ and $Q_{XP1}{}^{t}$ (and $TFP_{J1}{}^{t}$ and $TFP_{P1}{}^{t}$) cannot be distinguished in Figure 11.

$TFP_{J1}{}^t$, grew 2.43 fold over the sample period while predicted TFP, $TFP_{P1}{}^t$, grew 2.47 fold. The geometric average rates of growth for these two measures of Total Factor Productivity were 1.66% and 1.69% per year, a surprisingly small difference.

Another surprise is the rather high overall rate of TFP growth that the Corporate Nonfinancial Sector has been able to achieve over the 55 years in our sample. To see if there has been a TFP slowdown over the past fifteen years, we computed decade by decade geometric average rates of TFP growth.[36] Using Jorgensonian estimates for input growth, the resulting decade by decade averages were as follows: 2.57% (1960s), 1.22% (1970s), 1.51% (1980s), 1.99% (1990s), 1.09% (2000s) and 1.71% (2010s) per year.[37] *There is little evidence of a productivity slowdown in Sector 1*; the average TFP growth rate over the last five years in our sample is 1.71% per year, which is slightly higher than long run Jorgensonian average of 1.66% per year.

We turn our attention to developing alternative measures of capital services and productivity growth for Sector 2, the Noncorporate Nonfinancial Sector of the US private sector.

Again, the Törnqvist quantity index was used to aggregate the fourteen types of capital services used by Sector 2. Denote the aggregate *chained Törnqvist quantity index of Jorgensonian capital services* and of *predicted capital services* for Sector 2 for year t by $Q_{KJ2}{}^t$ and $Q_{KP2}{}^t$ respectively.[38] Denote the corresponding implicit price indexes by $P_{KJ1}{}^t$ and $P_{KP1}{}^t$ These series are listed in Table 13 and the quantity series are plotted on Figure 12 below. The Törnqvist quantity index was also used to aggregate the fourteen types of capital services and the one type of labour used by Sector 2. Denote the chained index for year t using Jorgensonian and predicted user costs by $Q_{XJ2}{}^t$ and $Q_{XP2}{}^t$ respectively.[39] These series, along with the labour input series $Q_{L2}{}^t$ (normalized to equal 1 in 1960) are also listed in Table 13 and plotted in Figure 12 below. Finally, the *year t levels of Jorgensonian and Predicted TFP* are defined as follows (and listed in Table 13):

(37) $TFP_{J2}{}^t \equiv [Q_{VA2}{}^t/Q_{VA2}{}^{1960}]/ Q_{XJ2}{}^t/Q_{XJ2}{}^{1960}]$; $\qquad t = 1960,...,2014;$

(38) $TFP_{P2}{}^t \equiv [Q_{VA2}{}^t/Q_{VA2}{}^{1960}]/ Q_{XP2}{}^t/Q_{XP2}{}^{1960}]$; $\qquad t = 1960,...,2014.$

[36] The last "decade" covers only the years 2010-2014.

[37] Using predicted user costs, the corresponding decade by decade geometric average rates of TFP growth in Sector 1 were as follows: 2.59%, 1.26%, 1.49%, 2.02%, 1.16% and 1.72% per year.

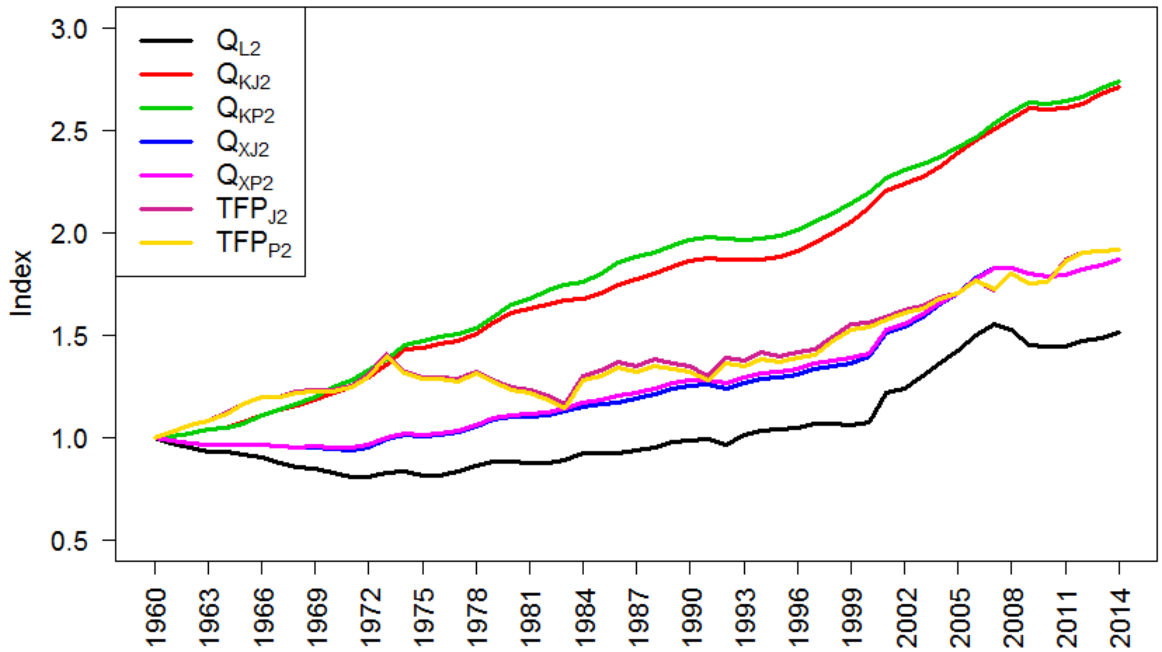
[38] These series are normalized to equal one in 1960 when they are listed in Table 13. The input price and quantity series used in the index number formula for $Q_{KJ2}{}^t$ and $Q_{KP2}{}^t$ are the $u_{2,n}{}^t$ and $u_{2,n}{}^{t*}$ listed in Tables 9 and 11 respectively and the corresponding quantity series $Q_{K2,n}{}^t$ are described in Table 5.

[39] These series were also normalized to equal one in 1960. The price and value of labour input for Sector 1 in year t, $P_{L2}{}^t$ and $V_{L2}{}^t$, are listed in Table 2. Define the quantity of labour used in Sector 2 in year t as $Q_{L2}{}^t \equiv V_{L2}{}^t/P_{L2}{}^t$. Thus we added $P_{L2}{}^t$ and $Q_{L2}{}^t$ to our user costs and capital stock quantities to form the overall chained Törnqvist input quantity indexes.

Table 13: Sector 2 Normalized Labour Input Q_{L2}^{t}, Jorgensonian and Predicted Capital Services Inputs Q_{KJ2}^{t} and Q_{JP2}^{t} and Total Factor Productivity Levels TFP_{J2}^{t} and TFP_{P2}^{t}, Price of Labour P_{L2}^{t} and Jorgensonian and Predicted Prices of Capital Services P_{KJ2}^{t} and P_{K21}^{t}

Year	Q_{L2}^{t}	Q_{KJ2}^{t}	Q_{KP2}^{t}	Q_{XJ2}^{t}	Q_{XP2}^{t}	TFP_{J2}^{t}	TFP_{P2}^{t}	P_{L2}^{t}	P_{KJ2}^{t}	P_{KP2}^{t}
1960	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1961	0.9731	1.0083	1.0082	0.9833	0.9833	1.0270	1.0270	1.0297	1.0772	1.0773
1962	0.9543	1.0210	1.0212	0.9739	0.9740	1.0593	1.0593	1.0720	1.1399	1.1397
1963	0.9326	1.0389	1.0386	0.9641	0.9640	1.0849	1.0850	1.1087	1.1844	1.1847
1964	0.9295	1.0493	1.0504	0.9650	0.9653	1.1197	1.1194	1.1635	1.2429	1.2417
1965	0.9166	1.0722	1.0714	0.9632	0.9629	1.1626	1.1629	1.2053	1.3742	1.3754
1966	0.9009	1.1082	1.1067	0.9638	0.9634	1.2009	1.2015	1.2675	1.4957	1.4977
1967	0.8785	1.1392	1.1387	0.9584	0.9582	1.2011	1.2013	1.3281	1.5034	1.5041
1968	0.8572	1.1588	1.1625	0.9498	0.9510	1.2222	1.2208	1.4232	1.5792	1.5743
1969	0.8493	1.1878	1.1996	0.9531	0.9567	1.2293	1.2247	1.5223	1.6066	1.5909
1970	0.8261	1.2191	1.2454	0.9458	0.9533	1.2344	1.2246	1.6246	1.6142	1.5801
1971	0.8083	1.2474	1.2792	0.9411	0.9500	1.2551	1.2433	1.7248	1.7265	1.6836
1972	0.8068	1.2935	1.3281	0.9536	0.9631	1.3053	1.2925	1.8306	1.9606	1.9095
1973	0.8311	1.3550	1.3839	0.9895	0.9970	1.4088	1.3983	1.9487	2.3838	2.3341
1974	0.8346	1.4306	1.4508	1.0156	1.0201	1.3201	1.3144	2.1193	2.2638	2.2323
1975	0.8157	1.4376	1.4726	1.0044	1.0131	1.2966	1.2854	2.3053	2.4395	2.3815
1976	0.8172	1.4588	1.4920	1.0119	1.0200	1.2948	1.2845	2.4811	2.6783	2.6187
1977	0.8328	1.4722	1.5050	1.0268	1.0348	1.2844	1.2744	2.6649	2.8839	2.8210
1978	0.8596	1.5092	1.5356	1.0566	1.0626	1.3198	1.3123	2.8772	3.2558	3.1999
1979	0.8800	1.5628	1.5907	1.0872	1.0937	1.2806	1.2731	3.1382	3.5075	3.4460
1980	0.8796	1.6057	1.6491	1.0997	1.1104	1.2476	1.2356	3.4595	3.3723	3.2837
1981	0.8771	1.6298	1.6762	1.1048	1.1162	1.2333	1.2207	3.7703	3.6309	3.5303
1982	0.8758	1.6522	1.7170	1.1100	1.1262	1.2034	1.1861	4.0618	3.5777	3.4429
1983	0.8925	1.6717	1.7453	1.1279	1.1465	1.1648	1.1459	4.2399	3.7079	3.5516
1984	0.9232	1.6803	1.7612	1.1528	1.1738	1.3021	1.2788	4.4382	4.6867	4.4716
1985	0.9238	1.7062	1.8032	1.1611	1.1866	1.3307	1.3021	4.6619	5.1498	4.8728
1986	0.9245	1.7469	1.8534	1.1741	1.2019	1.3705	1.3387	4.8851	5.3989	5.0889
1987	0.9371	1.7739	1.8803	1.1910	1.2187	1.3510	1.3203	5.0871	5.5370	5.2237
1988	0.9527	1.8024	1.9061	1.2105	1.2374	1.3809	1.3509	5.3541	6.0622	5.7325
1989	0.9765	1.8369	1.9384	1.2375	1.2637	1.3651	1.3367	5.5205	6.3868	6.0523
1990	0.9855	1.8627	1.9642	1.2516	1.2777	1.3515	1.3239	5.7961	6.4521	6.1186
1991	0.9887	1.8764	1.9765	1.2580	1.2836	1.3030	1.2770	6.0487	6.1787	5.8657
1992	0.9669	1.8720	1.9717	1.2413	1.2665	1.3875	1.3599	6.3684	6.9086	6.5591
1993	1.0103	1.8668	1.9684	1.2700	1.2964	1.3763	1.3483	6.4767	6.9997	6.6386
1994	1.0308	1.8709	1.9736	1.2855	1.3125	1.4152	1.3861	6.6155	7.4454	7.0579
1995	1.0422	1.8845	1.9884	1.2974	1.3248	1.3962	1.3673	6.7771	7.7737	7.3676
1996	1.0490	1.9071	2.0110	1.3092	1.3364	1.4188	1.3899	7.0498	8.5684	8.1257
1997	1.0681	1.9533	2.0526	1.3367	1.3623	1.4294	1.4025	7.3528	8.9027	8.4720
1998	1.0673	2.0010	2.0949	1.3516	1.3751	1.4958	1.4703	7.7929	9.6158	9.1850
1999	1.0631	2.0528	2.1406	1.3658	1.3868	1.5515	1.5279	8.1347	10.2847	9.8629
2000	1.0743	2.1194	2.1974	1.3950	1.4124	1.5627	1.5435	8.6602	10.8534	10.4682
2001	1.2144	2.2013	2.2694	1.5122	1.5268	1.5908	1.5756	8.9251	11.9076	11.5503
2002	1.2380	2.2403	2.3092	1.5403	1.5550	1.6212	1.6058	9.0834	12.2618	11.8960
2003	1.2983	2.2754	2.3323	1.5902	1.6011	1.6425	1.6313	9.3894	12.3747	12.0725
2004	1.3634	2.3231	2.3667	1.6476	1.6540	1.6865	1.6800	9.7942	13.0165	12.7768
2005	1.4220	2.3916	2.4173	1.7079	1.7081	1.7036	1.7033	10.1199	13.3968	13.2544
2006	1.5004	2.4512	2.4677	1.7774	1.7743	1.7652	1.7683	10.5245	14.3599	14.2636
2007	1.5510	2.5053	2.5307	1.8280	1.8275	1.7215	1.7220	10.9629	13.6640	13.5270
2008	1.5251	2.5567	2.5910	1.8282	1.8305	1.8005	1.7983	11.2585	14.7288	14.5339
2009	1.4542	2.6081	2.6351	1.7983	1.7980	1.7509	1.7511	11.4066	13.0826	12.9485
2010	1.4432	2.6003	2.6291	1.7884	1.7887	1.7576	1.7572	11.6811	13.7939	13.6424
2011	1.4431	2.6077	2.6396	1.7908	1.7920	1.8665	1.8652	11.9747	15.8114	15.6203
2012	1.4743	2.6309	2.6634	1.8183	1.8197	1.9049	1.9035	12.2744	16.7454	16.5408
2013	1.4850	2.6744	2.7013	1.8398	1.8392	1.9077	1.9084	12.3977	17.3651	17.1919
2014	1.5148	2.7104	2.7393	1.8707	1.8705	1.9147	1.9149	12.6666	17.9370	17.7479

Figure 12: Sector 2 Indexes of Labour Quantity, and Alternative Capital Services, Aggregate Input and TFP Estimates



The rates of input, output and productivity growth in Sector 2 are quite different from the corresponding rates in Sector 1 as can be seen by comparing Figures 11 and 12.

Labour input into the Noncorporate Nonfinancial Sector fell to 80.7% of its initial 1960 level in 1972 but then grew fairly steadily to a 1.07 fold increase in 2000 over its initial level. Then labour input growth grew rapidly to a 1.55 fold increase in 2007, fell to 1.44 in 2010 and then slowly increased to finish up with a 1.51 fold increase over its initial level. We note that the price of labour $P_{L2}{}^{t}$ has increased steadily to end up increasing 12.67 fold over the sample period. The geometric average rate of growth of $Q_{L2}{}^{t}$ was only 0.77% per year (compared to a 1.28% geometric rate of increase for $Q_{L1}{}^{t}$) and the geometric average rate of growth of $P_{L2}{}^{t}$ over the sample period was 4.81% per year, which is close to the rate of increase for $P_{L1}{}^{t}$ (5.00% per year).

The quantity of Jorgensonian capital services increased 2.71 fold in Sector 2 over the sample period (the Sector 1 increase was 6.02 fold) while the quantity of Sector 2 predicted capital services increased 2.74 fold. The geometric average rates of growth for these two measures of capital services were 1.86% and 1.88% per year (compared to 3.38% and 3.29% per year for Sector 1). Again, this difference in average rates of capital services growth is surprisingly small considering how different the two sets of user costs were.[40] The price index for Jorgensonian capital services increased 17.94 fold over the sample period while the price index of predicted capital services increased 17.75 fold (only 6.37 fold and 6.68 fold increases for Sector 1 capital service prices). The geometric average rates of growth for these two measures of Sector 2 capital services prices were 5.49% and 5.47% per year (the

[40] However, the predicted asset price inflation rates are on average quite close to the average ex post asset price inflation rates. Thus on average, the two sets of user costs are similar, giving rise to similar trends in the two sets of capital service prices.

corresponding rates for Sector 1 were 3.49% and 3.58% per year). Thus since land is a much more important input in Sector 2 compared to Sector 1, the overall rate of growth in the price of capital services in Sector 2 is much greater than in Sector 1.[41] Note that these rates of service price increase for Sector 2 are higher than the rate of increase in wages for Sector 2, which was only 4.81% per year.[42] Looking at Figure 12, it can be seen that the level of predicted capital services, Q_{KP2}^{t}, bulged above the corresponding level of Jorgensonian capital services, Q_{KJ2}^{t}, over the middle of the sample period but the two series were quite close near the endpoints of our sample period.

Sector 2 Jorgensonian input Q_{XJ2}^{t} and predicted input Q_{XP2}^{t} increased 1.87 fold over the sample period (the Sector 1 counterparts were 2.78 fold and 2.74 fold increases).[43] The geometric average rates of growth for these two input measures were both 1.17% per year (1.91% and 1.89% for Sector 1). Sector 2 real value added Q_{VA2}^{t} grew 3.58 fold (6.77 fold for Sector 1) over the sample period and the geometric average rate of growth was 2.39% per year (3.61% for Sector 1). Jorgensonian TFP and predicted TFP in Sector 2, TFP_{J2}^{t} and TFP_{P2}^{t}, both grew 1.91 fold over the sample period (2.43 and 2.47 for Sector 1). The geometric average rates of growth for the two Sector 2 measures of Total Factor Productivity were both 1.21% per year (1.66% and 1.69% per year for Sector 1).

Another surprise is the rather high overall rate of TFP growth that the Noncorporate Nonfinancial Sector has been able to achieve over the 55 years in our sample. To see if there has been a TFP slowdown over the past fifteen years, we computed decade by decade geometric average rates of TFP growth.[44] Using Jorgensonian estimates for input growth, the resulting decade by decade TFP_{J2}^{t} averages were as follows: 2.32% (1960s), 0.41% (1970s), 0.64% (1980s), 1.29% (1990s), 1.22% (2000s) and 1.81% (2010s) per year.[45] Thus *there is little evidence of a productivity slowdown in Sector 2*; the average Jorgensonian TFP growth rate for Sector 2 over the last five years in our sample is 1.81% per year, which is slightly higher than the corresponding Jorgensonian rate of 1.71% for Sector 1 over the past five years and higher than the long run Jorgensonian average of 1.66% per year for Sector 1.

Finally, we note that for the period 2000-2009, Jorgensonian TFP growth averaged 1.22% per year while the corresponding predicted TFP growth averaged 1.37% per year. This is a substantial difference. Thus, although for the most part Jorgensonian TFP growth rates based on the use of ex post asset inflation rates are close to our preferred TFP growth rates based on

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[41] Using Jorgensonian and predicted user costs, we find that the sample average input cost shares of labour and capital services were 56.7% and 43.3%. Using Jorgensonian user costs, the sample average cost shares of residential, farm and commercial land services (assets 10, 11 and 12) were 7.51%, 4.44% and 2.43%. Using predicted user costs, the sample average input cost shares for assets 10, 11 and 12 were 8.04%, 4.05% and 2.44%. These input cost shares for land are low compared to the share of land assets in total asset value: the average overall land share of total asset value was 51.6% while reproducible assets contributed 48.4% of total asset value. The average shares of the three types of land in total asset value were 28.2%, 16.4% and 7.1%. The user cost shares of capital services for land are lower than their corresponding asset value shares because the high land price inflation terms dramatically reduce land user costs relative to their asset prices.

[42] These trends in the prices and quantities of labour and capital input into Sector 2 indicate the presence of labour saving technical progress in this sector.

[43] Note that Q_{XJ2}^{t} and Q_{XP2}^{t} (and TFP_{J2}^{t} and TFP_{P2}^{t}) can hardly be distinguished in Figure 12.

[44] Again, the last "decade" covers only the years 2010-2014.

[45] Using predicted user costs, the corresponding decade by decade geometric average rates of predicted TFP growth, TFP_{P2}^{t}, were as follows, with the corresponding Jorgensonian rates of growth in brackets: 2.28% (2.32), 0.39% (0.41), 0.49% (0.64), 1.35% (1.29), 1.37% (1.22) and 1.80% (1.81) per year. Note that the difference is particularly large for the 2000s.

the use of predicted asset inflation rates, it can be seen that it is not always the case that these rates are close.

In the following section, we look at what happens to the rate of return on assets and on Jorgensonian TFP growth rates when we drop assets from the asset boundary.

7. Rates of Return and TFP Growth in Sector 1 with Alternative Asset Bases

Many national and international productivity data bases do not include money, inventories or land in their asset base.[46] Thus it is of interest to see what happens to rates of return on assets and on TFP growth when these assets are dropped from the list of productive inputs.

Recall equations (17) and (19) in Section 5 above which defined the year t nominal and real rate of return on all nine assets used in Sector 1, r_1^t and R_1^t respectively. Modify equation (17) by dropping asset 9 from the asset base, which gives rise to a new nominal and real rate of return on the new asset base without monetary services, which we denote by $r_{1,M}^t$ and $R_{1,M}^t$ respectively. Now modify equation (17) by dropping assets 8 and 9 from the asset base, which gives rise to a new nominal and real rate of return on the new asset base without inventory and monetary services, which we denote by $r_{1,IM}^t$ and $R_{1,IM}^t$ respectively. Finally modify equation (17) by dropping assets 5-9 from the asset base, which gives rise to a new nominal and real rate of return on the new asset base without land, inventory and monetary services, which we denote by $r_{1,LIM}^t$ and $R_{1,LIM}^t$ respectively. These real and nominal rates of return on the four alternative asset bases are listed in Table 14 below. The alternative nominal rates can be found in Figure 13 and the alternative real rates of return can be found in Figure 14.

[46] See the EUKLEMS and World KLEMS data bases on line; European Commission (2011) and Jorgenson and Timmer (2016).

Table 14: Sector 1 Nominal and Real Rates of Return on Alternative Asset Bases

Year	r_1^t	$r_{1,M}^t$	$r_{1,IM}^t$	$r_{1,LIM}^t$	R_1^t	$R_{1,M}^t$	$R_{1,IM}^t$	$R_{1,LIM}^t$
1960	0.0622	0.0647	0.0756	0.1071	0.0466	0.0490	0.0597	0.0908
1961	0.0819	0.0858	0.1001	0.1153	0.0748	0.0787	0.0929	0.1080
1962	0.0939	0.0985	0.1136	0.1329	0.0792	0.0838	0.0987	0.1177
1963	0.0958	0.1009	0.1223	0.1431	0.0819	0.0870	0.1081	0.1287
1964	0.1159	0.1220	0.1439	0.1678	0.1006	0.1066	0.1282	0.1518
1965	0.1352	0.1421	0.1612	0.1853	0.1183	0.1251	0.1439	0.1677
1966	0.1414	0.1476	0.1719	0.1967	0.1062	0.1122	0.1358	0.1599
1967	0.1272	0.1324	0.1582	0.1861	0.0990	0.1040	0.1292	0.1563
1968	0.1448	0.1500	0.1744	0.1986	0.0978	0.1028	0.1262	0.1493
1969	0.1478	0.1528	0.1722	0.1838	0.0959	0.1007	0.1192	0.1303
1970	0.1274	0.1311	0.1499	0.1641	0.0777	0.0812	0.0991	0.1128
1971	0.1350	0.1392	0.1563	0.1706	0.0940	0.0980	0.1145	0.1283
1972	0.1390	0.1434	0.1538	0.1631	0.1018	0.1060	0.1162	0.1251
1973	0.1805	0.1851	0.1858	0.2001	0.1014	0.1057	0.1063	0.1196
1974	0.2197	0.2241	0.2435	0.2676	0.0938	0.0977	0.1151	0.1368
1975	0.1438	0.1466	0.1699	0.1765	0.0706	0.0732	0.0950	0.1012
1976	0.1439	0.1476	0.1667	0.1758	0.0881	0.0916	0.1098	0.1185
1977	0.1523	0.1558	0.1745	0.1878	0.0809	0.0842	0.1018	0.1142
1978	0.1753	0.1794	0.1879	0.2020	0.0925	0.0963	0.1042	0.1173
1979	0.1781	0.1813	0.1890	0.2020	0.0727	0.0756	0.0826	0.0944
1980	0.1637	0.1659	0.1743	0.1871	0.0518	0.0538	0.0614	0.0730
1981	0.1414	0.1437	0.1660	0.1810	0.0605	0.0626	0.0833	0.0973
1982	0.0905	0.0916	0.1047	0.1152	0.0386	0.0397	0.0522	0.0622
1983	0.0785	0.0798	0.0862	0.0954	0.0389	0.0400	0.0463	0.0551
1984	0.0964	0.0986	0.1120	0.1297	0.0594	0.0616	0.0745	0.0916
1985	0.0850	0.0868	0.1038	0.1211	0.0476	0.0494	0.0658	0.0825
1986	0.0759	0.0782	0.0948	0.1096	0.0578	0.0601	0.0764	0.0909
1987	0.1014	0.1041	0.1125	0.1283	0.0615	0.0641	0.0722	0.0874
1988	0.1200	0.1232	0.1321	0.1464	0.0750	0.0781	0.0867	0.1004
1989	0.0985	0.1009	0.1139	0.1346	0.0577	0.0601	0.0726	0.0925
1990	0.0916	0.0932	0.1044	0.1250	0.0398	0.0413	0.0520	0.0716
1991	0.0719	0.0737	0.0882	0.0971	0.0463	0.0480	0.0623	0.0710
1992	0.0750	0.0769	0.0870	0.1048	0.0473	0.0491	0.0590	0.0764
1993	0.0892	0.0910	0.1024	0.1169	0.0476	0.0493	0.0603	0.0743
1994	0.0966	0.0997	0.1119	0.1341	0.0759	0.0789	0.0909	0.1127
1995	0.1047	0.1080	0.1199	0.1344	0.0819	0.0852	0.0968	0.1110
1996	0.0952	0.0983	0.1130	0.1295	0.0776	0.0807	0.0952	0.1114
1997	0.1014	0.1053	0.1236	0.1360	0.0979	0.1018	0.1201	0.1325
1998	0.0959	0.0994	0.1187	0.1216	0.0879	0.0914	0.1106	0.1134
1999	0.1019	0.1051	0.1165	0.1195	0.0810	0.0842	0.0954	0.0983
2000	0.1053	0.1089	0.1204	0.1191	0.0785	0.0819	0.0932	0.0919
2001	0.0819	0.0852	0.1002	0.0992	0.0682	0.0713	0.0862	0.0852
2002	0.0962	0.0993	0.1089	0.1019	0.0755	0.0785	0.0879	0.0810
2003	0.1007	0.1039	0.1129	0.1102	0.0811	0.0842	0.0930	0.0904
2004	0.1445	0.1499	0.1616	0.1687	0.1125	0.1178	0.1292	0.1362
2005	0.1507	0.1563	0.1689	0.1821	0.1162	0.1216	0.1338	0.1466
2006	0.1169	0.1219	0.1334	0.1707	0.0973	0.1022	0.1136	0.1502
2007	0.0860	0.0882	0.0819	0.1332	0.0509	0.0531	0.0470	0.0966
2008	0.0487	0.0500	0.0663	0.1336	0.0335	0.0348	0.0508	0.1172
2009	0.0321	0.0326	0.0348	0.0494	0.0199	0.0204	0.0226	0.0370
2010	0.0806	0.0834	0.0848	0.1290	0.0669	0.0696	0.0710	0.1147
2011	0.1032	0.1070	0.1130	0.1379	0.0746	0.0783	0.0841	0.1084
2012	0.1166	0.1216	0.1363	0.1317	0.0973	0.1022	0.1166	0.1121
2013	0.1116	0.1163	0.1328	0.1359	0.0982	0.1029	0.1191	0.1222
2014	0.0990	0.1037	0.1179	0.1257	0.0868	0.0914	0.1055	0.1132
Mean	0.1125	0.1160	0.1297	0.1459	0.0757	0.0791	0.0923	0.1080

Figure 13: Sector 1 Nominal Rates of Return on Alternative Asset Bases

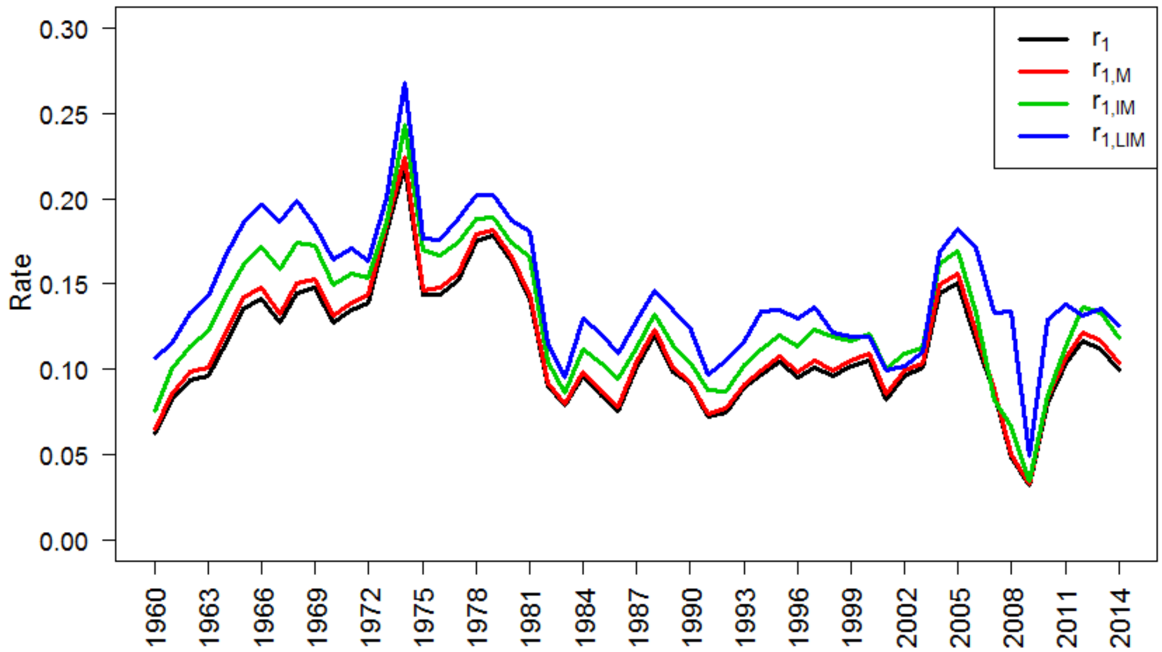
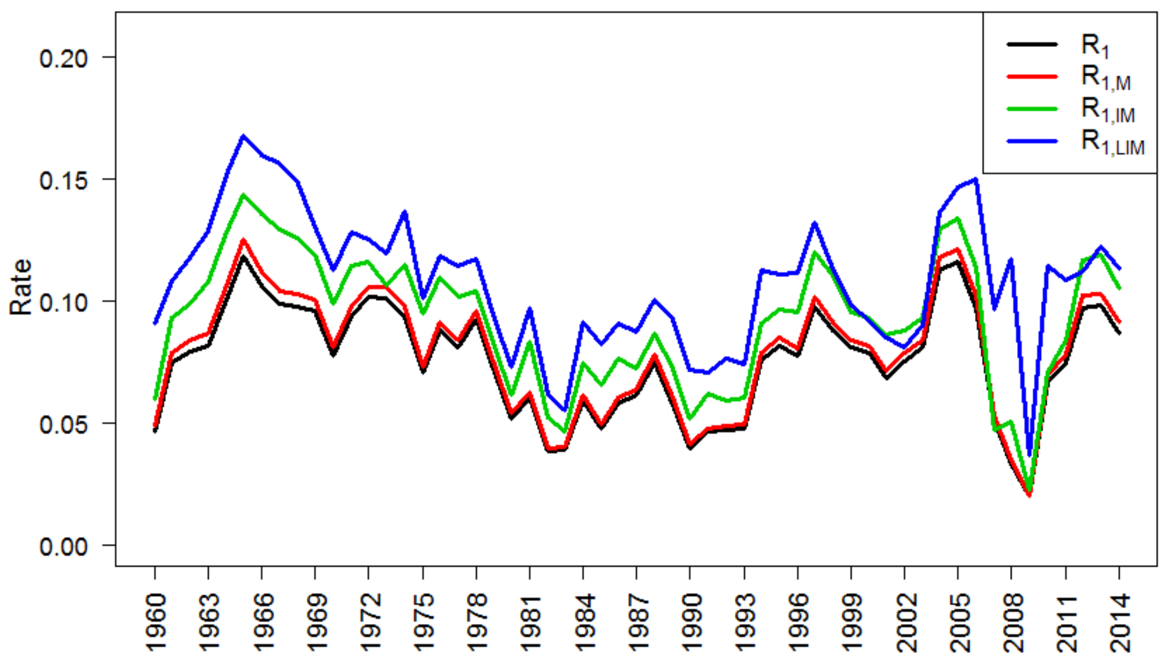


Figure 14: Sector 1 Real Rates of Return on Alternative Asset Bases



For each asset base, the value of capital services adds up to value added less the value of labour input. Thus as we decrease the number of assets in the asset base, the nominal and real rate of return on the remaining assets must increase and this fact is reflected in Figures 13 and 14. With all assets in the asset base, the average nominal rate of return on assets is 11.25%. Dropping monetary holdings from the asset base increases the average rate of return to

11.60% and then dropping inventory stocks further increases the average rate of return to 12.97%. Finally dropping residential, farm and commercial land from the asset base further increases the average rate of return on the remaining assets to 14.59% per year. Similarly, decreasing the asset base causes the average real rate of return on the remaining assets to go from 7.57% per year when all assets are included to 10.80% per year when money, inventories and land are dropped from the asset base. Our conclusion here is that dropping assets can substantially distort the estimated return on assets.

