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Technical Appendix: Capital Taxation During the U.S. Great Depression†

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Contents

In this appendix, I provide details on the data and computational methods used in "Capital Taxation During the U.S. Great Depression." I also conduct sensitivity analyses of the main results. Finally I provide evidence about the impact of capital taxation in several postwar episodes. Materials needed to replicate the results are available at `www.minneapolisfed.org/research` and listed under Staff Reports 451 (the main paper) and 452 (this appendix).

1. U.S. Data

The main sources for the data used in my analysis of the U.S. Great Depression are:[1]

- the U.S. Department of Commerce, Bureau of Economic Analysis (BEA), which publishes the U.S. national income and product accounts and fixed asset tables in the *Survey of Current Business* (*SCB* hereafter);
- Goldsmith (1962) for measures of capital stocks that are not included in the BEA fixed asset tables;
- Kendrick (1961) for manhours;
- the U.S. Department of the Treasury, Bureau of Internal Revenue, which publishes data from federal income tax returns in the *Statistics of Income* (*SOI* hereafter); and
- the Tax Research Foundation, which published tax rate schedules for U.S. states in a changing series titled variously *Federal and State Tax Systems*, *Tax Systems of the World*, and *Tax Systems*.

NIPA tables referenced below are the main tables of the National Income and Product Accounts found in the *SCB*. FA tables referenced below are the main tables of the BEA's Fixed Assets. Auxiliary references are discussed where relevant.

1.1. National Accounts and Capital Stocks

Gross domestic product (GDP), components of GDP, and capital stocks are all divided by population midyear (NIPA Table 2.1), which is plotted in Figure 1. At the start of the Depression, the U.S. population was close to 122 million. By 1939, it had risen to 131 million.

[1] Data for other time periods are described later.

In addition to dividing by population, I make several adjustments to make the data consistent with theory. Specifically, I define *adjusted GDP* to be GDP (NIPA Table 1.1.5) less sales taxes (NIPA Table 3.5) plus imputed capital rents (equal to 4.1 percent of the stock of consumer durables in FA Table 1.1 plus fixed government capital in FA Table 1.1) plus depreciation of consumer durables (FA Table 1.3). To convert to real dollars, the adjusted GDP series is then divided by the GDP deflator (NIPA Table 1.1.9). In Figure 2, I plot this adjusted series after dividing it by the population in Figure 1 and 1.019^{t-1929}, $t = 1929, \dots, 1939$. The latter is an estimate of the growth factor for labor-augmenting technical change. To convert the series into an index, I divide it by the 1929 value and multiply by 100.

Next, consider the main components of GDP. Consumption is defined to be personal consumption expenditures (NIPA Table 1.1.5) less PCE durables (NIPA Table 1.1.5) plus imputed capital rents (equal to 4.1 percent of the stock of consumer durables in FA Table 1.1 plus fixed government capital in FA Table 1.1) plus depreciation of consumer durables (FA Table 1.3) less a prorated portion of sales taxes on nondurables and services (NIPA Table 3.5). To convert to real dollars, the consumption series—along with all components of income and product—is divided by the GDP deflator. Finally, I divide the consumption series by the population times 1.019^{t-1929} times the 1929 level of adjusted GDP and then multiply by 100. The result is shown in Figure 3. Note that the 1929 value shown in the figure is the share of nondurables plus services (adjusted for taxes and capital services) in output of that year. This share, which is equal to 68 percent, is used later when parameterizing the models.

Investment is defined to be gross private domestic investment (NIPA Table 1.1.5) plus net exports (NIPA Table 1.1.5) plus government investment (NIPA Table 3.1) plus PCE durables (NIPA Table 1.1.5) less a prorated portion of sales taxes on durables (NIPA Table 3.5). To deflate and detrend the series, I use the same procedure as with consumption. Detrended real investment is plotted in Figure 4.

Government spending is defined to be government consumption (NIPA Table 3.1). To deflate and detrend this series, I again use the same procedure as with consumption.

Figure 5 plots the actual detrended series along with a smooth trend. All exogenous inputs are first filtered using the Hodrick and Prescott (1997) filter (with smoothing parameter equal to

1) before being fed into the models described later. I do this because these values are the basis of expectations of future spending and tax rates. In the case of the extended model, the computation is easier if expected future paths are smooth.

For the extended model, GDP and investment are subdivided into components for business and nonbusiness. Business GDP is the sum of corporate profits (NIPA Table 1.10) plus nonfarm proprietors' income (NIPA Table 1.12) plus compensation, net interest, and consumption of fixed capital of corporate business (NIPA Table 1.14) plus compensation and net interest of sole proprietorships and partnerships (available prior to 2002 in NIPA Table 1.15) plus nonfarm proprietors' consumption of fixed capital (NIPA Table 7.5) plus taxes on imports and production (NIPA Table 1.10) less taxes on imports and production of the housing sector (NIPA Table 7.4.5) and farm sector (NIPA Table 7.3.5) and less sales taxes (NIPA Table 3.5). Nonbusiness GDP is GDP as defined above less business GDP.

Business investment is the sum of fixed investment of corporations plus nonfarm proprietors (FA Table 6.7) plus a change in inventories (NIPA Table 1.1.5) less a change in farm inventories (NIPA Table 7.3.5). Nonbusiness investment is investment as defined above less business investment.

The nonbusiness subcomponents of GDP and investment—after the series has been deflated and detrended—are plotted in Figures 6 and 7. In addition, I plot the smoothed series after applying the Hodrick and Prescott (1997) filter.

The total value of all U.S. corporations is not available for this period, but an estimate for the index plotted in Figure 8 is constructed using the New York Stock Exchange market capitalization found in annual supplements of the *SCB* (1932–1950).

1.2. Hours Per Capita

Hours used in the study are total manhours from Kendrick (1961). The fraction of time at work is total manhours divided by time available for work, which is assumed to be 5,000 hours per year times the number of persons over 16. The population over 16 is from the U.S. Department of Commerce (1975, Series A39). In Figure 9, I plot per capita hours as a fraction of time at work. In 1929, 29 percent of available time was devoted to work.

For the extended model, I need business and nonbusiness hours. For nonbusiness hours, I use Kendrick's (1961) manhours for farm plus government. Nonbusiness hours per capita are plotted in Figure 10 along with the filtered series, which is used as an input for the numerical simulations. Business hours are then found residually by taking total hours less nonbusiness hours.

1.3. Tax Rates

I turn next to estimates for tax rates. The constructed tax rates, along with smoothed series used in the computer codes, are shown in Figures 11–16. The main text describes how all are constructed. Here I will provide more detail about the original sources of the data.

The average marginal tax rate on labor income constructed from federal and state individual tax returns is shown in Figure 11. The source of this series is Barro and Redlick (2011, Table 1), and the specific rate used is listed as "overall marginal tax rate."

Figure 12 shows the marginal tax rate schedule for dividend income (which was subject only to surtaxes prior to 1936). Figure 13 shows the *average* marginal tax rate on dividend income. The main source of the data used for constructing the federal rate is *SOI*, Tables 2 and 7, which provide detailed information from individual returns by net income class; specifically, these tables show number of returns, exemptions, taxes, and sources of income for each net income class. Total dividends are found in NIPA Table 2.1 (Personal Income and its Disposition). For the years 1936–1939, adjustments to total dividends on federal returns are made because the IRS did not consistently record dividends for fiduciaries for all years in my sample. In other words, dividend income listed in *SOI* Table 7 includes dividend income of fiduciaries in years 1929–1935 but excludes it in years 1936–1939. For 1936–1939, the dividend income of fiduciaries is included under "Fiduciary income." Thus, I estimate fiduciary dividend income with information from IRS Form 1041 filed by fiduciaries. Specifically, I compute the ratio of dividend income to the balance income (or amount available for distribution) on Form 1041 and use this as the fraction of fiduciary income on Form 1040 that constitutes dividend income.

The main sources of the data used for constructing the average marginal tax rate on dividend income by state are the *SOI*, Tables 2, 6, and 7, and the Tax Research Foundation (1930–1942). As noted above, *SOI* Tables 2 and 7 contain information that allows me to construct the distribution of dividend income by net income class for federal returns; I use it as a proxy for the distribution of dividend incomes for all states.[2] *SOI* Table 6 shows the distribution of dividend income on federal returns by state of residence of the filer for the years 1929–1939. The Tax Research Foundation (1930–1942) tables summarize the individual income tax rate schedules by state.

In Figure 14, I plot the statutory corporate income tax rate from the U.S. Treasury's *SOI*. This is the rate faced by firms paying taxes. To this I add Brown's (1949) estimate of 2 percent based on the capital stock tax that was applied in combination with an excess profit tax penalty.

Figure 15 shows the effective tax rate on business property based on data from NIPA Table 3.5. To construct taxes paid on property for the business sector, I sum taxes on imports and production plus business current transfer payments (net) and subtract these taxes and transfers for the farm (NIPA Table 7.3.5) and housing sectors (NIPA Table 7.4.5). To construct the tax rate, I then divide taxes paid by business fixed capital (FA Table 6.1) plus land and inventories from Goldsmith (1962).

Also in Figure 15 is an alternative estimate of the tax rate on property (or more generally wealth) that includes estate taxes. For this estimate I add estate tax revenues from U.S. Treasury (1990) to the taxes on property and the gross estate value less debts and mortgages to the value of the business capital stock when constructing the tax rate on property.

Finally, the effective tax rate on consumption shown in Figure 16 is found by dividing sales and excise taxes (NIPA Table 3.5) by consumption (as defined above).

[2] I only have data needed to construct the distribution of dividend income by net income class for one year and one state: California in 1938. Comparing the distribution in this case with that from the federal returns, I find close agreement.

2. Basic Model

The one-sector neoclassical growth model analyzed by Cole and Ohanian (1999) serves as the baseline for the conventional view described in the main text.

2.1. Household Problem

I'll start with the household's problem. The household chooses consumption c, investment x, and hours of work h to solve the following maximization problem:

$$\begin{aligned} \max_{\{c_t, x_t, h_t\}} \; & E \sum_{t=0}^{\infty} \beta^t \; \left[\log\left(c_t\right) + \psi\left(\left(1-h_t\right)^{\varphi} - 1\right)/\varphi\right] N_t \\ \text{subject to} \;\; & c_t + x_t = r_t k_t + w_t h_t + \kappa_t \\ & \qquad - \tau_{ht} w_t h_t - \tau_{pt}\{\left(r_t - \delta - \tau_{kt}\right) k_t\} \\ & k_{t+1} = \left[\left(1-\delta\right) k_t + x_t\right] / \left(1+\eta\right) \\ & x_t \geq 0 \quad \text{in all states} \end{aligned}$$

with processes for factor prices (r_t, w_t), taxes (τ_{ht}, τ_{pt}), and transfers (κ_t) given. Quantities are in per capita terms. N_t is the number of family members. Growth in N_t is η.

I next derive the necessary first-order conditions that I use in the computer code. The Lagrangian for the optimization problem is

$$\begin{aligned} \mathcal{L} = E \sum_t \left[\beta\left(1+\eta\right)\right]^t \Bigg\{ & \log\left(\hat{c}_t\right) + \psi\left(\left(1-h_t\right)^{\varphi} - 1\right)/\varphi + \frac{\zeta}{3} \min\left(\hat{x}_t, 0\right)^3 \\ & + \mu_t \Big\{ \left(r_t - \tau_{kt}\right) \hat{k}_t + \left(1-\tau_{ht}\right) \hat{w}_t h_t + \hat{\kappa}_t \\ & \qquad - \hat{c}_t - \hat{x}_t \\ & \qquad - \tau_{pt}\{\left(r_t - \delta - \tau_{kt}\right) \hat{k}_t\} \\ & + \lambda_t \Big\{ \left(1-\delta\right) \hat{k}_t + \hat{x}_t - \left(1+\eta\right)\left(1+\gamma\right) \hat{k}_{t+1} \Big\} \Bigg\}, \end{aligned}$$

where ζ is a penalty parameter used to deal with the constraint $x_t \geq 0$. Variables that grow over time with increasing technology are detrended, e.g., $\hat{c}_t = c_t/(1+\gamma)^t$.

Taking derivatives with respect to all decision variables yields the following first-order conditions:

$$1/\hat{c}_t = \mu_t \tag{2.1}$$

$$\psi \left(1-h_t\right)^{\varphi-1} = \mu_t \left(1-\tau_{ht}\right)\hat{w}_t \tag{2.2}$$

$$\zeta \min\left(\hat{x}_t, 0\right)^2 + \lambda_t = \mu_t \tag{2.3}$$

$$\begin{aligned}(1+\eta)(1+\gamma)\lambda_t = \tilde{\beta} E_t \Big[& \lambda_{t+1}(1-\delta) \\ & + \mu_{t+1}\big\{r_{t+1} - \tau_{pt+1}\left(r_{t+1}-\delta\right)\big\}\Big].\end{aligned} \tag{2.4}$$

If I simplify these equations, I have

$$\psi \hat{c}_t \left(1-h_t\right)^{\varphi-1} = \left(1-\tau_{ht}\right)\hat{w}_t \tag{2.5}$$

$$\begin{aligned}&\frac{1}{\hat{c}_t} - \zeta \min\left(\hat{x}_t, 0\right)^2 \\ &\quad = \hat{\beta} E\Bigg[\frac{1}{\hat{c}_{t+1}}\big\{1 + \left(1-\tau_{pt+1}\right)\left(r_{t+1}-\delta\right)\big\} \\ &\qquad\qquad - (1-\delta)\,\zeta \min\left(\hat{x}_{t+1}, 0\right)^2 \,\Bigg|\, k_t, s_t\Bigg],\end{aligned} \tag{2.6}$$

where $\hat{\beta} = \beta/(1+\gamma)$.

2.2. Factor Prices

Factor prices are derived from the first-order conditions of

$$\max_{\{K_t, L_t\}} K_t^{\theta}\left(Z_t L_t\right)^{1-\theta} - r_t K_t - w_t H_t,$$

which implies

$$r_t = \theta\left(\hat{k}_t\right)^{\theta-1}\left(z_t h_t\right)^{1-\theta}$$

$$\hat{w}_t = (1-\theta)\left(\hat{k}_t\right)^{\theta} z_t^{1-\theta} h_t^{-\theta}$$

when variables are normalized.

2.3. Government Budget Constraint

The government's budget constraint, written in per capita and detrended terms, is given by

$$\hat{g}_t + \hat{\kappa}_t = \tau_{ht}\hat{w}_t h_t + \tau_{pt}\left(r_t - \delta - \tau_{kt}\right)\hat{k}_t.$$

2.4. Resource Constraint

The original resource constraint of the economy is given by

$$N_t\left(c_t+x_t+g_t\right)=\left(N_t k_t\right)^\theta\left(Z_t N_t h_t\right)^{1-\theta},$$

where g_t is per capita spending of the government. Once I divide by population and account for growth in technology, I have a normalized resource constraint given by

$$\hat{c}_t+\hat{x}_t+\hat{g}_t=\hat{y}_t=\hat{k}_t^\theta\left(z_t h_t\right)^{1-\theta}.$$

2.5. Exogenous Processes

I next specify exogenous processes for $\{\hat{g}, \tau_h, \tau_p, z\}$. Let s index the state, where s is determined by an nth-order Markov chain. Then at time t if the state is s, $g_t=g(s)$, $\tau_{ht}=\tau_h(s)$, etc. The process for s is intended to capture different states of the world. Note that the state vector for the economy is $\hat{k}$, s.

2.6. Computation

The first step is to find α, which is used to represent the consumption function,

$$\hat{c}\left(\hat{k}, s\right)=\sum_{j=1}^{nnodes} \alpha_j^s \Phi_j\left(\hat{k}\right),$$

where the functions $\Phi_j(\hat{k})$ are known basis functions. For the finite element method, the $\Phi_j(\hat{k})$'s are low-order polynomials that are nonzero on small subdomains and the vector α satisfies

$$\begin{aligned} R\left(\hat{k}, s; \alpha\right)= & 1-\zeta \hat{c} \min \left(\hat{x}, 0\right)^2+\hat{\beta}\left(1-\delta\right) \zeta \hat{c} \sum_{s'} \pi_{s, s'} \min \left(\hat{x}', 0\right)^2 \\ & -\hat{\beta} \sum_{s'} \pi_{s, s'}\left(\frac{\hat{c}}{\hat{c}'}\right)\left\{1+\left(1-\tau_p\left(s'\right)\right)\left(\theta\left(\hat{k}'\right)^{\theta-1}\left(z\left(s'\right) h'\right)^{1-\theta}-\delta\right)\right\}. \end{aligned}$$

To speed up the computation, I will need the derivatives of R with respect to coefficients on current consumption and the coefficients on next period consumption. I'll start with current consumption:

$$\begin{aligned}
\frac{\partial R\left(\hat{k},s;\alpha\right)}{\partial\alpha_j^s} &= -\zeta[\min\left(\hat{x},0\right)^2 + 2\hat{c}\min\left(\hat{x},0\right)\frac{d\hat{x}}{d\hat{c}} - \hat{\beta}\left(1-\delta\right)\sum_{s'}\pi_{s,s'}\min\left(\hat{x}',0\right)^2]\frac{d\hat{c}}{d\alpha_j^s} \\
&\quad + 2\zeta\hat{\beta}\left(1-\delta\right)\hat{c}\sum_{s'}\pi_{s,s'}\min\left(\hat{x}',0\right)\frac{d\hat{x}'}{d\alpha_j^s} \\
&\quad - \hat{\beta}\sum_{s'}\pi_{s,s'}\left\{1+\left(1-\tau_p\left(s'\right)\right)\left(\theta\left(\hat{k}'\right)^{\theta-1}\left(z\left(s'\right)h'\right)^{1-\theta}-\delta\right)\right\}\left(\frac{\hat{c}}{\hat{c}'}\right) \\
&\qquad\qquad \cdot\left[\frac{1}{\hat{c}}\frac{d\hat{c}}{d\alpha_j^s} - \frac{1}{\hat{c}'}\frac{d\hat{c}'}{d\alpha_j^s}\right] \\
&\quad - \hat{\beta}\sum_{s'}\pi_{s,s'}\left(\frac{\hat{c}}{\hat{c}'}\right)\left(1-\tau_p\left(s'\right)\right)\theta\left(\theta-1\right)\left(\hat{k}'\right)^{\theta-1}\left(z\left(s'\right)h'\right)^{1-\theta} \\
&\qquad\qquad \cdot\left[\frac{1}{\hat{k}'}\frac{d\hat{k}'}{d\alpha_j^s} - \frac{1}{h'}\frac{dh'}{d\alpha_j^s}\right]\Bigg\}
\end{aligned}$$

and, then, next period consumption:

$$\begin{aligned}
\frac{\partial R\left(\hat{k},s;\alpha\right)}{\partial\alpha_j^{s'}} &= 2\zeta\hat{\beta}\left(1-\delta\right)\hat{c}\sum_{s'}\pi_{s,s'}\min\left(\hat{x}',0\right)\frac{d\hat{x}'}{d\alpha_j^{s'}} \\
&\quad - \hat{\beta}\sum_{s'}\pi_{s,s'}\left\{1+\left(1-\tau_p\left(s'\right)\right)\left(\theta\left(\hat{k}'\right)^{\theta-1}\left(z\left(s'\right)h'\right)^{1-\theta}-\delta\right)\right\}\left(\frac{\hat{c}}{\hat{c}'}\right) \\
&\qquad\qquad \cdot\left[-\frac{1}{\hat{c}'}\frac{d\hat{c}'}{d\alpha_j^{s'}}\right] \\
&\quad - \hat{\beta}\sum_{s'}\pi_{s,s'}\left(\frac{\hat{c}}{\hat{c}'}\right)\left(1-\tau_p\left(s'\right)\right)\theta\left(\theta-1\right)\left(\hat{k}'\right)^{\theta-1}\left(z\left(s'\right)h'\right)^{1-\theta} \\
&\qquad\qquad \cdot\left[-\frac{1}{h'}\frac{dh'}{d\alpha_j^{s'}}\right].
\end{aligned}$$

To compute these expressions, I need formulas for the derivatives in these equations.

I'll start with the next period capital, which has the derivative

$$\begin{aligned}
d\hat{k}' &= d\hat{x}/[\left(1+\eta\right)\left(1+\gamma\right)] \\
&= [\left(1-\theta\right)\hat{y}/hdh - d\hat{c}]/[\left(1+\eta\right)\left(1+\gamma\right)].
\end{aligned}$$

Next, I'll derive dh, which involves differentiating the intratemporal first-order condition (2.5):

$$\begin{aligned}
0 &= d[\left(1-h\right)^{\varphi-1}h^\theta\hat{c}] \\
&= \left(1-h\right)^{\varphi-1}h^\theta\hat{c}\left\{\left[-\frac{\varphi-1}{1-h}+\frac{\theta}{h}\right]dh + \frac{1}{\hat{c}}d\hat{c}\right\}.
\end{aligned}$$

This result shows that dh can be written as a function of dc. Next consider dh', which is slightly different since it depends on dk' as well:

$$\begin{aligned} 0 &= d[(1-h')^{\varphi-1}(h')^{\theta}\hat{c}'\left(\hat{k}'\right)^{-\theta}] \\ &= (1-h')^{\varphi-1}(h')^{\theta}\hat{c}'\left(\hat{k}'\right)^{-\theta}\left\{\left[-\frac{\varphi-1}{1-h'}+\frac{\theta}{h'}\right]dh'+\frac{1}{\hat{c}'}d\hat{c}'-\frac{\theta}{\hat{k}'}d\hat{k}'\right\}. \end{aligned}$$

Finally I need

$$\frac{d\hat{c}'}{d\alpha_j^s} = \left(\sum_l \alpha_l^s \frac{\partial N_l\left(\hat{k}'\right)}{\partial \hat{k}'}\right)\frac{d\hat{k}'}{d\alpha_j^s}$$

$$\frac{d\hat{c}'}{d\alpha_j^{s'}} = N_j\left(\hat{k}'\right),$$

and all other derivatives are explicit or implicit functions of these.

2.7. Sensitivity Analysis

In this section, I discuss the results of sensitivity analysis for the basic model. Four sets of results are discussed in which I vary expectations, estimates of tax rates, the accounting of nonbusiness activity, and the filtering of inputs. I find that most of these simulations are nearly indistinguishable from the benchmark simulations.

2.7.1. Vary expectations

In Figures 17–20, I compare the benchmark simulation, in which households are uncertain about future fiscal policy, with a simulation, in which households have perfect foresight about future fiscal policy. The model results are very close to each other and very different from the U.S. data.

2.7.2. Use alternative tax rates

In Figures 21–24, I compare simulations for two different choices of tax rates on labor income and profits. In the benchmark simulation, I use the estimates of Barro and Redlick (2011) for the tax rate on labor income and the statutory rate on corporate profits for the tax rate on profits. In the alternative, I use the tax rate estimates of Joines (1981), which were used by Cole and Ohanian (1999) in their analysis of the Great Depression. Although these simulations have some minor differences, the main conclusion of the basic model remains: fiscal policy played only a small role.

2.7.3. *Add a nonbusiness sector*

In Figures 25–28, I compare the simulations of the basic model in versions that differ with respect to the accounting of nonbusiness activity. In the benchmark simulation, I used an extremely basic one-sector version of the growth model, with profits taxes assessed on aggregate capital income. In the alternative, I distinguish business and nonbusiness income, and the tax on profits is assumed to be levied on just business income. Since households take nonbusiness hours, investment, and output as given, I compare their choices for business aggregates with the aggregates in the basic one-sector model. As the figures show, adding the nonbusiness sector does not improve the fit of the basic model.

2.7.4. *Use unfiltered inputs*

In Figures 29–32, I compare the benchmark results, in which the inputs are first smoothed, with those in which they are not. (See Figures 5–16 for the two sets of inputs.) These figures show that using the smoothed tax series does not affect the results for the basic model. The results are nearly indistinguishable.

3. Extended Model

To the basic model, I add a richer tax structure, and because some of the capital taxes are imposed on business incomes only, I distinguish between business and nonbusiness activity.

3.1. Household Problem

I'll start with the household's problem. The problem is to choose consumption c_t, hours h_t, and business investment x_{bt} to maximize

$$\max\ E\sum_{t=0}^{\infty}\beta^t[\log(c_t)+\psi\left((1-h_t)^{\varphi}-1\right)/\varphi]N_t$$

subject to

$$\begin{aligned}c_t+x_{bt}\le r_tk_{bt}&+w_th_t+\kappa_t\\&-\tau_{ct}c_t-\tau_{ht}w_th_t\\&-\tau_{xt}x_{bt}-\tau_{kt}k_{bt}\end{aligned}$$

$$
\begin{aligned}
&- \tau_{pt} \left[r_t k_{bt} - \delta k_{bt} - \tau_{kt} k_{bt} \right] \\
&- \tau_{ut} \left[(1+\eta)\, k_{bt+1} - k_{bt} \right] \\
&- \tau_{dt} \Big[r_t k_{bt} - x_{bt} - \tau_{kt} k_{bt} - \tau_{xt} x_{bt} \\
&\qquad\quad - \tau_{pt} \big(r_t k_{bt} - \delta k_{bt} - \tau_{kt} k_{bt} \big) \\
&\qquad\qquad\qquad - \tau_{ut} \left((1+\eta)\, k_{bt+1} - k_{bt} \right) \Big],
\end{aligned} \tag{3.1}
$$

taking as given the initial capital stocks, factor prices (r_t, w_t), other incomes (κ), and exogenous shocks. Total hours h_t are the sum of business hours h_{bt} and nonbusiness hours h_{nt}.

Constraints that must be satisfied in addition to the budget constraint are the capital accumulation equations:

$$
k_{bt+1} = \left[(1-\delta)\, k_{bt} + x_{bt} \right] / \left(1+\eta\right)
$$

and nonnegativity constraints on investment: $x_{bt} \geq 0$ for all t.

Note that I am assuming that households own the capital stocks and pay all taxes directly. Separating the problems of households and firms will not affect the equations to which I apply the numerical algorithm. Also, I will assume that nonbusiness income, investment, and hours are given exogenously. Here, they will be indexed by the state s.

Before deriving first-order conditions for the problem, I first modify the objective of the household to incorporate penalty functions for the nonnegativity constraints:

$$
\begin{aligned}
E \max \sum_{t=0}^{\infty} \sum_{s^t} \left[\beta \left(1+\eta\right) \right]^t \Big\{ & \log\left(\hat{c}_t\right) + \psi \left(\left(1-h_t\right)^{\varphi} - 1 \right) / \varphi \\
& + \zeta/3 \min\left(\hat{x}_{bt}, 0\right)^3 \Big\}.
\end{aligned}
$$

If $\zeta = 0$, this is the utility defined above.

The Lagrangian for the optimization problem is

$$
\begin{aligned}
\mathcal{L} = E \sum_t \left[\beta\left(1+\eta\right)\right]^t \Bigg\{ & \log\left(\hat{c}_t\right) + \psi\left(\left(1-h_t\right)^{\varphi} - 1\right)/\varphi \\
& + \frac{\zeta}{3} \min\left(\hat{x}_{bt}, 0\right)^3 \\
& + \mu_t \Big\{ \left(r_t - \tau_{kt}\right) \hat{k}_{bt} + \left(1-\tau_{ht}\right) \hat{w}_t h_t + \hat{\kappa}_t \\
& \quad - \tau_{pt} \big\{ \left(r_t - \delta - \tau_{kt}\right) \hat{k}_{bt} \big\} \\
& \quad - \tau_{ut} \big\{ \left(1+\eta\right)\left(1+\gamma\right) \hat{k}_{bt+1} - \hat{k}_{bt} \big\} \\
& \quad - \tau_{dt} \big\{ \left(r_t - \tau_{kt}\right) \hat{k}_{bt} - \left(1+\tau_{xt}\right) \hat{x}_{bt} \\
& \qquad - \tau_{pt} \{ \left(r_t - \delta - \tau_{kt}\right) \hat{k}_{bt} \} \\
& \qquad - \tau_{ut} \{ \left(1+\eta\right)\left(1+\gamma\right) \hat{k}_{bt+1} - \hat{k}_{bt} \} \big\} \\
& \quad - \left(1+\tau_{ct}\right) \hat{c}_t - \left(1+\tau_{xt}\right) \hat{x}_{bt} \\
& + \lambda_t \Big\{ \left(1-\delta\right) \hat{k}_{bt} + \hat{x}_{bt} - \left(1+\eta\right)\left(1+\gamma\right) \hat{k}_{bt+1} \Big\}.
\end{aligned}
$$

Consider the first-order conditions with respect to consumption, labor, and next period capital stocks. They are as follows:

$$
\begin{aligned}
& 1/\hat{c}_t = \left(1+\tau_{ct}\right) \mu_t \\
& \psi\left(1-h_t\right)^{\varphi-1} = \mu_t \left(1-\tau_{ht}\right) \hat{w}_t \\
& \zeta \min\left(\hat{x}_t, 0\right)^2 + \lambda_t = \mu_t \left(1+\tau_{xt}\right)\left(1-\tau_{dt}\right) \\
& \left(1+\eta\right)\left(1+\gamma\right)\left(\lambda_t + \mu_t \tau_{ut}\left(1-\tau_{dt}\right)\right) = \tilde{\beta} E_t \Big[\lambda_{t+1}\left(1-\delta\right) \\
& \qquad + \mu_{t+1}\left(1-\tau_{dt+1}\right) \left\{ r_{t+1} - \tau_{kt+1} - \tau_{pt+1}\left(r_{t+1} - \delta - \tau_{kt+1}\right) + \tau_{ut+1} \right\} \Big].
\end{aligned}
$$

Rewriting the dynamic first-order conditions, I get

$$
\begin{aligned}
& \frac{\left(1+\tau_{xt}+\tau_{ut}\right)\left(1-\tau_{dt}\right)}{\left(1+\tau_{ct}\right)\hat{c}_t} - \zeta \min\left(\hat{x}_{bt}, 0\right)^2 \\
& \quad = \hat{\beta} E \Big[\frac{\left(1-\tau_{dt+1}\right)}{\left(1+\tau_{ct+1}\right)\hat{c}_{t+1}} \{ \left(1-\tau_{pt+1}\right)\left(r_{t+1} - \tau_{kt+1}\right) \\
& \qquad\qquad + \left(1-\delta\right)\left(1+\tau_{xt+1}\right) + \delta \tau_{pt+1} + \tau_{ut+1} \} \\
& \qquad - \zeta\left(1-\delta\right) \min\left(\hat{x}_{bt+1}, 0\right)^2 \Big].
\end{aligned}
$$

3.2. Factor Prices

Assume that the production function for business value added is

$$\hat{y}_{bt} = \hat{k}_{bt}^{\theta} \left(z_t h_{bt}\right)^{1-\theta}.$$

In this case, the factor prices are

$$\begin{aligned} r_t &= \theta \hat{y}_{bt} / \hat{k}_{bt} \\ \hat{w}_t &= (1-\theta) \, \hat{y}_{bt} / h_{bt}. \end{aligned}$$

3.3. Government Budget Constraint

The government's budget constraint, written in per capita and detrended terms, is given by

$$\begin{aligned} \hat{g}_t + \tilde{\kappa}_t = \tau_{ct}\hat{c}_t + \tau_{ht}\hat{w}_t h_t + \tau_{xt}\hat{x}_{bt} + \tau_{kt}\hat{k}_{bt} & \\ + \tau_{pt}\{(r_t - \delta - \tau_{kt}) \, \hat{k}_{bt}\} & \\ + \tau_{ut}\{\hat{x}_{bt} - \delta \hat{k}_{bt}\} & \\ + \tau_{dt}\{(r_{bt} - \tau_{kt}) \, \hat{k}_{bt} - (1+\tau_{xt}) \, \hat{x}_{bt} & \\ - \tau_{pt}[(r_t - \delta - \tau_{kt}) \, \hat{k}_{bt}] & \\ - \tau_{ut} \left(\hat{x}_{bt} - \delta \hat{k}_{bt}\right)\}, & \end{aligned}$$

where $\tilde{\kappa} = \hat{\kappa} + \hat{w} h_n + \hat{x}_n - \hat{y}_n$.

3.4. Resource Constraint

GDP in this economy is (after normalizing)

$$\hat{y}_{bt} + \hat{y}_{nt} = \hat{c}_t + \hat{x}_{bt} + \hat{x}_{nt} + \hat{g}_t.$$

Total output is $\hat{y}_{bt} + \hat{y}_{nt}$.

3.5. Exogenous Processes

The exogenous variables for this model are $\{\hat{g}, \tau_c, \tau_h, \tau_x, \tau_k, \tau_p, \tau_d, z^1, z^2, h_n, \hat{x}_n, \hat{y}_n\}$. The state is indexed by s. Therefore, the full state vector for the economy is $[\hat{k}_b, \, s]$.

3.6. Computation

I compute the consumption decision function that is represented as a sum of known basis functions $\Phi_j(\hat{k}_b)$:

$$\hat{c}\left(\hat{k}_b, s\right) = \sum_{j=1}^{nnodes} \alpha_{cj}^s \Phi_j\left(\hat{k}_b\right). \tag{3.2}$$

The static first-order conditions can be used to determine the current period variables, given guesses for the decision variable c and the state variables $\hat{k}_b$ and s. Start by guessing a value for h given c and $\hat{k}_b$. If the guess for h is correct, then the following should hold exactly:

$$h = 1 - \left[(1-\tau_h)(1-\theta)(y_b/h_b) / (\psi(1+\tau_c)\hat{c})\right]^{1/(\varphi-1)}.$$

If it does not, then I update the guess for h and continue until convergence.

The unknown coefficients in (3.2), which I can stack into the vector $\vec{\alpha}$, are set so that the residual of the dynamic Euler equation is approximately zero. This residual can be written as follows:

$$\begin{aligned} R\left(k_b, s; \vec{\alpha}\right) = {} & (1+\tau_x(s)+\tau_u(s))(1-\tau_d(s)) / (1+\tau_c(s)) \\ & - \zeta\hat{c}\min\left(\hat{x}_b, 0\right)^2 + \hat{\beta}\zeta\hat{c}(1-\delta_T)\sum_{s'}\pi_{s,s'}\min\left(\hat{x}_b', 0\right)^2 \\ & - \hat{\beta}\sum_{s'}\pi_{s,s'}\Big\{\frac{(1-\tau_d(s'))}{(1+\tau_c(s'))}\frac{\hat{c}}{\hat{c}'}\big[(1-\tau_p(s'))(r'-\tau_k(s')) \\ & + (1-\delta)(1+\tau_x(s')) + \delta\tau_p(s') + \tau_u(s')\big]\Big\}, \end{aligned}$$

where $\hat{\beta} = \beta(1+\gamma)^{-\sigma}$. If I apply a standard finite element method, I find $\vec{\alpha}$ to ensure that the weighted sum of residual R is equal to zero.

When computing $\vec{\alpha}$, I take derivatives of the residual with respect to unknown coefficients; this speeds up the numerical algorithm considerably, especially if the number of unknowns is large.

3.7. Sensitivity Analysis

In this section, I describe the sensitivity results with respect to the extended model.

3.7.1. *Set key tax rates to zero*

Two key tax rates in my analysis are the tax rate on dividend income and the tax rate on undistributed profits. These are demonstrated in Figures 33–36, where I show results for the benchmark simulation along with two alternatives: one in which τ_{dt} is set equal to zero in all periods and another in which τ_{ut} is set equal to zero in all periods. When the tax rate on dividend income is set to zero, the model completely misses the large decline in business investment. In fact, the only reason why investment falls at all is because the nonbusiness investment falls exogenously. Similarly, there is little change in consumption, GDP, and hours. When the tax rate on undistributed profits is set to zero, the model completely misses the drop in investment during the 1938 recession. Similarly, there is less of a decline in GDP relative to trend and in per capita hours.

3.7.2. *Vary expectations*

Another potentially key factor in the analysis is household expectations. In Figures 37–40, I show the results for three alternative specifications for household expectations. The first is the benchmark. The second assumes households in 1930 expect no change to occur in tax and spending policies. The same is true in 1931. Because they are initially myopic, they do not anticipate a large change in the return to investment and, therefore, the declines in investment and hours and the rise in consumption are smaller. The third alternative for household expectations assumes perfect foresight, which results in immediate responses in all variables; households know perfectly that taxes and spending will rise and react right away to minimize the impact.

3.7.3. *Use alternative tax rates*

In Figures 41–44, I show the simulations as I vary estimated tax rates on dividend income. I consider three alternatives: two based on earlier studies and one based on a referee's suggestion. Although there are some quantitative differences, the main finding that capital taxation plays an important role during this period remains intact.

The first alternative is the rate constructed by McGrattan and Prescott (2003). Their rate, like mine, is the sum of rates based on federal and state returns; there are, however, two differences between our estimates of these rates. First, in constructing the average marginal tax rate from federal returns, McGrattan and Prescott (2003) used the total IRS dividends as an estimate of individual dividend income, whereas I use the NIPA personal dividends. The NIPA measure is slightly larger and is the more appropriate rate to use, since I want to account for those paying zero on an extra dollar of dividend income. The second and more significant difference is the estimate of the state tax rate. I construct an average marginal tax rate using state tax schedules, whereas McGrattan and Prescott (2003) multiplied the rate for federal returns by a factor equal to one plus the ratio of total state and local income taxes divided by total federal income taxes. I consider my new estimate a more accurate estimate of the overall marginal tax rate than the earlier one.

The second alternative is from Wright (1969), who claims to estimate the average marginal tax rate in exactly the same way that I do here, although the series is not the same. Unfortunately, he is not specific about the coverage (that is, federal plus state or federal only), the marginal rate used (that is, normal or surtax or both), the treatment of fidiuciary dividends, or the treatment of nonfilers.[3] As is clear from Figures 41–44, the tax rate can make a difference for the magnitudes in declines of economic activity, but the timing is the same. For example, with Wright's tax rate used for the rate on dividend income, the fall in investment is not as large, but the low point as before is 1932 when the major tax change takes place.

The third series shown in Figures 41–44 was suggested by a referee. Instead of taking a weighted average of marginal rates, I take a weighted average of *squared* marginal rates and then, after summing them, take the square root. Feeding this result into the model, I find a larger fall in investment, hours, and output, which is not surprising because this new rate rises faster between 1932 and 1939 than my benchmark estimate.

3.7.4. Add exogenous wedges

In the main text, I present results for investment when I add exogenous efficiency wedges that look like time-varying total factor productivity (TFP) shocks and labor wedges that look like time-varying tax rates on labor. I choose the series so that I get a perfect fit for GDP and hours of

[3] I attempted to replicate his series but could not.

work.[4] Here, I display the figure for investment again along with the results for the other model predictions. These results are shown in Figures 45 through 48.

The main message is that factors can be added that improve the overall fit of consumption, GDP, and hours without worsening the fit of the model to investment. Of course, the hard part is to find evidence for economic factors or policies that act like large and negative shocks to productivity and labor market conditions.[5]

3.7.5. Use unfiltered inputs

In Figures 49–52, I show results when I use the unfiltered inputs (shown in Figures 5–16) instead of the smoothed series. I do this in two steps—first with all series except the tax rate on dividends and then with all series. The purpose for two steps is to demonstrate that for all but the tax rate on dividends, using the filtered versus unfiltered inputs does not matter. The series are nearly indistinguishable.

When the dividend tax rate is left unfiltered, on the other hand, there are some identifiable differences in the model's equilibrium paths relative to the benchmark because the expected future rate relative to today's rate directly impacts the gross return to investment. I prefer to use the smoothed rate because it is the basis of household expectations. I do not want to assume that households have perfect knowledge of the exact variation in the ex-post marginal tax rate, averaged across all dividend earners. I prefer instead to assume that households merely believe the rate will rise over the decade.

3.7.6. Set policy variables constant

Above, I showed results when the key tax rates on dividends and undistributed profits are set to zero. Here, I fix the other rates and government spending at their 1929 levels to demonstrate that the main results are not changed by doing so. This is done in Figures 53–56 for tax rates on

---

[4] If instead I use U.S. data to back out TFP and a labor wedge and feed these series back into the model as Chari, Kehoe, and McGrattan (2007) do, then the fit is not perfect but is close.