Recall that the year t Jorgensonian user costs $u_{1,n}^t$ for the nine assets used by Sector 1 were defined by equations (30) in Section 5. These user costs involved the nominal rates of return on assets for Sector 1, the r_1^t. The user costs $u_{1,n}^t$ were used to form the Sector 1 Jorgensonian year t capital services aggregate, Q_{KJ1}^t, and the overall Sector 1 year t input aggregate, Q_{XJ1}^t. These input aggregates along with the Sector 1 output aggregates, Q_{VA1}^t, were used to form the year t Total Factor Productivity levels, TFP_{J1}^t, for Sector 1; see equations (35) above. When we drop monetary assets from the list of assets, we obtain the new year t Jorgensonian balancing nominal rate of return for year t, $r_{1,M}^t$, and this new rate of return can be inserted into equations (30) for n = 1,...,8 in order to obtain new year t Jorgensonian user costs for Sector 1, which we define as $u_{1M,n}^t$. These new user costs can be used to form new year t capital services aggregates, Q_{K1M}^t, and new year t aggregate input indexes, Q_{X1M}^t, for Sector 1. In a similar fashion, when we drop both monetary assets and inventory stocks, we obtain the year t capital services aggregates, Q_{K1IM}^t, and the year t aggregate input indexes, Q_{X1IM}^t, for Sector 1. Finally, when we drop monetary assets, inventory and land stocks from the list of productive assets, we obtain the year t capital services aggregates, Q_{K1LIM}^t, and the year t aggregate input indexes, Q_{X1LIM}^t, for Sector 1. These alternative measures of aggregate capital services are used to form the alternative TFP levels, TFP_{1M}^t, TFP_{1IM}^t and TFP_{1LIM}^t. These alternative measures of (normalized) Jorgensonian capital services and TFP are listed in Table 15 along with the (normalized) measure of labour input for Sector 1, Q_{L1}^t.[47]

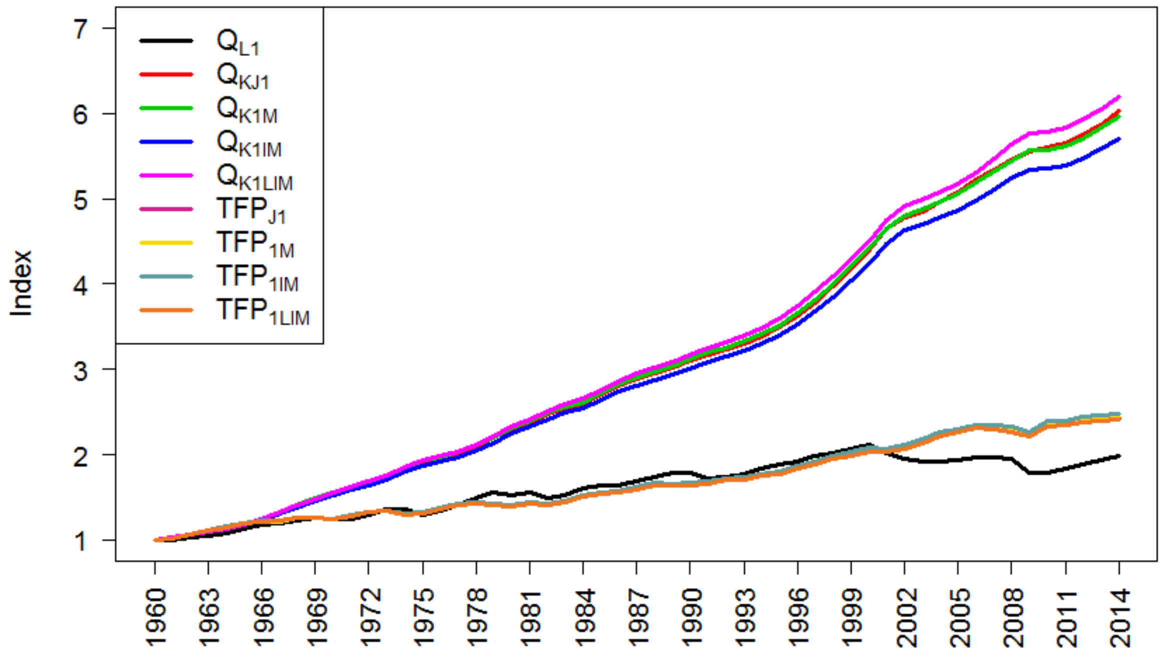
[47] To recover the un-normalized Q_{L1}^t, multiply the listed Q_{L1}^t series by the value of labour input in Sector 1 for 1960, which is 180.4. To recover the four un-normalized capital services series, multiply Q_{KJ1}^t, Q_{K1M}^t, Q_{K1IM}^t and Q_{K1LIM}^t by the Gross Operating Surplus for Sector 1 for 1960, which is 75.5.

Table 15: Sector 1 Normalized Labour Input, Jorgensonian Capital Services Quantity Aggregates and Jorgensonian TFP Estimates with Alternative Capital Asset Bases

Year	$Q_{L1}{}^{t}$	$Q_{KJ1}{}^{t}$	$Q_{K1M}{}^{t}$	$Q_{K1IM}{}^{t}$	$Q_{K1LIM}{}^{t}$	$TFP_{J1}{}^{t}$	$TFP_{1M}{}^{t}$	$TFP_{1IM}{}^{t}$	$TFP_{1LIM}{}^{t}$
1960	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1961	0.9939	1.0303	1.0309	1.0308	1.0327	1.0192	1.0190	1.0191	1.0185
1962	1.0301	1.0621	1.0591	1.0599	1.0632	1.0684	1.0693	1.0691	1.0681
1963	1.0498	1.1009	1.0951	1.0938	1.0989	1.1072	1.1090	1.1094	1.1078
1964	1.0749	1.1409	1.1374	1.1304	1.1379	1.1528	1.1539	1.1561	1.1538
1965	1.1257	1.1883	1.1864	1.1754	1.1856	1.1955	1.1960	1.1996	1.1964
1966	1.1826	1.2516	1.2497	1.2371	1.2513	1.2211	1.2216	1.2255	1.2212
1967	1.1952	1.3329	1.3362	1.3131	1.3329	1.2223	1.2212	1.2280	1.2222
1968	1.2252	1.4091	1.4121	1.3815	1.4066	1.2576	1.2566	1.2654	1.2582
1969	1.2699	1.4810	1.4855	1.4529	1.4829	1.2565	1.2552	1.2641	1.2560
1970	1.2438	1.5547	1.5639	1.5293	1.5643	1.2467	1.2445	1.2533	1.2445
1971	1.2381	1.6146	1.6258	1.5927	1.6317	1.2863	1.2835	1.2920	1.2824
1972	1.2937	1.6679	1.6796	1.6468	1.6886	1.3287	1.3259	1.3343	1.3240
1973	1.3615	1.7362	1.7463	1.7141	1.7590	1.3435	1.3411	1.3491	1.3385
1974	1.3593	1.8173	1.8271	1.7971	1.8480	1.3075	1.3053	1.3124	1.3012
1975	1.2989	1.9149	1.9285	1.8725	1.9288	1.3107	1.3079	1.3200	1.3081
1976	1.3524	1.9554	1.9660	1.9194	1.9779	1.3701	1.3678	1.3781	1.3656
1977	1.4158	2.0232	2.0326	1.9736	2.0353	1.4102	1.4083	1.4213	1.4080
1978	1.4967	2.1045	2.1126	2.0467	2.1135	1.4278	1.4262	1.4404	1.4263
1979	1.5516	2.1985	2.2072	2.1397	2.2126	1.4182	1.4164	1.4303	1.4158
1980	1.5313	2.3017	2.3134	2.2428	2.3233	1.3984	1.3962	1.4099	1.3948
1981	1.5506	2.3803	2.3967	2.3309	2.4189	1.4281	1.4251	1.4377	1.4215
1982	1.4935	2.4763	2.4993	2.4205	2.5166	1.4166	1.4127	1.4269	1.4101
1983	1.5178	2.5375	2.5597	2.4879	2.5891	1.4584	1.4546	1.4677	1.4500
1984	1.6086	2.5994	2.6169	2.5475	2.6540	1.5149	1.5118	1.5246	1.5057
1985	1.6360	2.7105	2.7292	2.6414	2.7574	1.5462	1.5430	1.5590	1.5387
1986	1.6430	2.8144	2.8309	2.7387	2.8636	1.5637	1.5609	1.5773	1.5560
1987	1.6887	2.8951	2.9090	2.8149	2.9469	1.6016	1.5993	1.6159	1.5935
1988	1.7364	2.9580	2.9739	2.8759	3.0133	1.6565	1.6539	1.6714	1.6478
1989	1.7823	3.0229	3.0389	2.9395	3.0834	1.6467	1.6441	1.6614	1.6374
1990	1.7825	3.0965	3.1156	3.0104	3.1626	1.6584	1.6554	1.6734	1.6484
1991	1.7246	3.1742	3.1967	3.0907	3.2499	1.6762	1.6727	1.6905	1.6648
1992	1.7338	3.2360	3.2586	3.1538	3.3189	1.7112	1.7076	1.7253	1.6987
1993	1.7715	3.2986	3.3248	3.2192	3.3922	1.7173	1.7132	1.7308	1.7034
1994	1.8333	3.3891	3.4120	3.3029	3.4865	1.7653	1.7618	1.7800	1.7509
1995	1.8929	3.4987	3.5213	3.3992	3.5955	1.7923	1.7889	1.8089	1.7783
1996	1.9232	3.6292	3.6542	3.5264	3.7368	1.8552	1.8515	1.8723	1.8396
1997	1.9934	3.7814	3.8056	3.6751	3.9012	1.9062	1.9026	1.9236	1.8889
1998	2.0206	3.9735	3.9979	3.8502	4.0914	1.9649	1.9614	1.9848	1.9483
1999	2.0731	4.1724	4.1972	4.0328	4.2872	2.0051	2.0016	2.0269	1.9893
2000	2.1096	4.4015	4.4150	4.2383	4.5065	2.0564	2.0545	2.0811	2.0424
2001	2.0218	4.6490	4.6554	4.4691	4.7514	2.0421	2.0413	2.0676	2.0293
2002	1.9561	4.7759	4.7990	4.6268	4.9176	2.0915	2.0885	2.1128	2.0738
2003	1.9163	4.8504	4.8767	4.7019	4.9962	2.1574	2.1539	2.1790	2.1389
2004	1.9264	4.9636	4.9563	4.7794	5.0793	2.2299	2.2312	2.2571	2.2154
2005	1.9427	5.0787	5.0621	4.8689	5.1786	2.2731	2.2759	2.3042	2.2611
2006	1.9705	5.2278	5.1874	4.9806	5.3104	2.3156	2.3219	2.3523	2.3063
2007	1.9760	5.3432	5.3226	5.1087	5.4719	2.3168	2.3200	2.3506	2.3010
2008	1.9446	5.4489	5.4376	5.2324	5.6346	2.2955	2.2973	2.3255	2.2723
2009	1.7909	5.5572	5.5624	5.3412	5.7671	2.2357	2.2351	2.2643	2.2104
2010	1.7897	5.5942	5.5700	5.3533	5.7831	2.3549	2.3589	2.3889	2.3316
2011	1.8370	5.6555	5.6091	5.3886	5.8331	2.3651	2.3725	2.4030	2.3436
2012	1.8886	5.7433	5.6948	5.4702	5.9263	2.4042	2.4119	2.4431	2.3820
2013	1.9315	5.8658	5.8248	5.5861	6.0514	2.4233	2.4297	2.4626	2.4011
2014	1.9845	6.0259	5.9592	5.7060	6.1841	2.4335	2.4437	2.4783	2.4159

Figure 15 plots the series in Table 15.

Figure 15: Sector 1 Labour and Measures of Capital Services and TFP with Alternative Asset Bases



It can be seen that there are some small differences in the growth of Jorgensonian capital services for Sector 1 as we drop assets. With all assets included, capital services grew 6.026 fold; dropping money led to a 5.959 fold increase; dropping money and inventories led to a 5.706 fold increase and dropping money, inventories and land led to a 6.184 fold increase (see the highest line on Figure 15). These small differences in the rates of growth of capital services as we decrease the number of assets led to even smaller differences in the rates of TFP growth. With all assets included, Jorgensonian TFP increased 2.433 fold and as we dropped assets, there were 2.444, 2.478 and 2.416 fold increases in TFP over the sample period for Sector 1. The corresponding geometric rates of growth were 1.661%, 1.668%, 1.695% and 1.647% per year so that all of these annual average TFP growth rates were within 0.05 of a percentage point. These differences are too small to show up in Figure 15.

Dropping nonreproducible assets (or zero depreciation assets) from the asset base had a significant effect on ex post rates of return on assets employed in the US Corporate Nonfinancial Sector. However, dropping zero depreciation assets had a negligible effect on overall rates of TFP growth for Sector 1. In the following section, we will see if the same conclusions hold for the US Noncorporate Nonfinancial Sector.

8. Rates of Return and TFP Growth in Sector 2 with Alternative Asset Bases

Recall equations (26) and (27) in Section 5 above which defined the year t nominal and real rate of return on all fourteen assets used in Sector 2, r_2^t and R_2^t respectively. Modify equation (26) by dropping asset 14 from the asset base, which gives rise to a new nominal and real rate of return on the new asset base without monetary services, which we denote by $r_{2,M}^t$ and $R_{2,M}^t$ respectively. Further modify equation (26) by dropping assets 13 and 14 from the asset base, which gives rise to a new nominal and real rate of return on the new asset base without inventory and monetary services, which we denote by $r_{2,IM}^t$ and $R_{2,IM}^t$ respectively. Finally modify equation (26) by dropping assets 10-14 from the asset base, which gives rise to a new nominal and real rate of return on the new asset base without land, inventory and monetary services, which we denote by $r_{2,LIM}{}^t$ and $R_{2,LIM}{}^t$ respectively.

Table 16: Sector 2 Nominal and Real Rates of Return on Alternative Asset Bases

Year	$r_2{}^t$	$r_{2,M}{}^t$	$r_{2,IM}{}^t$	$r_{2,LIM}{}^t$	$R_2{}^t$	$R_{2,M}{}^t$	$R_{2,IM}{}^t$	$R_{2,LIM}{}^t$
1960	0.0604	0.0629	0.0696	0.1359	0.0448	0.0472	0.0539	0.1192
1961	0.0811	0.0848	0.0938	0.1578	0.0740	0.0778	0.0866	0.1503
1962	0.0936	0.0976	0.1073	0.1746	0.0790	0.0829	0.0925	0.1589
1963	0.0842	0.0876	0.0997	0.1732	0.0705	0.0738	0.0858	0.1584
1964	0.0829	0.0861	0.0949	0.2058	0.0680	0.0711	0.0799	0.1893
1965	0.1090	0.1132	0.1206	0.2166	0.0925	0.0966	0.1039	0.1986
1966	0.1250	0.1290	0.1406	0.2483	0.0904	0.0942	0.1055	0.2098
1967	0.1289	0.1330	0.1465	0.2346	0.1006	0.1046	0.1178	0.2036
1968	0.1515	0.1556	0.1680	0.2559	0.1041	0.1081	0.1200	0.2043
1969	0.1637	0.1677	0.1786	0.2353	0.1111	0.1150	0.1254	0.1795
1970	0.1462	0.1493	0.1599	0.2187	0.0956	0.0986	0.1087	0.1650
1971	0.1418	0.1450	0.1530	0.2409	0.1005	0.1036	0.1113	0.1961
1972	0.1610	0.1648	0.1714	0.2433	0.1231	0.1268	0.1332	0.2027
1973	0.2460	0.2510	0.2570	0.3025	0.1624	0.1672	0.1728	0.2152
1974	0.2329	0.2365	0.2476	0.3167	0.1056	0.1088	0.1188	0.1807
1975	0.1856	0.1889	0.2007	0.2243	0.1098	0.1128	0.1238	0.1460
1976	0.1756	0.1787	0.1881	0.2356	0.1183	0.1212	0.1301	0.1753
1977	0.1879	0.1909	0.1992	0.2687	0.1143	0.1171	0.1249	0.1901
1978	0.2150	0.2184	0.2233	0.2693	0.1294	0.1325	0.1371	0.1798
1979	0.1805	0.1825	0.1853	0.2814	0.0749	0.0767	0.0793	0.1667
1980	0.1195	0.1198	0.1200	0.2400	0.0119	0.0122	0.0123	0.1208
1981	0.0914	0.0918	0.0964	0.2142	0.0141	0.0144	0.0187	0.1282
1982	0.0576	0.0578	0.0602	0.1570	0.0074	0.0075	0.0098	0.1020
1983	0.0835	0.0848	0.0872	0.1275	0.0437	0.0448	0.0472	0.0860
1984	0.0727	0.0738	0.0769	0.1791	0.0365	0.0376	0.0406	0.1393
1985	0.0980	0.1000	0.1060	0.1899	0.0602	0.0622	0.0679	0.1489
1986	0.1142	0.1179	0.1247	0.2013	0.0955	0.0991	0.1058	0.1811
1987	0.1205	0.1235	0.1266	0.1882	0.0800	0.0829	0.0858	0.1452
1988	0.1305	0.1335	0.1363	0.2048	0.0852	0.0881	0.0907	0.1564
1989	0.1224	0.1253	0.1294	0.1992	0.0807	0.0835	0.0875	0.1548
1990	0.0863	0.0875	0.0900	0.1947	0.0348	0.0359	0.0383	0.1380
1991	0.0889	0.0911	0.0953	0.1667	0.0629	0.0650	0.0692	0.1389
1992	0.0852	0.0872	0.0899	0.2041	0.0572	0.0592	0.0618	0.1731
1993	0.1015	0.1038	0.1070	0.2024	0.0594	0.0616	0.0647	0.1565
1994	0.0921	0.0948	0.0976	0.2196	0.0715	0.0741	0.0768	0.1966
1995	0.1119	0.1156	0.1186	0.2121	0.0890	0.0926	0.0956	0.1871
1996	0.1089	0.1128	0.1166	0.2315	0.0911	0.0950	0.0987	0.2118
1997	0.1278	0.1335	0.1397	0.2466	0.1243	0.1300	0.1362	0.2428
1998	0.1534	0.1607	0.1683	0.2637	0.1450	0.1523	0.1598	0.2545
1999	0.1568	0.1644	0.1690	0.2670	0.1349	0.1423	0.1469	0.2430
2000	0.1722	0.1813	0.1862	0.2791	0.1438	0.1526	0.1574	0.2480
2001	0.1629	0.1731	0.1791	0.2998	0.1481	0.1581	0.1641	0.2832
2002	0.1754	0.1854	0.1898	0.2964	0.1532	0.1630	0.1672	0.2719
2003	0.1642	0.1732	0.1769	0.2883	0.1434	0.1522	0.1559	0.2653
2004	0.1968	0.2074	0.2114	0.3398	0.1634	0.1737	0.1776	0.3024
2005	0.1916	0.2023	0.2059	0.3413	0.1558	0.1662	0.1697	0.3010
2006	0.1166	0.1235	0.1258	0.3185	0.0971	0.1038	0.1060	0.2954
2007	0.0380	0.0383	0.0361	0.2566	0.0045	0.0048	0.0027	0.2160
2008	-0.0070	-0.0089	-0.0070	0.2687	-0.0214	-0.0232	-0.0215	0.2503
2009	0.0515	0.0552	0.0563	0.1762	0.0391	0.0428	0.0439	0.1623
2010	0.0380	0.0405	0.0397	0.2403	0.0248	0.0272	0.0265	0.2245
2011	0.1093	0.1179	0.1197	0.2786	0.0806	0.0889	0.0907	0.2455
2012	0.2038	0.2236	0.2310	0.2990	0.1829	0.2024	0.2097	0.2765
2013	0.1755	0.1925	0.1988	0.3118	0.1613	0.1781	0.1843	0.2960
2014	0.1514	0.1651	0.1701	0.3067	0.1386	0.1522	0.1571	0.2922
Mean	0.1276	0.1322	0.1378	0.2373	0.0903	0.0949	0.1003	0.1968

These real and nominal rates of return on the four alternative asset bases for Sector 2 are listed in Table 16. The alternative nominal rates can be found in Chart 16 and the alternative real rates of return can be found in Chart 17.

Figure 16: Sector 2 Nominal Rates of Return on Alternative Asset Bases

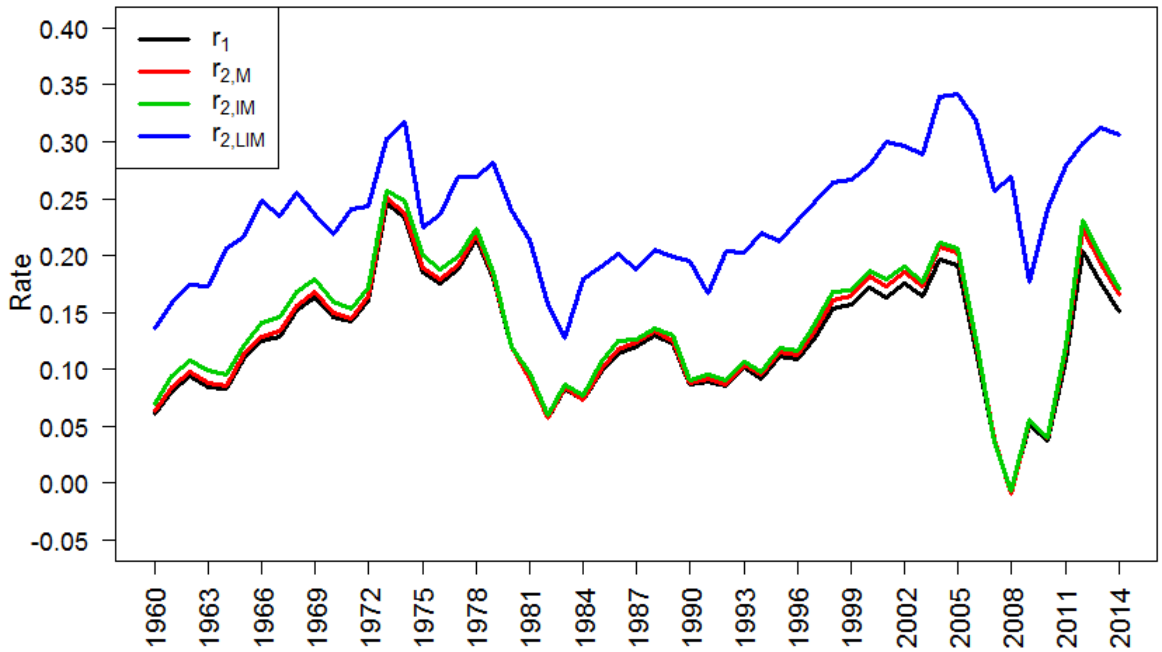
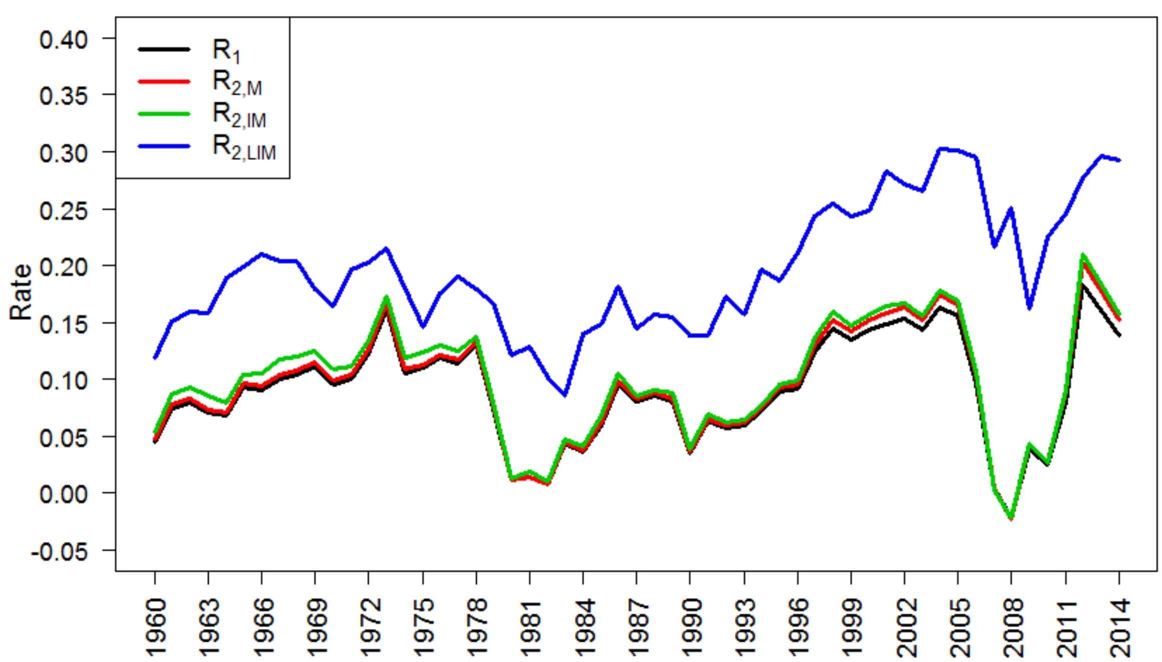


Figure 17: Sector 2 Real Rates of Return on Alternative Asset Bases



It can be seen that dropping assets leads to significant increases in the measured rates of return on the asset base. With all assets included, the Sector 2 average real rate of return was

9.03%; dropping money leads to a 9.49% rate of return, further dropping inventory stocks leads to a 10.03% rate of return and further dropping land leads to a huge 19.68% average rate of return on the remaining assets. Again, our conclusion here is that dropping assets can substantially distort the estimated return on assets.