[5] I also experiment with demand shocks that effectively change the price of consumption. These do not help with the overall fit of the model because they offset changes to the price of investment that arise from expected changes in the tax rate on dividends.

consumption (τ_c), tax rates on labor (τ_h), tax rates on property (τ_k), tax rates on profits (τ_p), and detrended government spending g.

3.7.7. Add estate taxes

In Figures 57–60, I compare results when using two different estimates of the tax on property (or wealth). (See Figure 15 for these rates.) Adding estate taxes implies tax rates on property are higher after 1932 and, thus, investment, GDP, and hours of work are all lower. However, the differences in the results are small.

4. Model with Non-Ricardian Consumers

In this section, I analyze a version of the growth model with households that live hand to mouth. I'll refer to them as *non-Ricardian.* They choose how much to work, and their consumption is given by wage income plus government transfers. The Ricardian consumers are, as before, able to save by investing in business capital. The point of the exercise is to see if such a model can better account for the large drop in consumption of U.S. households during the 1930s. To simplify the analysis, I assume that all work is done by non-Ricardian households.[6]

4.1. Household Problem

I'll start with the Ricardian households. These households choose consumption c_r and business investment x_b to solve the following maximization problem:

$$\begin{aligned}
&\max_{\{c_{rt},x_{bt}\}} E\sum_{t=0}^{\infty}\beta^t \log\left(c_{rt}\right) N_{rt} \\
&\text{subject to } \; c_{rt}+x_{bt} = r_t k_{bt} + \kappa_{rt} - \tau_{ct} c_{rt} - \tau_{xt} x_{bt} - \tau_{kt} k_{bt} \\
&\qquad\qquad - \tau_{pt}\left[r_t k_{bt} - \delta k_{bt} - \tau_{kt} k_{bt}\right] \\
&\qquad\qquad - \tau_{ut}\left[\left(1+\eta\right) k_{bt+1} - k_{bt}\right] \\
&\qquad\qquad - \tau_{dt}\left[r_t k_{bt} - x_{bt} - \tau_{kt} k_{bt} - \tau_{xt} x_{bt} \right.\\
&\qquad\qquad\qquad \left. - \tau_{pt}\left(r_t k_{bt} - \delta k_{bt} - \tau_{kt} k_{bt}\right)\right.
\end{aligned}$$

[6] I have also computed equilibria for a version of the model in which both types of households supply labor. Codes for this alternative case are available at my website, www.minneapolisfed.org/research/economists.

$$- \tau_{ut} \left((1+\eta) \, k_{bt+1} - k_{bt} \right) \Big],$$

$$k_{bt+1} = \left[(1-\delta) \, k_{bt} + x_{bt} \right] / \left(1+\eta \right)$$

$$x_{bt} \geq 0 \quad \text{in all states}$$

with processes for factor prices, taxes, and transfers given. Quantities are in per capita terms. N_{rt} is the number of family members, which is normalized to 1 initially. Growth in population is η.

The non-Ricardian households choose c_{nr} and h to solve a static problem each period:

$$\max_{c_{nr}, h} \log \left(c_{nr} \right) + \psi \left(\left(1-h \right)^{\phi} - 1 \right) / \phi$$

$$\text{subject to} \quad \left(1+\tau_c \right) c_{nr} = \left(1-\tau_h \right) w h_b + \kappa_{nr} + y_n - x_n$$

$$h = h_b + h_n,$$

where κ_{nr} are government transfers to these households and $y_n - x_n$ is net income from nonbusiness activities. As in the earlier models, I assume that the nonbusiness variables are exogenous.

I next derive the necessary first-order conditions that I use in the computer code. The Lagrangian for the Ricardian household optimization is

$$\begin{aligned}
\mathcal{L} = E \sum_t \left[\beta \left(1+\eta \right) \right]^t \Bigg\{ & \log \left(\hat{c}_{rt} \right) + \frac{\zeta}{3} \min \left(\hat{x}_{bt}, 0 \right)^3 \\
& + \mu_t \Big\{ \left(r_t - \tau_{kt} \right) \hat{k}_{bt} + \hat{\kappa}_{rt} \\
& \quad - \tau_{pt} \big\{ \left(r_t - \delta - \tau_{kt} \right) \hat{k}_{bt} \big\} \\
& \quad - \tau_{ut} \big\{ \left(1+\eta \right) \left(1+\gamma \right) \hat{k}_{bt+1} - \hat{k}_{bt} \big\} \\
& \quad - \tau_{dt} \big\{ \left(r_{bt} - \tau_{kt} \right) \hat{k}_{bt} - \left(1+\tau_{xt} \right) \hat{x}_{bt} \\
& \qquad - \tau_{pt} \{ \left(r_t - \delta - \tau_{kt} \right) \hat{k}_{bt} \\
& \qquad - \tau_{ut} \{ \left(1+\eta \right) \left(1+\gamma \right) \hat{k}_{bt+1} - \hat{k}_{bt} \} \big\} \\
& \quad - \left(1+\tau_{ct} \right) \hat{c}_{rt} - \left(1+\tau_{xt} \right) \hat{x}_{bt} \\
& + \lambda_t \Big\{ \left(1-\delta \right) \hat{k}_{bt} + \hat{x}_{bt} - \left(1+\eta \right) \left(1+\gamma \right) \hat{k}_{bt+1} \Big\} \Bigg\}.
\end{aligned}$$

Consider the first-order conditions with respect to consumption and next period capital stocks. They are as follows:

$$1/\hat{c}_{rt} = \left(1+\tau_{ct} \right) \mu_t$$

$$\zeta \min\left(\hat{x}_{bt}, 0\right)^2 + \lambda_t = \mu_t \left(1 + \tau_{xt}\right)\left(1 - \tau_{dt}\right)$$

$$\left(1+\eta\right)\left(1+\gamma\right)\left(\lambda_t + \mu_t \tau_{ut}\left(1-\tau_{dt}\right)\right) = \tilde{\beta} E_t \Big[\lambda_{bt+1}\left(1-\delta\right)$$
$$+ \mu_{t+1}\left(1-\tau_{dt+1}\right)\left\{r_{t+1} - \tau_{kt+1} - \tau_{pt+1}\left(r_{t+1} - \delta - \tau_{kt+1}\right) + \tau_{ut+1}\right\}\Big].$$

Rewriting the dynamic first-order conditions, I get

$$\frac{\left(1+\tau_{xt}+\tau_{ut}\right)\left(1-\tau_{dt}\right)}{\left(1+\tau_{ct}\right)\hat{c}_{rt}} - \zeta \min\left(\hat{x}_{bt}, 0\right)^2$$
$$= \hat{\beta} E \Big[\frac{\left(1-\tau_{dt+1}\right)}{\left(1+\tau_{ct+1}\right)\hat{c}_{rt+1}}\{\left(1-\tau_{pt+1}\right)\left(r_{t+1}-\tau_{kt+1}\right)$$
$$+ \left(1-\delta\right)\left(1+\tau_{xt+1}\right) + \delta\tau_{pt+1} + \tau_{ut+1}\}$$
$$- \zeta\left(1-\delta\right)\min\left(\hat{x}_{bt+1}, 0\right)^2\Big].$$

Turning next to the non-Ricardian consumers who solve a static problem, the relevant first-order condition is

$$\psi\left(1-h_t\right)^{\phi-1}\left(1+\tau_{ct}\right)\hat{c}_{nrt} = \left(1-\tau_{ht}\right)\hat{w}_t.$$

4.2. Factor Prices

Assume that the technology is

$$\hat{y}_{bt} = \hat{k}_{bt}^{\theta}\left(z_t\left[N_{nr}h_{bt}\right]\right)^{1-\theta}.$$

Then factor prices are

$$r_t = \theta \hat{y}_{bt}/\hat{k}_{bt}$$
$$\hat{w}_t = \left(1-\theta\right)\hat{y}_{bt}/\left[N_{nr}h_{bt}\right].$$

4.3. Government Budget Constraint

The government's budget constraint, written in per capita and detrended terms, is given by

$$\hat{g}_t + \kappa_{rt} + N_{nr}\kappa_{nr} = \tau_{ct}\left[\hat{c}_{rt} + N_{nr}\hat{c}_{nrt}\right] + \tau_{ht}\hat{w}_t N_{nr} h_{bt} + \tau_{xt}\hat{x}_{bt} + \tau_{kt}\hat{k}_{bt}$$
$$+ \tau_{pt}\{\left(r_t - \delta - \tau_{kt}\right)\hat{k}_{bt} + \tau_{ut}\{\hat{x}_{bt} - \delta\hat{k}_{bt}\}$$

$$
\begin{aligned}
&+ \tau_{dt}\{(r_t - \tau_{kt})\,\hat{k}_{bt} - (1+\tau_{xt})\,\hat{x}_{bt} \\
&\qquad - \tau_{pt}[(r_t - \delta - \tau_{kt})\,\hat{k}_{bt} \\
&\qquad - \tau_{ut}\left(\hat{x}_{bt} - \delta \hat{k}_{bt}\right)\}.
\end{aligned}
$$

4.4. Resource Constraint

GDP in this economy (after normalizing) is

$$
\hat{c}_t + \hat{x}_{bt} + N_{nr}\hat{x}_{nt} + \hat{g}_t = \hat{y}_{bt} + N_{nr}\hat{y}_{nt}.
$$

4.5. Exogenous Processes

The exogenous variables for this model are $\{\hat{g}, \tau_c, \tau_h, \tau_x, \tau_k, \tau_p, \tau_d, z, h_n, \hat{x}_n, \hat{y}_n, \hat{\kappa}_{nr}\}$. The state is indexed by s. Therefore, the full state vector for the economy is $[\hat{k}_b,\ s]$.

4.6. Computation

The computational task for this model is to find α, which is used to represent the Ricardian consumption function,

$$
\hat{c}_r\left(\hat{k}_b, s\right) = \sum_{j=1}^{nnodes} \alpha_j^s \Phi_j\left(\hat{k}_b\right),
$$

where the functions $\Phi_j(\hat{k}_b)$ are known basis functions. For the finite element method, the $\Phi_j(\hat{k}_b)$'s are low-order polynomials that are nonzero on small subdomains and the vector α satisfies

$$
\begin{aligned}
R\left(\hat{k}_b, s; \vec{\alpha}\right) &= \left(1 + \tau_x(s) + \tau_u(s)\right)\left(1 - \tau_d(s)\right) / \left(1 + \tau_c(s)\right) \\
&\quad - \zeta \hat{c}_r \min\left(\hat{x}_b, 0\right)^2 + \hat{\beta}\zeta\hat{c}_r\left(1-\delta\right)\sum_{s'} \pi_{s,s'} \min\left(\hat{x}_b', 0\right)^2 \\
&\quad - \hat{\beta}\sum_{s'} \pi_{s,s'} \Big\{ \frac{\left(1 - \tau_d(s')\right)}{\left(1 + \tau_c(s')\right)} \frac{\hat{c}_r}{\hat{c}_r'} \big[\left(1 - \tau_p(s')\right)\left(r' - \tau_k(s')\right) \\
&\qquad + \left(1-\delta\right)\left(1 + \tau_x(s')\right) + \delta\tau_p(s') + \tau_u(s')\big]\Big\}.
\end{aligned}
$$

The main difference between the code for this model and the codes for the basic and extended models is the intermediate fixed point solved in the labor market. Here, I find wages w that satisfies the non-Ricardian budget constraint, starting with the states $\hat{k}_b$ and s and a candidate solution

$\hat{c}_r$. Specifically, I apply a standard Newton-Raphson routine to find the fixed point of $g(w) = 0$, where

$$g(w) = (1 + \tau_c(s))\,\hat{c}_{nr} - (1 - \tau_h(s))\,wh_{nr} - \kappa_{nr}(s) - y_n(s) + x_n(s)$$

and

$$\begin{aligned} h_b &= \left(\left((1-\theta)\,\hat{k}_b^{\theta} z(s)^{1-\theta}/\hat{w}\right)^{1/\theta}\right)/N_{nr} \\ \hat{c}_{nr} &= (1 - \tau_h(s))\,\hat{w}\,(1 - h_b - h_n(s))\,/\,(\psi\,(1 + \tau_c(s)))\,. \end{aligned}$$

4.7. Results

Next I consider simulations of three versions of the model. The first has only variation in the fiscal policies and the exogenous nonbusiness activities. In the second and third, I allow for time-varying wedges to try to better fit consumption and hours of work. I show that the model needs the added wedges because the non-Ricardian households barely change their consumption without them.

Before computing the simulations, I need to choose parameters for the model. To parameterize the model, I use the same procedure used for the earlier models. Growth is set at 1 percent for population and 1.9 percent for technology. All other parameters—with the exception of the new ones N_{nr} and κ_{nr}—are set by matching observations in 1929. For the new ones, I have no real guidance from data without taking a stand on how segmented asset markets are. I chose $N_{nr} = 10$, which implies a 10 to 1 ratio of non-Ricardians to Ricardians, and I chose per capita transfers to non-Ricardians to be κ_{nr} such that Ricardians received no transfers, $\kappa_r = 0$.

In Figures 61–66, I show the results for the three simulations. In all cases I choose transfers for the non-Ricardian households so that κ_{rt} remains at zero. Notice that in the version of the model with no wedges, total consumption still rises (although by less than in the extended model of Section 3). Wages and transfers need to fall significantly in order to generate a large decline in their consumption, which does not happen in this experiment. When I add variation in the labor or efficiency wedges, I can then generate significant declines in consumption for non-Ricardian households. Overall, the fit is best in the experiment with a labor wedge added. But, as before, we are left in need of a theory for these time-varying wedges.

5. Model with Intangible Capital

Here, I consider an extension of the stochastic growth model that has both tangible and intangible capital. As in the extended model, I also include more taxes than Cole and Ohanian (1999).

The motivation for including intangible capital is the fact that a significant amount of this type of capital investment is expensed and thus nontaxable; this includes investment in advertising, R&D, and organizational capital. It has been argued that the stock of intangible capital at the start of the Great Depression was already large, and with taxes rising during the 1930s, companies had an incentive to further increase their intangible investments.[7] As a trustee of the Museum of Science and Industry noted in 1936, with taxes rising, "many manufacturers have concluded that it will be better business judgment to spend money for business promotion, advertising, newspaper campaigns, technical research, etc., in which they get full benefit of each dollar in building up business" (*New York Times*, July 23, 1936). This shift from tangible to intangible investment is also evident in statistics on R&D employment. For example, Mowery and Rosenberg (1989) report that between 1933 and 1940, employment of scientists and engineers in two-digit manufacturing industries nearly tripled, rising from 10,927 to 27,777, and the number of scientific personnel per 1,000 wage earners doubled, rising from 1.93 to 3.67.

The inclusion of intangible investments also potentially addresses concerns of Chari, Kehoe, and McGrattan (2007), who apply a business cycle accounting exercise to the 1930s and show that models with frictions manifested primarily as efficiency wedges and labor wedges are needed to account for fluctuations during this period. The inclusion of both intangible investment and time-varying taxes implies time variation in these key wedges.

5.1. Household Problem

I'll start with the household's problem. The problem is to choose consumption c_t, hours h_t, and investments x_{Tt}, x_{It} to maximize

$$\max \ E \sum_{t=0}^{\infty} \beta^t [\log (c_t) + \psi \left((1-h_t)^{\varphi} - 1 \right) / \varphi] N_t$$

[7] See, for example, Fisher (1930, Chapters 8 and 9) for evidence of industrial research and inventions and improved methods of management engineering.

subject to

$$
\begin{aligned}
c_t + x_{Tt} + q_t x_{It} \leq r_{Tt}k_{Tt} &+ r_{It}k_{It} + w_t h_t + \kappa_t \\
&- \tau_{ct}c_t - \tau_{ht}w_t h_t + \tau_{bt}\left(1-\chi\right) q_t x_{It} \\
&- \tau_{xt}x_{Tt} - \tau_{kt}k_{Tt} \\
&- \tau_{pt}\big[r_{Tt}k_{Tt} + r_{It}k_{It} - \delta_T k_{Tt} - \chi q_t x_{It} - \tau_{kt}k_{Tt}\big] \\
&- \tau_{ut}\big[\left(1+\eta\right) k_{Tt+1} - k_{Tt}\big] \\
&- \tau_{dt}\big[r_{Tt}k_{Tt} + r_{It}k_{It} - x_{Tt} - \chi q_t x_{It} - \tau_{kt}k_{Tt} - \tau_{xt}x_{Tt} \\
&\qquad - \tau_{pt}\big(r_{Tt}k_{Tt} + r_{It}k_{It} - \delta_T k_{Tt} \\
&\qquad\qquad - \chi q_t x_{It} - \tau_{kt}k_{Tt}\big) \\
&\qquad\qquad - \tau_{ut}\left(\left(1+\eta\right) k_{Tt+1} - k_{Tt}\right)\big],
\end{aligned}
\tag{5.1}
$$

taking as given the initial capital stocks, factor prices ($r_{Tt},\ r_{It},\ w_t$), other incomes (κ), and exogenous shocks. Hours are the sum of business hours $h_{bt} = h_{bt}^1 + h_{bt}^2$ and nonbusiness hours h_{nt}.

Constraints that must be satisfied in addition to the budget constraint are the capital accumulation equations:

$$
\begin{aligned}
k_{Tt+1} &= \left[\left(1-\delta_T\right) k_{Tt} + x_{Tt}\right] / \left(1+\eta\right) \\
k_{It+1} &= \left[\left(1-\delta_I\right) k_{It} + x_{It}\right] / \left(1+\eta\right)
\end{aligned}
$$

and nonnegativity constraints on investment: $x_{Tt} \geq 0$ and $x_{It} \geq 0$. Again, note that I am assuming that households own the capital stocks and pay all taxes directly without loss of generality.

Also, I will assume, as in McGrattan and Prescott (2010), that nonbusiness income, investment, and hours are given exogenously. Here, they will be indexed by the state s.

Before deriving first-order conditions for the problem, I first modify the objective of the household to incorporate penalty functions for the nonnegativity constraints:

$$
\begin{aligned}
E \max \sum_{t=0}^{\infty} \sum_{s^t} \left[\beta\left(1+\eta\right)\right]^t \Big\{ &\log\left(\hat{c}_t\right) + \psi\left(\left(1-h_t\right)^{\varphi} - 1\right)/\varphi \\
&+ \zeta/3\big(\min\left(\hat{x}_{Tt}, 0\right)^3 + \min\left(\hat{x}_{It}, 0\right)^3\big)\Big\}.
\end{aligned}
$$

If $\zeta = 0$, this is the utility defined above.