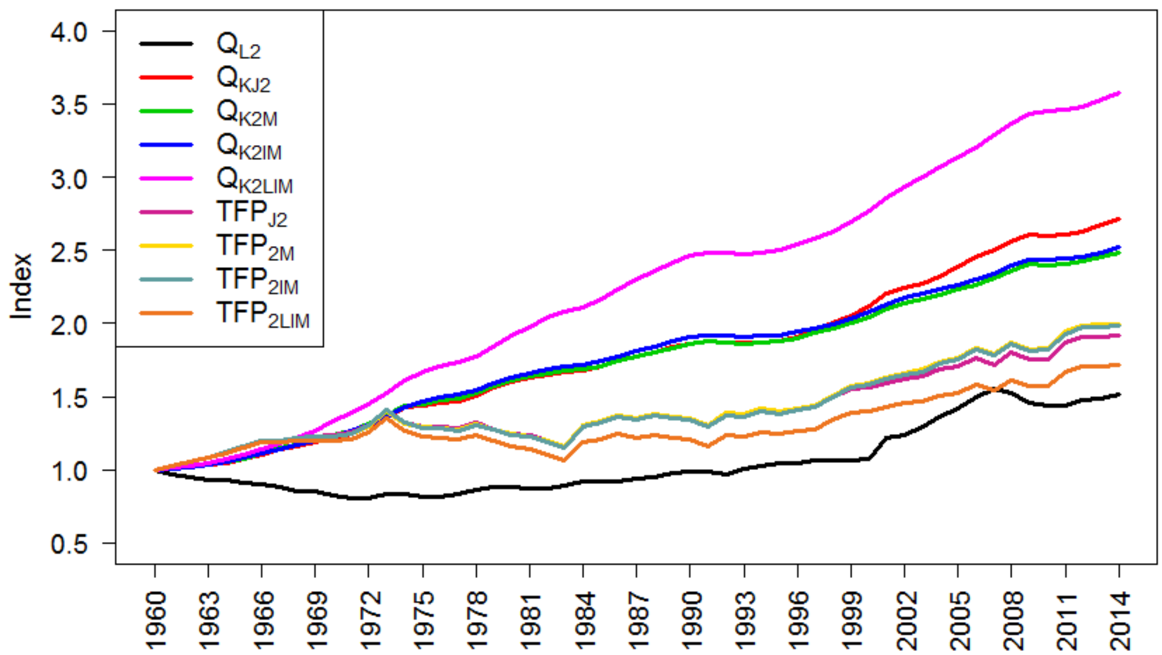
Recall that the year t Jorgensonian user costs $u_{2,n}^t$ for the fourteen assets used by Sector 2 were defined by equations (32) in Section 5. These user costs involved the nominal rates of return on assets for Sector 2, the r_2^t defined by equations (26). The user costs $u_{2,n}^t$ were used to form the Sector 2 Jorgensonian year t capital services aggregate, Q_{KJ2}^t, and the overall Sector 2 year t input aggregate, Q_{XJ2}^t. These input aggregates along with the Sector 2 output aggregates, Q_{VA2}^t, were used to form the year t Total Factor Productivity levels, TFP_{J2}^t, for Sector 2; see equations (37) above. When we drop monetary assets from the list of assets, we obtain the new year t Jorgensonian balancing nominal rate of return for year t, $r_{2,M}^t$, and this new rate of return can be inserted into equations (32) for n = 1,...,13 in order to obtain new year t Jorgensonian user costs for Sector 2, which we define as $u_{2M,n}^t$. These new user costs can be used to form new year t capital services aggregates, Q_{K2M}^t, and new year t aggregate input indexes, Q_{X2M}^t, for Sector 2. In a similar fashion, when we drop both monetary assets and inventory stocks, we obtain the year t capital services aggregates, Q_{K2IM}^t, and the year t aggregate input indexes, Q_{X2IM}^t, for Sector 2. Finally, when we drop monetary assets, inventory and land stocks from the list of productive assets, we obtain the year t capital services aggregates, Q_{K2LIM}^t, and the year t aggregate input indexes, Q_{X2LIM}^t, for Sector 2. These alternative measures of aggregate capital services are used to form the alternative TFP levels, TFP_{2M}^t, TFP_{2IM}^t and TFP_{2LIM}^t. These alternative measures of (normalized) Jorgensonian capital services and TFP are listed in Table 17 below along with the (normalized) measure of labour input for Sector 2, Q_{L2}^t.[48] See Figure 19 for plots of these series.

[48] To recover the un-normalized Q_{L2}^t, multiply the listed Q_{L2}^t series by the value of labour input in Sector 2 for 1960, which is 76.6. To recover the four un-normalized capital services series, multiply Q_{KJ2}^t, Q_{K2M}^t, Q_{K2IM}^t and Q_{K2LIM}^t by the Gross Operating Surplus for Sector 2 for 1960, which is 30.8.

Table 17: Sector 2 Normalized Labour Input, Jorgensonian Capital Services Quantity Aggregates and Jorgensonian TFP Estimates with Alternative Capital Asset Bases

Year	Q_{L2}^{t}	Q_{KJ2}^{t}	Q_{K2M}^{t}	Q_{K2IM}^{t}	Q_{K2LIM}^{t}	TFP_{J2}^{t}	TFP_{2M}^{t}	TFP_{2IM}^{t}	TFP_{2LIM}^{t}
1960	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1961	0.9731	1.0083	1.0104	1.0091	1.0129	1.0270	1.0263	1.0267	1.0256
1962	0.9543	1.0210	1.0236	1.0194	1.0255	1.0593	1.0586	1.0599	1.0580
1963	0.9326	1.0389	1.0426	1.0353	1.0457	1.0849	1.0837	1.0861	1.0828
1964	0.9295	1.0493	1.0542	1.0523	1.0707	1.1197	1.1181	1.1187	1.1126
1965	0.9166	1.0722	1.0781	1.0798	1.1018	1.1626	1.1606	1.1598	1.1524
1966	0.9009	1.1082	1.1156	1.1120	1.1406	1.2009	1.1983	1.1996	1.1897
1967	0.8785	1.1392	1.1489	1.1461	1.1846	1.2011	1.1978	1.1987	1.1855
1968	0.8572	1.1588	1.1701	1.1684	1.2177	1.2222	1.2182	1.2188	1.2016
1969	0.8493	1.1878	1.2019	1.1962	1.2665	1.2293	1.2243	1.2263	1.2019
1970	0.8261	1.2191	1.2366	1.2308	1.3305	1.2344	1.2283	1.2303	1.1965
1971	0.8083	1.2474	1.2649	1.2672	1.3888	1.2551	1.2490	1.2480	1.2075
1972	0.8068	1.2935	1.3110	1.3074	1.4503	1.3053	1.2992	1.3005	1.2523
1973	0.8311	1.3550	1.3726	1.3636	1.5232	1.4088	1.4026	1.4063	1.3502
1974	0.8346	1.4306	1.4421	1.4281	1.6082	1.3201	1.3171	1.3223	1.2653
1975	0.8157	1.4376	1.4526	1.4712	1.6728	1.2966	1.2923	1.2851	1.2246
1976	0.8172	1.4588	1.4766	1.4938	1.7032	1.2948	1.2895	1.2830	1.2212
1977	0.8328	1.4722	1.4879	1.5132	1.7333	1.2844	1.2800	1.2706	1.2069
1978	0.8596	1.5092	1.5218	1.5435	1.7749	1.3198	1.3167	1.3085	1.2408
1979	0.8800	1.5628	1.5733	1.5881	1.8385	1.2806	1.2785	1.2733	1.2038
1980	0.8796	1.6057	1.6153	1.6300	1.9222	1.2476	1.2460	1.2410	1.1641
1981	0.8771	1.6298	1.6395	1.6596	1.9763	1.2333	1.2316	1.2252	1.1446
1982	0.8758	1.6522	1.6624	1.6889	2.0438	1.2034	1.2017	1.1936	1.1078
1983	0.8925	1.6717	1.6816	1.7079	2.0826	1.1648	1.1632	1.1555	1.0692
1984	0.9232	1.6803	1.6874	1.7180	2.1126	1.3021	1.3013	1.2914	1.1907
1985	0.9238	1.7062	1.7122	1.7414	2.1692	1.3307	1.3303	1.3207	1.2108
1986	0.9245	1.7469	1.7460	1.7769	2.2382	1.3705	1.3726	1.3623	1.2426
1987	0.9371	1.7739	1.7723	1.8102	2.2993	1.3510	1.3533	1.3410	1.2185
1988	0.9527	1.8024	1.8040	1.8437	2.3571	1.3809	1.3821	1.3692	1.2405
1989	0.9765	1.8369	1.8363	1.8785	2.4167	1.3651	1.3670	1.3536	1.2228
1990	0.9855	1.8627	1.8632	1.9059	2.4678	1.3515	1.3530	1.3398	1.2068
1991	0.9887	1.8764	1.8776	1.9202	2.4852	1.3030	1.3043	1.2917	1.1636
1992	0.9669	1.8720	1.8728	1.9197	2.4834	1.3875	1.3890	1.3742	1.2382
1993	1.0103	1.8668	1.8651	1.9085	2.4742	1.3763	1.3787	1.3650	1.2287
1994	1.0308	1.8709	1.8690	1.9140	2.4876	1.4152	1.4177	1.4031	1.2617
1995	1.0422	1.8845	1.8783	1.9217	2.5057	1.3962	1.4001	1.3863	1.2447
1996	1.0490	1.9071	1.8960	1.9434	2.5408	1.4188	1.4244	1.4092	1.2637
1997	1.0681	1.9533	1.9353	1.9653	2.5804	1.4294	1.4374	1.4283	1.2782
1998	1.0673	2.0010	1.9685	1.9965	2.6319	1.4958	1.5093	1.5006	1.3404
1999	1.0631	2.0528	1.9999	2.0337	2.6966	1.5515	1.5728	1.5618	1.3911
2000	1.0743	2.1194	2.0439	2.0778	2.7743	1.5627	1.5923	1.5814	1.4037
2001	1.2144	2.2013	2.0978	2.1314	2.8622	1.5908	1.6305	1.6198	1.4337
2002	1.2380	2.2403	2.1361	2.1741	2.9355	1.6212	1.6612	1.6488	1.4555
2003	1.2983	2.2754	2.1663	2.2029	3.0032	1.6425	1.6843	1.6724	1.4694
2004	1.3634	2.3231	2.1960	2.2302	3.0673	1.6865	1.7354	1.7242	1.5085
2005	1.4220	2.3916	2.2321	2.2673	3.1362	1.7036	1.7635	1.7520	1.5287
2006	1.5004	2.4512	2.2661	2.3016	3.2050	1.7652	1.8355	1.8237	1.5862
2007	1.5510	2.5053	2.3085	2.3447	3.2873	1.7215	1.7929	1.7813	1.5446
2008	1.5251	2.5567	2.3566	2.3932	3.3689	1.8005	1.8748	1.8629	1.6123
2009	1.4542	2.6081	2.4045	2.4407	3.4329	1.7509	1.8230	1.8117	1.5686
2010	1.4432	2.6003	2.3971	2.4334	3.4483	1.7576	1.8301	1.8187	1.5693
2011	1.4431	2.6077	2.4054	2.4414	3.4593	1.8665	1.9429	1.9310	1.6663
2012	1.4743	2.6309	2.4267	2.4587	3.4803	1.9049	1.9829	1.9725	1.7029
2013	1.4850	2.6744	2.4526	2.4875	3.5242	1.9077	1.9916	1.9801	1.7087
2014	1.5148	2.7104	2.4855	2.5218	3.5742	1.9147	1.9990	1.9870	1.7144

Figure 18: Sector 2 Labour and Measures of Capital Services and TFP with Alternative Asset Bases



It can be seen that there are some large differences in the growth of Jorgensonian capital services for Sector 2 as we drop assets. With all assets included, capital services grew 2.71 fold; dropping real monetary balances (which increased more rapidly than other assets, particularly in recent years) led to a 2.49 fold increase in the remaining capital services; dropping money and inventories led to a 2.52 fold increase and dropping money, inventories and land led to a 3.57 fold increase in the remaining capital services (see the highest line on Figure 17). Since land stocks grow more slowly than other capital stocks and since land is a very large component of the Sector 2 capital stock, these results are not unexpected. These large differences in the rates of growth of capital services as we decrease the number of assets led to significant differences in the rates of TFP growth. With all assets included, Jorgensonian TFP increased 1.91 fold and as we dropped assets, there were 2.00, 1.99 and 1.71 fold increases in TFP over the sample period for Sector 2. The corresponding geometric average rates of TFP growth for Sector 2 were 1.21%, 1.29%, 1.28% and 1.00% per year. Thus dropping land from the list of in scope assets significantly reduced the measured rate of Jorgensonian TFP growth. Excluding money from the list of assets also had a significant (but smaller) effect.

Our conclusion is that dropping zero depreciation assets will in general significantly increase measured rates of return on assets. On the other hand, dropping zero depreciation assets will not *always* significantly affect long run average rates of TFP growth for a sector but for land intensive sectors, it is likely to significantly decrease measured long run average rates of TFP growth.

9. Conclusions

A number of tentative conclusions can be drawn from the above analysis:

- The technologies used in the Corporate Nonfinancial (Sector 1) and Noncorporate Nonfinancial (Sector 2) sectors are quite different. Sector 1 uses reproducible assets quite intensively while Sector 2 uses land and structure assets quite intensively.
- Total Factor Productivity growth in our two sectors over the years 1960-2014 has been excellent: the TFP growth rate for Sector 1 averaged 1.66% per year using Jorgensonian user costs (1.69% per year using predicted user costs) and 1.21% per year for Sector 2 using both sets of user costs. These are very high average rates of TFP growth over such a long period. Moreover, there is no indication of a TFP slowdown in our data.
- Average real rates of return on productive assets employed have been quite high in both sectors. The average annual real rate of return was 7.6% per year in Sector 1 and 9.0% per year in Sector 2. There is no indication of a long run slowdown in these rates of return (but there have been massive short run fluctuations in these rates).
- Jorgensonian user costs use actual ex post asset inflation rates in place of predicted asset inflation rates and as a result, Jorgensonian user costs are volatile and frequently negative if land assets are included in the asset boundary. These user costs are not suitable for many analytical purposes. Our predicted asset inflation rates generated relatively smooth user costs that could be used in production and cost function studies. However, Jorgensonian user costs are the right type of user cost to use when calculating ex post rates of return on assets employed.
- Somewhat surprisingly, Jorgensonian and predicted user costs can give rise to rates of growth of capital services and Total Factor Productivity that are very close to each other. Thus for Sector 1, we found that the long run average geometric rate of capital services growth generated by the alternative user cost approaches were 3.38% and 3.29% per year for Sector 1 and 1.86% and 1.88% per year for Sector 2. The resulting alternative annual rates of TFP growth were 1.66% and 1.69% per year in Sector 1 and 1.21% per year using both Jorgensonian and predicted user costs for Sector 2. These differences are not large.
- Dropping assets from the asset base can lead to very large biases in the measured rates of return on assets employed. Dropping land, inventory and monetary balances from the list of assets in scope increased the measured average ex post real rate of return on assets from 7.6% to 10.8% per year for Sector 1 and from 9.0% to 19.7% per year for Sector 2.
- Dropping assets from the asset base can lead to little change in measured TFP growth rates or it can lead to significant changes. Thus the Jorgensonian average TFP growth rate for Sector 1 changed from 1.66% per year with all assets in the base to 1.65% per year, after land, inventories and real monetary balances were dropped from the list of assets. On the other hand, the Jorgensonian average TFP growth rate for Sector 2 changed from 1.21% per year with all assets in the base to 1.00% per year after land, inventories and real monetary balances were dropped from the list of assets. This is a significant change.
- Our data are subject to a considerable degree of uncertainty. Hopefully, in future years, the BEA in cooperation with the BLS, the USDA and the Federal Reserve Board of Governors will be able to improve the quality of the underlying data. In particular, we note that our land and labour data are weak and we are missing data on resource stocks.
- More research is needed on choosing appropriate predicted asset inflation rates.

Appendix A: Data Construction

A1. Introduction and Overview

The BEA, in cooperation with the BLS and Federal Reserve Board has recently published some new tables on a regular basis: namely the Integrated Macroeconomic Accounts (IMA) for the US economy. These new tables provide basic accounting data for six sectors of the US economy on an annual basis back to 1960. Our interest is in two of these sectors: the Corporate Nonfinancial Sector (Sector 1) and the Noncorporate Nonfinancial Sector (Sector 2). The IMA tables provide information on the value added produced by each sector, the compensation of employees and various other flow variables as well as balance sheet information for each sector, including the year end values for stocks of reproducible capital, real estate, inventories and currency and deposits. These tables provide very valuable information that was not previously integrated with the BEA National Income and Product Accounts (NIPA) and the Fixed Asset Accounts. However, the Integrated Macro Accounts contain only value information: there are no deflators or volume indexes to match up with the various value entries in the tables. Thus our main task in this Appendix is to use other sources to develop deflators or volume indexes for the value entries in the IMA.

A big problem with the IMA is that the estimates for the value of Real Estate used by the various sectors are not very reliable. In addition, Real estate value is equal to the sum of structure and land value and so we require separate estimates for either structure value or land value and then in addition, we need deflators for these two value components. In Section A2, we make a start on these measurement problems by attempting to find indexes for the price and quantity of residential real estate (and its two subcomponents). In Section A3, we look at the problems associated with decomposing the value of farm real estate into price and quantity components.

In Section A4, we look at the IMA value data for sectoral value added, compensation of employees and the various balance sheet value estimates for our two Sectors.

In Sections A5 and A6, we go to the BEA Fixed Asset Tables and find price indexes for our reproducible capital stock components in sectors 1 and 2.

Section A7 attempts to bring together all of the real estate information that we have gathered in previous sections into a coherent price, volume and value framework.

Section A8 returns to the BEA Fixed Asset Tables to find depreciation rates for the reproducible capital stocks used in our two Sectors.

Section A9 constructs deflators for the value added estimates for our sectors 1 and 2 using the BEA NIPA accounts. We also make some adjustments to our value added estimates to convert from final demand prices to producer prices.

Sections A10 and A11 again utilize NIPA tables to find deflators for our labour input series and our inventory stock series.

Section A12 summarizes some of the weak points in our data construction process and offers some suggestions to the BEA (and its partners who helped to produce the Integrated Macro Accounts) to improve the data.

A2. Residential Land

Morris Davis (2015) has constructed three residential land price (and quantity) series for the US that are readily available. All three series were constructed from estimates of the value of residential properties and Bureau of Economic Analysis (BEA) estimates for the value of residential structures were subtracted from the estimated property values to generate estimates for the value of residential land. The methodology used to further decompose residential land values into price and quantity components is explained in Davis and Heathcote (2007). Two of the data series are quarterly, running from the first quarter in 1975 to the first quarter in 2015. One of the quarterly series is based on the Case-Shiller-Weiss (CSW) house price index and the other is based on the repeat sales index constructed by the Federal Housing Finance Agency (FHFA). Davis regards the FHFA series as the more reliable of the two quarterly series and so we will use it for the years 1975-2015. The third Davis data set is an annual one which runs from 1930 to 2000. The annual series is based on the Decennial Census of Housing and uses interpolation methods to fill in the data for the missing years. Note that the Census asks for estimates for the current property value as of the time of the Census, which is April. We use these estimates as beginning of the year values for residential land.

We obtained beginning of the year values and prices for both land and structures for the years 1976-2015 by taking the average of the first quarter values and prices for each of these years with the preceding fourth quarter estimates from the Davis FHFA series. These operations generate our estimated beginning of the year residential land and structure value series, $V_{LR}{}^t$ and $V_{SR}{}^t$, for t = 1976,...,2015 and the corresponding price series, $P_{LR}{}^t$ and $P_{SR}{}^t$. These FHFA based value and price series were linked to the corresponding Davis Census based series so that the resulting value and price series cover the 56 years 1960 to 2015. The price series were then normalized to equal unity in 1960 and then the corresponding beginning of the year land and structure quantity series were defined as $Q_{LR}{}^t \equiv V_{LR}{}^t/P_{LR}{}^t$ and $Q_{SR}{}^t \equiv V_{SR}{}^t/P_{SR}{}^t$ for t = 1960,...,2015. These series are listed in Table A1 below. The units for the values are in billions of dollars and for the quantities (or volumes) are in billions of 1960 dollars.

Table A1: Beginning of the Year Value, Quantity and Price of US Residential Land and Structures and the Nominal and Real Land to Structure Ratios

Year	V_{LR}^{t}	V_{SR}^{t}	Q_{LR}^{t}	Q_{SR}^{t}	P_{LR}^{t}	P_{SR}^{t}	$R_{VL/VS}^{t}$	$R_{QL/QS}^{t}$
1960	115.5	465.2	115.5	465.2	1.00000	1.00000	0.24824	0.24824
1961	119.7	483.4	118.0	481.3	1.01466	1.00440	0.24756	0.24506
1962	125.1	501.8	120.7	498.0	1.03585	1.00762	0.24923	0.24244
1963	136.7	517.7	124.1	517.1	1.10149	1.00111	0.26395	0.23990
1964	141.0	545.6	127.2	538.4	1.10876	1.01339	0.25853	0.23629
1965	133.5	585.4	132.3	559.4	1.00924	1.04642	0.22808	0.23648
1966	131.4	627.9	136.4	578.0	0.96335	1.08632	0.20922	0.23593
1967	134.5	675.2	139.9	594.4	0.96122	1.13597	0.19912	0.23531
1968	149.0	733.3	143.7	611.7	1.03709	1.19887	0.20315	0.23484
1969	178.5	795.7	148.3	630.6	1.20378	1.26193	0.22439	0.23523
1970	237.4	844.4	156.4	648.5	1.51815	1.30201	0.28112	0.24110
1971	291.6	921.0	161.2	668.9	1.80914	1.37688	0.31665	0.24099
1972	320.5	1033.2	164.9	695.2	1.94346	1.48606	0.31026	0.23724
1973	355.2	1169.1	168.7	723.9	2.10535	1.61505	0.30378	0.23304
1974	438.7	1333.4	172.1	747.6	2.54885	1.78360	0.32897	0.23021
1975	582.7	1477.9	177.7	764.5	3.27934	1.93329	0.39428	0.23244
1976	726.1	1617.9	181.7	782.3	3.99660	2.06805	0.44879	0.23223
1977	825.4	1810.1	183.3	811.1	4.50255	2.23164	0.45600	0.22601
1978	996.6	2116.8	185.3	844.5	5.37936	2.50667	0.47080	0.21939
1979	1217.0	2428.1	187.0	872.6	6.50717	2.78271	0.50121	0.21434
1980	1330.5	2821.9	188.7	905.0	7.05060	3.11823	0.47149	0.20852
1981	1300.2	3163.8	189.9	920.8	6.84643	3.43581	0.41096	0.20624
1982	1320.5	3386.2	191.1	928.3	6.91159	3.64781	0.38997	0.20582
1983	1334.5	3519.9	192.1	929.4	6.94688	3.78723	0.37913	0.20669
1984	1477.1	3668.5	193.8	949.5	7.62235	3.86349	0.40264	0.20409
1985	1624.8	3873.8	195.6	974.8	8.30632	3.97391	0.41943	0.20067
1986	1863.6	4088.6	197.3	1001.5	9.44743	4.08248	0.45580	0.19696
1987	2132.8	4406.9	199.0	1033.3	10.71971	4.26503	0.48397	0.19256
1988	2350.4	4690.3	200.6	1065.9	11.71897	4.40051	0.50112	0.18817
1989	2595.8	4966.9	202.0	1092.5	12.85006	4.54648	0.52262	0.18491
1990	2869.4	5232.0	203.3	1118.2	14.11101	4.67897	0.54843	0.18185
1991	2894.8	5401.7	204.5	1133.0	14.15633	4.76744	0.53591	0.18048
1992	3043.3	5512.7	205.5	1147.4	14.80761	4.80440	0.55205	0.17912
1993	3059.3	5850.9	206.7	1177.9	14.79868	4.96742	0.52288	0.17551
1994	3164.9	6189.1	208.0	1204.4	15.21290	5.13877	0.51137	0.17273
1995	3181.3	6620.7	209.5	1235.2	15.18392	5.35992	0.48051	0.16962
1996	3338.1	6877.4	210.9	1255.6	15.82648	5.47721	0.48537	0.16798
1997	3443.8	7256.7	212.4	1288.4	16.20998	5.63247	0.47457	0.16490
1998	3664.0	7642.4	214.0	1321.0	17.12360	5.78544	0.47943	0.16198
1999	4089.6	8162.4	215.6	1363.4	18.96829	5.98681	0.50103	0.15814
2000	4548.0	8780.4	217.2	1405.5	20.93631	6.24721	0.51797	0.15456
2001	5173.4	9347.6	218.7	1438.8	23.65235	6.49661	0.55345	0.15202
2002	5762.4	9977.1	220.1	1470.7	26.17992	6.78384	0.57756	0.14966
2003	6646.1	10778.4	221.5	1531.3	30.00003	7.03890	0.61661	0.14468
2004	7547.9	11668.5	222.9	1575.6	33.85718	7.40577	0.64686	0.14149
2005	8622.6	12936.9	224.3	1613.6	38.43491	8.01727	0.66651	0.13903
2006	9727.9	14460.3	225.8	1667.6	43.07364	8.67132	0.67273	0.13543
2007	9841.8	15337.4	227.2	1701.8	43.32553	9.01250	0.64169	0.13348
2008	8879.5	15466.4	228.2	1714.4	38.91296	9.02134	0.57412	0.13310
2009	6974.2	15203.0	229.1	1717.1	30.44584	8.85406	0.45874	0.13341
2010	6665.9	14943.8	229.6	1716.8	29.02844	8.70440	0.44606	0.13376
2011	5532.5	15061.4	230.2	1713.9	24.03061	8.78765	0.36733	0.13433
2012	5179.5	15198.6	230.9	1707.4	22.42844	8.90138	0.34079	0.13525
2013	6084.6	15710.6	231.8	1723.4	26.25095	9.11630	0.38729	0.13450
2014	6815.7	16579.2	232.7	1723.9	29.28817	9.61700	0.41110	0.13499
2015	7347.0	17251.4	233.7	1724.6	31.43507	10.00321	0.42588	0.13552

The ratios of the value and quantity of residential land to the value and quantity of residential structures at the beginning of year t, $R_{VL/VS}^{t}$ and $R_{QL/QS}^{t}$ respectively, are also listed in Table A1. It can be seen that the ratio of land value to structure value, $R_{VL/VS}^{t}$, starts at 24.8% in

1960, hits a peak at 67.3% in 2006, collapses to 34.1% in 2012 and trends up a bit to end up at 42.6% in 2015. On the other hand, the ratio of land quantity to structure quantity, $R_{QL/QS}{}^{t}$, starts at 24.8% in 1960 and trends down steadily to end up at 13.6% in 2015. This decline in the real land to structure ratio is explained by the fact that land prices grew 31.4 fold while structure prices grew only 10.0 fold over the sample period. Over the sample period, land prices grew at the geometric rate of 6.5% per year while structure prices grew at only 4.3% per year. The quantity of residential land grew at the geometric rate of 1.3% per year while the quantity of structures grew almost twice as fast at the rate of 2.4% per year.

The numbers in Table A1 are probably subject to a fairly large margin of error but they seem to be reasonable. We turn now to the problems associated with finding estimates for the price and quantity of agricultural or farm land by sector.

A3. Farm Land

The US Department of Agriculture (USDA) collects information on the value of US farm real estate (excluding residential housing). End of year estimates for the years 1960-2014 are readily available; see USDA (2016). We converted these end of year estimates into beginning of the year estimates for the years 1961-2015 and the estimate for year t is denoted by $V_{REF}{}^{t}$.

The Bureau of Economic Analysis (2015b) provides estimates for end of year values for farm structures for the years 1959-2014 which we converted to beginning of the year values for the years 1960-2015; see the Fixed Asset Table 3.1S; Current-Cost Net Stock of Private Structures by Industry; Private Sector; Farms.[49] We label these estimates for year t as $V_{SF}{}^{t}$. An estimate for the value of farm land in year t, $V_{LF}{}^{t}$, for the years 1961-2015 can be obtained by subtracting the value of farm structures from the value of farm real estate; i.e., define $V_{LF}{}^{t} \equiv V_{REF}{}^{t} - V_{SF}{}^{t}$ for t = 1961,...,2015. Eldon Ball, who is in charge of the productivity program at the USDA, kindly provided us with estimates for the price, quantity and value of farm land in the US for the years 1960 and 1961. We used this implied rate of growth in the value of US farm land from 1960 to 1961 to extend $V_{LF}{}^{1961}$ back to 1960. We then defined $V_{REF}{}^{1960}$ as $V_{REF}{}^{1960} \equiv V_{LF}{}^{1960} + V_{SF}{}^{1960}$. The series $V_{REF}{}^{t}$, $V_{LF}{}^{t}$ and $V_{SF}{}^{t}$ are listed in Table A2 below.

An index for the quantity of farm land in use by year, say $Q_{LF}{}^{t}$ for year t, can be obtained for the years 1960-2013 from the productivity program of the USDA; see USDA (2015). We assumed that the quantity of farm land for the years 2014 and 2015 was equal to the corresponding quantity in use for 2013. A preliminary price index for the quantity of farm land in use in year t, $P_{LF}{}^{t}$, was obtained by dividing the value $V_{LF}{}^{t}$ by the corresponding quantity $Q_{LF}{}^{t}$; i.e., define $P_{LF}{}^{t} \equiv V_{LF}{}^{t}/Q_{LF}{}^{t}$ for t = 1960,...,2015. The price series $P_{LF}{}^{t}$ was normalized so that it is equal to unity in 1960 and the quantity series $Q_{LF}{}^{t}$ was normalized in the opposite direction. The normalized price and quantity series for farm land, $P_{LF}{}^{t}$ and $Q_{LF}{}^{t}$, are also listed in Table A2.

There is one remaining problem associated with the data on US farm land: we need to allocate the total private sector use of farm land into the corporate nonfinancial sector and the noncorporate nonfinancial sector. The USDA (1999) undertook a survey of the ownership of farm land by sector using the 1997 Census of Agriculture; see Table 2 in this publication. The number of acres of farm land owned by four types of organizations (in millions of acres) for

[49] As of February 2016, the BEA's Fixed Asset Tables were last revised on August 31, 2015.

the survey year were as follows: (i) Individual or family sole proprietorships: 672.256; (ii) Partnerships: 111.004; (iii) Corporations: 122.721 and (iv) Other cooperatives, estates, trusts, institutional, etc.: 11.335. We set the share of corporate land in total farm land, s_1, to be the number of acres in category (ii) divided by the sum of the four categories. This fraction turned out to be 0.134. We used this fraction to allocate the total quantity of private farm land in year t, Q_{LF}^t, into the quantity used in Sector 1 (the nonfinancial corporate sector) Q_{LF1}^t plus the quantity used in Sector 2 (the nonfinancial, noncorporate sector) Q_{LF2}^t where $Q_{LF1}^t \equiv s_1Q_{LF}^t$ and $Q_{LFs}^t \equiv (1-s\,)Q_{LF}^t$ for t = 1969,...,2015. Q_{LF1}^t and Q_{LF2}^t are listed in Table A2. We set the price of Sector 1 and Sector 2 farm land at the beginning of year t, P_{LF1}^t and P_{LF2}^t, to equal our earlier estimate for the price of farm land, P_{LF}^t. Finally, the value of farm land in sector i in year t is defined as follows: $V_{LFi}^t \equiv P_{LFi}^tQ_{LFi}^t$ for i = 1,2 and t = 1960,...,2015.

Note that the price of farm land increased 26.7 fold over the sample period whereas the quantity of land decreased from 100.2 to 78.4 in billions of 1960 dollars.

Table A2: Value of Farm Real Estate, Land and Structures, V_{REF}^t, V_{LF}^t and V_{SF}^t, Total Quantity of Farm Land Q_{LF}^t, Quantity of Farm Land in Sectors 1 and 2, Q_{LF1}^t and Q_{LF2}^t, and the Price of Farm Land P_{LF}^t

Year	V_{REF}^t	V_{LF}^t	V_{SF}^t	Q_{LF}^t	Q_{LF1}^t	Q_{LF2}^t	P_{LF}^t
1960	120.6	20.4	100.2	100.2	13.4	86.8	1.00000
1961	123.3	20.6	102.7	100.0	13.4	86.6	1.02637
1962	129.1	21.2	107.9	100.0	13.4	86.6	1.07927
1963	134.6	22.1	112.5	99.8	13.4	86.5	1.12706
1964	142.4	23.0	119.4	99.5	13.3	86.2	1.19947
1965	150.5	24.4	126.1	98.9	13.3	85.7	1.27468
1966	161.5	25.6	135.9	98.1	13.1	84.9	1.38602
1967	171.2	27.1	144.1	97.0	13.0	84.0	1.48621
1968	180.9	28.6	152.3	95.7	12.8	82.9	1.59227
1969	189.4	31.0	158.4	94.2	12.6	81.6	1.68149
1970	195.3	33.4	161.9	92.6	12.4	80.2	1.74838
1971	202.4	36.2	166.2	91.0	12.2	78.8	1.82559
1972	217.6	40.1	177.5	89.7	12.0	77.7	1.97865
1973	243.0	43.1	199.9	88.7	11.9	76.8	2.25405
1974	298.3	47.5	250.8	88.2	11.8	76.4	2.84366
1975	335.6	55.8	279.8	88.3	11.8	76.5	3.16861
1976	383.6	59.8	323.8	88.7	11.9	76.8	3.64917
1977	456.5	65.0	391.5	89.2	11.9	77.2	4.39060
1978	509.3	72.9	436.4	89.3	12.0	77.4	4.88472
1979	601.8	82.9	518.9	89.0	11.9	77.1	5.82993
1980	706.1	96.3	609.8	88.3	11.8	76.5	6.90652
1981	782.8	108.6	674.2	87.4	11.7	75.7	7.71281
1982	785.6	117.8	667.8	86.6	11.6	75.0	7.71124
1983	750.0	123.2	626.8	86.0	11.5	74.5	7.28983
1984	753.4	126.5	626.9	85.5	11.5	74.1	7.32869
1985	661.8	130.9	530.9	85.2	11.4	73.8	6.23214
1986	586.2	132.9	453.3	84.8	11.4	73.4	5.34454
1987	542.4	135.8	406.6	84.4	11.3	73.1	4.81944
1988	563.7	138.8	424.9	83.8	11.2	72.6	5.07006
1989	582.3	141.9	440.4	83.2	11.1	72.0	5.29503
1990	600.1	144.8	455.3	82.6	11.1	71.5	5.51388
1991	619.1	146.6	472.5	82.1	11.0	71.1	5.75414
1992	624.8	145.3	479.5	81.9	11.0	70.9	5.85337
1993	640.8	146.1	494.7	82.0	11.0	71.0	6.03151
1994	677.6	149.9	527.7	82.3	11.0	71.3	6.40964
1995	704.1	155.6	548.5	82.7	11.1	71.6	6.63313
1996	740.5	158.0	582.5	83.0	11.1	71.9	7.01705
1997	769.5	161.4	608.1	83.2	11.1	72.0	7.31240
1998	808.2	165.8	642.4	83.1	11.1	71.9	7.73237
1999	840.4	170.9	669.5	82.8	11.1	71.7	8.08956
2000	887.0	176.5	710.5	82.3	11.0	71.2	8.63602
2001	946.4	184.0	762.4	81.7	10.9	70.7	9.33533
2002	996.2	190.8	805.4	81.1	10.9	70.2	9.93734
2003	1003.7	195.1	808.6	80.5	10.8	69.7	10.04640
2004	1016.4	201.3	815.1	80.0	10.7	69.2	10.19305
2005	1161.6	217.4	944.2	79.4	10.6	68.8	11.88420
2006	1372.6	237.0	1135.6	78.9	10.6	68.3	14.38901
2007	1536.6	252.4	1284.2	78.4	10.5	67.9	16.38536
2008	1549.0	259.1	1289.9	77.9	10.4	67.4	16.56367
2009	1566.6	261.9	1304.7	77.5	10.4	67.1	16.83387
2010	1554.1	244.4	1309.7	77.3	10.4	67.0	16.93808
2011	1651.4	241.8	1409.6	77.4	10.4	67.0	18.21710
2012	1795.1	243.6	1551.5	77.7	10.4	67.3	19.97074
2013	2073.1	251.0	1822.1	78.4	10.5	67.9	23.24763
2014	2252.9	268.0	1984.9	78.4	10.5	67.9	25.32517
2015	2378.7	284.9	2093.8	78.4	10.5	67.9	26.71409

A4. Sectoral Value Data from the Integrated Macroeconomic Accounts

The Integrated Macroeconomic Accounts (IMA) that are jointly produced by the BEA, BLS and the Federal Reserve Board and published by the Bureau of Economic Analysis (2016)[50] provide basic accounting data for six sectors of the US economy on an annual basis for the years 1960-2014. The six sectors are: (i) Households and nonprofit institutions serving households; (ii) Nonfinancial noncorporate business; (iii) Nonfinancial corporate business; (iv) Financial business; (v) Federal government and (vi) State and local government. Our Sectors 1 and 2 are the sectors (iii) and (ii) listed above respectively. Since our focus in this paper is on the Total Factor Productivity (TFP) of the business sector of the economy, one might ask why we did not include sector (iv) above in our study. The answer is that, at present, there is no general agreement among economists on how outputs and inputs in the financial sector should be measured and so we have omitted developing data for measuring the productivity of this sector until there is a consensus on how to measure financial sector outputs and inputs.[51] However, the share of financial business value added in the entire private business sector is relatively small and so the productivity performance of the nonfinancial business sector (our Sectors 1 and 2) will largely determine the productivity performance of the entire US private business sector.[52]

A major advantage of the IMA data is that value information on the outputs produced and inputs used by sector are integrated with balance sheet information. The IMA Balance Sheet Accounts provide information on end of year stocks of reproducible assets (equipment and structures), intangible assets (Intellectual Property Products) and other assets (real estate and monetary holdings). In particular, the information on holdings of real estate assets along with information on structure holdings enables us to obtain estimates for holdings of land. Since land prices have generally increased much more rapidly than other prices over our sample period, it is important to have accurate data on the price and quantity of land used in production in order to form accurate estimates of TFP growth. We have also included holdings of money and deposits in our list of productive assets and fortunately, this information is also available in the balance sheet accounts of the IMA. In addition to the availability of the asset information, the IMA also includes information on direct and indirect taxes paid by the various sectors. The information on indirect taxes is required to form approximate basic prices for our two sectors.[53] Another major advantage of the IMA data is that using these data, we are able to form *sectoral estimates* for US TFP growth for the corporate and noncorporate nonfinancial sectors back to 1960. To our knowledge, this has not been done before. The main disadvantage of the IMA data base is that it includes only *values* for inputs, outputs and asset holdings: there is no *price* or *volume* information included in the

[50] We use the most current IMA data (as of February 2016) that was last revised on December 23, 2015.

[51] For descriptions of the user cost approach to measuring financial sector output, see Diewert (2014) and Diewert, Fixler and Zieschang (2016). For other approaches, see Mester (1997), Basu, Inklaar and Wang (2011), Colangelo and Inklaar (2012) and Inklaar and Wang (2013).

[52] Using Table S.2.A from the IMA, we can calculate the average shares of private business sector gross value added over the years 1960-2014 for our sectors 1 and 2 and sector 3 (equal to the financial business sector): 0.705, 0.218 and 0.077. The maximum and minimum shares for the financial sector over the sample period were 0.107 and 0.048.

[53] Jorgenson and Griliches (1972) pointed out the importance for productivity measurement of adjusting final demand prices for indirect taxes paid by final demanders so that approximations to the prices that producers actually face could be formed.

IMA. Thus in subsequent sections of this Appendix, we will make use of other BEA sources to obtain the missing price or volume information as best we can.

The following value series (in billions of dollars) were downloaded for Sector 1 for the years 1960-2014 from the Bureau of Economic Analysis (2016) Integrated Macroeconomic Accounts Table S.5.A: Nonfinancial Corporate Business: $V_{VA1}{}^{t}$ (Gross value added); $V_{E1}{}^{t}$ (Compensation of employees); $V_{IT1}{}^{t}$ (Taxes on production and imports less subsidies) and $V_{TI1}{}^{t}$ (Taxes on income, wealth, etc.). Analogous value series (in billions of dollars) were downloaded for Sector 2 for the years 1960-2014 from the Bureau of Economic Analysis (2016) Integrated Macroeconomic Accounts Table S.4.A: Nonfinancial Noncorporate Business: $V_{VA2}{}^{t}$ (Gross value added); $V_{E2}{}^{t}$ (Compensation of employees); $V_{IT2}{}^{t}$ (Taxes on production and imports less subsidies) and $V_{TI1}{}^{t}$ (Other current transfers). We interpret this last category as income and wealth taxes on the earnings of Sector 2. These value series are listed in Table A3 below. Note that the tax burdens on Sector 2 are much lighter than the corresponding tax burdens on Sector 1.

Table A3: Sector 1 and 2 Integrated Macroeconomic Accounts Data on Value Added V_{VAi}^{t}, Compensation of Employees V_{Ei}^{t}, Taxes on Production and Imports less Subsidies (Net Indirect Taxes) V_{ITi}^{t} and Taxes on Income and Wealth V_{TIi}^{t}

Year	V_{VA1}^{t}	V_{E1}^{t}	V_{IT1}^{t}	V_{TI1}^{t}	V_{VA2}^{t}	V_{E2}^{t}	V_{IT2}^{t}	V_{VTI2}^{t}
1960	282.5	180.4	26.6	19.1	117.1	37.3	9.7	0.3
1961	290.4	184.5	27.6	19.4	119.7	36.9	9.5	0.3
1962	316.8	199.3	29.9	20.6	124.0	37.8	9.8	0.3
1963	337.8	210.1	31.7	22.8	127.3	38.8	10.2	0.3
1964	364.5	225.7	33.9	23.9	133.5	40.8	10.5	0.4
1965	400.7	245.4	36.0	27.1	140.7	41.9	10.7	0.4
1966	440.1	272.9	37.0	29.5	149.0	44.4	10.5	0.5
1967	463.2	291.1	39.3	27.8	153.7	45.2	11.6	0.5
1968	510.9	320.9	45.5	33.5	161.7	46.8	11.9	0.5
1969	554.6	356.1	50.2	33.3	170.3	48.6	12.5	0.5
1970	572.8	374.5	54.2	27.3	177.3	50.0	13.9	0.6
1971	618.0	396.2	59.5	30.0	188.7	50.5	15.6	0.6
1972	685.9	439.9	63.7	33.8	206.5	52.6	15.3	0.7
1973	768.8	495.1	70.1	40.4	241.4	59.4	17.9	0.8
1974	830.1	542.9	74.4	42.8	256.7	63.8	21.5	0.8
1975	898.3	569.0	80.2	41.9	274.7	67.1	22.7	1.0
1976	1014.8	640.0	86.7	53.5	299.5	72.8	23.9	1.4
1977	1147.5	723.3	94.6	60.6	324.5	78.7	23.8	1.6
1978	1304.1	829.5	102.7	67.6	364.7	87.1	24.0	1.9
1979	1450.4	942.4	108.8	70.6	406.9	96.6	26.6	1.9
1980	1574.2	1030.7	121.5	68.2	429.1	103.3	29.3	2.2
1981	1788.4	1139.8	146.7	66.0	468.7	110.4	33.2	2.4
1982	1854.3	1183.3	152.9	48.8	480.0	116.2	25.5	2.6
1983	1985.5	1250.1	168.0	61.7	503.4	121.3	22.7	2.2
1984	2225.5	1388.2	185.0	75.9	584.4	133.6	28.1	2.3
1985	2369.5	1490.1	196.6	71.1	630.4	143.2	30.0	3.4
1986	2465.3	1578.2	204.6	76.2	664.6	150.3	28.3	5.5
1987	2642.5	1685.5	216.8	94.2	695.8	155.3	28.3	6.5
1988	2874.5	1825.3	233.8	104.0	760.4	163.4	33.3	5.4
1989	3020.8	1934.8	248.2	101.2	813.4	175.9	39.3	5.3
1990	3161.2	2037.5	263.5	98.5	852.1	187.9	44.6	5.6
1991	3231.8	2071.1	285.7	88.6	862.7	192.1	47.7	5.5
1992	3377.1	2188.7	302.5	94.4	921.5	201.2	51.7	6.9
1993	3535.3	2271.0	319.3	108.0	950.4	213.2	46.9	5.9
1994	3816.5	2398.7	350.7	132.4	1008.5	225.5	57.3	6.5
1995	4041.4	2524.6	358.7	140.3	1049.5	238.0	57.5	6.1
1996	4296.1	2667.7	371.7	152.9	1132.4	251.3	62.9	9.0
1997	4608.4	2862.6	388.9	161.4	1209.8	269.0	72.9	10.4
1998	4873.7	3093.8	402.9	158.7	1311.6	292.8	82.2	8.9
1999	5169.9	3310.0	424.6	171.4	1392.9	312.4	80.6	11.1
2000	5513.0	3597.3	449.9	170.2	1506.4	338.4	85.7	11.2
2001	5471.2	3584.6	445.0	111.2	1728.2	450.7	91.1	14.0
2002	5538.9	3542.0	472.9	97.1	1812.5	483.1	105.5	15.2
2003	5724.5	3595.7	495.8	132.9	1911.9	532.2	111.4	19.8
2004	6107.9	3762.8	530.9	187.0	2079.1	599.1	125.4	20.1
2005	6532.1	3930.3	573.2	271.9	2218.8	664.7	130.2	21.8
2006	6988.0	4129.3	610.1	307.7	2440.1	747.4	147.0	22.7
2007	7203.9	4305.3	632.5	293.8	2513.9	827.5	157.6	19.8
2008	7256.8	4358.0	632.7	227.4	2632.4	843.4	157.9	15.0
2009	6859.8	4088.4	605.9	177.8	2466.4	805.4	145.4	21.0
2010	7238.7	4158.7	633.0	220.6	2546.2	816.6	150.7	23.0
2011	7592.3	4363.4	670.6	228.8	2751.6	845.9	158.7	25.5
2012	8011.9	4593.3	690.4	266.7	2909.8	892.6	167.5	27.3
2013	8316.8	4747.4	724.9	284.6	3015.6	919.6	175.8	29.3
2014	8641.0	4995.8	745.2	316.2	3146.9	971.8	180.6	26.6

The Balance Sheet data in the Integrated Macroeconomic Accounts, Table S.5.A, list end of year data on asset holdings for the Nonfinancial Corporate Business Sector (our Sector 1) for the years 1960-2014, which we convert into beginning of the year data for the years 1961-2015. Table A4 below lists the Sector 1 beginning of the year data for the following the following five asset classes: Real estate ($V_{R1}{}^t$); Equipment ($V_{EQ1}{}^t$); Intellectual property products ($V_{IP1}{}^t$); Inventories ($V_{I1}{}^t$) and Currency and Deposits (Money) ($V_{M1}{}^t$). Table S.4.A in the Integrated Macroeconomic Accounts lists end of year data for the Nonfinancial Noncorporate Business Sector (our Sector 2) for the years 1960-2014, which we again convert into beginning of the year data for the years 1961-2015. This IMA Table S.4.A provides data on 6 asset classes for Sector 2 (holdings of real estate are split up into holdings of Residential real estate $V_{RR}{}^t$ and of Nonresidential real estate $V_{RN}{}^t$) and these estimates are also listed in Table A4 below. The units are in billions of dollars.

We will obtain estimates for the starting stocks for 1960 for the first three asset classes later but we are able to obtain estimates for 1960 for inventories and money by using the Capital Accounts and the Revaluation Accounts in IMA Tables S.4.A and S.5.A. From Table S.5.A, we find that the change in inventories for 1960 was 2.1 billion dollars and from the revaluation account, we find the entry 0.4. Thus the implied value of inventory stocks at the beginning of 1960 for Sector 1 is (approximately) equal to the end of 1960 value of inventory stocks 89.9 less 2.1 less 0.4 which equals 87.4. Also using IMA Table S.5.A, we find that the net acquisition of currency and deposits for Sector 1 in 1960 was 0.6 billion dollars. Thus the implied value of holdings of currency and deposits for Sector 1 at the beginning of 1960 is equal to the end of 1960 holdings less 0.6. Finally, IMA Table S.5.A lists the value of revaluation for real estate in 1960 as −2.7 billion dollars. We will assume that investment in real estate was approximately equal to real estate depreciation and estimate the beginning of the year value of real estate for 1960 as the end of 1960 value plus 2.7. A similar set of computations was undertaken to obtain approximate beginning of 1960 holdings of inventories, currency and deposits and real estate for Sector 2, except that the information in IMA Table S.4.A was used in place of Table S.5.A information. The resulting estimates for beginning of the year asset holdings are listed in Table A4.

Table A4: Beginning of the Year IMA Asset Values for Sector 1: Real Estate V_{RE1}^{t}, Equipment V_{EQ1}^{t}, Intellectual Property Products V_{IP1}^{t}, Inventory Stocks V_{I1}^{t}, Currency and Deposits V_{M1}^{t}, and for Sector 2: Residential Real Estate V_{RR2}^{t}, Nonresidential Real Estate Real Estate V_{RN2}^{t}, Equipment V_{EQ2}^{t}, Intellectual Property Products V_{IP2}^{t}, Inventory Stocks V_{I2}^{t} and Currency and Deposits V_{M2}^{t}

Year	V_{RE1}	V_{EQ1}	V_{IP1}	V_{I1}	V_{M1}	V_{RR2}	V_{RN2}	V_{EQ2}	V_{IP2}	V_{I2}	V_{M2}
1960	355.4			87.4	31.0	154.2	184.3			34.1	18.7
1961	352.7	141.9	25.2	89.9	31.6	163.6	185.5	45.5	5.2	35.0	18.0
1962	362.5	145.1	27.2	91.6	36.2	176.3	193.8	45.4	5.5	36.6	18.2
1963	372.0	151.5	29.1	96.8	40.6	189.3	202.4	46.2	5.7	38.6	18.2
1964	381.3	158.5	31.6	101.5	40.1	192.1	213.3	47.6	6.0	36.2	18.0
1965	399.4	168.4	34.2	107.9	40.7	204.2	226.5	49.6	6.2	35.1	18.1
1966	424.0	182.2	37.5	117.6	43.1	215.2	243.2	52.4	6.5	39.6	18.2
1967	454.0	204.2	41.6	133.0	42.1	234.1	259.5	56.8	6.7	40.7	18.2
1968	483.2	225.2	46.8	143.3	45.8	247.4	275.5	60.6	7.0	40.8	18.3
1969	524.9	249.7	52.5	153.2	48.5	275.6	293.7	64.8	7.3	44.2	18.5
1970	580.4	276.2	59.3	167.9	48.3	297.8	311.2	70.0	7.8	47.9	18.6
1971	638.0	303.4	65.3	176.1	50.5	316.6	331.5	75.7	8.1	46.8	20.1
1972	707.0	324.8	69.7	187.1	53.7	356.0	363.7	80.4	8.2	53.6	21.8
1973	775.7	350.0	75.3	202.4	59.4	406.7	405.4	85.1	8.3	64.4	23.7
1974	883.3	388.3	84.0	240.9	66.7	469.2	483.6	94.5	8.5	81.9	29.9
1975	1062.9	478.8	95.6	305.8	73.6	536.6	556.1	114.5	9.0	76.5	31.5
1976	1170.9	550.2	103.6	307.2	85.4	578.7	618.3	127.4	9.3	80.1	32.4
1977	1292.1	608.3	113.3	340.6	95.6	633.7	707.4	139.1	9.7	78.7	35.8
1978	1430.7	686.1	124.8	376.5	108.3	723.9	788.8	153.8	10.0	86.2	41.1
1979	1620.8	782.6	139.7	435.5	120.0	823.2	919.5	174.0	11.0	111.3	47.7
1980	1860.2	905.8	159.8	513.8	130.1	956.2	1077.2	202.1	12.2	130.9	56.4
1981	2112.6	1053.1	182.8	576.7	133.9	1097.6	1216.2	227.6	13.7	134.1	62.2
1982	2397.0	1170.4	209.6	626.6	125.6	1194.4	1291.2	254.0	15.3	128.3	66.0
1983	2546.3	1239.0	234.8	618.5	142.2	1281.9	1307.8	265.3	16.6	133.6	72.1
1984	2616.9	1275.7	260.7	639.6	174.5	1361.2	1343.6	268.1	17.9	130.0	84.2
1985	2755.2	1341.3	290.4	708.6	185.7	1474.0	1315.4	275.5	19.9	137.0	92.6
1986	2872.9	1416.4	319.8	720.6	211.9	1603.3	1308.9	283.7	22.0	135.9	112.4
1987	2956.9	1491.4	348.0	714.9	232.8	1735.6	1319.2	294.6	24.4	124.5	116.7
1988	3096.1	1552.9	382.0	771.5	239.9	1819.7	1388.7	303.7	28.1	129.5	115.6
1989	3297.0	1635.0	414.9	833.3	255.5	1914.6	1474.1	319.7	31.7	135.5	126.7
1990	3446.5	1718.9	452.8	876.8	256.0	1997.9	1559.2	333.5	35.7	139.5	129.3
1991	3433.1	1813.3	492.9	909.8	256.2	2026.6	1560.8	342.2	39.4	144.8	134.2
1992	3205.3	1861.3	532.7	894.9	267.8	2031.6	1490.2	343.1	42.9	133.1	138.6
1993	2947.6	1915.6	568.8	910.4	261.4	2037.3	1422.2	343.3	46.2	141.5	150.9
1994	2933.3	1994.4	603.7	942.9	296.7	2105.2	1442.2	349.6	49.4	139.9	157.5
1995	3104.9	2106.5	648.3	1016.2	314.1	2198.2	1509.1	362.1	52.8	146.7	173.4
1996	3223.0	2249.1	700.1	1079.0	323.8	2299.7	1561.7	377.3	56.6	143.4	191.3
1997	3260.0	2368.6	753.8	1104.5	346.9	2383.5	1580.1	393.4	59.9	180.1	214.0
1998	4021.9	2477.4	824.2	1147.8	365.2	2567.3	1819.7	405.8	64.6	182.0	247.1
1999	4529.7	2582.5	892.2	1174.3	384.9	2724.5	1976.6	420.1	72.0	168.0	293.9
2000	4715.6	2720.5	986.6	1258.5	459.7	2973.7	2053.3	433.9	83.5	174.9	352.1
2001	5363.4	2888.8	1081.1	1340.0	522.7	3290.4	2260.9	453.2	96.4	184.8	428.6
2002	5279.3	2961.3	1119.5	1273.0	469.2	3552.1	2247.9	470.2	105.3	174.7	436.5
2003	5608.8	2975.8	1144.4	1312.2	472.1	3901.4	2314.6	485.5	115.5	183.0	453.7
2004	5814.6	3006.1	1195.9	1360.4	605.1	4305.5	2436.2	501.8	125.9	196.2	504.4
2005	7050.8	3145.4	1242.2	1491.6	661.3	4998.4	2896.7	536.0	135.3	206.3	598.1
2006	7923.8	3297.8	1322.0	1623.9	781.9	5811.0	3238.5	574.4	147.6	218.4	698.3
2007	8892.1	3513.6	1401.1	1730.5	697.1	5894.1	3579.3	620.5	159.5	222.8	793.2
2008	10381.4	3673.4	1492.3	1871.7	634.7	5550.0	4044.7	659.4	170.1	247.3	875.0
2009	9360.1	3857.2	1564.1	1810.5	420.7	4753.4	3712.3	699.6	178.6	239.6	877.6
2010	6767.8	3793.1	1600.7	1704.6	675.2	4275.6	3023.0	696.3	183.2	222.5	887.7
2011	7545.7	3853.6	1669.1	1872.7	823.8	4416.1	3255.2	709.2	189.9	256.9	887.9
2012	8230.6	4008.0	1746.9	2009.6	862.1	4608.0	3392.8	740.7	196.6	291.3	918.5
2013	8799.4	4139.4	1819.4	2100.0	850.4	4980.5	3706.9	772.6	204.7	289.3	987.8
2014	10205.8	4269.8	1920.0	2152.9	1004.4	5550.4	4175.4	804.9	214.6	287.1	1011.4
2015	11313.6	4442.8	2002.7	2197.7	1020.1	5827.7	4525.7	838.2	223.3	303.3	1071.6

A5. Price and Volume Data for Sector 1 Assets from the BEA Fixed Asset Tables

Our next task is to match up the IMA data on the value of asset holdings in our two sectors with corresponding price (or volume) data. In order to accomplish this task, we turn to the Bureau of Economic Analysis (2015b) Fixed Asset Tables.[54] These tables provide end of year information on sectoral capital stocks for the years 1959-2014 which we convert to beginning of the year estimates for the years 1960-2015. For Sector 1, we use the Fixed Asset Table 4.1: Current-Cost Net Stock of Private Nonresidential Fixed Assets by Industry Group and Legal Form of Organization. We used the Corporate Nonfinancial section of this Table and downloaded the current cost value for the following assets for the beginning of years 1960 through to 2015: Equipment ($V_{EQ1}{}^{t}$); Nonresidential Structures ($V_{SN1}{}^{t}$) and Intellectual Property Products ($V_{IP1}{}^{t}$). For information on Sector 1 holdings of residential structure assets, we turned to the BEA Fixed Asset Table 5.1: Current-Cost Net Stock of Residential Fixed Assets by Type of Owner, Legal Form of Organization and Tenure Group. This Table has information on corporate holdings of Residential Fixed Assets ($V_{SR1}{}^{t}$) for the private corporate sector assets for the beginning of years 1960 through to 2015. We assume that the financial corporate sector does not hold any residential structure assets. The Fixed Asset Tables estimates for these Sector 1 reproducible assets, $V_{EQ1}{}^{t}$, $V_{SN1}{}^{t}$, $V_{SR1}{}^{t}$ and $V_{IP1}{}^{t}$ are listed in Table A5 below. It can be seen that the IMA estimates for Sector 1 Equipment stocks listed in Table A4 are very close to the corresponding FA estimates listed in Table A5 and the IPP stocks listed in Table A4 are identical to the corresponding FA estimates listed in Table A5. In what follows, when we have alternative estimates for a value series from the IMA and FA Tables, we will use the Fixed Asset estimates since they are generally more detailed and have consistent price deflators associated with them (whereas there are no price deflators associated with the Integrated Macroeconomic Accounts data).

The beginning of the year value of Real Estate in Sector 1, $V_{RE1}{}^{t}$, is listed in Table A4 above while the value of residential and nonresidential structures, $V_{SR1}{}^{t}$ and $V_{SN1}{}^{t}$, are listed in Table A5 below. Estimates for the beginning of the year t value of all land in Sector 1, $V_{L1}{}^{t}$, can be obtained by subtracting structure values from the corresponding real estate value; i.e., define $V_{L1}{}^{t} \equiv V_{RE1}{}^{t} - V_{SN1}{}^{t} - V_{SR1}{}^{t}$ for t = 1960,...,2015. The new beginning of the year asset values for Sector 1, $V_{E1}{}^{t}$, $V_{SN1}{}^{t}$, $V_{SR1}{}^{t}$, $V_{IP}{}^{t}$ and $V_{L1}{}^{t}$, are listed in Table A5 below (along with our IMA based asset series for inventories and money, $V_{I1}{}^{t}$ and $V_{M1}{}^{t}$). To see whether the resulting land values are reasonable, we also calculate the ratio of land value to structure value in year t as $R_{VL/VS}{}^{t} \equiv V_{L1}{}^{t}/(V_{SN1}{}^{t} + V_{SR1}{}^{t})$. This ratio series is also listed in Table A5.

[54] The data for the Fixed Asset Tables were last revised on August 31, 2015.