The Lagrangian for the optimization problem is

$$
\begin{aligned}
\mathcal{L} = E \sum_t \left[\beta\left(1+\eta\right)\right]^t \Bigg\{ & \log\left(\hat{c}_t\right) + \psi\left(\left(1-h_t\right)^{\varphi}-1\right)/\varphi \\
& \qquad\qquad + \frac{\zeta}{3}\left[\min\left(\hat{x}_{Tt},0\right)^3 + \min\left(\hat{x}_{It},0\right)^3\right] \\
& + \mu_t \Big\{ \left(r_{Tt}-\tau_{kt}\right)\hat{k}_{Tt} + r_{It}\hat{k}_{It} + \left(1-\tau_{ht}\right)\hat{w}_t h_t + \hat{\kappa}_t \\
& \qquad - \tau_{pt}\big\{\left(r_{Tt}-\delta_T-\tau_{kt}\right)\hat{k}_{Tt} + r_{It}\hat{k}_{It} - \chi q_t \hat{x}_{It}\big\} \\
& \qquad - \tau_{ut}\big\{\left(1+\eta\right)\left(1+\gamma\right)\hat{k}_{Tt+1} - \hat{k}_{Tt}\big\} \\
& \qquad - \tau_{dt}\big\{\left(r_{Tt}-\tau_{kt}\right)\hat{k}_{Tt} + r_{It}\hat{k}_{It} - \chi q_t \hat{x}_{It} - \left(1+\tau_{xt}\right)\hat{x}_{Tt} \\
& \qquad\qquad - \tau_{pt}\{\left(r_{Tt}-\delta_T-\tau_{kt}\right)\hat{k}_{Tt} + r_{It}\hat{k}_{It} - \chi q_t \hat{x}_{It}\} \\
& \qquad\qquad - \tau_{ut}\{\left(1+\eta\right)\left(1+\gamma\right)\hat{k}_{Tt+1} - \hat{k}_{Tt}\}\big\} \\
& \qquad - \left(1+\tau_{ct}\right)\hat{c}_t - \left(1+\tau_{xt}\right)\hat{x}_{Tt} - \left(1-\left(1-\chi\right)\tau_{bt}\right)q_t\hat{x}_{It} \\
& + \lambda_{Tt}\Big\{ \left(1-\delta_T\right)\hat{k}_{Tt} + \hat{x}_{Tt} - \left(1+\eta\right)\left(1+\gamma\right)\hat{k}_{Tt+1}\Big\} \\
& + \lambda_{It}\Big\{ \left(1-\delta_I\right)\hat{k}_{It} + \hat{x}_{It} - \left(1+\eta\right)\left(1+\gamma\right)\hat{k}_{It+1}\Big\}\Bigg\}.
\end{aligned}
$$

Consider the first-order conditions with respect to consumption, labor, and next period capital stocks. They are as follows:

$$
\begin{aligned}
& 1/\hat{c}_t = \left(1+\tau_{ct}\right)\mu_t \\
& \psi\left(1-h_t\right)^{\varphi-1} = \mu_t\left(1-\tau_{ht}\right)\hat{w}_t \\
& \zeta\min\left(\hat{x}_{Tt},0\right)^2 + \lambda_{Tt} = \mu_t\left(1+\tau_{xt}\right)\left(1-\tau_{dt}\right) \\
& \zeta\min\left(\hat{x}_{It},0\right)^2 + \lambda_{It} = \mu_t q_t[\left(1-\chi\right)\left(1-\tau_{ht}\right) + \chi\left(1-\tau_{pt}\right)\left(1-\tau_{dt}\right)] \\
& \left(1+\eta\right)\left(1+\gamma\right)\left(\lambda_{Tt} + \mu_t\tau_{ut}\left(1-\tau_{dt}\right)\right) = \tilde{\beta}E_t\Big[\lambda_{Tt+1}\left(1-\delta_T\right) \\
& \qquad + \mu_{t+1}\left(1-\tau_{dt+1}\right)\left\{r_{Tt+1} - \tau_{kt+1} - \tau_{pt+1}\left(r_{Tt+1}-\delta_T-\tau_{kt+1}\right) + \tau_{ut+1}\right\}\Big] \\
& \left(1+\eta\right)\left(1+\gamma\right)\lambda_{It} = \tilde{\beta}E_t\Big[\lambda_{It+1}\left(1-\delta_I\right) \\
& \qquad + \mu_{t+1}\left(1-\tau_{pt+1}\right)\left(1-\tau_{dt+1}\right)r_{It+1}\Big].
\end{aligned}
$$

Rewriting the dynamic first-order conditions, I get

$$
\frac{\left(1+\tau_{xt}+\tau_{ut}\right)\left(1-\tau_{dt}\right)}{\left(1+\tau_{ct}\right)\hat{c}_t} - \zeta\min\left(\hat{x}_{Tt},0\right)^2
$$

$$= \hat{\beta} E \Big[\frac{(1-\tau_{dt+1})}{(1+\tau_{ct+1})\,\hat{c}_{t+1}} \{ (1-\tau_{pt+1})\,(r_{Tt+1}-\tau_{kt+1})$$

$$+ (1-\delta_T)\,(1+\tau_{xt+1}) + \delta_T \tau_{pt+1} + \tau_{ut+1} \}$$

$$- \zeta\,(1-\delta_T) \min\left(\hat{x}_{Tt+1}, 0\right)^2 \Big]$$

$$\frac{q_t\left[(1-\chi)\,(1-\tau_{ht}) + \chi\,(1-\tau_{pt})\,(1-\tau_{dt})\right]}{(1+\tau_{ct})\,\hat{c}_t} - \zeta \min\left(\hat{x}_{It}, 0\right)^2$$

$$= \hat{\beta} E \Big[\frac{1}{(1+\tau_{ct+1})\,\hat{c}_{t+1}} \{ (1-\tau_{dt+1})\,(1-\tau_{pt+1})\, r_{It+1}$$

$$+ (1-\delta_I)\, q_{t+1} [(1-\chi)\,(1-\tau_{ht+1})$$

$$+ \chi\,(1-\tau_{pt+1})\,(1-\tau_{dt+1})] \}$$

$$- \zeta\,(1-\delta_I) \min\left(\hat{x}_{It+1}, 0\right)^2 \Big].$$

5.2. Factor Prices

Assume that the technologies are

$$\hat{y}_{bt} = \left(\hat{k}_{Tt}^1\right)^{\theta_1} \left(\hat{k}_{It}\right)^{\phi_1} \left(z_t^1 h_t^1\right)^{1-\theta_1-\phi_1}$$

$$\hat{x}_{It} = \left(\hat{k}_{Tt}^2\right)^{\theta_2} \left(\hat{k}_{It}\right)^{\phi_2} \left(z_t^2 h_t^2\right)^{1-\theta_2-\phi_2},$$

where the total tangible capital (in business) is $\hat{k}_{Tt} = \hat{k}_{Tt}^1 + \hat{k}_{Tt}^2$ and total hours is $h_t = h_t^1 + h_t^2 + h_{nt}$.

The factor prices are

$$r_{Tt} = \theta_1 \hat{y}_{bt} / \hat{k}_{Tt}^1 = \theta_2 q_t \hat{x}_{It} / \hat{k}_{Tt}^2$$

$$r_{It} = \left(\phi_1 \hat{y}_{bt} + \phi_2 q_t x_{It}\right) / \hat{k}_{It}$$

$$\hat{w}_t = (1-\theta_1-\phi_1)\, \hat{y}_{bt} / h_t^1 = (1-\theta_2-\phi_2)\, q_t \hat{x}_{It} / h_t^2.$$

5.3. Government Budget Constraint

The government's budget constraint, written in per capita and detrended terms, is given by

$$\hat{g}_t + \tilde{\kappa}_t = \tau_{ct}\hat{c}_t + \tau_{ht}\hat{w}_t h_t + \tau_{bt}\,(1-\chi)\, q_t x_{It} + \tau_{xt}\hat{x}_{Tt} + \tau_{kt}\hat{k}_{Tt}$$

$$+ \tau_{pt}\{ (r_{Tt} - \delta_T - \tau_{kt})\, \hat{k}_{Tt} + r_{It}\hat{k}_{It} - \chi q_t \hat{x}_{It} \}$$

$$
\begin{aligned}
&+ \tau_{ut}\{\hat{x}_{Tt} - \delta_T \hat{k}_{Tt}\} \\
&+ \tau_{dt}\{(r_{Tt} - \tau_{kt})\,\hat{k}_{Tt} - (1+\tau_{xt})\,\hat{x}_{Tt} + r_{It}\hat{k}_{It} - \chi q_t \hat{x}_{It} \\
&\qquad\qquad - \tau_{pt}[(r_{Tt} - \delta_T - \tau_{kt})\,\hat{k}_{Tt} + r_{It}\hat{k}_{It} - \chi q_t \hat{x}_{It}] \\
&\qquad\qquad - \tau_{ut}\left(\hat{x}_{Tt} - \delta_T \hat{k}_{Tt}\right)\},
\end{aligned}
$$

where $\tilde{\kappa} = \hat{\kappa} + \hat{w}h_n + \hat{x}_n - \hat{y}_n$.

5.4. Resource Constraint

GDP in this economy (after normalizing) is

$$\hat{y}_{bt} + \hat{y}_{nt} = \hat{c}_t + \hat{x}_{Tt} + \hat{x}_{nt} + \hat{g}_t.$$

Total output is $\hat{y}_{bt} + \hat{y}_{nt} + q_t\hat{x}_{It}$.

5.5. Exogenous Processes

The exogenous variables for this model are $\{\hat{g}, \tau_c, \tau_h, \tau_x, \tau_k, \tau_p, \tau_d, z^1, z^2, h_n, \hat{x}_n, \hat{y}_n\}$. The state is indexed by s. Therefore, the full state vector for the economy is $[\hat{k}_T,\ \hat{k}_I,\ s]$.

5.6. Computation

I compute two decision functions that are represented as sums of known basis functions $\Phi_j(\hat{k}_T, \hat{k}_I)$:

$$\hat{c}\left(\hat{k}_T, \hat{k}_I, s\right) = \sum_{j=1}^{nnodes} \alpha^s_{cj}\Phi_j\left(\hat{k}_T, \hat{k}_I\right) \tag{5.2}$$

$$\hat{x}_T\left(\hat{k}_T, \hat{k}_I, s\right) = \sum_{j=1}^{nnodes} \alpha^s_{xj}\Phi_j\left(\hat{k}_T, \hat{k}_I\right). \tag{5.3}$$

The static first-order conditions can be used to determine the current period variables, given guesses for the decision variables c and x_T and the state variables $\hat{k}_T$, $\hat{k}_I$, and all exogenous variables. Start by guessing a value for h^1 given c, $\hat{k}_T$, and $\hat{k}_I$. Then I have (in order):

$$
\begin{aligned}
\hat{y}_b &= \hat{c} + \hat{x}_T + \hat{g} + (\hat{x}_n - \hat{y}_n) \\
\hat{w} &= (1 - \theta_1 - \phi_1)\,\hat{y}_b / h^1 \\
h &= 1 - [(1-\tau_h)\,\hat{w} / (\psi\,(1+\tau_c)\,\hat{c})]^{1/(\varphi-1)}
\end{aligned}
$$

$$h^2 = h - h^1 - h_n$$

$$\xi = (1 - \theta_2 - \phi_2)\, h^1 / \left[(1 - \theta_1 - \phi_1)\, h^2\right]$$

$$\hat{k}_T^1 = \theta_1 \xi / (\theta_2 + \theta_1 \xi)\, \hat{k}_T,$$

where $\xi = \hat{y}_b/(q\hat{x}_I)$. If the guess for h^1 is correct, then the following should hold exactly:

$$\hat{y}_b = \hat{A}^1 \left(\hat{k}_T^1\right)^{\theta_1} \left(\hat{k}_I\right)^{\phi_1} \left(h^1\right)^{1-\theta_1-\phi_1}.$$

If it does not, then I update the guess for h^1 and continue until convergence.

With values for $\hat{k}_1^T$, $\hat{w}$, and h^2, I can back out

$$\hat{k}_T^2 = \hat{k}_T - \hat{k}_T^1$$

$$q\hat{x}_I = \hat{w} h^2 / (1 - \theta_2 - \phi_2)$$

$$\hat{x}_I = \hat{A}^2 \left(\hat{k}_T^2\right)^{\theta_2} \left(\hat{k}_I\right)^{\phi_2} \left(h^2\right)^{1-\theta_2-\phi_2}$$

$$q = (q\hat{x}_I)/\hat{x}_I.$$

Then, capital stocks can be updated given current period investments x_T and x_I.

The unknown coefficients in (5.2) and (5.3), which I can stack into the vector $\vec{\alpha}$, are set so that the residuals of the two dynamic Euler equations are approximately zero. These residuals can be written as follows:

$$\begin{aligned}
R_1\left(\vec{k}, s; \vec{\alpha}\right) = {} & (1 + \tau_x(s) + \tau_u(s))(1 - \tau_d(s)) / (1 + \tau_c(s)) \\
& - \zeta \hat{c} \min(\hat{x}_T, 0)^2 + \hat{\beta} \zeta \hat{c} (1 - \delta_T) \sum_{s'} \pi_{s,s'} \min(\hat{x}_T', 0)^2 \\
& - \hat{\beta} \sum_{s'} \pi_{s,s'} \Big\{ \frac{(1 - \tau_d(s'))}{(1 + \tau_c(s'))} \frac{\hat{c}}{\hat{c}'} \big[(1 - \tau_p(s'))(r_T' - \tau_k(s')) \\
& + (1 - \delta_T)(1 + \tau_x(s')) + \delta_T \tau_p(s') + \tau_u(s')\big] \Big\}
\end{aligned}$$

$$\begin{aligned}
R_2\left(\vec{k}, s; \vec{\alpha}\right) = {} & q[(1 - \chi)(1 - \tau_b(s)) + \chi (1 - \tau_d(s))(1 - \tau_p(s))] / (1 + \tau_c(s)) \\
& - \zeta \hat{c} \min(\hat{x}_I, 0)^2 + \hat{\beta} \zeta \hat{c} (1 - \delta_I) \sum_{s'} \pi_{s,s'} \min(\hat{x}_I', 0)^2 \\
& - \hat{\beta} \sum_{s'} \pi_{s,s'} \Big\{ \frac{1}{(1 + \tau_c(s'))} \frac{\hat{c}}{\hat{c}'} \big[(1 - \tau_d(s'))(1 - \tau_p(s')) r_I' \\
& + (1 - \delta_I) q' [(1 - \chi)(1 - \tau_b(s')) \\
& + \chi (1 - \tau_d(s'))(1 - \tau_p(s'))]\big] \Big\},
\end{aligned}$$

where $\hat{\beta} = \beta(1+\gamma)^{-\sigma}$ and $\vec{k} = (\hat{k}_T, \hat{k}_I)$. If I apply a standard finite element method, I find $\vec{\alpha}$ to ensure that weighted sums of residuals R_1 and R_2 are equal to zero.

As in the basic model, I take derivatives with respect to the unknown coefficients in $\vec{\alpha}$ to speed up the numerical algorithm.

5.7. Results

Next, I analyze the role of intangible capital—which is a firm's untaxed alternative to business tangible—for the main findings. I show that varying the parameters governing the size of intangible capital, including fully turning it off (with ϕ set to 0), does not affect the paper's main results. The results for the model with intangible capital are shown in Figures 67–70.

For my simulations, I set growth rates as follows: $\gamma = 0.019$ and $\eta = 0.01$. The time series for nonbusiness activities are set exogenously to be equal to U.S. values. (The detrended paths of nonbusiness hours, investment, and output are shown in Table B.1.) The parameter χ, which governs the fraction of expensing done by capital owners, is set equal to 0.5 as in McGrattan and Prescott (2010).

The remaining parameters are set so that aggregates in the model economy are equal to their U.S. analogues in 1929. Specifically, in addition to the values of tax rates, government spending, and nonbusiness variables discussed earlier, I use 1929 values from U.S. data for real GDP, real consumption, real tangible business investment, real tangible business capital, real business compensation measured as in NIPA, and per capita hours. This implies parameter values of $\psi = 2.055$, $\beta = 0.98$, $\delta_T = 0.0358$, $\theta = 0.236$, and $\phi = 0.113$. Because the intangible depreciation rate and the share of intangible capital in production ϕ cannot be separately identified, I normalize δ_I to 0 and show below that this choice is made without loss of generality. I compute equilibrium paths starting with initial capital stocks consistent with 1929 observations and use the same transition matrix for expectations as that discussed in the main paper (Table 2).

In Figures 67 through 70, I compare the main equilibrium paths for three different parameterizations of the model with intangible capital to the benchmark without ($\phi = 0$). In versions of the model with intangible capital, I vary the fraction expensed by shareholders versus business owners and the depreciation rate.[8] The parameterization with $\chi = .5$ and $\delta_I = 0$ assumes that half of intangible investments are expensed by shareholders and that the depreciation rate on intangible capital is zero. The two alternative parameterizations have a higher fraction of expensing done by shareholders and equal depreciation rates for intangible and tangible investment.

As Figures 67–70 make clear, these alternatives generate similar model predictions. The main finding that capital taxation had a significant impact on economic activity in the 1930s is not overturned by these alternative numerical experiments.

6. U.S. Postwar Episodes

The post-Depression time period provides additional opportunities to test the theory because the United States has had several instances of large tax changes. Here, I reconsider several postwar episodes using neoclassical theory as above. The first episode, which is similar in many respects to the Great Depression, is the period after 2004, which includes the Great Recession (2008–2009). The second is the period 1990–2003, which, at the end, includes major policy changes enacted under President Bush. I chose to begin in 1990 because I want to extend the analysis of McGrattan and Prescott (2010)—who study the technology boom of the 1990s—by including details of the Bush tax cuts. Finally, I discuss a period that includes two major tax reforms under President Reagan and which brought about many changes in policy relevant for my theory.

6.1. Great Recession, 2008–2009

In this section, I consider the recent U.S. Great Recession (2008–2009) because it is a period in which future income tax rates were uncertain, but the nature of the uncertainty is relatively easy to model. For this period, as in the U.S. Great Depression, I find that the timing and magnitude of potential income tax changes are consistent with a large decline in U.S. investment. Before describing the numerical experiments and the quantitative findings, I provide some detail about the data used.

Figures 71–72 show estimates of the average marginal tax rates on labor and dividend income

[8] In each case, the parameters of the model are recalibrated so that the model generates 1929 levels of consumption, tangible investment, tangible capital, GDP, NIPA compensation, and hours comparable to levels in the United States.

over the period 2000–2010. As is clear from the figures, there were significant changes in individual income tax policy occurring in the beginning of the decade when George W. Bush was the U.S. President. The main policy changes are the Economic Growth and Tax Relief Reconciliation Act in 2001 and the Jobs and Growth Tax Relief Reconciliation Act in 2003. These policies—commonly referred to as the *Bush tax cuts*—lowered average marginal income tax rates relative to their 2000 level.

The tax rate on labor shown in Figure 71 is from Barro and Redlick (2011), and the tax rate on dividend income is constructed using data on equity holdings and marginal rates from federal and state income data. The details of the computation for the tax rate on dividend income are shown in Table 1. The first columns show the fraction of equity held in nontaxed accounts. Pensions include equity holdings of private pension funds, life insurance companies, state and local government, and federal government. These holdings are found in Table B.100.e of the *Flow of Funds Accounts* (FOF) of the Federal Reserve Board of Governors (2000–2010). Holdings for individual retirement accounts (IRAs) are found by multiplying total holdings shown in FOF Table L.225.i by an estimate of the fraction that is equity based on data on mutual funds from the Investment Company Institute (ICI). Specifically, I estimate the equity fraction to be the ratio of mutual fund IRA assets that are equity to total assets found in ICI (2010, Figure A9). For these calculations, I assume that hybrid accounts have an equal share of equity and debt. For nonprofit holdings, I take corporate equity and mutual fund holdings from FOF Table L.100.a. I multiply the mutual fund holdings by an estimate of the fraction that is equity. This equity fraction is estimated to be the ratio of equity assets to total assets, with hybrid accounts again assumed to have an equal share of equity and debt.

The source of data for the marginal tax rate that does not account for nontaxed entities is the National Bureau of Economic Research's (NBER) TAXSIM. (See Feenberg and Coutts, 1993, and the NBER website.) There are two TAXSIM rates for dividend income on federal and state tax returns: one on ordinary dividends and one on qualified dividends. I use a weighted average of these rates with weights equal to the fraction of dividends of each type shown on federal tax

Table 1. Average Marginal Tax Rates on Dividend Income, 2000–2010

	Fraction of Equity in Nontaxed Accounts				Tax Rates with Nontaxed	
	Pensions	IRAs	Nonprofits	Total	Excluded	Included
2000	.342	.149	.048	.539	.336	.155
2001	.357	.161	.048	.565	.318	.139
2002	.384	.182	.048	.614	.307	.119
2003	.386	.170	.048	.604	.206	.082
2004	.393	.169	.048	.610	.209	.081
2005	.410	.178	.048	.636	.215	.078
2006	.408	.180	.048	.635	.224	.082
2007	.424	.202	.048	.674	.227	.074
2008	.404	.219	.048	.671	.215	.071
2009	.407	.205	.048	.660	.214	.073
2010	.403	.198	.048	.649	.215	.075

Note: Sources of underlying data are Federal Reserve Board of Governors (1945–2010), Investment Company Institute (2010,1997–2011), Feenberg and Coutts (1993), and U.S. Treasury (1916–2010).

forms. The final column in Table 1 shows the constructed rate shown in Figure 72. This rate—with nontaxed included—is found by multiplying the fraction of nontaxed equity by the weighted average of TAXSIM rates—with nontaxed excluded.

As Figures 71 and 72 show, between 2000 and 2003, the policies enacted under President Bush led to a significant decline in these average marginal tax rates, from roughly 39 percent to a little over 35 percent on labor income, and from a little over 15 percent to a little under 8 percent on dividend income.

Relevant for household expectations are not only the tax policies but also the tax politics. In 2004, Bush was reelected and urged Congress to make permanent the tax policies enacted in 2001 and 2003. By 2007, many of the Democrats campaigning for the job of U.S. President in 2008 promised to let the policies expire on schedule. When Barak Obama was elected, he sought to make some of the legislated tax cuts permanent, but he also wanted tax rates of high earners to rise. Gains by Republican candidates in the 2010 midterm elections shifted sentiments yet again, with many Tea Party candidates promising to make the Bush tax policies permanent. As the deadline for expiration approached, proposals were made to extend the deadline, which was ultimately what was done.

These events motivate my choice of expectations shown in Table 2. I assume that, with the reelection of Bush in 2004, households expect the policies to be made permanent in 2011. With time, they are less certain and put more weight on the possibility that the legislation will expire as scheduled. For example, between 2007 and 2008, that expectation shifts, with households putting increasing weight on the probability that the policies will expire. With Obama's election, households become almost certain that they will expire. Then, in 2010, sentiment changes and the possibility of an extension is proposed.

The remaining model parameters are set in the same way as in the extended model during the U.S. Great Depression. I set growth rates as follows: $\gamma = 0.019$ and $\eta = 0.01$. The parameter χ, which governs the fraction of expensing done by capital owners, is set equal to 0.5. The other parameters are set so that aggregates in the model economy are equal to their U.S. analogues over the period 2005–2007. Specifically, I use averages over 2005–2007 from U.S. data for real GDP, real consumption, real tangible business investment, real tangible business capital, real business compensation measured as in NIPA, and per capita hours. This implies parameter values of $\psi = 1.3541$, $\beta = 0.98$, $\delta_T = 0.0416$, $\theta = 0.232$, and $\phi = 0.123$. As before, intangible depreciation is normalized to 0 without loss of generality.

To simplify the analysis, I compute equilibrium paths, starting in 2004, assuming that the only policies or inputs that *might* change over the sample period are average marginal income tax rates, τ_{ht} and τ_{dt}; in other words, I assume no time variation in other tax rates, government spending, and nonbusiness activities. The only thing that I assume does change over the period 2004–2011 is household expectations of the expiration of the Bush policies. A change in policy is never actually realized, so the tax rates on labor and dividend income stay at 35 percent and 7.8 percent, respectively, over the entire sample period. I abstract from all other changes considered in simulations of the Great Depression.

The results are shown Figures 73–76. Two model predictions are displayed: one that assumes that only τ_d is stochastic and one that assumes that both τ_d and τ_h are stochastic. I include both to see how much each anticipated rate change affects the results. Figure 73 shows that both model

Table 2. Expectations for 2004–2011 Model Simulation

	% Probability that Bush Tax Policies		
Expectations Formed in	Permanent in 2011	Expire in 2011	Extended until 2013
2004	100	0	0
2005	90	10	0
2006	90	10	0
2007	80	20	0
2008	50	50	0
2009	10	90	0
2010	25	25	50

predictions are a surprisingly close match to observed tangible investment, which falls close to 60 percent by mid-2009. Of course, how quickly and how steeply it drops off in the model is a function of the likelihood of an increase in tax rates. If the election of Obama had not had a significant effect on household expectations, the decline in investment would have been smaller.

In the case where households put some probability on both τ_d and τ_h rising in 2011, the drops in model business value added (Figure 75) and hours of work (Figure 76) account for 20 percent and 36 percent of the actual declines. Suppose, alternatively, that households assume that only τ_d can possibly rise—say, because Obama increases rates on higher earners, who earn most of the dividends, but not on lower earners, who earn most of the labor income. In this case, the drops in model business value added and hours of work account for 28 percent and 45 percent of the actual declines. In both simulations, model consumption shown in Figure 74 rises with increased distributions as in the simulations for the Great Depression.

Overall, the lesson learned from the simulation for the U.S. Great Recession is much like the lesson learned from the simulation for the U.S. Great Depression: anticipated changes in individual income taxes can have first-order effects on economic activity.

6.2. Bush Tax Cuts, 2001–2003

In this section, I extend the analysis of McGrattan and Prescott (2010) and include the Bush tax cuts, which occur at the end of the period they studied. I show that incorporating the change in tax policies yields results that are similar to theirs but do not rely on an assumption that there was a technology bust in 2000 following the technology boom in the 1990s.

McGrattan and Prescott (2010) use a version of the model with intangible capital (Section 5) with nonneutral technology change to study the technology boom of the 1990s. They begin their study by noting that the standard real business cycle (RBC) model, in which productivity shocks are important drivers of cyclical activity, does a terrible job in accounting for the 1990s—a period that is arguably most appropriate for such a theory. In fact, they show that a standard RBC model predicts a depressed rather than booming economy in the 1990s. Especially troubling is the boom in hours that occurs coincidentally with a decline in compensation per hour.

McGrattan and Prescott (2010) hypothesize that productivity in production of intangibles was abnormally high relative to productivity in production of final goods and services. Since intangible investments are not counted in GDP, but hours of work of those doing R&D and other activities related to creating new intangible investments are counted with total hours, we would expect lackluster TFP even if there indeed is a technology boom.

Here, I work with a stochastic version of their model, which is almost the same as the model of intangible capital discussed in Section 5. The difference is that here I allow for differences in TFP in the two technologies, namely,

$$
\begin{aligned}
\hat{y}_{bt} &= \left(\hat{k}_{Tt}^{1}\right)^{\theta}\left(\hat{k}_{It}\right)^{\phi}\left(z_t^1 h_t^1\right)^{1-\theta-\phi} \\
\hat{x}_{It} &= \left(\hat{k}_{Tt}^{2}\right)^{\theta}\left(\hat{k}_{It}\right)^{\phi}\left(z_t^2 h_t^2\right)^{1-\theta-\phi}.
\end{aligned}
$$

McGrattan and Prescott (2010) abstracted from variations in tax rates on dividend income. Here, to keep things simple, I allow for variations in the tax rate on dividend income and the productivities z_t^1, z_t^2—which are central to their theory—but abstract from all other time-varying processes that they considered.

In Figures 77–79, I show the paths for the three exogenous variables that I use as inputs in the model. In each figure, I show two series. The first corresponds to the original McGrattan and Prescott (2010) economy. The second is the alternative I want to consider. This alternative has time variation in the tax rate on dividends and no absolute drop in TFP for either sector (once the variables are multiplied by the growth trend). This is the sense in which I mean that my alternative simulation does not rely on a *technology bust.* In this case, technology booms during the 1990s and reverts to its long-run growth trend without falling absolutely.

Next consider the expectations about these processes. To generate a nonneutrality and some correlation in the sectoral TFPs, as in McGrattan and Prescott (2010), I model the two TFPs, $A_t^1 = (z_t^1)^{1-\theta-\phi}$ and $A_t^2 = (z_t^2)^{1-\theta-\phi}$, as functions of the same AR(1) process. Specifically I construct an 11-state Markov chain for an AR(1) process $\ln s_{t+1} = \rho \ln s_t + \varepsilon_t$ with $\varepsilon_t \simeq N(0, \sigma_\varepsilon^2)$. I set A_t^1 equal to its steady state plus one times $\ln s_t$ and set A_t^2 equal to its steady state plus two times $\ln s_t$. The transition matrix is found by applying Tauchen's (1986) method for a specific value of ρ, which here I take to be 0.95. The value of σ_ε is set so it is consistent with the shocks during the 1990s.

For the simulation with variation in the tax rate on dividends, I assume that households do not expect any change (from the 15 percent benchmark level) until 2000, the year when discussions about tax cuts began in earnest. In 2001, the Economic Growth and Tax Relief Reconciliation Act is enacted and households find out that tax rates on income are now a bit lower. At this point they put some weight on the probability that rates will fall further. In 2002, households put even more weight on a rate fall, and, in 2003, such an event occurs.

The key results for the two simulations are shown in Figures 80–82. At the beginning of the sample, the paths line up because the inputs and expectations are the same for the two simulations. Starting in 2000 we see some differences, but both generate significant drops in business investment, output, and hours.

The fact that the results for a technology bust and a tax boon look similar is at first counterintuitive but upon further investigation makes perfect sense. The simulations for the economy with time-varying tax rates on dividends mask an important theoretical factor. As soon as there is any weight put on the possibility that taxes will come down in the future, firms lower their distributions by increasing investment. Once taxes start to come down, firms increase distributions and hence lower their investment. In effect, investment has an inverted V-shaped pattern. This is the opposite of what happens in simulations for the U.S. Great Depression. At the beginning of the Depression, firms increase their distributions by lowering investment, and once taxes start to rise, they decrease distributions and increase investment. Thus, in the case of the Depression, there is a V-shaped pattern for investment.

6.3. Reagan Tax Cuts, 1981–1986

Finally, in this section, I discuss another interesting postwar period that includes two major tax reforms, namely the Economic Recovery Tax Act of 1981 (ERTA) and the Tax Reform Act of 1986 (TRA). Although the impact of these reforms can in theory be analyzed with the models discussed earlier, other factors must be taken into account, which make this time period much more difficult to analyze than those discussed earlier. The most important factors are early attempts to pass ERTA and policies related to pension reform.

In Figure 83, I provide a partial timeline of some key policy changes that occurred between 1970 and 1989, along with a plot of business tangible investment, which is the most likely place to look for effects of policies related to capital taxation. The first major policy change shown in the figure is the Employee Retirement Income Security Act of 1974 (ERISA), which establishes standards for pension plans of private employers and rules concerning the taxation of income in employee benefit plans.

In 1978, two major events occur. First, even before Reagan was elected, early attempts to pass ERTA were made by Representative Jack Kemp and Senator William Roth. Although the bills did not ultimately become law, many credit these congressmen with the legislation that finally did pass when Reagan was President. A second important policy change was the Revenue Act of 1978, and specifically a provision in section 401(k) that allowed employees to defer a certain amount of compensation before paying income taxes.

A clarification of the Prudent Man Law under ERISA (section 404(a)) was made in 1979 and would have been a partial impetus to greater sheltering of incomes from equities. Prior to ERISA, equities were only a small component of retirement savings. Another relevant clarification, this time by the Securities and Exchange Commission, is made in 1982 with their Rule 10b-18. This rule clarified guidelines for share repurchase programs and led to a significant shift by firms from issuing dividends to repurchasing shares. The reason for doing so was to take advantage of tax rate differences on dividends and capital gains. This advantage disappeared when TRA 1986 was enacted.

As this brief history suggests, a lot of important changes during this period affected both the statutory tax rate on distributions—dividends and repurchases—and household expectations about future tax rates. The period is an exciting one to study but also one that will require a more detailed investigation of the many relevant policy changes.

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Figures 1–16.
U.S. Data, 1929–1939

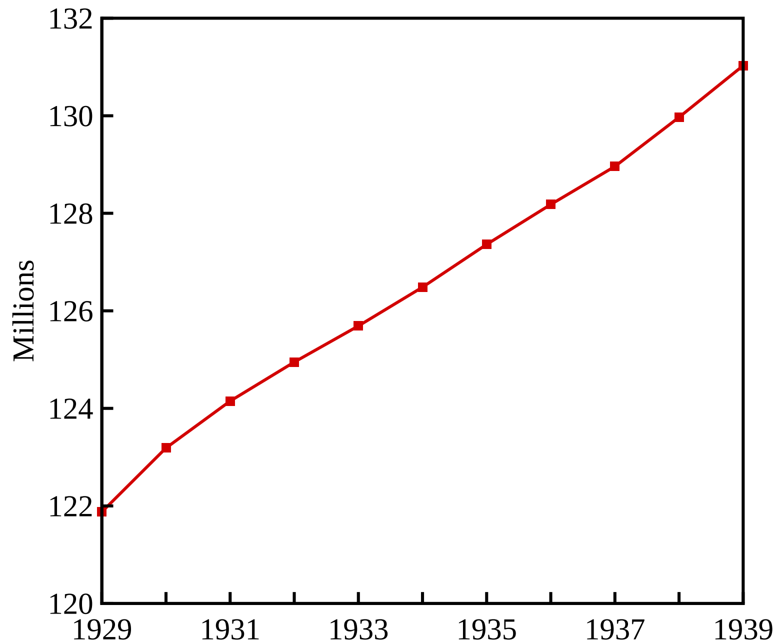

FIGURE 1. POPULATION AT MIDYEAR
Data Source: *SCB* (1929–1939)

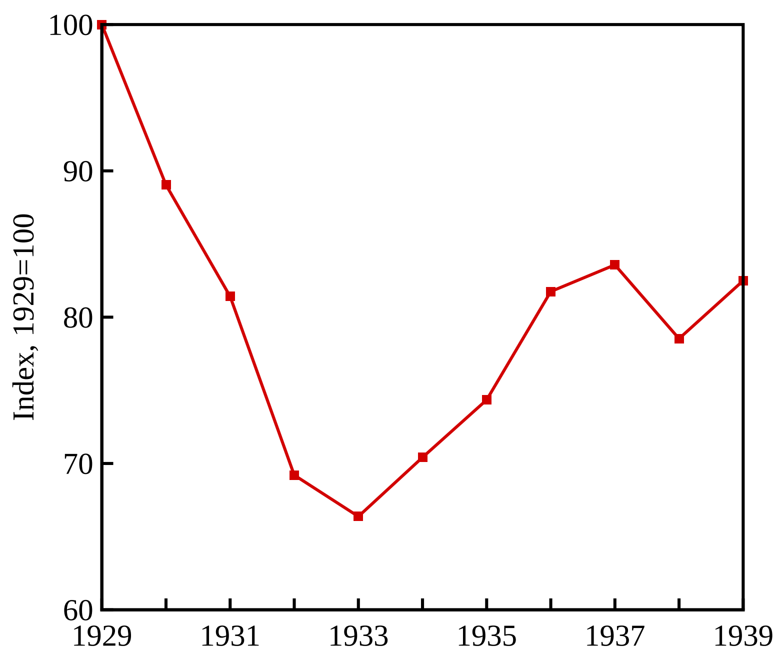

FIGURE 2. DETRENDED REAL GDP
Data Source: *SCB* (1929–1939)

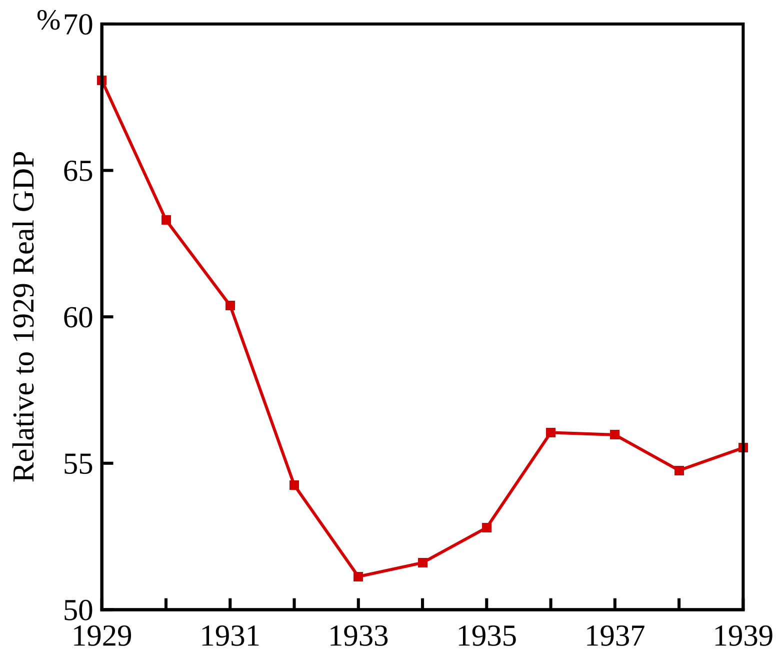

Figure 3. Detrended Real Consumption
Data Source: *SCB* (1929–1939)

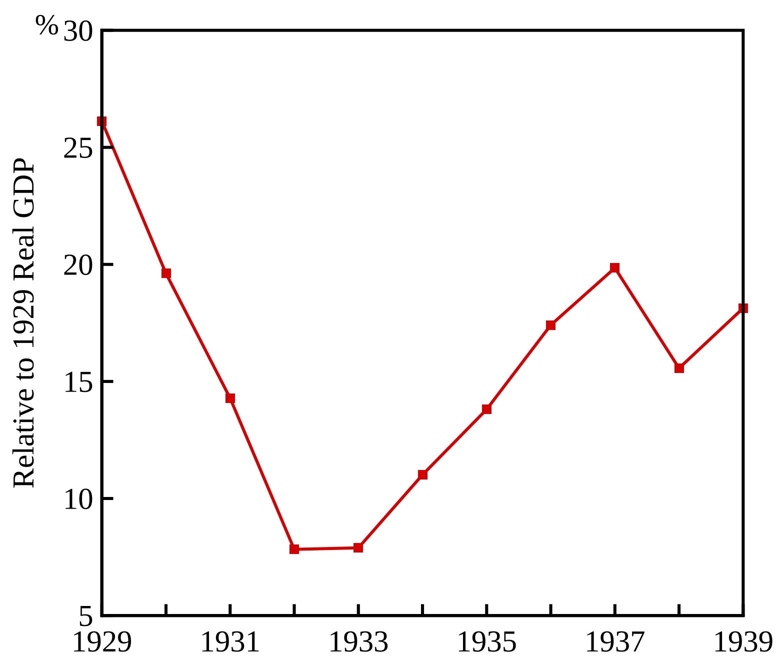

Figure 4. Detrended Real Investment
Data Source: *SCB* (1929–1939)

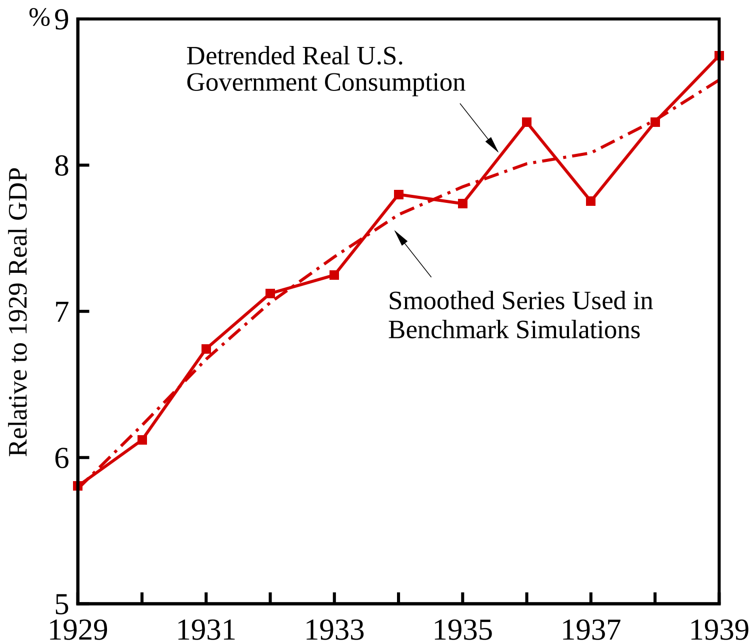

Figure 5. Detrended Government Spending
Data Source: *SCB* (1929–1939)

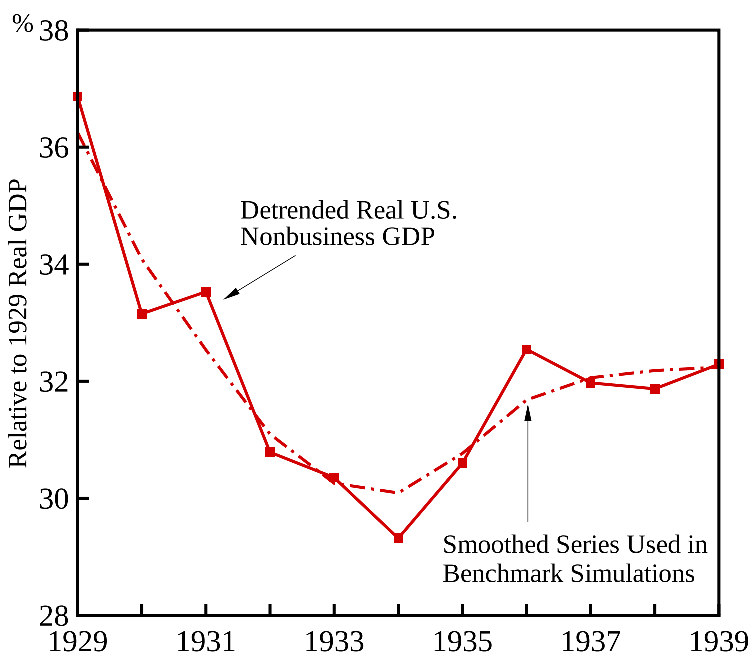

Figure 6. Detrended Nonbusiness Output
Data Source: *SCB* (1929–1939)