Table A5: Beginning of the Year Asset Values for Sector 1: Equipment $V_{EQ1}{}^t$, Nonresidential Structures $V_{SN1}{}^t$, Intellectual Property Products $V_{IP1}{}^t$, Inventory Stocks $V_{I1}{}^t$, Currency and Deposits $V_{M1}{}^t$, Land $V_{L1}{}^t$ and the Land to Structure Value Ratio, $R_{VL/VS}{}^t$

Year	$V_{EQ1}{}^t$	$V_{SR1}{}^t$	$V_{SN1}{}^t$	$V_{IP1}{}^t$	$V_{I1}{}^t$	$V_{M1}{}^t$	$V_{L1}{}^t$	$R_{VL/VS}{}^t$
1960	136.3	4.7	256.9	23.3	87.4	31.0	93.8	0.3586
1961	141.8	5.2	258.7	25.2	89.9	31.6	88.8	0.3365
1962	145.0	5.8	264.4	27.2	91.6	36.2	92.3	0.3416
1963	151.4	6.4	270.1	29.1	96.8	40.6	95.5	0.3454
1964	158.3	6.9	275.6	31.6	101.5	40.1	98.8	0.3497
1965	168.3	7.8	288.3	34.2	107.9	40.7	103.3	0.3489
1966	182.1	8.5	305.4	37.5	117.6	43.1	110.1	0.3507
1967	204.0	9.7	325.8	41.6	133.0	42.1	118.5	0.3532
1968	225.0	10.7	348.9	46.8	143.3	45.8	123.6	0.3437
1969	249.5	11.7	380.8	52.5	153.2	48.5	132.4	0.3373
1970	276.0	12.5	417.6	59.3	167.9	48.3	150.3	0.3495
1971	303.2	13.1	459.8	65.3	176.1	50.5	165.1	0.3491
1972	324.5	14.8	510.3	69.7	187.1	53.7	181.9	0.3464
1973	349.8	16.7	554.0	75.3	202.4	59.4	205.0	0.3592
1974	388.1	19.2	630.7	84.0	240.9	66.7	233.4	0.3591
1975	478.5	21.8	772.7	95.6	305.8	73.6	268.4	0.3378
1976	549.8	23.4	838.6	103.6	307.2	85.4	308.9	0.3584
1977	607.9	25.1	916.5	113.3	340.6	95.6	350.5	0.3722
1978	685.6	28.8	1008.0	124.8	376.5	108.3	393.9	0.3799
1979	782.1	32.1	1139.8	139.7	435.5	120.0	448.9	0.3831
1980	905.2	36.4	1307.9	159.8	513.8	130.1	515.9	0.3838
1981	1052.3	40.5	1485.3	182.8	576.7	133.9	586.8	0.3846
1982	1169.6	43.7	1696.9	209.6	626.6	125.6	656.4	0.3771
1983	1238.1	46.2	1795.4	234.8	618.5	142.2	704.7	0.3827
1984	1274.7	47.8	1825.9	260.7	639.6	174.5	743.2	0.3966
1985	1340.2	49.9	1925.8	290.4	708.6	185.7	779.5	0.3945
1986	1415.3	52.5	2006.7	319.8	720.6	211.9	813.7	0.3952
1987	1490.2	56.3	2056.9	348.0	714.9	232.8	843.7	0.3993
1988	1551.6	58.5	2153.7	382.0	771.5	239.9	883.9	0.3996
1989	1633.6	60.5	2287.8	414.9	833.3	255.5	948.7	0.4040
1990	1717.4	61.5	2411.8	452.8	876.8	256.0	973.2	0.3935
1991	1811.8	62.6	2532.3	492.9	909.8	256.2	838.2	0.3230
1992	1859.7	63.8	2566.9	532.7	894.9	267.8	574.6	0.2184
1993	1913.8	66.2	2652.2	568.8	910.4	261.4	229.2	0.0843
1994	1992.5	67.9	2787.2	603.7	942.9	296.7	78.2	0.0274
1995	2104.4	70.8	2931.0	648.3	1016.2	314.1	103.1	0.0343
1996	2246.9	73.4	3079.6	700.1	1079.0	323.8	70.0	0.0222
1997	2366.3	77.0	3224.1	753.8	1104.5	346.9	–41.1	–0.0125
1998	2475.0	82.3	3416.4	824.2	1147.8	365.2	523.2	0.1495
1999	2580.1	88.4	3598.2	892.2	1174.3	384.9	843.1	0.2287
2000	2718.0	93.9	3771.1	986.6	1258.5	459.7	850.6	0.2201
2001	2886.2	100.2	4030.3	1081.1	1340.0	522.7	1232.9	0.2985
2002	2958.6	106.8	4303.2	1119.5	1273.0	469.2	869.3	0.1971
2003	2973.0	114.0	4526.0	1144.4	1312.2	472.1	968.8	0.2088
2004	3003.3	121.7	4717.0	1195.9	1360.4	605.1	975.9	0.2017
2005	3142.5	134.4	5247.3	1242.2	1491.6	661.3	1669.1	0.3101
2006	3294.6	151.1	5883.5	1322.0	1623.9	781.9	1889.2	0.3131
2007	3510.2	162.6	6429.6	1401.1	1730.5	697.1	2299.9	0.3489
2008	3669.9	168.4	6796.8	1492.3	1871.7	634.7	3416.2	0.4905
2009	3853.6	169.7	7287.2	1564.1	1810.5	420.7	1903.2	0.2552
2010	3789.7	166.9	6901.5	1600.7	1704.6	675.2	–300.6	–0.0425
2011	3850.4	169.6	7123.8	1669.1	1872.7	823.8	252.3	0.0346
2012	4004.6	169.1	7425.5	1746.9	2009.6	862.1	636.0	0.0837
2013	4136.0	174.4	7678.2	1819.4	2100.0	850.4	946.8	0.1206
2014	4266.4	181.6	7976.6	1920.0	2152.9	1004.4	2047.6	0.2510
2015	4439.5	187.4	8227.1	2002.7	2197.7	1020.1	2899.1	0.3445

It can be seen that the land to structure value ratio trends upwards from 35.9% in 1960 to 40.4% in 1989 but after 1990, the ratio becomes highly erratic. Thus while our estimated land values V_{L1}^t for the corporate nonfinancial sector look reasonable for the years 1960-1990, they are not reasonable after 1990 and in fact, the land estimates are negative for 1997 and 2010. The problem is with the IMA estimated real estate values for the period 1991-2015. They are not plausible and hence we will have to generate alternative estimates for the value of land in the corporate sector for the post 1990 period.

We obtained a quantity or volume index Q_{SR1}^t that corresponds to the Sector 1 estimated asset values for residential housing V_{SR1}^t from the following BEA Fixed Asset Table 5.2: Chain-Type Quantity Indexes for Net Stock of Residential Fixed Assets by Type of Owner, Legal Form of Organization, and Tenure Group; Index Numbers 2009 =100; Last Revised on August 31, 2015. In a similar fashion, we obtained quantity indexes Q_{E1}^t, Q_{SN}^t, and Q_{IP}^t that correspond to the Sector 1 asset value series for equipment, nonresidential structures and intellectual property products, V_{EQ1}^t, V_{SN}^t and V_{IP}^t, from the following BEA Fixed Asset Table 4.2: Chain-Type Quantity Indexes for Net Stock of Private Nonresidential Fixed Assets by Industry Group and Legal Form of Organization; Index Numbers 2009 =100; Last Revised on August 31, 2015. The quantity indexes were normalized so that they equalled the corresponding value for 1960 and then asset price indexes for Sector 1, P_{SR1}^t, P_{EQ1}^t, P_{SN}^t and P_{IP}^t, were defined as the value series divided by the corresponding normalized quantity indexes. These Sector 1 price and quantity indexes are listed in Table A6 below.

Table A6: Beginning of Year Sector 1 Asset Price and Quantity Indexes for Residential Structures, Nonresidential Structures, Equipment and Intellectual Property Products, 1960-2015

Year	P_{SR1}^t	P_{SN1}^t	P_{E1}^t	P_{IP1}^t	Q_{SR1}^t	Q_{SN1}^t	Q_{EQ1}^t	Q_{IP1}^t
1960	1.00000	1.00000	1.00000	1.00000	4.7	256.9	136.3	23.3
1961	1.00206	0.98588	1.00355	1.01176	5.2	262.4	141.3	24.9
1962	1.01592	0.98763	0.99754	1.01902	5.7	267.7	145.4	26.7
1963	1.00953	0.98892	1.00154	1.02433	6.3	273.1	151.2	28.4
1964	0.99698	0.99004	1.00317	1.03855	6.9	278.4	157.8	30.4
1965	1.03232	1.01117	1.01129	1.05710	7.6	285.1	166.4	32.4
1966	1.06015	1.03803	1.01714	1.07634	8.0	294.2	179.0	34.8
1967	1.11223	1.06883	1.04527	1.09603	8.7	304.8	195.2	38.0
1968	1.15953	1.10745	1.07848	1.13687	9.2	315.0	208.6	41.2
1969	1.24295	1.17050	1.11983	1.18170	9.4	325.3	222.8	44.4
1970	1.28620	1.24165	1.15911	1.24686	9.7	336.3	238.1	47.6
1971	1.31199	1.32472	1.21217	1.31070	10.0	347.1	250.1	49.8
1972	1.42958	1.42991	1.24713	1.35349	10.4	356.9	260.2	51.5
1973	1.53289	1.50938	1.27837	1.40395	10.9	367.0	273.6	53.6
1974	1.69785	1.66761	1.32681	1.50667	11.3	378.2	292.5	55.8
1975	1.86306	1.98535	1.54116	1.66015	11.7	389.2	310.5	57.6
1976	1.98519	2.10964	1.71774	1.75909	11.8	397.5	320.1	58.9
1977	2.12320	2.25891	1.83705	1.85078	11.8	405.7	330.9	61.2
1978	2.41638	2.43397	1.97171	1.94418	11.9	414.1	347.7	64.2
1979	2.66017	2.67798	2.11877	2.07570	12.1	425.6	369.1	67.3
1980	2.95679	2.97842	2.30858	2.23968	12.3	439.1	392.1	71.3
1981	3.25105	3.27166	2.57218	2.42773	12.5	454.0	409.1	75.3
1982	3.47862	3.61495	2.75114	2.60867	12.6	469.4	425.1	80.3
1983	3.67471	3.71752	2.85464	2.74508	12.6	483.0	433.7	85.5
1984	3.76951	3.70400	2.88562	2.85988	12.7	493.0	441.7	91.2
1985	3.88698	3.80207	2.92496	2.94871	12.8	506.5	458.2	98.5
1986	4.02935	3.84824	2.98629	3.01198	13.0	521.5	473.9	106.2
1987	4.24170	3.86884	3.07014	3.06362	13.3	531.7	485.4	113.6
1988	4.35034	3.98019	3.14691	3.18692	13.4	541.1	493.1	119.9
1989	4.46036	4.15986	3.25102	3.29282	13.6	550.0	502.5	126.0
1990	4.49657	4.31546	3.34666	3.39258	13.7	558.9	513.2	133.5
1991	4.55120	4.43130	3.46268	3.48113	13.8	571.5	523.2	141.6
1992	4.60338	4.42243	3.51007	3.56516	13.9	580.4	529.8	149.4
1993	4.74738	4.51761	3.54698	3.62623	13.9	587.1	539.6	156.9
1994	4.84243	4.68983	3.58370	3.67309	14.0	594.3	556.0	164.4
1995	4.99306	4.87925	3.63614	3.77750	14.2	600.7	578.7	171.6
1996	5.08749	5.04435	3.69535	3.87544	14.4	610.5	608.0	180.7
1997	5.25605	5.18356	3.69702	3.91893	14.6	622.0	640.1	192.3
1998	5.48564	5.38919	3.65923	3.98567	15.0	633.9	676.4	206.8
1999	5.77002	5.56063	3.60960	4.03841	15.3	647.1	714.8	220.9
2000	5.97686	5.71582	3.58185	4.16777	15.7	659.8	758.8	236.7
2001	6.19827	5.96804	3.57584	4.27208	16.2	675.3	807.1	253.1
2002	6.43568	6.24658	3.53538	4.22819	16.6	688.9	836.9	264.8
2003	6.68906	6.50409	3.49846	4.22379	17.0	695.9	849.8	270.9
2004	6.93515	6.72707	3.47506	4.30408	17.5	701.2	864.2	277.9
2005	7.43569	7.44507	3.55602	4.34642	18.1	704.8	883.7	285.8
2006	8.12293	8.30515	3.61445	4.44775	18.6	708.4	911.5	297.2
2007	8.54570	8.97979	3.69976	4.52203	19.0	716.0	948.8	309.8
2008	8.69880	9.34848	3.73418	4.62194	19.4	727.0	982.8	322.9
2009	8.67627	9.85206	3.83898	4.66315	19.6	739.7	1003.8	335.4
2010	8.52433	9.26343	3.82863	4.67157	19.6	745.0	989.8	342.6
2011	8.68307	9.54139	3.87700	4.73617	19.5	746.6	993.1	352.4
2012	8.66685	9.90328	3.95346	4.81426	19.5	749.8	1012.9	362.9
2013	8.91113	10.15674	3.96659	4.86895	19.6	756.0	1042.7	373.7
2014	9.22182	10.45461	3.97901	4.97159	19.7	763.0	1072.2	386.2
2015	9.43697	10.65465	4.00924	5.00431	19.9	772.2	1107.3	400.2

A6. Price and Volume Data for Sector 2 Assets from the BEA Fixed Asset Tables

We will use the BEA Fixed Asset Tables to obtain information on the value, price and quantity of reproducible assets used in Sector 2. Again, we will convert end of year estimates for the years 1959-2014 into beginning of the year estimates for the years 1960-2015. Information on the value of residential structures used in Sector 2 can be obtained from the BEA Fixed Asset Table 5.1: Current-Cost Net Stock of Private Residential Fixed Assets by Industry Group and Legal Form of Organization. The noncorporate private business sector holdings of residential structure assets are decomposed into three components: (i) Sole proprietorships and partnerships; (ii) Nonprofit institutions and (iii) households. We use only the residential structure asset holdings that correspond to sector (i) and denote the Sector 2 beginning of year t residential structure asset value as $V_{SR2}{}^{t}$ for t =1960,...,2015. These estimates are listed in Table A7.

Recall the BEA Fixed Asset Table 4.1: Current-Cost Net Stock of Private Nonresidential Fixed Assets by Industry Group and Legal Form of Organization. We can obtain Sector 2 capital stock values from this Table for equipment, nonresidential structures and intellectual property products for the years 1960-2015 but the data are listed by five classes of noncorporate legal form of organization: (i) Sole proprietorships; (ii) Partnerships; (iii) Nonprofit institutions; (iv) Households and (v) Tax exempt cooperatives. Sectors (i), (ii) and (v) make up our Nonfinancial Noncorporate Business Sector 2. We relabel these subsectors of the noncorporate sector as sectors 2a, 2b and 2c. The beginning of year t values for the stocks of equipment, nonresidential structures and intellectual property products in these three subsectors are denoted by $V_{EQ2a}{}^{t}$, $V_{SN2a}{}^{t}$, $V_{IP2a}{}^{t}$, $V_{EQ2b}{}^{t}$, $V_{SN2b}{}^{t}$, $V_{IP2b}{}^{t}$ and $V_{EQ2c}{}^{t}$, $V_{SN2c}{}^{t}$, $V_{IP2c}{}^{t}$. These estimates (in billions of dollars) are listed in Table A7.[55]

Chained Fisher residential structure indexes for the Noncorporate Sector $Q_{SR2}{}^{t}$ that correspond to the beginning of year t value of residential structures in Sector 2, $V_{SR2}{}^{t}$, can be found in BEA Fixed Asset Table 5.2: Chain-Type Quantity Indexes for the Net Stock of Private Nonresidential Fixed Assets by Industry Group, Legal Form of Organization and Tenure Group. We normalized these quantity indexes so that $Q_{SR2}{}^{1960}$ equals the corresponding 1960 value, $V_{SR2}{}^{1960}$, and then the Sector 2 residential structure price indexes $P_{SR2}{}^{t}$ were defined as $V_{SR2}{}^{t}/Q_{SR2}{}^{t}$ for t = 1960,...,2015. These price indexes $P_{SR2}{}^{t}$ are listed in Table A8.

Chained Fisher quantity indexes that correspond to the Sector 2 reproducible asset value series, $V_{EQ2a}{}^{t}$, $V_{SN2a}{}^{t}$, $V_{IP2a}{}^{t}$, $V_{EQ2b}{}^{t}$, $V_{SN2b}{}^{t}$, $V_{IP2b}{}^{t}$, $V_{EQ2c}{}^{t}$ and $V_{SN2c}{}^{t}$, can be obtained from BEA Fixed Asset Table 4.2: Chain-Type Quantity Indexes for the Net Stock of Private Nonresidential Fixed Assets by Industry Group and Legal Form of Organization. We normalized these quantity indexes to equal their value counterparts at the beginning of 1960. Denote the resulting normalized quantity indexes by $Q_{EQ2a}{}^{t}$, $Q_{SN2a}{}^{t}$, $Q_{IP2a}{}^{t}$, $Q_{EQ2b}{}^{t}$, $Q_{SN2b}{}^{t}$, $Q_{IP2b}{}^{t}$, $Q_{EQ2c}{}^{t}$ and $Q_{SN2c}{}^{t}$ and define the corresponding price indexes by dividing each value series by its quantity counterpart; e.g., $P_{EQ2a}{}^{t} \equiv V_{EQ2a}{}^{t}/Q_{EQ2a}{}^{t}$, $P_{EQ2b}{}^{t} \equiv V_{EQ2b}{}^{t}/Q_{EQ2b}{}^{t}$, etc. These price indexes are listed in Table A8 below. In the following section, we will find it useful to have an aggregate index of the quantities of nonresidential structures that are used in the three subsectors of Sector 2. The chained Fisher quantity index of $Q_{SN2a}{}^{t}$, $Q_{SN2b}{}^{t}$ and $Q_{SN2c}{}^{t}$ for year t is denoted by $Q_{SN2}{}^{t}$ and is listed in Table A7.

[55] The value of Intellectual Property Products in the Tax Exempt Cooperative Sector, $V_{IP2c}{}^{t}$, was negligible so we simply set this variable equal to 0. Hence it does not appear in Table A7.

Table A7: Sector 2 Beginning of Year Value of Residential Structures V_{SR2}^t and Values of Equipment, Nonresidential Structures and Intellectual Property Products, V_{E2i}^t, V_{SN2i}^t, V_{IP2i}^t, for Subsectors i = a, b, c where a = Sole Proprietors, b = Partnerships and c = Tax Exempt Cooperatives and Sector 2 Quantity of Nonresidential Structures Q_{SN2}^t

Year	V_{SR2}	V_{EQ2a}	V_{SN2a}	V_{IP2a}	V_{EQ2b}	V_{SN2b}	V_{IP2b}	V_{EQ2c}	V_{SN2c}	Q_{SN2}
1960	45.0	27.2	32.3	2.3	14.5	19.7	2.6	1.7	3.2	55.2
1961	45.6	27.4	32.7	2.4	14.6	20.1	2.7	1.8	3.2	55.5
1962	46.3	27.2	34.0	2.5	14.6	21.0	2.9	1.8	3.3	57.8
1963	47.0	27.7	35.6	2.6	14.9	22.2	3.1	1.9	3.5	60.0
1964	46.9	28.4	37.2	2.7	15.4	23.4	3.2	1.9	3.7	62.6
1965	49.5	29.5	39.8	2.9	16.1	25.3	3.3	2.0	3.9	66.5
1966	51.3	31.2	42.3	3.0	17.1	27.5	3.5	2.0	4.1	70.4
1967	54.7	33.7	45.4	3.1	18.8	30.0	3.6	2.2	4.3	74.1
1968	57.5	35.9	48.1	3.3	20.1	32.3	3.8	2.3	4.8	76.8
1969	66.5	38.1	52.4	3.4	21.6	35.4	3.9	2.5	5.2	81.3
1970	75.7	40.9	57.1	3.6	23.5	39.2	4.2	2.7	5.7	85.8
1971	84.2	44.0	62.3	3.9	25.5	43.3	4.4	2.9	6.4	90.2
1972	100.1	46.6	69.4	3.9	27.1	49.1	4.4	3.1	7.2	98.1
1973	119.9	49.3	75.7	4.0	28.4	54.6	4.5	3.3	7.8	105.4
1974	143.1	55.4	84.2	4.1	30.9	62.3	4.6	3.5	9.2	112.7
1975	168.4	67.4	99.4	4.3	37.0	74.3	4.9	4.2	11.2	114.2
1976	182.0	75.1	105.5	4.5	40.6	79.0	5.0	5.1	12.7	111.3
1977	197.3	82.5	113.6	4.7	43.6	85.3	5.3	5.8	14.2	111.8
1978	228.5	91.6	126.5	4.8	47.5	95.0	5.4	6.7	15.6	115.8
1979	257.5	104.4	143.5	5.3	53.5	108.0	5.9	7.1	17.3	121.4
1980	296.1	122.0	166.0	5.9	61.9	127.8	6.6	8.2	20.0	127.9
1981	333.3	136.7	190.2	6.7	70.5	150.3	7.4	9.4	22.2	133.6
1982	362.9	152.2	218.0	7.5	79.7	179.3	8.3	10.0	24.1	141.5
1983	387.8	158.1	232.7	8.2	84.7	198.2	8.9	10.1	25.1	145.1
1984	406.1	159.1	238.2	8.9	86.3	208.2	9.5	9.9	25.4	147.0
1985	428.4	162.1	252.0	9.9	90.2	229.5	10.5	9.7	25.7	155.7
1986	456.2	163.9	264.6	10.9	95.0	253.8	11.6	10.8	26.6	164.6
1987	496.1	167.5	276.5	12.0	100.3	276.2	12.9	11.4	27.1	169.9
1988	520.0	170.1	290.2	13.8	105.3	301.0	14.9	11.6	28.1	177.4
1989	541.7	177.0	306.4	15.4	112.9	328.8	16.9	11.9	29.6	183.7
1990	553.6	182.5	320.9	17.2	119.3	354.5	19.1	12.5	30.6	189.7
1991	565.9	185.7	331.7	18.9	121.6	371.9	21.1	13.1	31.2	191.2
1992	576.4	185.7	330.7	20.4	121.3	374.1	22.9	13.2	31.7	187.3
1993	596.6	185.9	335.4	21.9	120.3	380.0	24.6	13.5	32.4	186.2
1994	611.2	189.6	346.5	23.5	121.8	394.3	26.2	13.9	33.8	189.3
1995	631.2	197.1	361.4	25.1	125.4	412.3	28.0	14.3	35.0	193.8
1996	654.2	205.4	371.9	26.7	130.3	426.6	30.2	14.8	36.4	195.9
1997	685.6	211.0	383.3	28.0	134.7	441.7	32.2	15.1	37.2	201.3
1998	728.0	217.0	400.3	30.2	139.1	464.2	35.0	15.4	38.6	211.3
1999	777.5	221.3	419.4	32.7	147.5	491.1	40.3	15.7	39.5	222.4
2000	818.2	223.5	436.8	36.0	161.4	518.3	49.2	16.5	41.1	232.9
2001	861.1	224.9	457.6	38.6	180.8	550.9	60.2	17.9	44.3	245.3
2002	906.0	222.3	477.0	38.8	197.5	583.1	69.1	19.4	47.7	258.1
2003	954.9	220.4	490.7	39.1	213.4	610.8	79.2	20.9	50.2	267.7
2004	1004.4	221.0	504.1	40.0	228.0	634.7	89.0	22.4	52.9	275.3
2005	1095.3	229.6	549.1	40.9	251.4	700.9	97.9	24.2	57.8	293.8
2006	1206.8	239.0	605.0	42.7	276.0	783.8	108.6	26.5	62.0	320.0
2007	1291.2	250.2	649.7	44.4	305.5	863.2	119.1	30.1	68.0	340.8
2008	1332.3	259.0	671.8	45.8	331.8	920.6	129.1	33.9	75.0	353.3
2009	1344.1	263.8	697.9	45.6	363.7	989.1	138.7	37.8	82.4	362.0
2010	1320.0	256.5	652.4	45.2	368.3	944.4	144.4	39.7	82.3	341.9
2011	1339.6	255.6	648.5	45.6	384.4	958.3	150.9	42.2	89.7	340.3
2012	1329.4	261.3	658.4	46.2	406.7	990.4	157.5	45.6	97.1	341.6
2013	1362.0	269.7	669.8	47.4	428.7	1021.9	164.8	48.3	103.6	348.2
2014	1403.4	278.7	692.6	49.0	452.4	1069.4	173.2	50.4	108.2	360.1
2015	1434.2	287.1	710.8	50.4	478.4	1111.3	180.7	52.5	114.0	369.5

Table A8: Sector 2 Price Indexes for Beginning of the Year Stocks of Residential Structures P_{SR2}^{t} and Equipment, Nonresidential Structures and Intellectual Property Products, P_{E2i}^{t}, P_{SN2i}^{t}, P_{IP2i}^{t}, for Subsectors i = a, b, c where a = Sole Proprietors, b = Partnerships and c = Tax Exempt Cooperatives

Year	P_{SR2}	P_{EQ2a}	P_{SN2a}	P_{IP2a}	P_{EQ2b}	P_{SN2b}	P_{IP2b}	P_{EQ2c}	P_{SN2c}
1960	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1961	1.00322	1.01163	0.98380	1.02710	1.00276	0.98645	1.02009	1.01952	0.96123
1962	1.00604	1.01225	0.99587	1.03227	1.00356	0.99423	1.05128	0.98845	0.95723
1963	1.00597	1.02337	1.01062	1.04838	1.01143	1.01025	1.09445	1.00429	0.98060
1964	0.99022	1.02885	1.02256	1.07052	1.02148	1.02294	1.11127	0.96406	1.00407
1965	1.02860	1.03764	1.06009	1.14919	1.02501	1.05782	1.14499	0.99836	1.02448
1966	1.05318	1.05016	1.08881	1.18578	1.03428	1.08816	1.21569	0.96861	1.04048
1967	1.10295	1.07732	1.13588	1.22424	1.06424	1.13235	1.25820	1.01226	1.05590
1968	1.14486	1.10838	1.17358	1.32126	1.08865	1.17292	1.35236	1.02169	1.13223
1969	1.22463	1.14228	1.25250	1.37111	1.12486	1.24856	1.39862	1.06849	1.18166
1970	1.26718	1.18518	1.33380	1.45713	1.16491	1.33219	1.51912	1.11438	1.24823
1971	1.29993	1.23618	1.42335	1.58619	1.20955	1.42176	1.61336	1.14825	1.34935
1972	1.40730	1.27184	1.55620	1.59618	1.24267	1.55396	1.64310	1.18893	1.46522
1973	1.50920	1.29919	1.67015	1.66890	1.26794	1.66332	1.72217	1.21845	1.53610
1974	1.66345	1.36475	1.81340	1.74102	1.32105	1.80954	1.79969	1.23599	1.75502
1975	1.83386	1.59685	2.08946	1.87535	1.54649	2.09849	1.96700	1.40684	2.08175
1976	1.94714	1.74644	2.16910	2.01009	1.68271	2.18223	2.05580	1.62070	2.25807
1977	2.08422	1.87851	2.28656	2.09943	1.79656	2.30261	2.17587	1.74702	2.42169
1978	2.36646	2.02212	2.49034	2.16550	1.91806	2.50661	2.24764	1.88330	2.53304
1979	2.59969	2.18559	2.73940	2.32428	2.06992	2.75464	2.39282	1.97375	2.75915
1980	2.88470	2.42249	3.06825	2.43476	2.27015	3.08205	2.53956	2.14544	3.07011
1981	3.17108	2.68367	3.39957	2.61500	2.51792	3.41613	2.72097	2.44572	3.35233
1982	3.39014	2.95041	3.72801	2.74208	2.74125	3.76888	2.87701	2.56654	3.56916
1983	3.59263	3.11869	3.84598	2.87962	2.87440	3.87572	3.01799	2.65308	3.71979
1984	3.68972	3.18592	3.86520	2.96771	2.92180	3.87527	3.11708	2.69221	3.80125
1985	3.80236	3.23344	4.00106	3.08302	2.96473	4.00611	3.23554	2.71602	3.87906
1986	3.93869	3.28979	4.10429	3.17439	3.01575	4.10683	3.31700	2.77902	3.92832
1987	4.14806	3.39435	4.21696	3.23637	3.10079	4.21555	3.40575	2.83122	3.96437
1988	4.25288	3.47166	4.34765	3.36430	3.16859	4.34391	3.54343	2.90505	4.10813
1989	4.35786	3.59731	4.51264	3.44140	3.27544	4.50867	3.64846	2.98171	4.34409
1990	4.38576	3.69808	4.67018	3.54311	3.36365	4.66727	3.76625	3.16871	4.50338
1991	4.43436	3.82321	4.80583	3.67155	3.46804	4.80098	3.89559	3.27994	4.56786
1992	4.49545	3.91158	4.80016	3.74095	3.52803	4.80139	3.97783	3.31314	4.61711
1993	4.63467	3.99472	4.90579	3.78037	3.57880	4.90322	4.03861	3.34850	4.71197
1994	4.71579	4.06822	5.07459	3.84733	3.62926	5.06996	4.10180	3.37160	4.89173
1995	4.86177	4.14617	5.30229	3.93584	3.68148	5.29508	4.19428	3.40926	5.07363
1996	4.95912	4.23191	5.45148	4.04039	3.74066	5.44774	4.30618	3.46553	5.24976
1997	5.11972	4.25369	5.60428	4.09037	3.75162	5.59949	4.35437	3.46361	5.31050
1998	5.34861	4.23988	5.84058	4.15834	3.72326	5.82855	4.42334	3.44244	5.46449
1999	5.62721	4.23712	6.09333	4.19738	3.68448	6.07694	4.46177	3.39956	5.52354
2000	5.81743	4.24053	6.32551	4.34313	3.65912	6.30552	4.60340	3.38416	5.66101
2001	6.02718	4.24940	6.60209	4.46152	3.64930	6.57441	4.72898	3.38234	5.88027
2002	6.24720	4.24548	6.88411	4.45535	3.60973	6.84537	4.69427	3.35951	6.05498
2003	6.48504	4.25084	7.11569	4.47701	3.57435	7.07275	4.70564	3.32908	6.20393
2004	6.70781	4.27299	7.34527	4.53592	3.54548	7.29427	4.76628	3.31047	6.38971
2005	7.20472	4.38847	8.04967	4.57826	3.61582	7.99517	4.80381	3.36621	6.89087
2006	7.87033	4.46846	8.92927	4.66702	3.65908	8.87035	4.89740	3.43602	7.30321
2007	8.29680	4.56653	9.64927	4.75830	3.72594	9.58831	4.98864	3.58851	7.88572
2008	8.47311	4.63593	10.01334	4.84799	3.73727	9.95561	5.07322	3.69537	8.43049
2009	8.51600	4.79341	10.40216	4.89934	3.83061	10.37391	5.11963	3.86463	8.98727
2010	8.38347	4.81550	9.77348	4.90381	3.81660	9.76423	5.11842	3.87729	8.59469
2011	8.56836	4.87262	9.81348	4.95578	3.85265	9.86847	5.16326	3.95051	9.07306
2012	8.55307	4.98518	10.06147	5.02461	3.91711	10.14920	5.21935	4.06543	9.52962
2013	8.80635	5.02204	10.31576	5.08126	3.91497	10.39002	5.27318	4.08370	9.73735
2014	9.06536	5.05720	10.73212	5.17773	3.92846	10.76992	5.36055	4.08181	9.90182
2015	9.23313	5.09619	11.06162	5.20010	3.95821	11.05631	5.38893	4.09376	10.11028

From Table A8, it can be seen that the price of equipment in the three subsectors ends up at 5.10, 3.96 and 4.09 for Sector 2 at the beginning of 2015. The price of nonresidential structures ends up at 11.06, 11.05 and 10.11 at the beginning of 2015. Thus there is some asset price heterogeneity within these three subsectors and some useful information will be lost if we aggregate our reproducible capital stocks (by asset class) across these sectors. Hence, we decided not to aggregate these assets across sectors (which has the disadvantage of making our data for Sector 2 more unwieldy). The asset quantity indexes which correspond to the above price indexes can be obtained by dividing the values in Table A7 by their price index counterparts in Table A8 and so these quantity indexes are not listed.

A7. Real Estate Land Price and Quantity Data Problems

Recall that Estimates for the value, quantity and price of *farm land* in Sectors 1 and 2 ($V_{LF1}{}^t$, $V_{LF2}{}^t$, $Q_{LF1}{}^t$, $Q_{LF2}{}^t$ and $P_{LF1}{}^t = P_{LF2}{}^t \equiv P_{LF}{}^t$) are listed in Table A2 above.

In Section A5 we saw that the IMA real estate values for Sector 1 were not realistic after 1990. We are now in a position to see if the IMA real estate values for Sector 2 are reasonable. From Table A4, we have estimates for beginning of year t values for residential and nonresidential real estate in the Noncorporate Business Sector, $V_{RR2}{}^t$ and $V_{RN2}{}^t$. From Table A7, we can find beginning of year t values for residential structures in Sector 2, $V_{SR2}{}^t$, Thus estimates for the Sector 2 value of residential land for year t can be formed as the value of residential real estate less the value of residential structures; i.e., define $V_{LR2}{}^t \equiv V_{RR2}{}^t - V_{SR2}{}^t$. We can obtain estimates for the value of nonresidential structures at the beginning of year t in Sector 2, $V_{SN2}{}^t$, as the sum of the nonresidential structure values for subsectors a, b and c that are listed in Table A7; i.e., define $V_{SN2}{}^t \equiv V_{SN2a}{}^t + V_{SN2b}{}^t + V_{SN2c}{}^t$ for t = 1960,...,2015. Estimates for the Sector 2 value of nonresidential land for year t can be formed as the value of nonresidential real estate less the value of nonresidential structures less the value of Sector 2 farm land; i.e., define $V_{LN2}{}^t \equiv V_{RN2}{}^t - V_{SN2}{}^t - V_{LF2}{}^t$ for t = 1960,...,2015. We performed these operations and as a check on the reasonableness of the resulting value of land estimates for residential and nonresidential land in Sector 2, we also calculated the ratios of residential land value to residential structure value for each year t, $V_{LR2}{}^t/V_{SR2}{}^t$, and the ratios of nonresidential land value to nonresidential structure value for each year t, $V_{LN2}{}^t/V_{SN2}{}^t$. We expected these ratios to be between 0.1 and 0.6. However, they turned out to be far too big: the average land to structure value ratio for residential land was 2.68 and for nonresidential land was 1.59. Thus the estimated residential and nonresidential estimated real estate values for the noncorporate sector that are in the Integrated Macroeconomic Accounts are much too high. Since the IMA data for the value of real estate in both sectors are not reliable, we will generate alternative estimates for the value of land used in Sectors 1 and 2.

We form estimates for the quantity of *residential land* used in Sectors 1 and 2 using the information on the quantity of residential structures used in Sector 1, $Q_{SR1}{}^t$, and the information on the Sector 2 value and price of residential structures, which allows us to form estimates for the quantity of residential structures $Q_{SR2}{}^t \equiv V_{SR2}{}^t/P_{SR2}{}^t$. The relevant series are listed in Tables A6-A8. Table A1 lists our earlier estimates for the land to structure ratio for all residential housing for each year t, $R_{QL/QS}{}^t$. We apply this ratio to our estimates for the quantity of structures in each sector in order to generate estimates for the quantity of residential land at the beginning of year t for sectors 1 and 2, $Q_{LR1}{}^t$ and $Q_{LR2}{}^t$; i.e., define $Q_{LR1}{}^t \equiv Q_{SR1}{}^t\, R_{QL/QS}{}^t$ and $Q_{LR2}{}^t \equiv Q_{SR2}{}^t\, R_{QL/QS}{}^t$ for t = 1960,...,2015. We set the price of residential land at the beginning of year t in both sectors equal to the overall Davis (2015) based price index for residential land P_{LR}^t that is listed in Table A1; i.e., define $P_{LR1}^t = P_{LR2}^t \equiv P_{LR}^t$ for t = 1960,...,2015. Finally, we define the year t value of residential land in Sector i as $V_{LRi}^t \equiv P_{LRi}^t\, Q_{LRi}^t$ for i = 1,2. The residential land price series P_{LR}^t is listed in Table A1 and the sectoral residential land value and quantity series, V_{LR1}^t, V_{LR2}^t, Q_{LR1}^t, Q_{LR2}^t, are listed in Table A9 below.

We are now in a position to generate preliminary values for *commercial (nonresidential and nonfarm) land* V_{LN1}^t in *Sector 1*. For the commercial land value in Sector 1 at the beginning of year t, define V_{LN1}^t as $V_{RE1}^t - V_{LR1}^t - V_{LF1}^t - V_{SR1}^t - V_{SN1}^t$ for t = 1960,...,2015; i.e., we subtract the Sector 1 value of residential land V_{LR1}^t , farm land V_{LF1}^t, residential structures V_{SR1}^t and nonresidential structures V_{SN1}^t from the corresponding IMA estimate for the value of Sector 1 real estate, V_{RE1}^t. We found that the resulting commercial land values V_{LN1}^t were reasonable for the years t = 1960-1990. However, they were not reasonable for the years which followed 1990. Hence for the years 1991-2015, we will generate estimates for V_{LN1}^t by an alternative method which will be explained shortly.

From Table A1, it can be seen that the ratio of the quantity of residential land to the quantity of residential structures, $R_{QL/QS}^t$, trended smoothly downward from 24.8% in 1960 to 13.6% in 2015. We expect a similar downward trend in the ratio of commercial land to the quantity of nonresidential structures in Sector 1 but at a slower rate of decline. The ratio of commercial land value to the corresponding nonresidential structure value in 1960 for Sector 1 implied by our data is equal to $V_{LN1}^{1960}/V_{SN1}^{1960} = 79.2/256.9 = 0.30829$.[56] This value ratio is also equal to the corresponding quantity ratio for 1960; i.e., $R_{LN/SN}^{1960} \equiv Q_{LN1}^{1960}/Q_{SN1}^{1960} = 0.30829$. We assume that this ratio declines by 0.18 percentage points each year. Under this assumption about the rate of decline, the 2015 ratio $R_{LN/SN}^{2015} \equiv Q_{LN1}^{2015}/Q_{SN1}^{2015} = 0.20932$. Thus the 2015 land to structure ratio for Sector 1 commercial properties is approximately equal to 2/3 of the 1960 value under our assumptions. The resulting land to structure ratios for commercial properties in Sector 1, $R_{LN/SN}^t$, are listed in Table A9 below. Now multiply the year t commercial property land-structure ratio $R_{LN/SN}^t$ by the quantity of structures at the beginning of year t in Sector 1, Q_{SN1}^t to generate an estimate Q_{LN1}^t for the quantity of commercial land at the beginning of year t in Sector 1; i.e., $Q_{LN1}^t \equiv R_{LN/SN}^t\, Q_{LN1}^t$ for t = 1960,...,2015 where Q_{LN1}^t is listed in Table A6. For the years t = 1960,...,1990, generate the price of commercial land in Sector 1, P_{LN1}^t, as the Sector 1 estimated value of commercial land divided by its quantity counterpart; i.e., define $P_{LN1}^t \equiv V_{LN1}^t/Q_{LN1}^t$. For the years 1991-2015, we will use the movements in the residential land price index P_{LR}^t listed in Table A1 above to extend our commercial land price index for Sector 1, P_{LN1}^t, which up to this point, is only defined to 1990; i.e., for t = 1991,...,2015, define $P_{LN1}^t \equiv P_{LR}^t\, P_{LN1}^{1990}/ P_{LR}^{1990}$. Finally, the Sector 1 value of commercial land is redefined for t = 1991,...,2015 as $V_{LN1}^t \equiv P_{LN1}^t\, Q_{LN1}^t$. The new definition for V_{LN1}^t will equal the old value for V_{LN1}^t that was defined by the IMA real estate data for Sector 1 for the years 1960-1990 (the sensible years) but will be different for the subsequent years. The series V_{LN1}^t, Q_{LN1}^t and P_{LN1}^t are listed in Table A9 below.

Our procedures for generating beginning of the year estimates for the value, price and quantity of *commercial land* in *Sector 2* can be readily explained. We define the year t price

[56] Nonresidential structures include farm structures but the value of farm structures is relatively small compared to the value of commercial structures.

of commercial land in Sector 2 to equal the corresponding Sector 1 price; i.e., define $P_{LN2}{}^t \equiv P_{LN1}{}^t$ for t = 1960,...,2015. Recall that the year t chained Fisher quantity index for nonresidential structures in Sector 2 was defined as $Q_{SN2}{}^t$ and these indexes were listed in Table A7. We multiply the year t commercial property land-structure ratio $R_{LN/SN}{}^t$ listed in Table A9 by the quantity of structures at the beginning of year t in Sector 2, $Q_{SN2}{}^t$, to generate an estimate $Q_{LN2}{}^t$ for the quantity of commercial land at the beginning of year t in Sector 2; i.e., $Q_{LN2}{}^t \equiv R_{LN/SN}{}^t\, Q_{LN2}{}^t$ for t = 1960,...,2015. Finally, the Sector 2 value of commercial property is defined for t = 1960,...,2015 as $V_{LN2}{}^t \equiv P_{LN2}{}^t\, Q_{LN2}{}^t$. The series $P_{LN2}{}^t$ and $Q_{LN2}{}^t$ are also listed in Table A9. The units are in billions of dollars for the value series and in billions of 1960 constant dollars for the quantity series.

Geltner and Bokhari (2015) argue that the value of commercial land in the US to the corresponding property value is 30%, which translates into a land-structure value ratio of 43%. However, it is not clear what time period this estimate refers to. In any case, our assumptions generate an average land-structure value ratio for the Sector 1 commercial property land-structure value ratios, $V_{LN1}{}^t/V_{SN1}{}^t$, equal to 33.6% with the min and max ratios equal to 21.3% and 51.3% respectively.[57] The corresponding average land-structure quantity ratio for the Sector 1 land-structure quantity ratios, $Q_{LN1}{}^t/Q_{SN1}{}^t$, is equal to 25.9% with the min and max ratios equal to 20.9% and 30.8% respectively. Thus our assumptions have generated Sector 1 values of commercial land that are more or less consistent with the "facts" in Geltner and Bokhari (2015).

It can be seen that our estimates for the price and value of commercial land in the two Sectors are only very rough approximations to the "truth". However, we believe that they are considerably better than the existing estimates that are implied by the IMA Balance Sheets.

We conclude this section by noting that the rate of growth of land prices tends to be much higher than the rate of growth of other asset prices. The annual average geometric rate of growth of prices for residential, farm and commercial land in both sectors, $P_{LR}{}^t$, $P_{LF}{}^t$ and $P_{LN}{}^t$, over the sample period was 6.47%, 6.16% and 4.88% respectively.

[57] Our assumptions generate an average commercial property land-structure value ratio for Sector 2, $V_{LN2}{}^t/V_{SN2}{}^t$, equal to 31.8% with the min and max ratios equal to 20.9% and 48.1% respectively.

Table A9: Sector i Beginning of Year Values and Quantities for Residential Land, V_{LRi}^t and Q_{LRi}^t, for Commercial Land, V_{LNi}^t and Q_{LRi}^t, for i = 1,2; the Price of Commercial Land P_{LN}^t for Both Sectors and the Land to Structure Ratio $R_{LN/SN}$

Year	V_{LR1}	Q_{LR1}	V_{LR2}	Q_{LR2}	V_{LN1}	Q_{LN1}	V_{LN2}	Q_{LN2}	P_{LN}^t	$R_{LN/SN}$
1960	1.2	1.2	63.8	63.8	79.2	79.2	17.0	17.0	1.00000	0.30832
1961	1.3	1.3	65.2	64.3	73.8	80.4	15.6	17.0	0.91694	0.30652
1962	1.4	1.4	67.2	64.9	76.4	81.6	16.5	17.6	0.93666	0.30472
1963	1.7	1.5	72.2	65.5	78.7	82.7	17.3	18.2	0.95182	0.30292
1964	1.8	1.6	72.9	65.8	81.0	83.8	18.2	18.8	0.96626	0.30112
1965	1.8	1.8	68.0	67.4	84.6	85.3	19.7	19.9	0.99135	0.29932
1966	1.8	1.9	66.9	69.4	90.1	87.5	21.6	20.9	1.02892	0.29752
1967	2.0	2.1	68.9	71.7	97.2	90.1	23.6	21.9	1.07847	0.29572
1968	2.2	2.2	76.7	74.0	100.9	92.6	24.6	22.6	1.09007	0.29392
1969	2.7	2.2	92.1	76.5	108.5	95.0	27.1	23.7	1.14181	0.29212
1970	3.6	2.3	123.1	81.1	125.0	97.6	31.9	24.9	1.28068	0.29032
1971	4.4	2.4	151.3	83.6	138.5	100.1	36.0	26.0	1.38278	0.28852
1972	4.8	2.5	164.5	84.7	153.3	102.3	42.2	28.1	1.49867	0.28672
1973	5.3	2.5	180.1	85.5	172.9	104.6	49.7	30.0	1.65306	0.28492
1974	6.6	2.6	221.9	87.1	193.2	107.1	57.5	31.9	1.80393	0.28312
1975	8.9	2.7	296.7	90.5	222.0	109.5	65.1	32.1	2.02755	0.28132
1976	10.9	2.7	368.9	92.3	254.6	111.1	71.3	31.1	2.29121	0.27952
1977	12.0	2.7	412.9	91.7	286.0	112.7	78.8	31.1	2.53827	0.27772
1978	14.1	2.6	488.8	90.9	321.4	114.3	89.8	31.9	2.81231	0.27592
1979	16.8	2.6	593.6	91.2	362.5	116.7	103.4	33.3	3.10744	0.27412
1980	18.1	2.6	645.6	91.6	416.1	119.6	121.2	34.8	3.47960	0.27232
1981	17.6	2.6	641.0	93.6	478.9	122.8	140.9	36.1	3.89919	0.27052
1982	17.9	2.6	667.8	96.6	549.0	126.1	165.6	38.0	4.35276	0.26872
1983	18.1	2.6	693.5	99.8	602.7	128.9	181.0	38.7	4.67505	0.26692
1984	19.7	2.6	766.9	100.6	639.5	130.7	190.6	39.0	4.89300	0.26512
1985	21.4	2.6	844.3	101.6	687.0	133.4	211.2	41.0	5.15073	0.26332
1986	24.2	2.6	970.3	102.7	728.7	136.4	230.0	43.0	5.34368	0.26152
1987	27.4	2.6	1097.4	102.4	761.8	138.1	243.4	44.1	5.51722	0.25972
1988	29.7	2.5	1193.2	101.8	797.3	139.6	261.4	45.7	5.71307	0.25792
1989	32.2	2.5	1306.8	101.7	857.5	140.9	286.3	47.0	6.08746	0.25612
1990	35.1	2.5	1434.1	101.6	877.1	142.1	297.7	48.2	6.17101	0.25432
1991	35.1	2.5	1460.0	103.1	893.3	144.3	298.8	48.3	6.19083	0.25252
1992	36.8	2.5	1539.5	104.0	942.4	145.5	304.1	47.0	6.47565	0.25072
1993	36.2	2.4	1524.8	103.0	945.7	146.1	300.0	46.4	6.47174	0.24892
1994	36.8	2.4	1561.7	102.7	977.1	146.9	311.2	46.8	6.65289	0.24712
1995	36.5	2.4	1547.1	101.9	978.5	147.4	315.7	47.5	6.64022	0.24532
1996	38.4	2.4	1623.0	102.6	1029.0	148.7	330.2	47.7	6.92122	0.24352
1997	39.2	2.4	1662.6	102.6	1065.8	150.3	344.9	48.6	7.08893	0.24172
1998	41.6	2.4	1758.3	102.7	1138.9	152.1	379.6	50.7	7.48848	0.23992
1999	46.0	2.4	1941.0	102.3	1278.1	154.1	439.3	53.0	8.29519	0.23812
2000	50.8	2.4	2134.9	102.0	1427.5	155.9	503.9	55.0	9.15585	0.23632
2001	58.1	2.5	2428.2	102.7	1638.1	158.4	595.1	57.5	10.34362	0.23452
2002	65.0	2.5	2699.1	103.1	1835.4	160.3	687.5	60.1	11.44898	0.23272
2003	74.0	2.5	3020.4	100.7	2108.1	160.7	811.0	61.8	13.11958	0.23092
2004	84.1	2.5	3359.0	99.2	2378.7	160.7	933.9	63.1	14.80639	0.22912
2005	96.6	2.5	3766.2	98.0	2692.9	160.2	1122.6	66.8	16.80832	0.22732
2006	108.5	2.5	4132.5	95.9	3009.4	159.8	1359.5	72.2	18.83692	0.22552
2007	110.0	2.5	4140.7	95.6	3035.0	160.2	1444.5	76.2	18.94708	0.22372
2008	100.3	2.6	3765.6	96.8	2745.6	161.3	1334.1	78.4	17.01738	0.22192
2009	79.4	2.6	3004.3	98.7	2167.8	162.8	1060.9	79.7	13.31454	0.22012
2010	76.0	2.6	2892.8	99.7	2064.8	162.7	947.5	74.6	12.69469	0.21832
2011	63.1	2.6	2410.1	100.3	1698.8	161.7	774.4	73.7	10.50904	0.21652
2012	59.2	2.6	2274.5	101.4	1579.1	161.0	719.4	73.3	9.80838	0.21472
2013	69.1	2.6	2669.1	101.7	1847.8	161.0	851.0	74.1	11.48004	0.21292
2014	77.9	2.7	3016.5	103.0	2063.1	161.1	973.6	76.0	12.80827	0.21112
2015	84.6	2.7	3289.5	104.6	2221.9	161.6	1063.4	77.4	13.74715	0.20932

A8. Depreciation Rates for Reproducible Assets

The BEA (2015b) Fixed Asset Tables (last revised on August 31, 2015) provide estimates for the value of current cost depreciation for the 4 reproducible assets in Sector 1 and the 9 reproducible assets in Sector 2 for the years 1960-2014. From the Fixed Asset Table 5.4, Current-Cost Depreciation of Private Residential Fixed Assets by Industry Group and Legal Form of Organization, we can obtain year t current cost depreciation estimates $V_{DSR1}{}^t$ for residential fixed assets for the corporate sector. We calculated the residential structure depreciation rate for Sector 1 as $\delta_{SR1}{}^t \equiv V_{DSR1}{}^t/V_{SR1}{}^t$ for t = 1960,...,2014 where the beginning of the year t value for the (nonfinancial)[58] corporate sector value of residential structures is $V_{SR1}{}^t$, listed in Table A5 above. Because the entries for $V_{DSR1}{}^t$ in Table 5.4 were so small for the first 25 years in our sample, the resulting depreciation rates $\delta_{SR1}{}^t$ for these years were erratic and so we set $\delta_{SR1}{}^t$ equal to the sample average rate for these early years which was 0.02415. The resulting depreciation rates for residential structures in Sector 1 are listed in Table A10 below.[59]

From the BEA Fixed Asset Table 4.4, Current-Cost Depreciation of Private Nonresidential Fixed Assets by Industry Group and Legal Form of Organization, we can obtain year t current cost depreciation estimates $V_{DE1}{}^t$, $V_{DSN1}{}^t$ and $V_{DIP1}{}^t$ for equipment, nonresidential structures and intellectual property products for the corporate nonfinancial sector. We calculated the corresponding Sector 1 depreciation rates as $\delta_{EQ1}{}^t \equiv V_{DEQ1}{}^t/V_{EQ1}{}^t$, $\delta_{SN1}{}^t \equiv V_{DSN1}{}^t/V_{SN1}{}^t$ and $\delta_{IP1}{}^t \equiv V_{DIP1}{}^t/V_{IP1}{}^t$ for t = 1960,...,2014 where the corresponding beginning of the year t value asset values are the $V_{EQ1}{}^t$, $V_{SN1}{}^t$ and $V_{IP1}{}^t$ listed in Table A5 above. These depreciation rates are also listed in Table A10. The sample average depreciation rates for the four asset classes are listed in the last row of Table A10.

From the Fixed Asset Table 5.4, we can obtain year t current cost depreciation estimates $V_{DSR2}{}^t$ for residential fixed assets for Sole Proprietorships and Partnerships. We calculated the residential structure depreciation rate for Sector 2 as $\delta_{SR1}{}^t \equiv V_{DSR2}{}^t/V_{SR2}{}^t$ for t = 1960,...,2014 where the beginning of the year t value for the Sector 2 value of residential structures is $V_{SR2}{}^t$, listed in Table A7 above. Because the entries for $V_{DSR2}{}^t$ in the BEA Fixed Assets Table 5.4 were so small for the first 10 years in our sample, the resulting depreciation rates $\delta_{SR2}{}^t$ for these years were erratic and so we set $\delta_{SR2}{}^t$ equal to the 1970 depreciation rate $\delta_{SR2}{}^{1970}$. The resulting depreciation rates for residential structures in Sector 2 are listed in Table A11.

From the BEA Fixed Asset Table 4.4, Current-Cost Depreciation of Private Nonresidential Fixed Assets by Industry Group and Legal Form of Organization, we can obtain year t current cost depreciation estimates $V_{DEQ2i}{}^t$, $V_{DSN2i}{}^t$ and $V_{DIP2i}{}^t$ for equipment, nonresidential structures and intellectual property products for i = 1,2,3 for our three noncorporate, nonfinancial subsectors. We calculated the corresponding Sector 2 depreciation rates as $\delta_{EQ2i}{}^t \equiv V_{DEQ2i}{}^t/V_{EQ2i}{}^t$, $\delta_{SN2i}{}^t \equiv V_{DSN2i}{}^t/V_{SN2i}{}^t$ and $\delta_{IP2i}{}^t \equiv V_{DIP2i}{}^t/V_{IP2i}{}^t$ for t = 1960,...,2014 and i = 1,2,3 where the corresponding beginning of the year t value asset values are the $V_{EQ1i}{}^t$, $V_{SN1i}{}^t$ and $V_{IP1i}{}^t$ listed in Table A7 above. Since the stock of nonresidential structures in the Tax Exempt

[58] We continue to assume that the Corporate Financial Sector does not hold any residential real estate.

[59] In the main text, we interpret the depreciation rates $\delta_{SR1}{}^t$ as real geometric depreciation rates. Thus we are implicitly assuming that the beginning of year asset price for corporate residential structures, $P_{SR1}{}^t$, is also the correct deflator for the year t depreciation expenditures for this asset. A similar comment applies to the depreciation rates for the other reproducible assets that are considered in this section.

Cooperative Sector was so small, the BEA depreciation estimates were also small and not enough decimals were given in Table 4.4 to determine accurate depreciation rates. Thus we set the depreciation rates for nonresidential structures in the Tax Exempt Cooperative sector, $\delta_{SN23}{}^{t}$, equal to the sample average of the estimated rates, which was 0.02336. The resulting Sector 2 depreciation rates are listed in Table A11, with the exception of $\delta_{IP2i}{}^{t}$ for i = 3 since $V_{DIP23}{}^{t}$ and $V_{IP23}{}^{t}$ were very small for this subsector of Sector 2 (i.e., the Tax Exempt Cooperative Sector had a negligible amount of Intellectual Property Products).

Note that the sample annual average depreciation rates for residential structures that are listed on the last rows of Tables A10 and A11 are 2.6% and 2.9% per year and the corresponding annual average depreciation rates for nonresidential structures are 3.1%, 2.9%, 3.0% and 2.3%. These depreciation rates may be too low. Geltner and Bokhari (2015) recently undertook a large evidence based study of business sector depreciation rates in the US and they found much larger depreciation rates for apartment structures (8.8% per year) and non apartment commercial structures (6.7% per year).[60]

[60] These depreciation rates include depreciation of the initial structures as well as on going capital expenditures on the properties. Their estimated depreciation rates for the initial structure on a commercial property were 3.9% for apartments and 3.1% for other commercial structures. Accounting for subsequent capital expenditures on the properties added an additional 4.9% and 3.5% respectively to the depreciation rates for the initial structures. The BEA should count capital expenditures on commercial structures as investments so the BEA depreciation rates may significantly understate actual depreciation and hence the BEA capital stocks for structures may be too high. If the BEA depreciation rates are in fact too low, this means that the BEA structure capital stocks are too high and hence our productivity growth estimates will be too low. However, it may be the case that some of the capital expenditures on business structures are expensed by the BEA capital stock accounts so that the extent of the potential understatement in BEA depreciation rates is unknown.

Table A10: Sector 1 Geometric Depreciation Rates for Residential Structures, Equipment, Nonresidential Structures and Intellectual Property Products

Year t	$\delta_{SR1}{}^{t}$	$\delta_{EQ1}{}^{t}$	$\delta_{SN1}{}^{t}$	$\delta_{IP1}{}^{t}$
1960	0.02415	0.11592	0.02764	0.19313
1961	0.02415	0.11495	0.02783	0.19444
1962	0.02415	0.11655	0.02799	0.19485
1963	0.02415	0.11757	0.02814	0.19931
1964	0.02415	0.11939	0.02830	0.19937
1965	0.02415	0.12181	0.02879	0.20175
1966	0.02415	0.12411	0.02914	0.20533
1967	0.02415	0.12353	0.02885	0.20673
1968	0.02415	0.12400	0.02923	0.20940
1969	0.02415	0.12385	0.02941	0.21143
1970	0.02415	0.12391	0.02945	0.21079
1971	0.02415	0.12269	0.02936	0.20980
1972	0.02415	0.12388	0.02900	0.21234
1973	0.02415	0.12664	0.03105	0.21780
1974	0.02415	0.13321	0.03266	0.22381
1975	0.02415	0.13020	0.03106	0.22071
1976	0.02415	0.12605	0.03077	0.21911
1977	0.02415	0.12864	0.03175	0.21977
1978	0.02415	0.13011	0.03254	0.22196
1979	0.02415	0.13131	0.03325	0.22548
1980	0.02415	0.13213	0.03257	0.22716
1981	0.02415	0.12896	0.03447	0.22867
1982	0.02415	0.12697	0.03400	0.22519
1983	0.02415	0.12519	0.03164	0.22317
1984	0.02415	0.12693	0.03193	0.22440
1985	0.02405	0.12849	0.03178	0.22417
1986	0.02476	0.12951	0.03125	0.22358
1987	0.02487	0.12985	0.03039	0.22443
1988	0.02564	0.13180	0.03097	0.22487
1989	0.02479	0.13192	0.03073	0.22584
1990	0.02602	0.13171	0.03060	0.22615
1991	0.02556	0.12954	0.03037	0.22804
1992	0.02665	0.12964	0.03000	0.22358
1993	0.02719	0.13047	0.03016	0.22433
1994	0.02651	0.13245	0.02996	0.22644
1995	0.02684	0.13500	0.03016	0.23199
1996	0.02725	0.13401	0.02997	0.23311
1997	0.02857	0.13434	0.03049	0.24038
1998	0.02795	0.13422	0.03088	0.24193
1999	0.02828	0.13565	0.03029	0.25006
2000	0.02982	0.13753	0.03052	0.25522
2001	0.02994	0.13457	0.03124	0.24984
2002	0.02996	0.13246	0.03146	0.24734
2003	0.03070	0.13216	0.03144	0.24703
2004	0.03205	0.13435	0.03294	0.24350
2005	0.03274	0.13467	0.03436	0.24618
2006	0.03243	0.13534	0.03529	0.24539
2007	0.03137	0.13429	0.03470	0.24516
2008	0.03029	0.13390	0.03518	0.24258
2009	0.02946	0.12775	0.03193	0.23515
2010	0.02936	0.12903	0.03347	0.23515
2011	0.02889	0.13095	0.03356	0.23426
2012	0.02898	0.13057	0.03379	0.23321
2013	0.02982	0.13092	0.03403	0.23315
2014	0.02974	0.13208	0.03400	0.23214
Average	0.02644	0.12887	0.03121	0.22546

Table A11: Sector 2 Geometric Depreciation Rates for Residential Structures and Geometric Depreciation Rates for Equipment, Nonresidential Structures and Intellectual Property Products for Sectors 2i for i = 1,2,3.