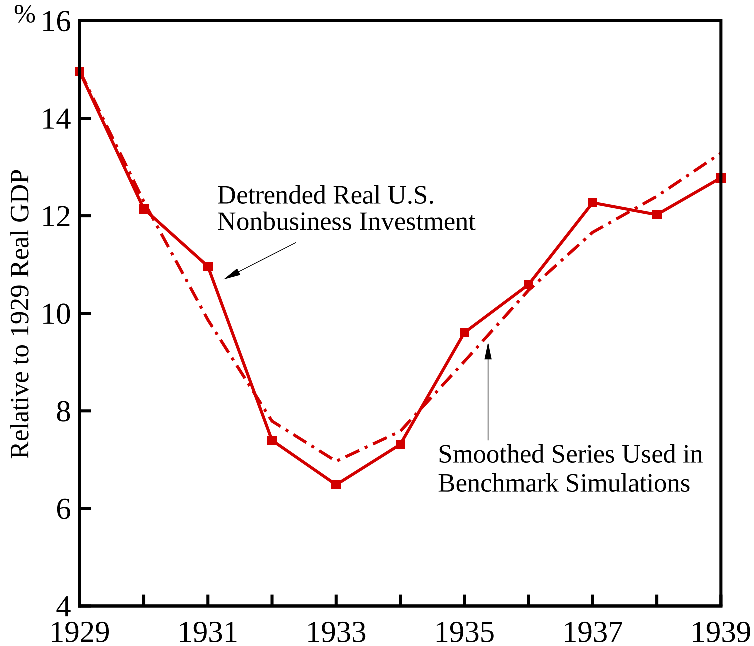

Figure 7. Detrended Nonbusiness Investment
Data Source: *SCB* (1929–1939)

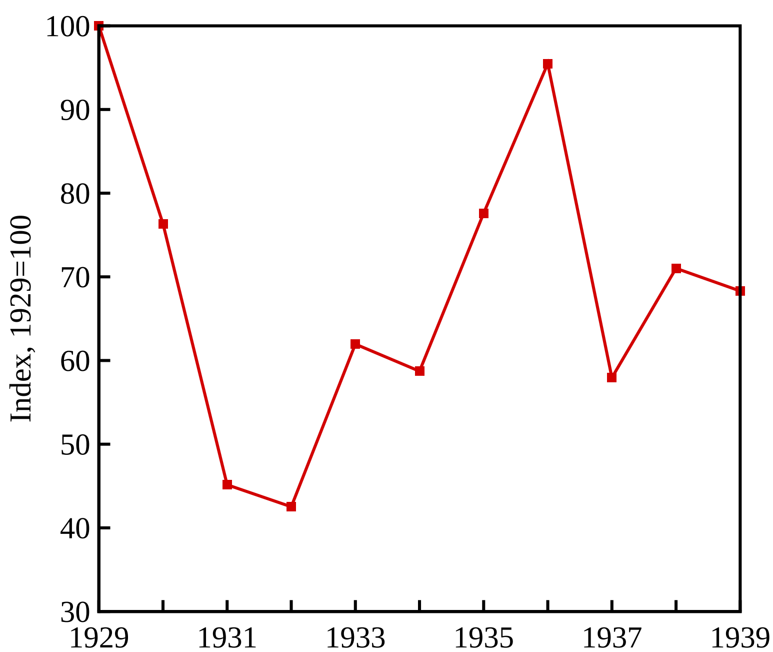

Figure 8. New York Stock Exchange Market Value
Data Source: *SCB*, Annual Supplements (1932–1950)

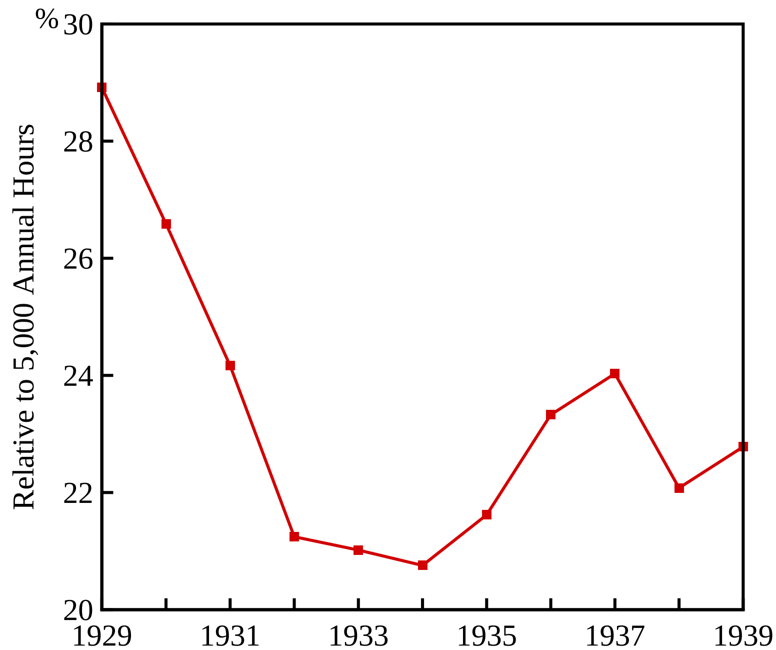

Figure 9. Per Capita Hours
Data Sources: Kendrick (1961), U.S. Commerce (1975)

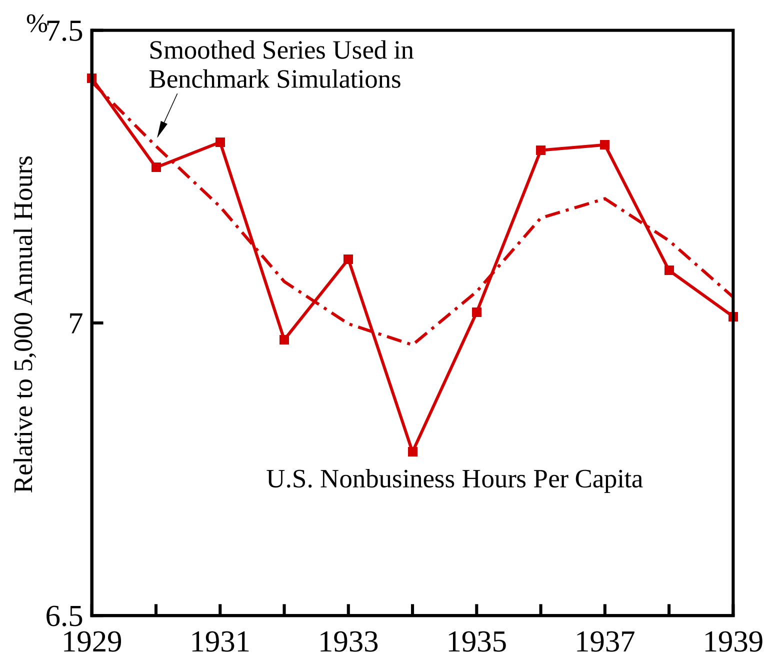

Figure 10. Per Capita Nonbusiness Hours
Data Sources: Kendrick (1961), U.S. Commerce (1975)

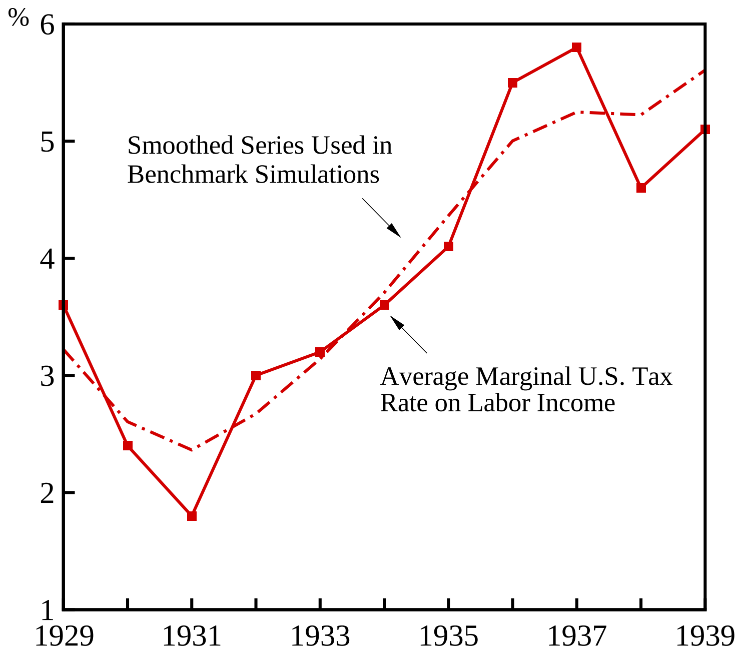

Figure 11. Average Marginal Tax Rate on Labor Income
Data Source: Barro and Redlick (2011)

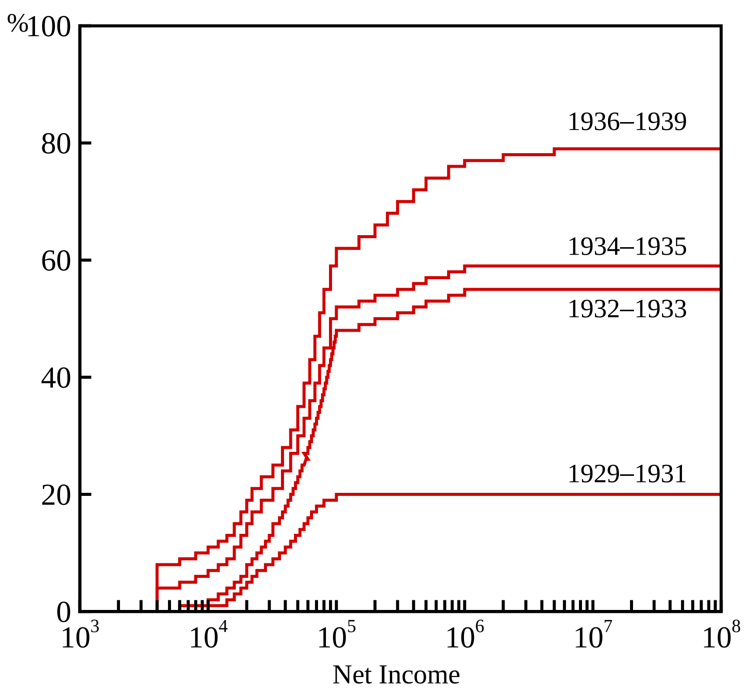

Figure 12. Marginal Tax Rate Schedule for Dividend Income
Data Source: *SOI*, 1929–1939

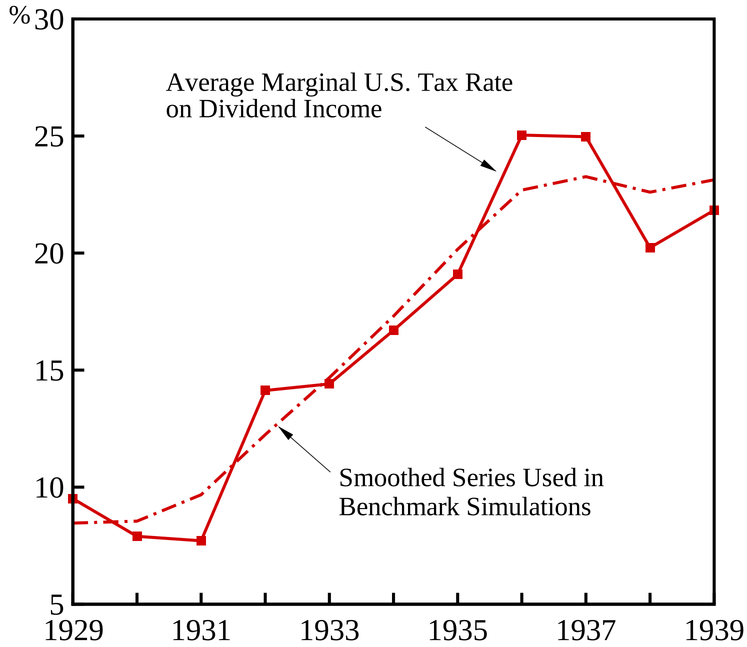

Figure 13. Average Marginal Income Tax Rate on Dividends

Data Sources: *SOI*, 1929–1939, Tax Research Foundation (1930–1942)

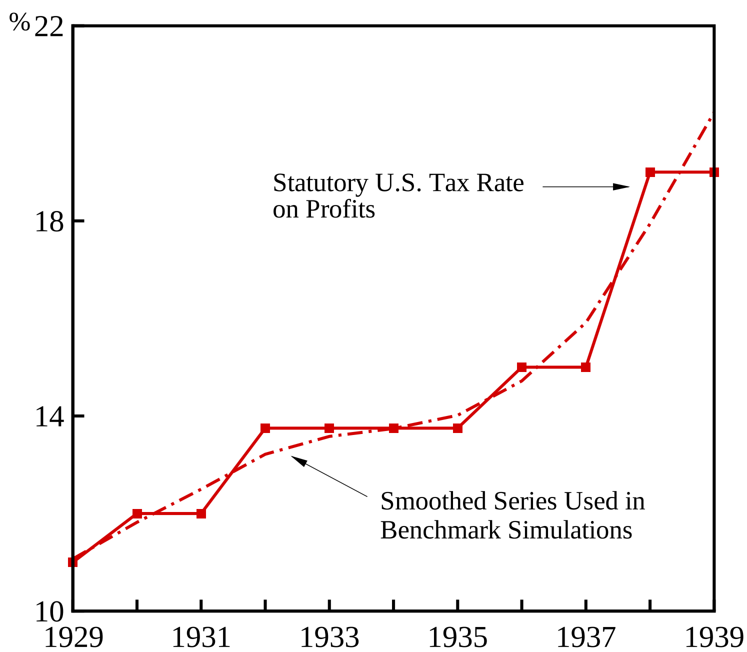

Figure 14. Statutory Tax Rate on Profits

Data Source: *SOI* (1929–1939)

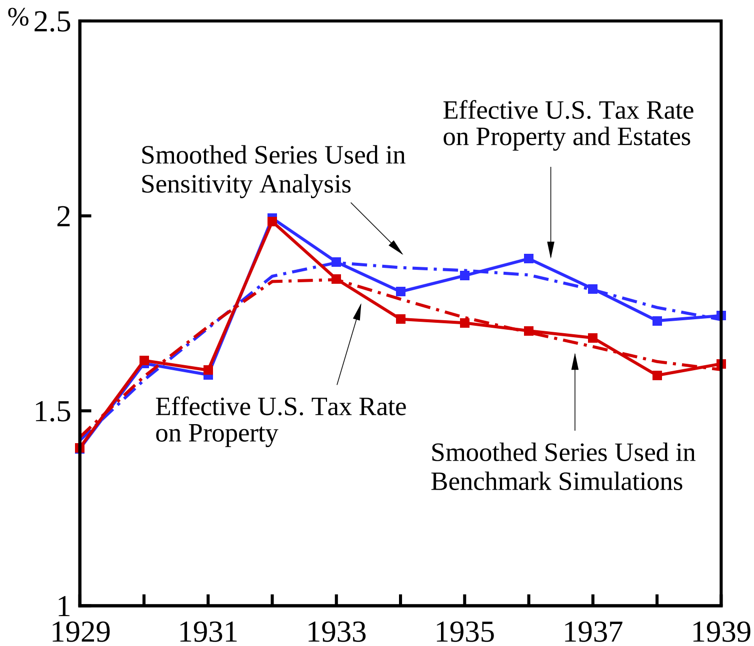

Figure 15. Effective Tax Rate on Business Property
Data Sources: *SCB* (1929–1939), *SOI Bulletin* (1990)

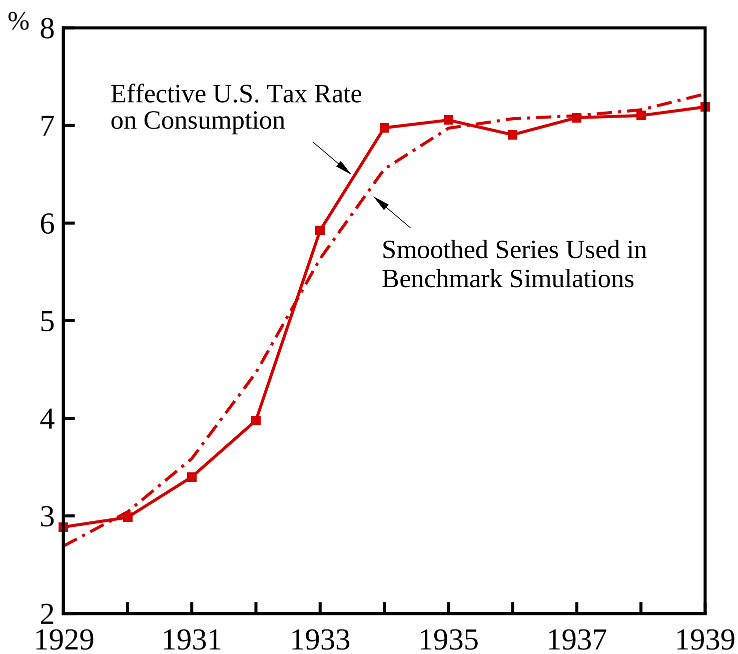

Figure 16. Effective Tax Rate on Consumption

Figures 17–20.
Varying Expectations in the Basic Model

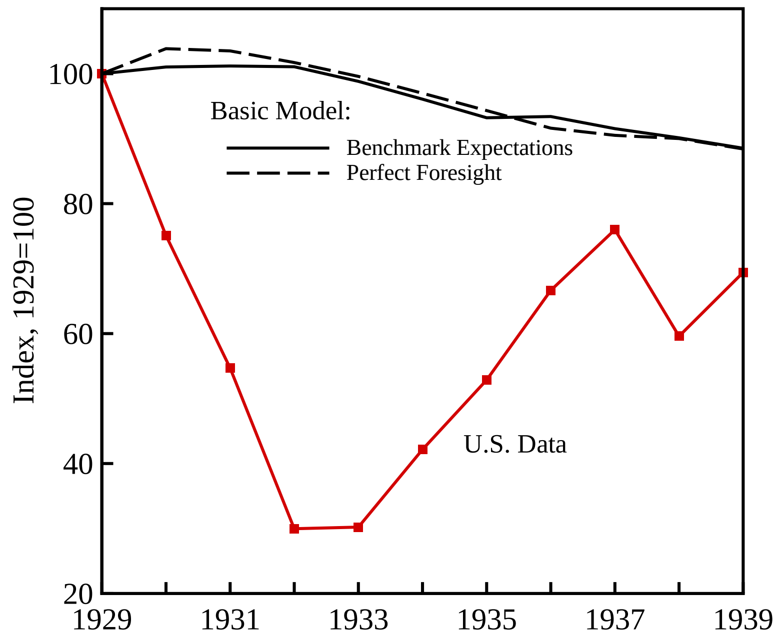

Figure 17. Detrended Real Investment in the United States and Predictions of the Basic Model, 1929–1939

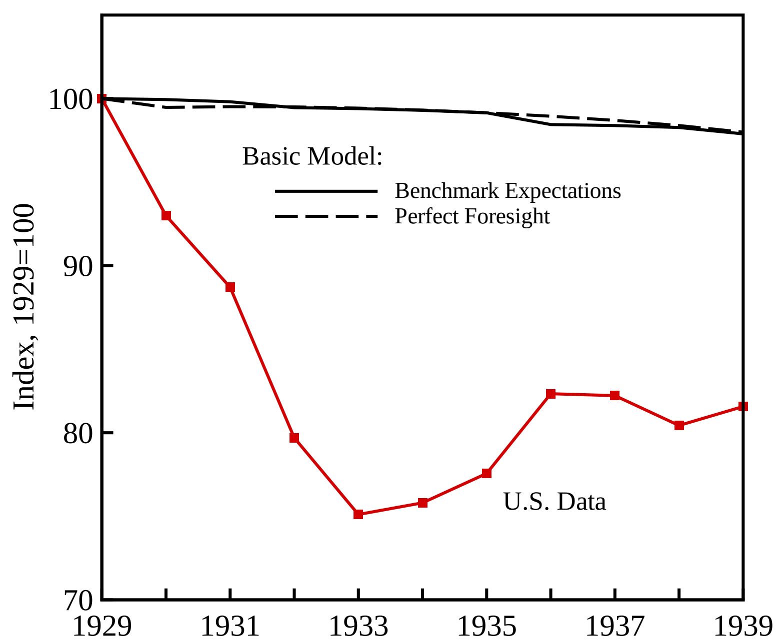

Figure 18. Detrended Real Consumption in the United States and Predictions of the Basic Model, 1929–1939

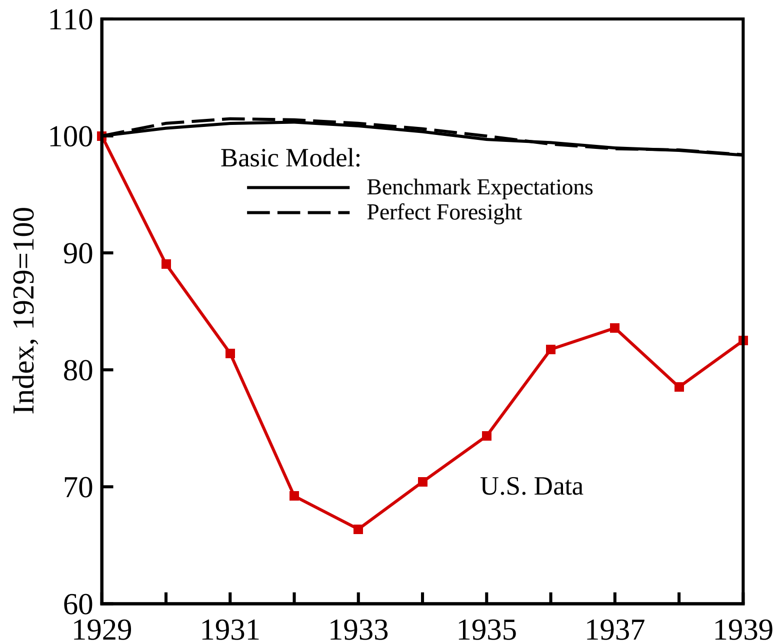

Figure 19. Detrended Real GDP in the United States and Predictions of the Basic Model, 1929–1939

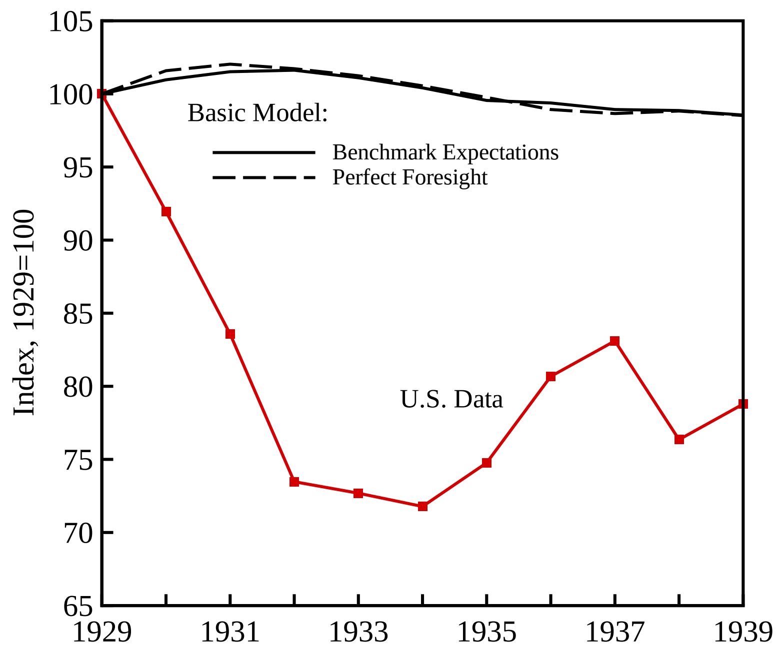

Figure 20. Hours Per Capita in the United States and Predictions of the Basic Model, 1929–1939

Figures 21–24.
Using Alternative Tax Rates in the Basic Model

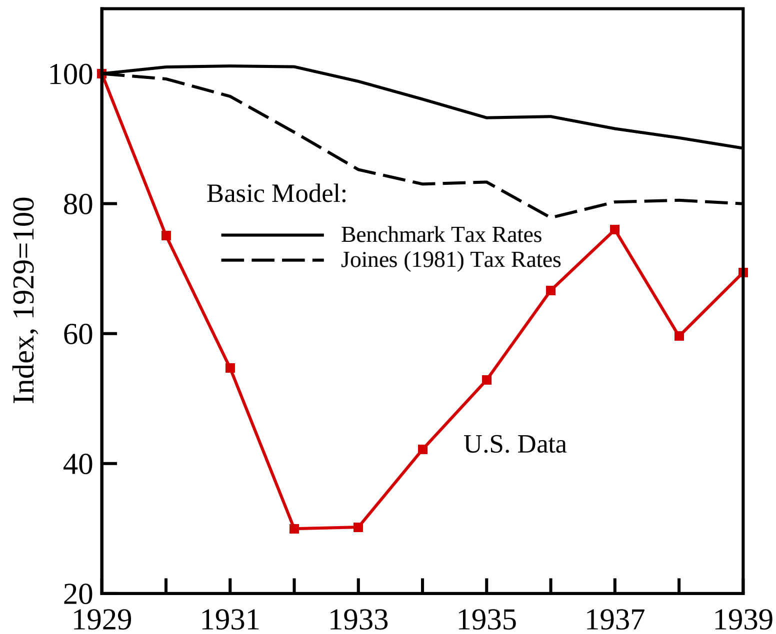

Figure 21. Detrended Real Investment in the United States and Predictions of the Basic Model, 1929–1939

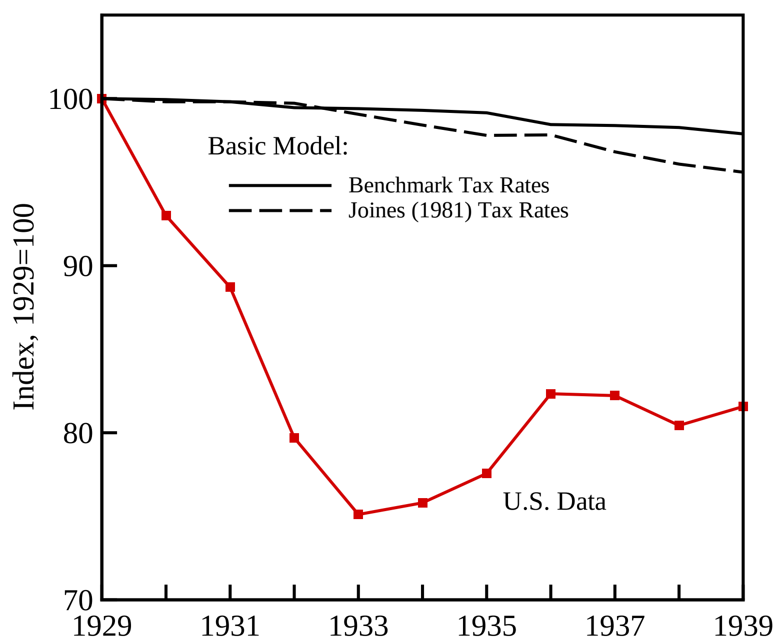

Figure 22. Detrended Real Consumption in the United States and Predictions of the Basic Model, 1929–1939

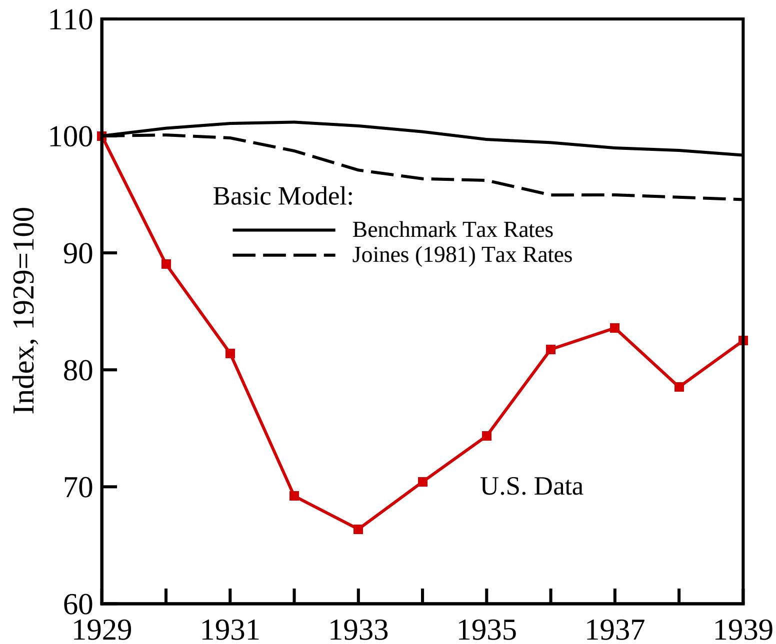

Figure 23. Detrended Real GDP in the United States and Predictions of the Basic Model, 1929–1939

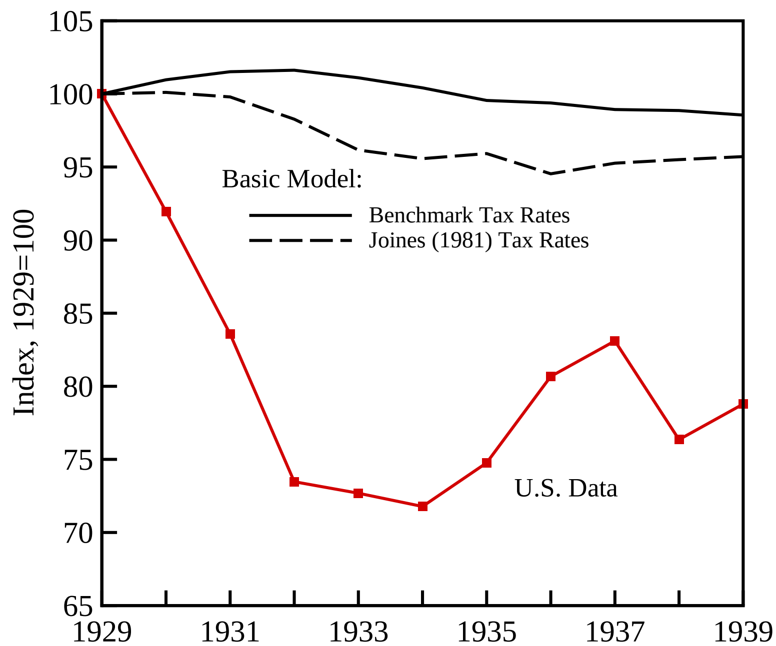

Figure 24. Hours Per Capita in the United States and Predictions of the Basic Model, 1929–1939

Figures 25–28.
Adding a Nonbusiness Sector in the Basic Model

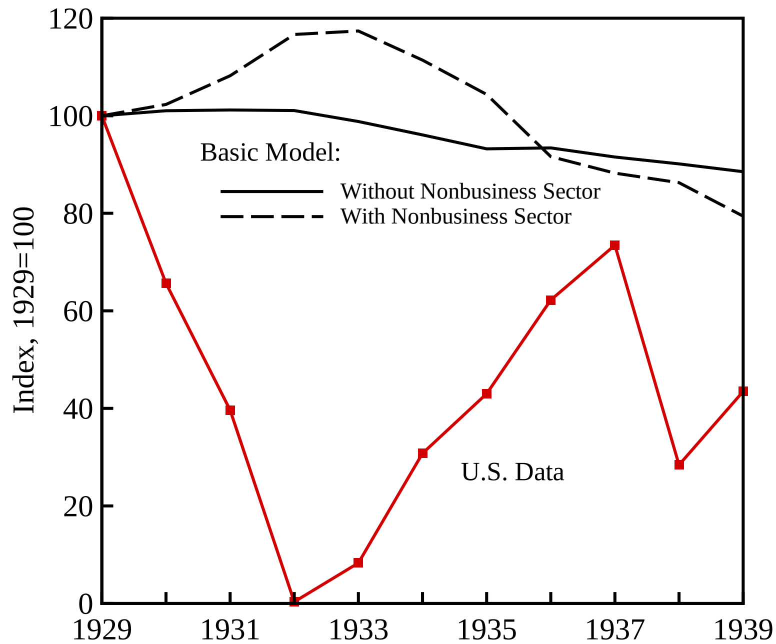

Figure 25. Detrended Real Business Investment in the United States and Predictions of the Basic Model, 1929–1939

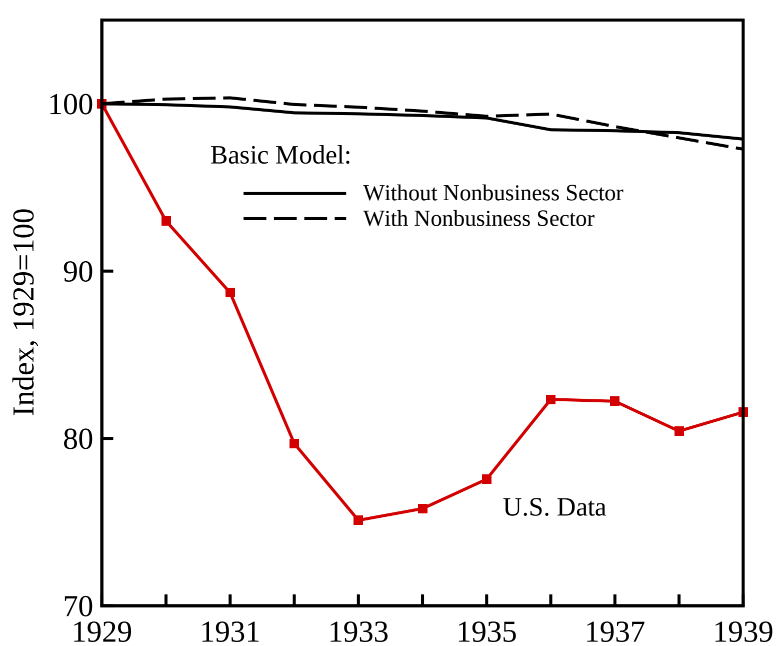

Figure 26. Detrended Real Consumption in the United States and Predictions of the Basic Model, 1929–1939

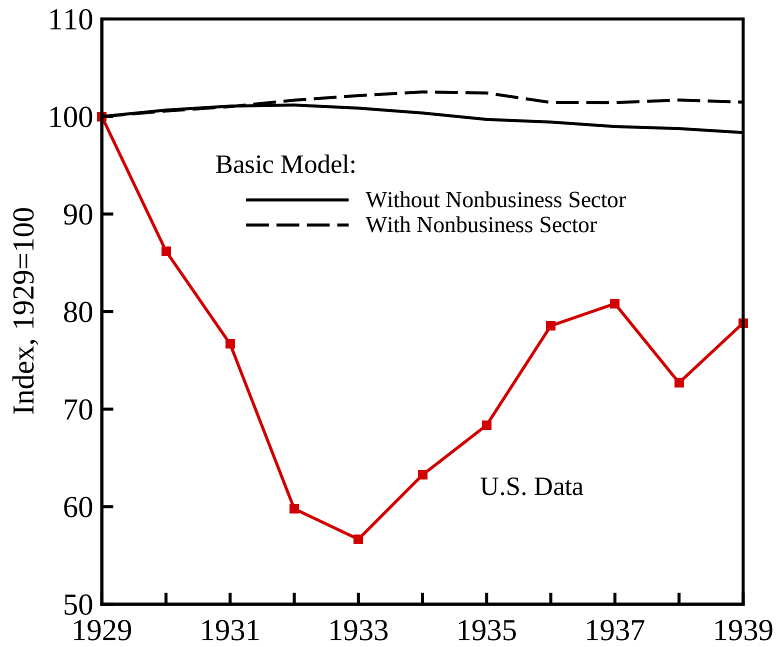

Figure 27. Detrended Real Business GDP in the United States and Predictions of the Basic Model, 1929–1939

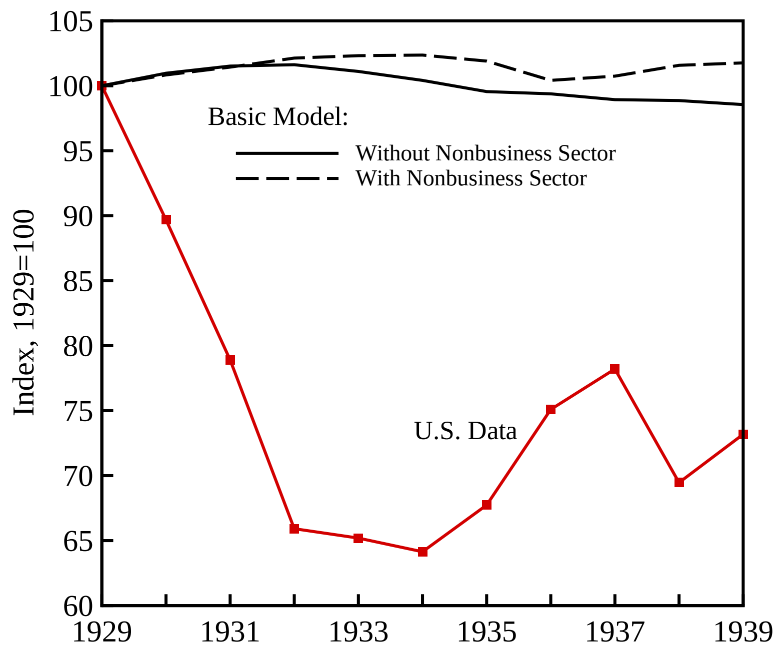

Figure 28. Business Hours Per Capita in the United States and Predictions of the Basic Model, 1929–1939

Figures 29–32.
Using Unfiltered Inputs in the Basic Model

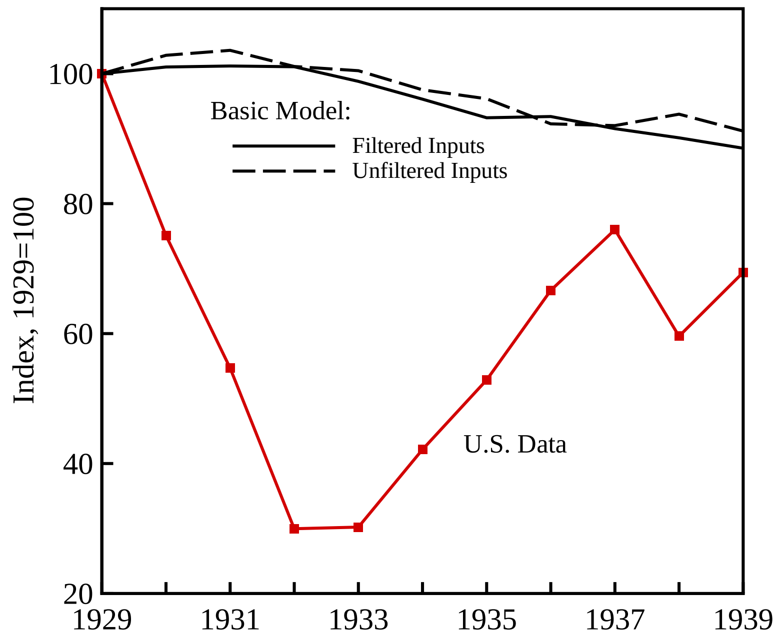

Figure 29. Detrended Real Investment in the United States and Predictions of the Basic Model, 1929–1939