Year	δ_{SR2}	δ_{EQ21}	δ_{EQ22}	δ_{EQ23}	δ_{SN21}	δ_{SN22}	δ_{SN23}	δ_{IP21}	δ_{IP22}
1960	0.02642	0.16176	0.15172	0.11765	0.02786	0.03046	0.02336	0.13043	0.15385
1961	0.02642	0.16058	0.15068	0.11111	0.02752	0.02985	0.02336	0.16667	0.14815
1962	0.02642	0.16176	0.15068	0.11111	0.02647	0.02857	0.02336	0.16000	0.13793
1963	0.02642	0.16245	0.15436	0.10526	0.02809	0.02703	0.02336	0.15385	0.12903
1964	0.02642	0.16197	0.15584	0.10526	0.02688	0.02991	0.02336	0.14815	0.15625
1965	0.02642	0.16271	0.15528	0.10000	0.02764	0.02767	0.02336	0.13793	0.15152
1966	0.02642	0.16346	0.15789	0.10000	0.02837	0.02909	0.02336	0.16667	0.14286
1967	0.02642	0.16320	0.15426	0.09091	0.02643	0.03000	0.02336	0.16129	0.13889
1968	0.02642	0.16156	0.15423	0.13043	0.02703	0.02786	0.02336	0.15152	0.15789
1969	0.02642	0.16273	0.15741	0.12000	0.02672	0.02825	0.02336	0.17647	0.15385
1970	0.02642	0.16137	0.15745	0.11111	0.02802	0.02806	0.02336	0.16667	0.16667
1971	0.02850	0.16136	0.15294	0.10345	0.02729	0.03002	0.02336	0.17949	0.15909
1972	0.02897	0.16094	0.15498	0.09677	0.02738	0.02851	0.02336	0.17949	0.15909
1973	0.02836	0.16633	0.15493	0.09091	0.02774	0.02930	0.02336	0.17500	0.17778
1974	0.02865	0.17148	0.16181	0.11429	0.02850	0.03050	0.02336	0.19512	0.17391
1975	0.02791	0.16469	0.15676	0.09524	0.02817	0.02961	0.02336	0.18605	0.16327
1976	0.02802	0.16112	0.15271	0.09804	0.02844	0.02911	0.02336	0.17778	0.18000
1977	0.02838	0.16364	0.15367	0.10345	0.02905	0.03048	0.02336	0.19149	0.16981
1978	0.02801	0.16485	0.15579	0.10448	0.03004	0.03158	0.02336	0.18750	0.18519
1979	0.02835	0.16571	0.15701	0.09859	0.03066	0.03333	0.02336	0.20755	0.18644
1980	0.02803	0.16230	0.15670	0.09756	0.03012	0.03286	0.02336	0.20339	0.19697
1981	0.02730	0.16094	0.15461	0.09574	0.03207	0.03526	0.02336	0.22388	0.20270
1982	0.02700	0.15506	0.15056	0.10000	0.03257	0.03514	0.02336	0.21333	0.19277
1983	0.02682	0.15117	0.14522	0.08911	0.03051	0.03280	0.02336	0.21951	0.19101
1984	0.02709	0.15148	0.14716	0.09091	0.03065	0.03266	0.02336	0.22472	0.20000
1985	0.02754	0.15114	0.14856	0.10309	0.03016	0.03224	0.02336	0.22222	0.20000
1986	0.02828	0.15314	0.14947	0.10185	0.02948	0.03113	0.02336	0.22936	0.20690
1987	0.02842	0.15343	0.14955	0.09649	0.02857	0.03005	0.02336	0.23333	0.20930
1988	0.02885	0.15579	0.15195	0.09483	0.02895	0.03023	0.02336	0.23188	0.21477
1989	0.02898	0.15593	0.15146	0.10084	0.02872	0.02981	0.02336	0.24026	0.21893
1990	0.02926	0.15397	0.14753	0.09600	0.02836	0.02934	0.02336	0.23256	0.21466
1991	0.02933	0.15186	0.14556	0.09924	0.02804	0.02877	0.02336	0.23280	0.21801
1992	0.02932	0.15186	0.14427	0.09848	0.02782	0.02833	0.02336	0.22549	0.21397
1993	0.02950	0.15223	0.14547	0.09630	0.02803	0.02868	0.02336	0.22831	0.21545
1994	0.02978	0.15401	0.14696	0.10072	0.02771	0.02840	0.02336	0.22553	0.21374
1995	0.03010	0.15525	0.14912	0.09790	0.02767	0.02838	0.02336	0.22709	0.21786
1996	0.03042	0.15385	0.14812	0.09459	0.02770	0.02836	0.02336	0.22846	0.21854
1997	0.03034	0.15403	0.14848	0.09934	0.02792	0.02853	0.02336	0.23571	0.22360
1998	0.03036	0.15300	0.15097	0.09740	0.02823	0.02887	0.02336	0.24172	0.23714
1999	0.03010	0.15273	0.15458	0.09554	0.02790	0.02851	0.02336	0.25688	0.26303
2000	0.03055	0.15347	0.15799	0.09697	0.02793	0.02875	0.02336	0.26389	0.27439
2001	0.03089	0.15207	0.15542	0.09497	0.02819	0.02904	0.02336	0.25648	0.27076
2002	0.03079	0.15160	0.15392	0.08763	0.02809	0.02898	0.02336	0.25773	0.27062
2003	0.03100	0.15200	0.15230	0.08612	0.02833	0.02898	0.02336	0.26343	0.26515
2004	0.03196	0.15475	0.15439	0.08482	0.02936	0.03025	0.02336	0.26500	0.25955
2005	0.03241	0.15505	0.15354	0.08678	0.03023	0.03125	0.02336	0.27384	0.26047
2006	0.03207	0.15481	0.15254	0.08679	0.03058	0.03177	0.02336	0.27635	0.25783
2007	0.03113	0.15388	0.15057	0.08306	0.02986	0.03139	0.02336	0.27703	0.25609
2008	0.03047	0.15135	0.15069	0.08260	0.02992	0.03161	0.02336	0.27074	0.25716
2009	0.02946	0.14594	0.14325	0.07672	0.02794	0.02932	0.02336	0.26316	0.25234
2010	0.02970	0.14620	0.14472	0.07557	0.02882	0.03028	0.02336	0.26106	0.25208
2011	0.02881	0.14789	0.14620	0.07583	0.02914	0.03068	0.02336	0.25877	0.25050
2012	0.02926	0.14849	0.14605	0.07456	0.02931	0.03100	0.02336	0.25974	0.25016
2013	0.02966	0.14794	0.14649	0.07246	0.02956	0.03131	0.02336	0.25949	0.24939
2014	0.02986	0.14819	0.14721	0.07143	0.02931	0.03133	0.02336	0.25714	0.24885
Average	0.02874	0.15655	0.15167	0.09619	0.02866	0.03006	0.02336	0.21708	0.20611

A9. The Construction of Sectoral Value Added Deflators

Table A3 in section A4 above listed BEA Integrated Macroeconomic Accounts data for nominal value added for our sectors 1 and 2. In this section, we will construct deflators for the sectoral value added estimates using the deflators that are available in the BEA National Income and Product Accounts (NIPA) Tables.

We used information on the nominal and real value added of the gross value added of the nonfinancial corporate business sector for 1960-2014, $V_{VA1}{}^t$ and $Q_{VA1}{}^t$ that are listed in NIPA Table 1.14: Gross Value Added of Domestic Corporate Business in Current Dollars and Gross Value Added of Nonfinancial Domestic Corporate Business in Current and Chained Dollars. We note that chained Fisher quantity indexes were used by the BEA to construct $Q_{VA1}{}^t$. The data in NIPA Table 1.14 were published as of January 29, 2016. We also note that the nominal value added estimates for our Sector 1 that are listed in this NIPA Table 1.14 coincided with the IMA estimates that are listed in Table A3 above. Define preliminary Sector 1 value added deflators as $P_{VA1}{}^t \equiv V_{VA1}{}^t/Q_{VA1}{}^t$ for t = 1960,...,2014. We normalized these price and quantity series by dividing the period t price $P_{VA1}{}^t$ by $P_{VA1}{}^{1960}$ and in order to preserve values, we multiplied $Q_{VA1}{}^t$ by $P_{VA1}{}^{1960}$ for t = 1960,...,2014. The resulting normalized price and quantity series are listed in Table A12 below along with the corresponding value series $V_{VA1}{}^t$ (in billions of dollars).[61]

Table A3 above lists the estimates for our Sector 2 nominal value added, $V_{VA2}{}^t$, which were listed in the BEA's Integrated Macroeconomic Accounts as of January 29, 2016. However, it appears that the BEA does not publish either a deflator or estimates of real value added for the noncorporate business sector so we have constructed a deflator for the value added of this sector by an indirect route.

We can obtain a price index for business sector value added from NIPA Table 1.3.4: Price Indexes for Gross Value Added by Sector, which we denote by $P_{VAB}{}^t$ for t = 1960,...,2014. We normalize this index to equal 1 in 1960 and the resulting index is listed in Table A12 below. Business sector value added is equal to the sum of the value added of (i) nonfinancial corporate business; (ii) nonfinancial noncorporate business; (iii) financial corporate business and (iv) government enterprises. We have estimates for the first two components of business sector value added, $V_{VA1}{}^t$ and $V_{VA2}{}^t$, which are listed in Table A3 above. Estimates for the gross value added of the corporate financial sector in year t, which we denote by $V_{VA3}{}^t$, are available in NIPA Table 1.14 and are listed in Table A12 below. Unfortunately, NIPA Table 1.14 does not list the real value added of this sector and it does not list a deflator for this sector. However, we can find an approximately valid deflator for this industry in NIPA Table 1.5.4. Price Indexes for Gross Domestic Product, Expanded Detail. We list the deflator (normalized to equal one in 1960) for Financial services and insurance from this table and it is listed as $P_{VA3}{}^t$ in Table A12 below. Now define the year t quantity index for Sector 3, the corporate financial sector, as $Q_{VA3}{}^t \equiv V_{VA3}{}^t/P_{VA3}{}^t$ for t = 1960,...,2014. Define the year t value added of the private business sector as $V_{VAB}{}^t \equiv V_{VA1}{}^t + V_{VA2}{}^t + V_{VA3}{}^t$ for t = 1960,...,2014. We assume that the business sector value added deflator, $P_{VAB}{}^t$, is an appropriate deflator for the private business sector and define the year t private business quantity index as $Q_{VAB}{}^t \equiv$

[61] In order to simplify the notation, the normalized series are also denoted by $P_{VA1}{}^t$ and $Q_{VA1}{}^t$.

$V_{VAB}{}^t/P_{VAB}{}^t$ for t = 1960,...,2014.[62] Now construct Fisher chained price and quantity indexes, $P_{VA2}{}^t$ and $Q_{VA2}{}^t$, that aggregate over three subindexes which have the price components for year t, $P_{VAB}{}^t$, $P_{VA1}{}^t$, $P_{VA3}{}^t$, and quantity components, $Q_{VAB}{}^t$, $-Q_{VA1}{}^t$, $-Q_{VA3}{}^t$. The indexes $P_{VA2}{}^t$ and $Q_{VA2}{}^t$ are also listed in Table A12 and they provide a price and quantity decomposition for the Sector 2 value added, $V_{VA2}{}^t$.

The average shares of value added for our three subsectors of the US private business sector over the sample period were 71.0% (corporate nonfinancial), 21.9% (noncorporate nonfinancial) and 7.0% (corporate financial). The geometric annual average rates of growth for prices for the three sectors over the sample period were 2.8% (corporate nonfinancial), 3.8% (noncorporate nonfinancial) and 3.9% (corporate financial). The corresponding annual average rates of growth for quantities or volumes for the sectors were 3.6%, 2.4% and 4.2%. Thus the movements in prices and quantities in our Sectors 1 and 2 were quite different over the 55 years in our sample.

Following Jorgenson and Griliches (1972), we need to make some adjustments to the final demand prices which appear in the above table due to indirect taxes; i.e., for productivity measurement purposes, we want to use output prices that producers face, not the after tax output prices that purchasers face. Thus we will make some very rough adjustments to the output price indexes for our Sectors 1 and 2, $P_{VA1}{}^t$ and $P_{VA2}{}^t$, that are listed in Table A12. Recall that the BEA IMA estimates for indirect taxes (less subsidies) paid by our Sectors 1 and 2, $V_{IT1}{}^t$ and $V_{IT2}{}^t$, are listed in Table A3. Define the sector i *indirect* (net) *tax rate* for year t as $\tau_{ITi}{}^t \equiv V_{IT1}{}^t/V_{VAi}{}^t$; i.e., as net indirect taxes paid by Sector i in year t divided by sector i value added in year t for i = 1,2. These indirect tax rates are listed in Table A13. The *value added output price faced by producers* in Sector i, $P_{VAPi}{}^t$, is defined as $P_{VAPi}{}^t \equiv (1-\tau_{ITi}{}^t)P_{VAi}{}^t$ for i = 1,2 where the final demand price index for sector i, $P_{VAi}{}^t$, is listed in Table A12. A new estimate for year t value added in Sector i, $V_{VAPi}{}^t$, is generated by $V_{VAPi}{}^t \equiv P_{VAPi}{}^tQ_{VAi}{}^t$ for i =1,2 and t = 1960,...,2014 where the $Q_{VAi}{}^t$ are also listed in Table A12. The normalized producer price for value added in sector i for year t is defined as $P_{VAPi}{}^{t*} \equiv P_{VAPi}{}^t/P_{VAPi}{}^{1960}$ and the corresponding normalized quantity is defined as $Q_{VAPi}{}^{t*} \equiv P_{VAPi}{}^{1960}\,Q_{VAi}{}^t$ for i = 1,2. The producer price and quantity value added indexes for sector i, $P_{VAPi}{}^{t*}$ and $Q_{VAPi}{}^{t*}$ are listed in Table A13 along with the corresponding estimates of Sector i producer price value added, $V_{VAPi}{}^{t*} \equiv P_{VAPi}{}^{t*}\,Q_{VAPi}{}^{t*}$ for i = 1,2, except that in order to make the notation more compact, we denoted $P_{VAPi}{}^{t*}$, $Q_{VAPi}{}^{t*}$ and $V_{VAPi}{}^{t*}$ by $P_{VAi}{}^t$, $Q_{VAi}{}^t$ and $V_{VAi}{}^t$ for i = 1,2. The year t shares of nonfinancial private business sector value added at producer prices for our Sectors 1 and 2, $s_{VA1}{}^t$ and $s_{VA2}{}^t$, are also listed in Table A13. As usual, the value series are in billions of dollars and the quantity series are in billions of 1960 (chained) dollars.

[62] $P_{VAB}{}^t$ is an appropriate deflator for the entire business sector which is equal to the private business sector plus the government enterprise sector. However, the government business sector is quite small and so our use of the deflator for the entire business sector will be approximately correct.

Table A12: Value, Quantity and Price of Value Added in Sector i, V_{VAi}^t, Q_{VAi}^t, P_{VAi}^t, for i = 1,2,3 and Price Index for the Private Business Sector Value Added P_{VAB}^t

Year	V_{VA1}^t	Q_{VA1}^t	V_{VA2}^t	Q_{VA2}^t	V_{VA3}^t	Q_{VA3}^t	P_{VA1}^t	P_{VA2}^t	P_{VA3}^t	P_{VAB}^t
1960	282.5	282.5	117.1	117.1	17.5	17.5	1.00000	1.00000	1.00000	1.00000
1961	290.4	289.2	119.7	118.3	18.4	17.8	1.00403	1.01225	1.03380	1.00757
1962	316.8	313.7	124.0	120.8	19.3	17.9	1.00978	1.02637	1.07637	1.01711
1963	337.8	333.1	127.3	122.5	19.6	18.2	1.01418	1.03929	1.07758	1.02362
1964	364.5	356.5	133.5	126.5	21.6	19.2	1.02258	1.05507	1.12269	1.03532
1965	400.7	386.4	140.7	131.1	23.2	20.2	1.03694	1.07304	1.15128	1.05113
1966	440.1	415.0	149.0	135.5	25.1	20.6	1.06049	1.09935	1.22066	1.07705
1967	463.2	426.9	153.7	134.8	28.1	22.5	1.08507	1.14020	1.24868	1.10561
1968	510.9	454.6	161.7	135.9	31.3	23.3	1.12391	1.18946	1.34113	1.14893
1969	554.6	472.8	170.3	137.2	36.2	24.8	1.17313	1.24127	1.46102	1.20154
1970	572.8	468.7	177.3	136.7	39.4	25.7	1.22223	1.29696	1.53606	1.25320
1971	618.0	487.1	188.7	138.3	43.1	26.5	1.26871	1.36433	1.62812	1.30610
1972	685.9	524.0	206.5	145.8	47.2	27.3	1.30890	1.41670	1.72787	1.35133
1973	768.8	555.9	241.4	163.2	51.7	29.2	1.38307	1.47877	1.76873	1.42177
1974	830.1	547.4	256.7	157.0	59.9	31.4	1.51637	1.63504	1.91041	1.56059
1975	898.3	539.7	274.7	152.5	67.6	32.9	1.66455	1.80139	2.05178	1.71249
1976	1014.8	583.8	299.5	153.4	73.0	34.2	1.73817	1.95218	2.13463	1.80243
1977	1147.5	626.8	324.5	154.4	85.5	37.2	1.83063	2.10136	2.29862	1.90939
1978	1304.1	667.5	364.7	163.3	103.4	39.7	1.95356	2.23336	2.60194	2.04269
1979	1450.4	688.9	406.9	163.0	114.6	41.8	2.10525	2.49569	2.74369	2.21501
1980	1574.2	682.2	429.1	160.7	128.5	43.5	2.30750	2.67076	2.95597	2.41353
1981	1788.4	709.9	468.7	159.6	146.8	46.2	2.51924	2.93763	3.17936	2.63649
1982	1854.3	694.4	480.0	156.4	164.5	48.9	2.67037	3.06865	3.36286	2.78638
1983	1985.5	728.4	503.4	153.8	187.4	50.8	2.72591	3.27230	3.68702	2.88198
1984	2225.5	793.3	584.4	175.8	209.7	53.5	2.80549	3.32465	3.92013	2.96555
1985	2369.5	830.0	630.4	180.9	236.3	55.6	2.85475	3.48427	4.24932	3.04864
1986	2465.3	851.7	664.6	188.4	247.1	57.3	2.89466	3.52732	4.31311	3.09052
1987	2642.5	896.8	695.8	188.4	260.4	63.4	2.94646	3.69293	4.10769	3.14783
1988	2874.5	951.9	760.4	195.7	276.8	64.3	3.01963	3.88459	4.30415	3.24750
1989	3020.8	970.0	813.4	197.8	308.2	69.6	3.11415	4.11205	4.42893	3.36571
1990	3161.2	984.1	852.1	198.1	316.0	70.3	3.21243	4.30186	4.49247	3.47722
1991	3231.8	979.0	862.7	191.9	332.3	74.4	3.30122	4.49453	4.46680	3.57617
1992	3377.1	1008.8	921.5	201.7	373.4	80.9	3.34755	4.56900	4.61560	3.63343
1993	3535.3	1033.7	950.4	204.7	391.6	80.6	3.42005	4.64339	4.86035	3.71728
1994	3816.5	1097.3	1008.5	213.0	402.8	81.3	3.47808	4.73415	4.95241	3.78279
1995	4041.4	1150.3	1049.5	212.1	442.5	87.4	3.51342	4.94765	5.06011	3.84959
1996	4296.1	1217.7	1132.4	217.5	484.0	92.5	3.52804	5.20621	5.23312	3.90953
1997	4608.4	1299.0	1209.8	223.7	545.2	100.2	3.54773	5.40713	5.44126	3.96674
1998	4873.7	1372.7	1311.6	236.7	612.1	112.4	3.55041	5.54013	5.44387	3.98759
1999	5169.9	1447.4	1392.9	248.1	645.6	119.5	3.57182	5.61352	5.40333	4.01231
2000	5513.0	1526.7	1506.4	255.3	714.3	130.9	3.61100	5.90104	5.45778	4.08683
2001	5471.2	1494.3	1728.2	281.7	754.8	138.8	3.66136	6.13503	5.43738	4.15837
2002	5538.9	1507.1	1812.5	292.4	779.9	140.0	3.67526	6.19850	5.57049	4.18827
2003	5724.5	1539.8	1911.9	305.9	819.8	141.0	3.71763	6.25097	5.81409	4.24649
2004	6107.9	1609.1	2079.1	325.4	859.8	142.4	3.79581	6.38952	6.03647	4.34386
2005	6532.1	1662.2	2218.8	340.7	951.9	153.0	3.92988	6.51264	6.22320	4.47937
2006	6988.0	1726.2	2440.1	367.4	1038.3	162.5	4.04829	6.64146	6.39024	4.60214
2007	7203.9	1743.5	2513.9	368.5	985.2	149.8	4.13197	6.82204	6.57577	4.70794
2008	7256.8	1720.9	2632.4	385.5	835.7	125.7	4.21676	6.82923	6.64712	4.77852
2009	6859.8	1598.8	2466.4	368.7	964.1	151.7	4.29062	6.68960	6.35364	4.79180
2010	7238.7	1687.4	2546.2	368.1	996.7	150.8	4.28985	6.91765	6.60734	4.84719
2011	7592.3	1729.7	2751.6	391.4	1019.5	150.7	4.38936	7.02992	6.76733	4.95199
2012	8011.9	1799.5	2909.8	405.6	1136.9	160.1	4.45233	7.17421	7.09937	5.04600
2013	8316.8	1854.0	3015.6	411.0	1137.1	152.5	4.48587	7.33709	7.45543	5.12205
2014	8641.0	1912.8	3146.9	419.4	1249.5	161.0	4.51735	7.50284	7.75901	5.19311

Table A13: Sector i Value, Quantity and Price of Value Added at Producer Prices $V_{VAi}{}^t$, $Q_{VAi}{}^t$, $P_{VAi}{}^t$, Net Indirect Tax Rates $\tau_{VAi}{}^t$ and Shares of Private Business Nonfinancial Value Added at Producer Prices $s_{VAi}{}^t$ for Sectors i = 1,2.

Year	$V_{VA1}{}^t$	$Q_{VA1}{}^t$	$V_{VA2}{}^t$	$Q_{VA2}{}^t$	$P_{VA1}{}^t$	$P_{VA2}{}^t$	$\tau_{VA1}{}^t$	$\tau_{VA2}{}^t$	$s_{VA1}{}^t$	$s_{VA2}{}^t$
1960	255.9	255.9	107.4	107.4	1.00000	1.00000	0.09416	0.08284	0.70438	0.29562
1961	262.8	262.0	110.2	108.5	1.00305	1.01608	0.09504	0.07937	0.70456	0.29544
1962	286.9	284.2	114.2	110.8	1.00954	1.03063	0.09438	0.07903	0.71528	0.28472
1963	306.1	301.7	117.1	112.3	1.01454	1.04236	0.09384	0.08013	0.72330	0.27670
1964	330.6	322.9	123.0	116.1	1.02388	1.05988	0.09300	0.07865	0.72884	0.27116
1965	364.7	350.0	130.0	120.3	1.04188	1.08098	0.08984	0.07605	0.73721	0.26279
1966	403.1	375.9	138.5	124.3	1.07230	1.11417	0.08407	0.07047	0.74428	0.25572
1967	423.9	386.7	142.1	123.6	1.09623	1.14936	0.08484	0.07547	0.74894	0.25106
1968	465.4	411.8	149.8	124.7	1.13024	1.20145	0.08906	0.07359	0.75650	0.24350
1969	504.4	428.2	157.8	125.8	1.17785	1.25404	0.09052	0.07340	0.76170	0.23830
1970	518.6	424.5	163.4	125.4	1.22161	1.30323	0.09462	0.07840	0.76041	0.23959
1971	558.5	441.2	173.1	126.9	1.26574	1.36458	0.09628	0.08267	0.76340	0.23660
1972	622.2	474.7	191.2	133.7	1.31076	1.43021	0.09287	0.07409	0.76494	0.23506
1973	698.7	503.5	223.5	149.7	1.38762	1.49277	0.09118	0.07415	0.75764	0.24236
1974	755.7	495.9	235.2	144.0	1.52395	1.63340	0.08963	0.08376	0.76264	0.23736
1975	818.1	488.9	252.0	139.9	1.67352	1.80178	0.08928	0.08264	0.76451	0.23549
1976	928.1	528.9	275.6	140.7	1.75491	1.95864	0.08544	0.07980	0.77104	0.22896
1977	1052.9	567.8	300.7	141.6	1.85432	2.12311	0.08244	0.07334	0.77785	0.22215
1978	1201.4	604.7	340.7	149.8	1.98679	2.27483	0.07875	0.06581	0.77907	0.22093
1979	1341.6	624.1	380.3	149.5	2.14974	2.54321	0.07501	0.06537	0.77914	0.22086
1980	1452.7	618.0	399.8	147.4	2.35075	2.71313	0.07718	0.06828	0.78418	0.21582
1981	1641.7	643.1	435.5	146.3	2.55297	2.97606	0.08203	0.07083	0.79034	0.20966
1982	1701.4	629.0	454.5	143.5	2.70487	3.16805	0.08246	0.05312	0.78918	0.21082
1983	1817.5	659.8	480.7	141.1	2.75464	3.40696	0.08461	0.04509	0.79084	0.20916
1984	2040.5	718.6	556.3	161.2	2.83966	3.45063	0.08313	0.04808	0.78577	0.21423
1985	2172.9	751.9	600.4	165.9	2.89001	3.61816	0.08297	0.04759	0.78351	0.21649
1986	2260.7	771.5	636.3	172.8	2.93035	3.68213	0.08299	0.04258	0.78036	0.21964
1987	2425.7	812.4	667.5	172.8	2.98587	3.86270	0.08204	0.04067	0.78420	0.21580
1988	2640.7	862.3	727.1	179.5	3.06238	4.04995	0.08134	0.04379	0.78410	0.21590
1989	2772.6	878.7	774.1	181.4	3.15539	4.26681	0.08216	0.04832	0.78174	0.21826
1990	2897.7	891.4	807.5	181.7	3.25074	4.44489	0.08335	0.05234	0.78206	0.21794
1991	2946.1	886.8	815.0	176.0	3.32219	4.62950	0.08840	0.05529	0.78331	0.21669
1992	3074.6	913.8	869.8	185.0	3.36449	4.70216	0.08957	0.05610	0.77948	0.22052
1993	3216.0	936.4	903.5	187.7	3.43456	4.81293	0.09032	0.04935	0.78068	0.21932
1994	3465.8	994.0	951.2	195.4	3.48679	4.86845	0.09189	0.05682	0.78465	0.21535
1995	3682.7	1042.0	992.0	194.5	3.53437	5.09895	0.08876	0.05479	0.78779	0.21221
1996	3924.4	1103.0	1069.5	199.5	3.55779	5.36112	0.08652	0.05555	0.78584	0.21416
1997	4219.5	1176.7	1136.9	205.2	3.58599	5.54023	0.08439	0.06026	0.78775	0.21225
1998	4470.8	1243.5	1229.4	217.1	3.59545	5.66193	0.08267	0.06267	0.78432	0.21568
1999	4745.3	1311.1	1312.3	227.6	3.61926	5.76635	0.08213	0.05786	0.78336	0.21664
2000	5063.1	1383.0	1420.7	234.1	3.66103	6.06797	0.08161	0.05689	0.78088	0.21912
2001	5026.2	1353.6	1637.1	258.4	3.71320	6.33652	0.08133	0.05271	0.75431	0.24569
2002	5066.0	1365.2	1707.0	268.2	3.71089	6.36495	0.08538	0.05821	0.74797	0.25203
2003	5228.7	1394.8	1800.5	280.5	3.74861	6.41842	0.08661	0.05827	0.74385	0.25615
2004	5577.0	1457.6	1953.7	298.4	3.82615	6.54641	0.08692	0.06031	0.74057	0.25943
2005	5958.9	1505.7	2088.6	312.5	3.95768	6.68416	0.08775	0.05868	0.74047	0.25953
2006	6377.9	1563.6	2293.1	337.0	4.07891	6.80506	0.08731	0.06024	0.73554	0.26446
2007	6571.4	1579.3	2356.3	338.0	4.16098	6.97187	0.08780	0.06269	0.73607	0.26393
2008	6624.1	1558.9	2474.5	353.5	4.24922	6.99939	0.08719	0.05998	0.72804	0.27196
2009	6253.9	1448.2	2321.0	338.2	4.31825	6.86380	0.08833	0.05895	0.72933	0.27067
2010	6605.7	1528.5	2395.5	337.6	4.32164	7.09602	0.08745	0.05919	0.73387	0.26613
2011	6921.7	1566.8	2592.9	359.0	4.41763	7.22277	0.08833	0.05768	0.72748	0.27252
2012	7321.5	1630.0	2742.3	372.0	4.49159	7.37188	0.08617	0.05756	0.72751	0.27249
2013	7591.9	1679.4	2839.8	377.0	4.52053	7.53339	0.08716	0.05830	0.72777	0.27223
2014	7895.8	1732.7	2966.3	384.7	4.55684	7.71100	0.08624	0.05739	0.72691	0.27309

It can be seen that the producer price of output for Sector 1 grew only 4.56 fold over the sample period whereas the Sector 2 price of output grew 7.71 fold. This reflects the fact that noncorporate nonfinancial sector uses inputs of property much more intensively than the corporate financial sector and as we have seen, land prices have grown much more rapidly than other prices over our sample period, leading to higher rates of output price inflation for Sector 2. It can also be seen that Sector 1 pays a higher rate of indirect taxes on its outputs than Sector 2: the average indirect tax rates over the sample period were 8.67% and 6.32% for Sectors 1 and 2 respectively.[63] Viewing Table A13, it can be seen that there are some substantial fluctuations in the shares of value added (at producer prices) for our two sectors: the Sector 1 share started at 70.4% in 1960, trended up to 79.1% in 1983, slowly trended down to 78.1% in 2000 and then fell more rapidly to finish up at 72.7% in 2014. The average sectoral shares over the sample period were 76.9% and 24.0%. Thus the nonfinancial corporate sector has on average about three times the value added of the nonfinancial noncorporate sector over the sample period.

The sectoral price and quantity data listed in Table A13 are the data that we use as our output measures in our sectoral productivity estimates that are developed in the main text.

A10. The Construction of Sectoral Labour Data

Table A3 in Section A4 lists BEA Integrated Macroeconomic Accounts data for the compensation of employees for our sectors 1 and 2, $V_{E1}{}^t$ and $V_{E2}{}^t$. In this section, we will construct deflators for these values plus deal with the problems associated with imputing wages and hours of work for the self employed in each sector.

The IMA series $V_{E1}{}^t$ agrees with the compensation of employees series for the nonfinancial corporate business sector series that is published in Table 1.14 of the NIPA accounts (last revised on January 29, 2016). The IMA series $V_{E2}{}^t$ is quite close to the sum of the compensation of employee series for Sole proprietors and partnerships plus Other (noncorporate) private business, where the latter two series are published in Table 1.13 of the BEA National Income and Product (NIPA) accounts. Thus the IMA and NIPA sectoral labour compensation series are consistent.

We do not have wage rates or hours of work series that match up with our two IMA sectoral labour compensation series for employees, $V_{E1}{}^t$ and $V_{E2}{}^t$. However, we can use information from the NIPA accounts to construct an average wage for employees in both sectors. We can obtain data on the compensation of employees by industry from NIPA Table 6.2B Historical (Annual data from 1960 to 1969), NIPA Table 6.2B (Annual data from 1969 to 1987), NIPA Table 6.2C (Annual data from 1987 to 2000) and from NIPA Table 6.2D (Annual data from 1998 to 2014). Let $V_{ET}{}^t$ equal the total compensation of employees in year t for Private domestic industries using the latest information from the NIPA Tables 6.2 listed above.[64] The above Tables (with the exception of Table 6.2D) decompose the Finance, Insurance and Real

[63] There is a major problem with our treatment of indirect taxes. Indirect taxes include property taxes but these taxes should be a part of the user cost of capital and should not be regarded as taxes on the outputs of sectors that use property inputs. We could not find a breakdown of property taxes paid by our two Sectors and so we were forced to make the above (incorrect) adjustments to our output price indexes. In general, there are problems with the treatment of indirect taxes and subsidies in the System of National Accounts if we are attempting to calculate productivity growth rates using the economic theory of production.

[64] When there is a conflict between the tables, we use the estimates in the later table.

Estate (FIRE) industries into the following seven subsectors: (1) Banking; (2), Credit agencies other than banks; (3) Security and commodity brokers; (4) Insurance carriers; (5) Insurance agents, brokers and service; (6) Real estate and (7) Holding and other investment offices. For the years 1960-1997, denote the value of employee compensation in these seven FIRE industries in year t as $V_{EFi}{}^{t}$ for i = 1,...,7. It appears that the financial industry in the Integrated Macro Accounts consists of the first five of the above seven subsectors of the FIRE sector; i.e., the IMA Financial Sector excludes the Real Estate and Holding company activities. Thus $V_E{}^t$ defined as $V_E{}^t \equiv V_{ET}{}^t - \Sigma_{i=6}{}^7\, V_{EFi}{}^t$ should be a close approximation to the sum of employee compensation for our Sectors 1 and 1, $V_{E1}{}^t + V_{E2}{}^t$, for year t = 1960,...,1997. For later purposes, we define the fraction of FIRE employee compensation in year t that is due to real estate and holding company activities as $s_{RE}{}^t \equiv (V_{EF6}{}^t + V_{EF7}{}^t)/(\Sigma_{i=1}{}^7\, V_{EFi}{}^t)$ for t = 1960,...,1997.

For the years 1998-2014, NIPA Table 6.2D decomposes the FIRE sector into the following six subsectors: (1) Federal reserve banks, credit intermediation and related activities; (2) Securities, commodity contracts and investments; (3) Insurance carriers and related activities; (4) Funds, trusts and other financial vehicles; (5) Real estate and (6) Rental and leasing services and lessors of intangible assets. We will assume that the IMA financial industry consists of the first four industries listed above. For the years 1998-2014, denote the value of employee compensation in these 6 FIRE industries in year t as $V_{EFi}{}^{t*}$ for i = 1,...,6. It appears that the financial industry in the Integrated Macro Accounts consists of the first 4 of the above six subsectors of the FIRE sector; i.e., the IMA Financial Sector excludes the Real Estate and leasing activities. Thus $V_E{}^t$ defined as $V_E{}^t \equiv V_{ET}{}^t - \Sigma_{i=5}{}^6\, V_{EFi}{}^{t*}$ should be a close approximation to the sum of employee compensation for our Sectors 1 and 1, $V_{E1}{}^t + V_{E2}{}^t$, for year t = 1998,...,2014. For later purposes, we define the fraction of FIRE employee compensation in year t that is due to real estate and rental and leasing services $s_{RE}{}^t \equiv (V_{EF5}{}^{t*} + V_{EF6}{}^{t*})/(\Sigma_{i=1}{}^6\, V_{EFi}{}^{t*})$ for t = 1998,...,2014.[65]

We can obtain data on the hours worked by full time and part time employees by industry from NIPA Table 6.9B Historical (Annual data from 1960 to 1969), NIPA Table 6.9B (Annual data from 1969 to 1987), NIPA Table 6.9C (Annual data from 1987 to 1999) and from NIPA Table 6.9D (Annual data from 2000 to 2014). Let $H_{ET}{}^t$ equal the total hours worked by employees in year t for Private domestic industries using the latest information from the NIPA Tables 6.9 listed above.[66] The above tables (with the exception of Table 6.9D) also list the hours worked $H_{EF}{}^t$ by full time and part time employees for the aggregate Finance, Insurance and Real Estate (FIRE) industry for t = 1960,...,1999. Table 6.9D lists the hours worked $H_{EF}{}^t$ by full time and part time employees for the aggregate Finance, insurance, real estate, rental and leasing for the years 2000,..,2014. We approximate the hours worked for year t in only the finance and insurance industries by multiplying the total FIRE hours worked series, $H_{EF}{}^t$, by the fraction $1 - s_{RE}{}^t$ where $s_{RE}{}^t$ is the year t fraction of value added that is due to the real estate and rental component of the FIRE industry. Thus the series $H_E{}^t \equiv H_{ET}{}^t - (1 - s_{RE}{}^t)H_{EF}{}^t$ is our estimate of total employee hours worked in year t for the nonfinancial sector. Recall that our estimate of the corresponding total employee compensation for the

[65] The new classification of FIRE industries that covers the years 1998-2014 does not quite match up with the old classification that covered the years 1960-2000. For our purposes, the differences are small enough to ignore; i.e., the value added of the financial industry in the Integrated Macroeconomic Accounts can be adequately approximated by $\Sigma_{i=1}{}^5\, V_{EFi}{}^t$ for the years 1960-1997 and by $\Sigma_{i=1}{}^4\, V_{EFi}{}^{t*}$ for the years 1998-2014.

[66] When there is a conflict between the tables, we use the estimates in the later table.

nonfinancial sector in year t was V_E^t. We use the series V_E^t and H_E^t to define the year t average employee wage rate as $w_E^t \equiv V_E^t/H_E^t$ for t = 1960,...,2014. This employee wage rate series, in dollars per hour, is listed in Table A14. Define the normalized employee wage rate series for sectors 1 and 2 as $P_{E1}^t \equiv P_{E2}^t \equiv w_E^t/w_E^{1960}$ for t = 1960,...,2014. We use this normalized wage rate series to define the implicit quantity of employee labour used in our sectors 1 and 2 as follows:[67] $Q_{E1}^t \equiv V_{E1}^t/P_{E1}^t$ and $Q_{E2}^t \equiv V_{E2}^t/P_{E2}^t$ where V_{E1}^t and V_{E2}^t are listed in Table A3 above. The series P_{E1}^t, P_{E2}^t, Q_{E1}^t and Q_{E2}^t are listed in Table A14.

Finally, it is necessary to construct price and quantity series for self employed and unpaid family workers who work in the nonfinancial noncorporate sector. Our strategy here will be to use the annual full time wage of an employee in the private sector as the price series and the number of self employed persons that work in our Sector 2 as the quantity series for nonemployee labour in Sector 2.[68] We turn to NIPA Table 6.6B (Historical): Wages and Salaries per Full Time Equivalent Employee by Industry; Annual data from 1948 to 1969; BEA; Data published August 6, 2015; Row Title: Domestic Private Industries. Denote this series for the annual self employed annual wage as w_{SE2}^t in year t for the years 1960-1968. For the years 1969-1986, we continue the series w_{SE2}^t using NIPA Table 6.6B; for the years 1987-1997, using NIPA Table 6.6C and for the years 1998-2014, using NIPA Table 6.6D.

Information on the number of self employed workers by industry can be obtained from NIPA Table 6.7. NIPA Table 6.7B (Historical): Self Employed Persons by Industry; thousands; BEA Annual data from 1948 to 1969; Data published August 6, 2015; Row title: Self employed persons. Denote this series as N_{SE}^t for t = 1960,...,1968. We also use the series N_{SEF}^t for the number of self employed in the FIRE sector (row title: Finance, insurance and real estate). The Table noted that self employed persons consist of active proprietors or partners who devote a majority of their working hours to their unincorporated businesses. For the years 1969-1986, we continue the series N_{SE}^t and N_{SEF}^t using NIPA Table 6.7B; for the years 1987-2000, using NIPA Table 6.7C and for the years 2001-2014, using NIPA Table 6.7D.[69] We estimate the number of self employed workers in just the Finance part of FIRE in year t (i.e., excluding real estate activities) as $(1 - s_{RE}^t)N_{SEF}^t$ where s_{RE}^t is the fraction of year t value added for the FIRE sector that can be attributed to real estate activities. Thus our estimate for the number of self employed workers in our Sector 2 is $N_{SE2t} \equiv N_{SE}^t - (1 - s_{RE}^t)N_{SEF}^t$. Using the year t annual average wage w_{SE2}^t, we estimate the year t value of self employment labour input into sector 2 as $V_{SE}^t \equiv w_{SE2}^t N_{SE2}^t$ for t = 1960,...,2014. Now normalize the annual wage series w_{SE2}^t so that the normalized wage series, P_{SE2}^t, is equal to 1 when t = 1960; i.e., define $P_{SE2}^t \equiv w_{SE2}^t/w_{SE2}^{1960}$ for t = 1960,...,2014. Define the corresponding normalized quantity series for self employment as $Q_{SE2}^t \equiv Q_{SE2}^t/P_{SE2}^t$ for t = 1960,...,2014. The employee wage rate for year t (in dollars per hour), w_E^t, is listed in Table

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[67] It is unlikely that the employee wage rate is the same across our Sectors 1 and 2 but we do not have any information on the distribution of employees by industry and by type of employer (corporate or noncorporate). Thus our estimates for the price and quantity of employee labour input by sector are subject to an unknown amount of measurement error.

[68] We ignore the contribution of unpaid family workers in Sector 2.

[69] The definition of the FIRE sector changed in Table 6.7D; from Finance, insurance and real estate in Table 6.7C to Finance, insurance, real estate and leasing in Table 6.7D. In 2000, the more recent Table listed 735,000 self employed workers in the new FIRE sector for the year 2000 while the Table 6.7C listed the number of FIRE self employed workers as 712,000 workers. We multiplied the Table 6.7D entries for FIRE by 712/735 to make the new series comparable to the older series.

A14 along with $P_{E1}{}^t$ and $Q_{E1}{}^t$ (the normalized price and quantity of employee labour in Sector 1), $P_{E2}{}^t$ and $Q_{E2}{}^t$ (the normalized price and quantity of employee labour in Sector 2) and $P_{SE2}{}^t$ and $Q_{SE2}{}^t$ (the normalized price and quantity of self employed labour in Sector 2). We also formed chained Fisher price and quantity indexes over the two types of labour in Sector 2 and these indexes are denoted as $P_{L2}{}^t$ and $Q_{L2}{}^t$. These series are also listed in Table A14 as is the value of labour input into Sector 2, $V_{L2}{}^t \equiv P_{L2}{}^tQ_{L2}{}^t$. The units of measurement for the quantities are in billions of 1960 dollars and the units for $V_{L2}{}^t$ are in billions of current dollars.

Note that the average employee wage rate in the two sectors grew from $2.54 per hour in 1960 to $35.47 per hour in 2014. The geometric average rate of growth of employee wages was 5.00% per year. The corresponding rates of growth for self employed (imputed) wages and for overall labour wages in Sector 2 was 4.64% and 4.81% per year respectively. The quantity of employee labour used in Sectors 1 and 2 grew at the average geometric rate of 1.28% and 1.16% per year respectively while self employed and overall labour input in Sector 2 grew at the average geometric rate of 0.16% and 0.77% per year. Thus self employed labour input growth in Sector 2 was very low over the sample period while employee labour in both sectors averaged well over 1% per year.

Table A14: Average Employee Wage Rate w_E^t, Price and Quantity of Employee Labour Input in Sector i, P_{Ei}^t and Q_{Ei}^t for i =1,2, Price and Quantity of Self Employed Labour in Sector 2, P_{SE2}^t and Q_{SE2}^t, Overall Price and Quantity of Labour Input in Sector 2, P_{L2}^t and Q_{L2}^t and Total Value of Labour Input in Sector 2, V_{L2}^t

Year	w_E^t	P_{E1}^t	P_{E2}^t	P_{SE2}^t	P_{L2}^t	Q_{E1}^t	Q_{E2}^t	Q_{SE2}^t	Q_{L2}^t	V_{L2}^t
1960	2.54	1.00000	1.00000	1.00000	1.00000	180.4	37.3	39.3	76.6	76.6
1961	2.62	1.02900	1.02900	1.03028	1.02966	179.3	35.9	38.7	74.6	76.8
1962	2.73	1.07248	1.07248	1.07147	1.07196	185.8	35.2	37.9	73.1	78.4
1963	2.82	1.10939	1.10939	1.10814	1.10874	189.4	35.0	36.5	71.5	79.2
1964	2.96	1.16396	1.16396	1.16313	1.16352	193.9	35.1	36.2	71.2	82.9
1965	3.07	1.20847	1.20847	1.20227	1.20531	203.1	34.7	35.6	70.2	84.7
1966	3.25	1.27923	1.27923	1.25602	1.26753	213.3	34.7	34.3	69.0	87.5
1967	3.43	1.35006	1.35006	1.30628	1.32808	215.6	33.5	33.8	67.3	89.4
1968	3.69	1.45189	1.45189	1.39485	1.42321	221.0	32.2	33.5	65.7	93.5
1969	3.95	1.55445	1.55445	1.49063	1.52232	229.1	31.3	33.9	65.1	99.1
1970	4.24	1.66899	1.66899	1.58167	1.62465	224.4	30.0	33.4	63.3	102.8
1971	4.51	1.77389	1.77389	1.67745	1.72481	223.4	28.5	33.6	61.9	106.8
1972	4.79	1.88492	1.88492	1.77837	1.83055	233.4	27.9	34.1	61.8	113.2
1973	5.12	2.01570	2.01570	1.88548	1.94869	245.6	29.5	34.3	63.7	124.1
1974	5.63	2.21404	2.21404	2.03234	2.11934	245.2	28.8	35.3	64.0	135.6
1975	6.17	2.42836	2.42836	2.19464	2.30533	234.3	27.6	35.1	62.5	144.1
1976	6.67	2.62329	2.62329	2.35427	2.48112	244.0	27.8	35.1	62.6	155.4
1977	7.20	2.83198	2.83198	2.51740	2.66486	255.4	27.8	36.3	63.8	170.1
1978	7.81	3.07219	3.07219	2.70690	2.87716	270.0	28.4	37.8	65.9	189.5
1979	8.56	3.36681	3.36681	2.94068	3.13818	279.9	28.7	39.1	67.4	211.6
1980	9.48	3.73098	3.73098	3.22801	3.45953	276.3	27.7	40.2	67.4	233.2
1981	10.36	4.07462	4.07462	3.51226	3.77030	279.7	27.1	40.7	67.2	253.4
1982	11.16	4.39204	4.39204	3.78229	4.06183	269.4	26.5	41.4	67.1	272.6
1983	11.60	4.56565	4.56565	3.96004	4.23988	273.8	26.6	42.6	68.4	290.0
1984	12.16	4.78376	4.78376	4.14233	4.43817	290.2	27.9	43.5	70.7	314.0
1985	12.83	5.04887	5.04887	4.33553	4.66187	295.1	28.4	43.1	70.8	330.0
1986	13.53	5.32469	5.32469	4.52091	4.88515	296.4	28.2	43.3	70.8	346.1
1987	14.06	5.53260	5.53260	4.71555	5.08705	304.6	28.1	44.5	71.8	365.3
1988	14.81	5.82700	5.82700	4.96066	5.35411	313.2	28.0	45.9	73.0	390.9
1989	15.29	6.01745	6.01745	5.10896	5.52047	321.5	29.2	46.4	74.8	413.1
1990	16.10	6.33621	6.33621	5.35242	5.79608	321.6	29.7	46.7	75.5	437.7
1991	16.92	6.65680	6.65680	5.55819	6.04868	311.1	28.9	47.9	75.8	458.3
1992	17.78	6.99763	6.99763	5.85870	6.36838	312.8	28.8	46.2	74.1	471.9
1993	18.06	7.10638	7.10638	5.96478	6.47672	319.6	30.0	48.3	77.4	501.4
1994	18.43	7.25300	7.25300	6.09619	6.61553	330.7	31.1	48.7	79.0	522.6
1995	18.79	7.39298	7.39298	6.26921	6.77705	341.5	32.2	48.4	79.9	541.2
1996	19.54	7.68905	7.68905	6.52255	7.04983	346.9	32.7	48.4	80.4	566.7
1997	20.23	7.96034	7.96034	6.84346	7.35283	359.6	33.8	48.6	81.8	601.8
1998	21.57	8.48754	8.48754	7.21710	7.79292	364.5	34.5	47.7	81.8	637.3
1999	22.49	8.85048	8.85048	7.54047	8.13467	374.0	35.3	46.5	81.5	662.7
2000	24.02	9.45242	9.45242	8.00453	8.66016	380.6	35.8	46.8	82.3	712.9
2001	24.98	9.82805	9.82805	8.17425	8.92507	364.7	45.9	46.5	93.1	830.6
2002	25.51	10.03735	10.03735	8.28363	9.08340	352.9	48.1	45.7	94.9	861.7
2003	26.43	10.40118	10.40118	8.53512	9.38936	345.7	51.2	47.1	99.5	934.1
2004	27.52	10.82730	10.82730	8.92832	9.79422	347.5	55.3	47.5	104.5	1023.3
2005	28.50	11.21466	11.21466	9.19238	10.11993	350.5	59.3	47.7	109.0	1102.7
2006	29.52	11.61647	11.61647	9.61977	10.52446	355.5	64.3	48.1	115.0	1210.0
2007	30.70	12.07780	12.07780	10.05191	10.96286	356.5	68.5	47.3	118.9	1303.0
2008	31.57	12.42257	12.42257	10.29516	11.25854	350.8	67.9	45.9	116.9	1315.8
2009	32.16	12.65447	12.65447	10.33162	11.40665	323.1	63.6	45.1	111.4	1271.1
2010	32.74	12.88069	12.88069	10.69125	11.68110	322.9	63.4	44.5	110.6	1291.8
2011	33.46	13.16690	13.16690	11.01442	11.97467	331.4	64.2	43.4	110.6	1324.2
2012	34.26	13.48156	13.48156	11.31246	12.27441	340.7	66.2	43.7	113.0	1386.7
2013	34.63	13.62476	13.62476	11.41421	12.39775	348.4	67.5	43.0	113.8	1410.8
2014	35.47	13.95482	13.95482	11.60659	12.66660	358.0	69.6	43.0	116.1	1470.4

A11. Deflators for Inventory Stocks and Monetary Stocks

Recall that we obtained information on the beginning of the year value of inventory and monetary stocks for Sectors 1 and 2 from the Integrated Macroeconomic Accounts for the years 1960-2015; see Table A4 for a listing of these values, V_{I1}^t, V_{I2}^t, and V_{M1}^t, V_{M2}^t.

We are unable to find sectoral price deflators for the inventory series but we can find an overall inventory deflator series. We turned to the BEA Historical Table 5.8.9A: Implicit Price Deflators for Private Inventories by Industry; Index Numbers (2009=100); Seasonally adjusted; Quarterly data from 1947 To 1969; Bureau of Economic Analysis; Data published August 07, 2013; Row title: Private inventories. The deflators in this series are as of the end of the quarter and are consistent with end of the quarter inventory stocks. Thus we will use the fourth quarter entry for a year as the beginning of the following year t price of inventories for both of our business sectors. Denote this series as P_I^t for t = 1960,...,1970. To continue this series for t =1971,...,1998, we turned to BEA NIPA Table 5.8.9A: Implicit Price Deflators for Private Inventories by Industry; Index Numbers (2009=100); Seasonally adjusted; Quarterly data from 1969 To 1997; Bureau of Economic Analysis; Data published August 06, 2015; Row title: Private inventories. Finally, to continue the series for t = 1999,...,2015,[70] we turned to NIPA Table 5.8.9B: Implicit Price Deflators for Private Inventories by Industry; Index Numbers (2009=100); Seasonally adjusted; Quarterly data from 1996 to 2014; Bureau of Economic Analysis; Data published October 29, 2015; Row title: Private inventories. The resulting inventory price series was normalized to equal 1 in 1960. We list the resulting normalized series in Table A15 below and denote it as P_I^t. We set the sectoral price deflators for inventories, P_{I1}^t and P_{I2}^t, to the common deflator P_I^t. The constant dollar quantities of inventory stocks in Sectors 1 and 2 at the beginning of year t are denoted as Q_{I1}^t and Q_{I2}^t and are defined as $Q_{I1}^t \equiv V_{I1}^t/P_I^t$ and $Q_{I2}^t \equiv V_{I2}^t/P_I^t$ where the V_{I1}^t and V_{I2}^t are listed in Table A4 above. The series Q_{I1}^t and Q_{I2}^t are also listed in Table A15.

We turn now to the problems associated with finding an appropriate deflator for the monetary stocks held by our two sectors. Some holdings of money are required to facilitate production; i.e., to pay workers and to purchase intermediate inputs and capital inputs. Some holdings of money may be for other purposes; i.e., as reserves in case of downturns in demand or to make asset acquisitions or to make periodic and extraordinary cash dividends. Thus to some extent, the appropriate deflator for monetary deposits held by firms depends on the ultimate purpose for which the balances are held. Since there is no widespread consensus on what the appropriate deflator should be, we will simply use a consumption price index to deflate the beginning of the period monetary holdings of our two Sectors. In particular, we will choose the US personal consumption expenditures deflator in the last quarter of a year as the appropriate beginning of next year deflator for monetary balances. Thus we turned to the Historical NIPA Table 1.1.4: Price Indexes for Gross Domestic Product; Index Numbers; 2009=100; Quarterly data from 1947 To 1969; Bureau of Economic Analysis; Data published July 30, 2014; Row title: Personal consumption expenditures. We used the fourth quarter entry for a year as the beginning of the following year t price of currency and deposits for both of our business sectors. Denote this series as P_M^t for t = 1960,...,1969. To continue this series for t =1970,...,2015, we turned to NIPA Table 1.1.4: Price Indexes for Gross Domestic Product; Index Numbers; 2009=100; Quarterly data from 1969 To 2015; Bureau of Economic Analysis; Data published October 29, 2015; Row title: Personal consumption expenditures.

[70] The published deflators were consistent across the various Tables for the overlap years.

The resulting consumption price series was normalized to equal 1 in 1960. We list the resulting normalized series in Table A15 below and denote it as P_C^t. We set the sectoral price deflators for monetary stocks, P_{M1}^t and P_{M2}^t, to the common deflator P_C^t. The constant dollar quantities of monetary stocks held in Sectors 1 and 2 at the beginning of year t are denoted as Q_{M1}^t and Q_{M2}^t and are defined as $Q_{M1}^t \equiv V_{M1}^t/P_C^t$ and $Q_{M2}^t \equiv V_{M2}^t/P_C^t$ where the V_{M1}^t and V_{M2}^t are listed in Table A4 above. The series Q_{M1}^t and Q_{M2}^t are also listed in Table A15. The units of measurement for the quantities are in billions of 1960 dollars and the units for V_{M1}^t and V_{M2}^t are in billions of current dollars.

Table A15: Beginning of the Year Price Indexes for Inventory and Personal Consumption Expenditures, P_I^t and P_C^t, Quantities of Inventories in Sectors 1 and 2, Q_{I1}^t and Q_{I2}^t, Real Monetary Balances in Sectors 1 and 2, Q_{M1}^t and Q_{M2}^t, and the Corresponding Values.

Year	P_I^t	P_C^t	Q_{I1}^t	Q_{I2}^t	Q_{M1}^t	Q_{M2}^t	V_{I1}^t	V_{I2}^t	V_{M1}^t	V_{M2}^t
1960	1.00000	1.00000	87.4	34.1	31.0	18.7	87.4	34.1	31.0	18.7
1961	1.00039	1.01494	89.9	35.0	31.1	17.7	89.9	35.0	31.6	18.0
1962	1.00335	1.02161	91.3	36.5	35.4	17.8	91.6	36.6	36.2	18.2
1963	1.01352	1.03546	95.5	38.1	39.2	17.6	96.8	38.6	40.6	18.2
1964	0.99216	1.04873	102.3	36.5	38.2	17.2	101.5	36.2	40.1	18.0
1965	0.99054	1.06333	108.9	35.4	38.3	17.0	107.9	35.1	40.7	18.1
1966	1.02569	1.07936	114.7	38.6	39.9	16.9	117.6	39.6	43.1	18.2
1967	1.04086	1.11367	127.8	39.1	37.8	16.3	133.0	40.7	42.1	18.2
1968	1.03704	1.14229	138.2	39.3	40.1	16.0	143.3	40.8	45.8	18.3
1969	1.05934	1.19125	144.6	41.7	40.7	15.5	153.2	44.2	48.5	18.5
1970	1.11013	1.24763	151.2	43.1	38.7	14.9	167.9	47.9	48.3	18.6
1971	1.14173	1.30521	154.2	41.0	38.7	15.4	176.1	46.8	50.5	20.1
1972	1.18866	1.35412	157.4	45.1	39.7	16.1	187.1	53.6	53.7	21.8
1973	1.28571	1.39980	157.4	50.1	42.4	16.9	202.4	64.4	59.4	23.7
1974	1.51862	1.50037	158.6	53.9	44.5	19.9	240.9	81.9	66.7	29.9
1975	1.69301	1.67312	180.6	45.2	44.0	18.8	305.8	76.5	73.6	31.5
1976	1.73076	1.78754	177.5	46.3	47.8	18.1	307.2	80.1	85.4	32.4
1977	1.78971	1.87920	190.3	44.0	50.9	19.1	340.6	78.7	95.6	35.8
1978	1.87068	2.00328	201.3	46.1	54.1	20.5	376.5	86.2	108.3	41.1
1979	2.11159	2.15516	206.2	52.7	55.7	22.1	435.5	111.3	120.0	47.7
1980	2.39970	2.36693	214.1	54.5	55.0	23.8	513.8	130.9	130.1	56.4
1981	2.68167	2.61870	215.1	50.0	51.1	23.8	576.7	134.1	133.9	62.2
1982	2.71977	2.81846	230.4	47.2	44.6	23.4	626.6	128.3	125.6	66.0
1983	2.75460	2.95908	224.5	48.5	48.1	24.4	618.5	133.6	142.2	72.1
1984	2.85866	3.07212	223.7	45.5	56.8	27.4	639.6	130.0	174.5	84.2
1985	2.89160	3.17930	245.1	47.4	58.4	29.1	708.6	137.0	185.7	92.6
1986	2.83742	3.29268	254.0	47.9	64.4	34.1	720.6	135.9	211.9	112.4
1987	2.75945	3.34895	259.1	45.1	69.5	34.8	714.9	124.5	232.8	116.7
1988	2.89152	3.47469	266.8	44.8	69.0	33.3	771.5	129.5	239.9	115.6
1989	3.07928	3.61991	270.6	44.0	70.6	35.0	833.3	135.5	255.5	126.7
1990	3.13354	3.75938	279.8	44.5	68.1	34.4	876.8	139.5	256.0	129.3
1991	3.20178	3.94667	284.2	45.2	64.9	34.0	909.8	144.8	256.2	134.2
1992	3.13570	4.04316	285.4	42.4	66.2	34.3	894.9	133.1	267.8	138.6
1993	3.16092	4.15016	288.0	44.8	63.0	36.4	910.4	141.5	261.4	150.9
1994	3.20135	4.31492	294.5	43.7	68.8	36.5	942.9	139.9	296.7	157.5
1995	3.24843	4.39808	312.8	45.2	71.4	39.4	1016.2	146.7	314.1	173.4
1996	3.33914	4.49066	323.1	42.9	72.1	42.6	1079.0	143.4	323.8	191.3
1997	3.33603	4.56382	331.1	54.0	76.0	46.9	1104.5	180.1	346.9	214.0
1998	3.26581	4.57801	351.5	55.7	79.8	54.0	1147.8	182.0	365.2	247.1
1999	3.14614	4.61146	373.3	53.4	83.5	63.7	1174.3	168.0	384.9	293.9
2000	3.21541	4.70042	391.4	54.4	97.8	74.9	1258.5	174.9	459.7	352.1
2001	3.29607	4.81748	406.5	56.1	108.5	89.0	1340.0	184.8	522.7	428.6
2002	3.21076	4.87966	396.5	54.4	96.2	89.5	1273.0	174.7	469.2	436.5
2003	3.27475	4.97385	400.7	55.9	94.9	91.2	1312.2	183.0	472.1	453.7
2004	3.36696	5.06431	404.0	58.3	119.5	99.6	1360.4	196.2	605.1	504.4
2005	3.53410	5.20959	422.1	58.4	126.9	114.8	1491.6	206.3	661.3	598.1
2006	3.70866	5.37084	437.9	58.9	145.6	130.0	1623.9	218.4	781.9	698.3
2007	3.79333	5.46664	456.2	58.7	127.5	145.1	1730.5	222.8	697.1	793.2
2008	4.33295	5.64899	432.0	57.1	112.4	154.9	1871.7	247.3	634.7	875.0
2009	3.97758	5.73214	455.2	60.2	73.4	153.1	1810.5	239.6	420.7	877.6
2010	4.03203	5.80064	422.8	55.2	116.4	153.0	1704.6	222.5	675.2	887.7
2011	4.32180	5.87535	433.3	59.4	140.2	151.1	1872.7	256.9	823.8	887.9
2012	4.58091	6.03161	438.7	63.6	142.9	152.3	2009.6	291.3	862.1	918.5
2013	4.62910	6.13781	453.7	62.5	138.6	160.9	2100.0	289.3	850.4	987.8
2014	4.58860	6.21275	469.2	62.6	161.7	162.8	2152.9	287.1	1004.4	1011.4
2015	4.55566	6.28251	482.4	66.6	162.4	170.6	2197.7	303.3	1020.1	1071.6

A12. The Way Forward

The BEA does a great job in producing a set of US production accounts that is implicit in its NIPA and Fixed Asset Tables. However, we believe that these production accounts are incomplete from the viewpoint of producing annual (and quarterly) productivity accounts. There are three main gaps in the existing Tables:

- We require price and quantity information on the holdings of land and natural resource stocks by industry. This information is required in order to produce more accurate estimates of the rate of return on assets by industry and on industry TFP growth rates. The information on reproducible capital stocks is first rate but information on land stocks is almost nonexistent.
- Labour input by industry should be disaggregated into demographic and educational cells and the BEA should cooperate with the BLS and Census to provide wage and hours of work information by labour category and by industry.[71] Some consistent disaggregation of labour input would be better than the present situation of no disaggregation at all. Some attempt to provide better imputations for self employed wages and hours of work should be made.
- A more detailed treatment of indirect taxes paid by industry is required. Following Jorgenson and Griliches (1972; 67), indirect taxes that fall on industry outputs should not be included in the price of the taxed output but indirect taxes that fall on an industry input should be included in the price of the taxed intermediate input. Thus given a commodity classification by industry for both outputs and intermediate inputs, the BEA should provide detailed information on indirect taxes paid by industry and commodity. We note that typically in the System of National Accounts, property taxes are regarded as an indirect tax but property taxes should become part of the user cost of land (and structures if a property tax is assessed on structures).[72] This information on the incidence of taxes is required when modeling the effects of a tax reform.

[71] Fernald (2014) manages to produce quarterly TFP estimates for the US private sector on a regular basis. His paper notes that the Current Survey of Population and the BLS produce data that enable some quality adjustment of labour input.

[72] We were unable to find information on property taxes paid on the land and structure components of the capital stock used by our two sectors and so our user costs of land are too small.

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