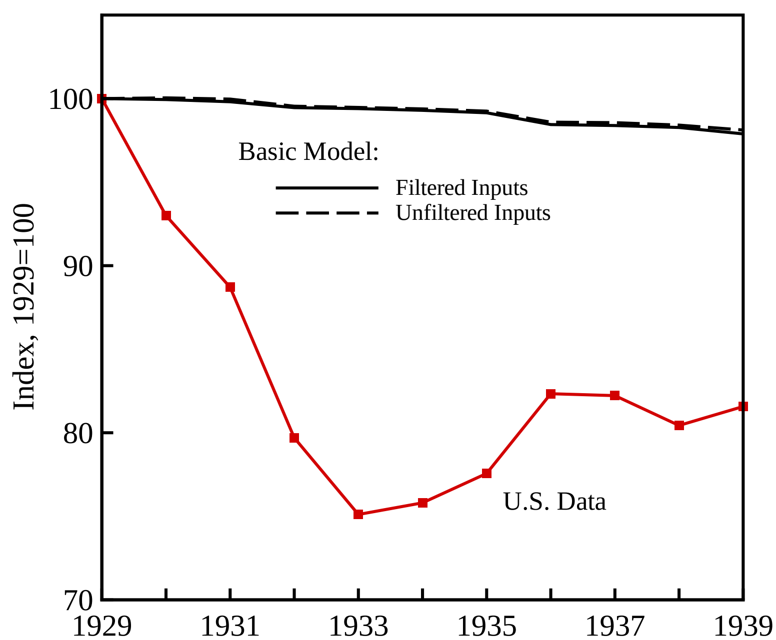

Figure 30. Detrended Real Consumption in the United States and Predictions of the Basic Model, 1929–1939

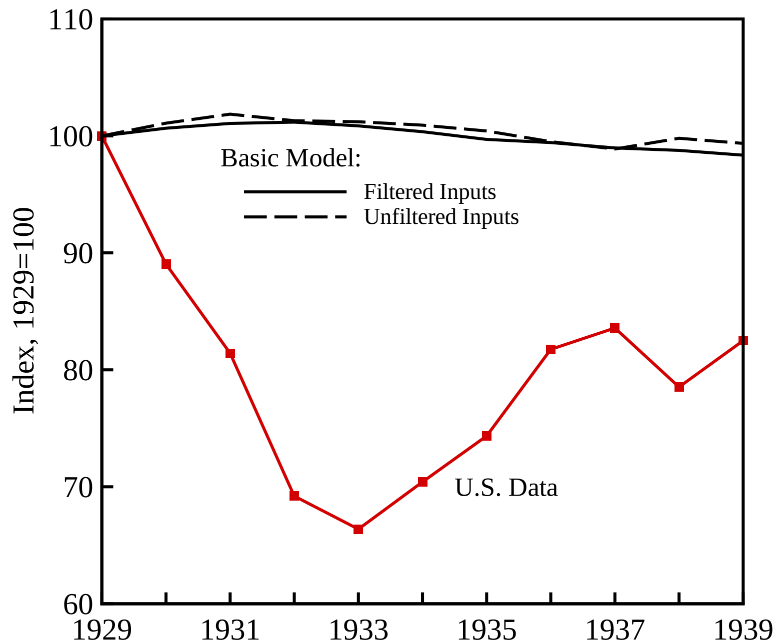

Figure 31. Detrended Real GDP in the United States and Predictions of the Basic Model, 1929–1939

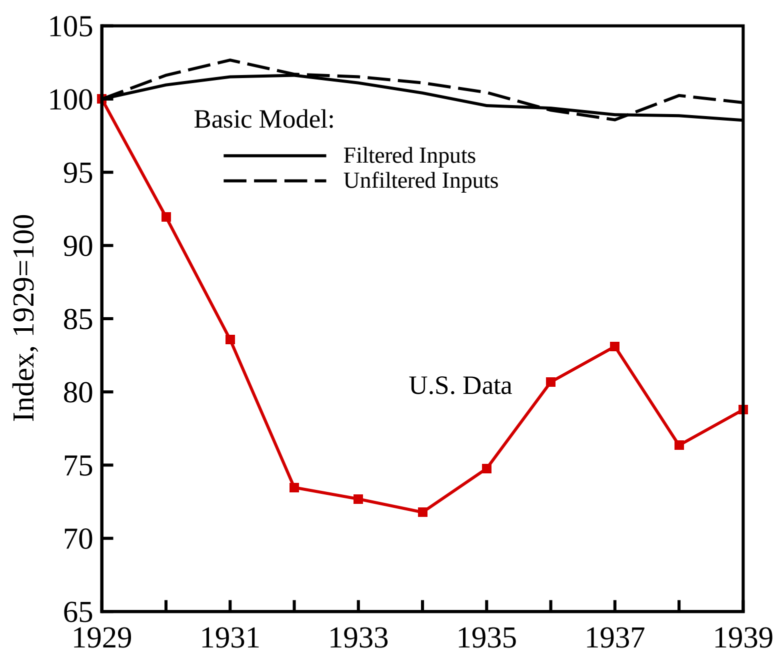

Figure 32. Hours Per Capita in the United States and Predictions of the Basic Model, 1929–1939

Figures 33–36.
Setting Key Tax Rates to Zero in the Extended Model

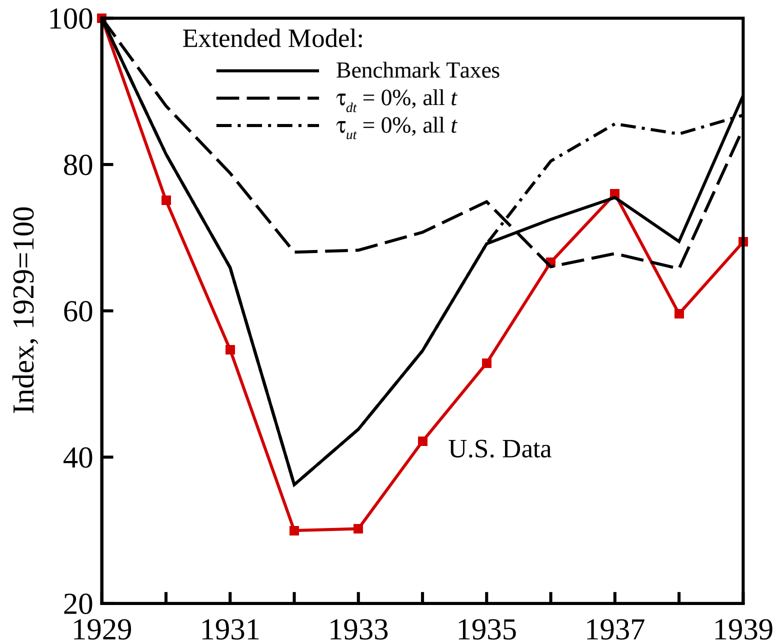

Figure 33. Detrended Real Investment in the United States and Predictions of the Extended Model, 1929–1939

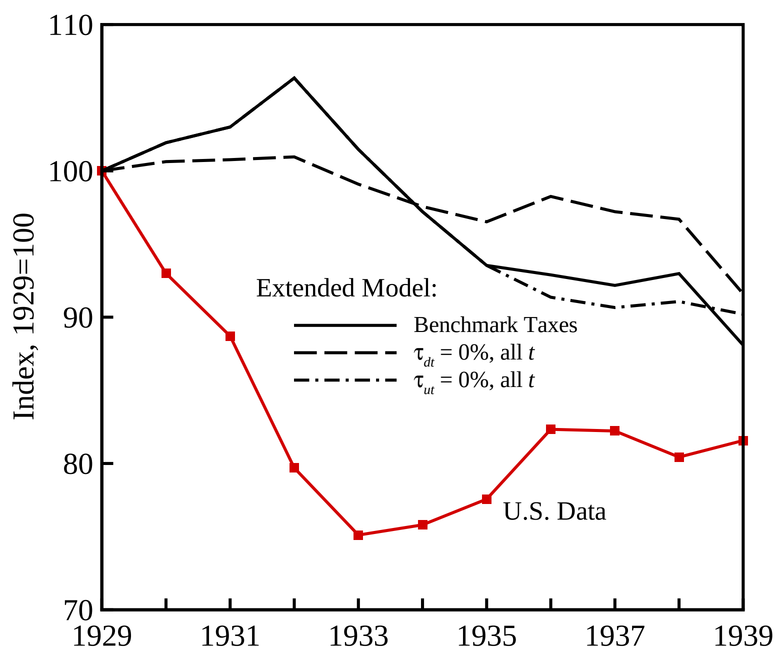

Figure 34. Detrended Real Consumption in the United States and Predictions of the Extended Model, 1929–1939

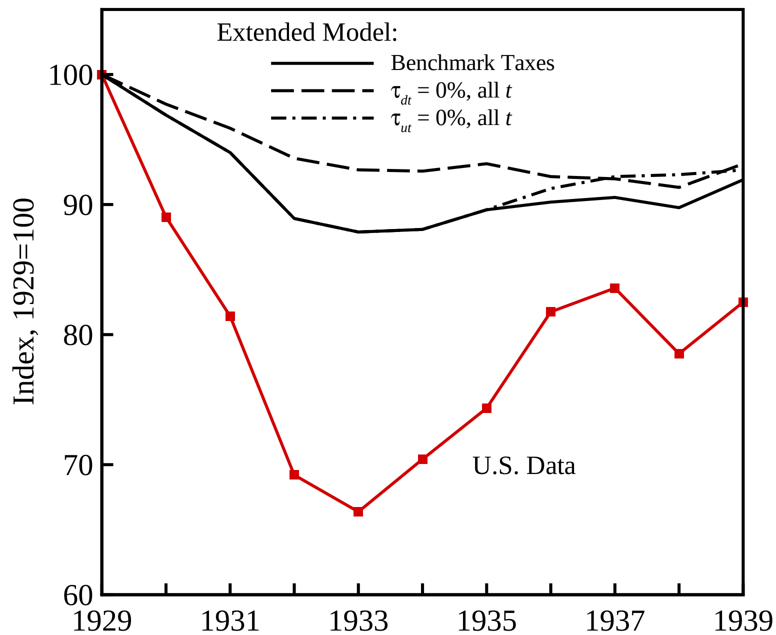

Figure 35. Detrended Real GDP in the United States and Predictions of the Extended Model, 1929–1939

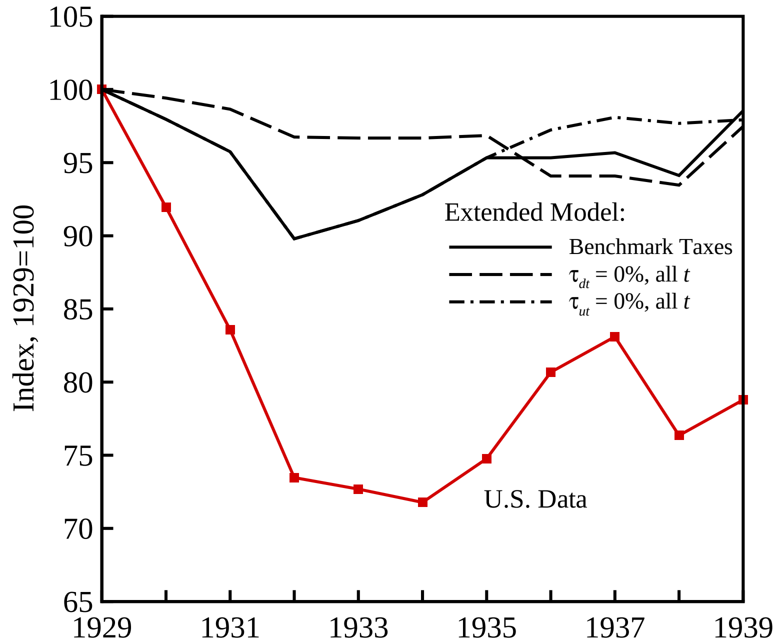

Figure 36. Hours Per Capita in the United States and Predictions of the Extended Model, 1929–1939

Figures 37–40.
Varying Expectations in the Extended Model

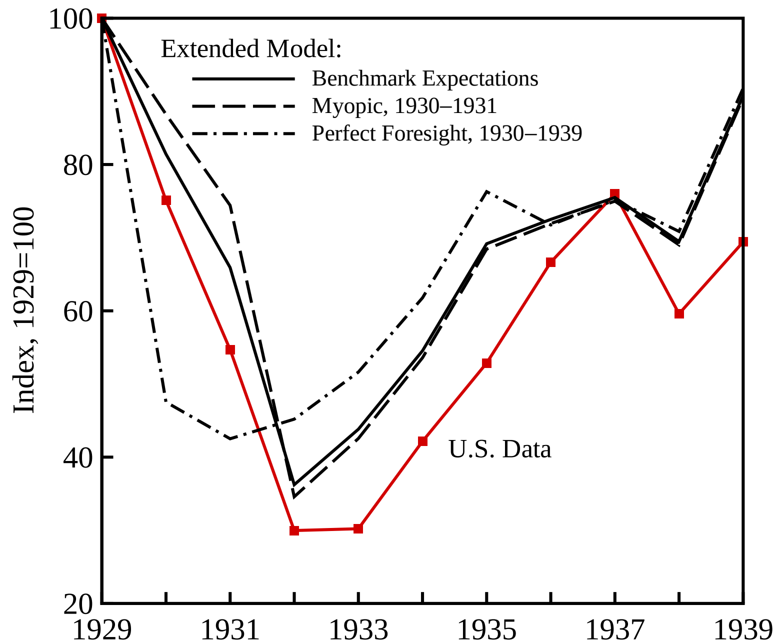

Figure 37. Detrended Real Investment in the United States and Predictions of the Extended Model, 1929–1939

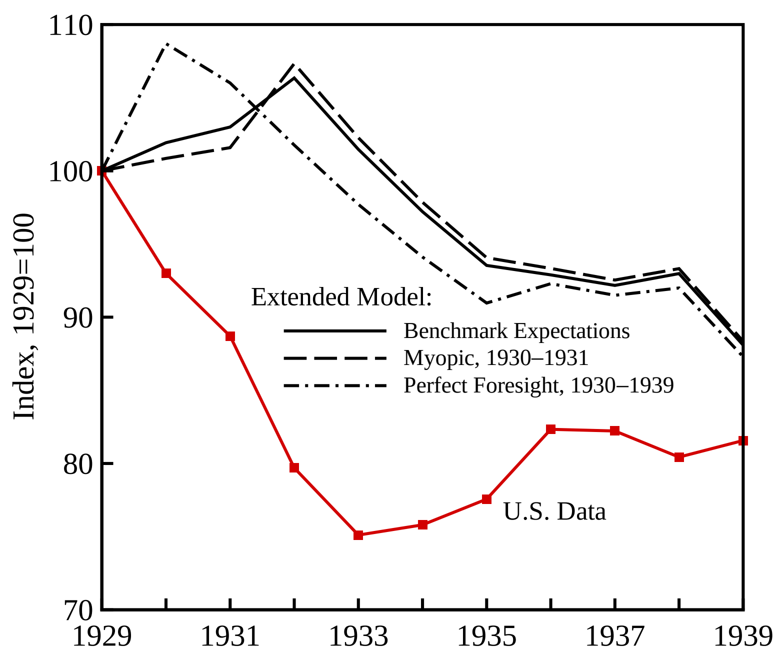

Figure 38. Detrended Real Consumption in the United States and Predictions of the Extended Model, 1929–1939

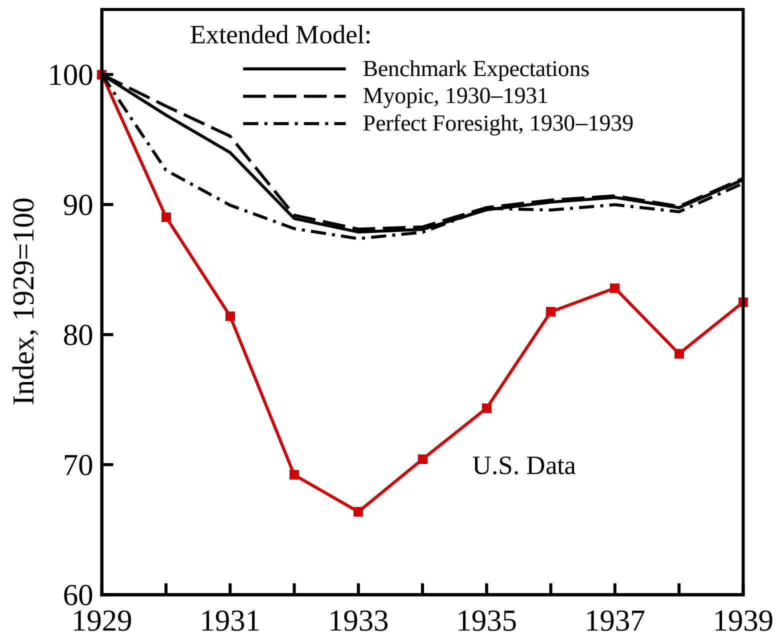

Figure 39. Detrended Real GDP in the United States and Predictions of the Extended Model, 1929–1939

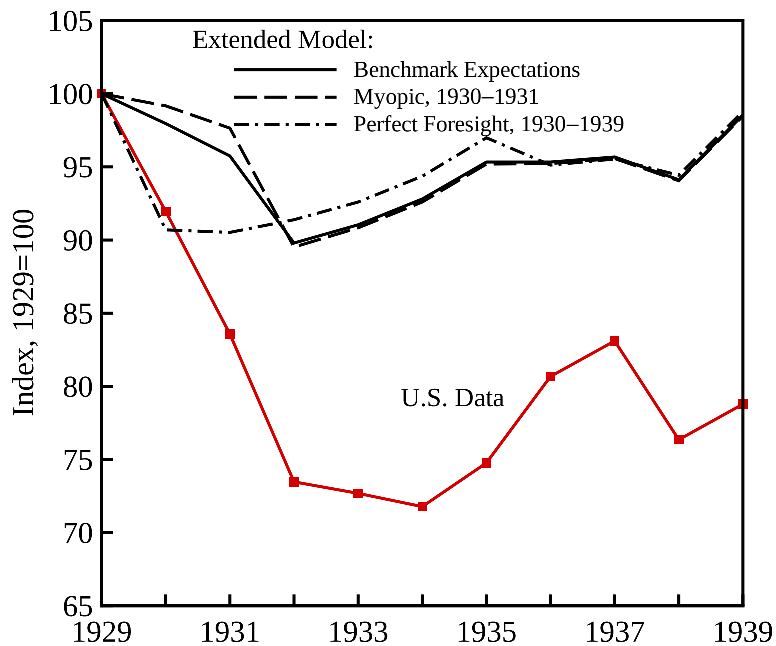

Figure 40. Hours Per Capita in the United States and Predictions of the Extended Model, 1929–1939

Figures 41–44.
Using Alternative Tax Rates in the Extended Model

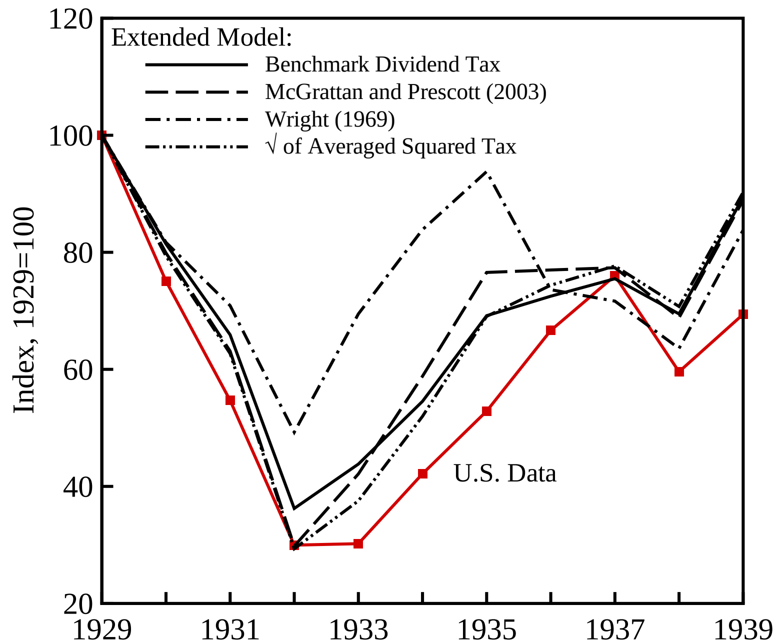

Figure 41. Detrended Real Investment in the United States and Predictions of the Extended Model, 1929–1939

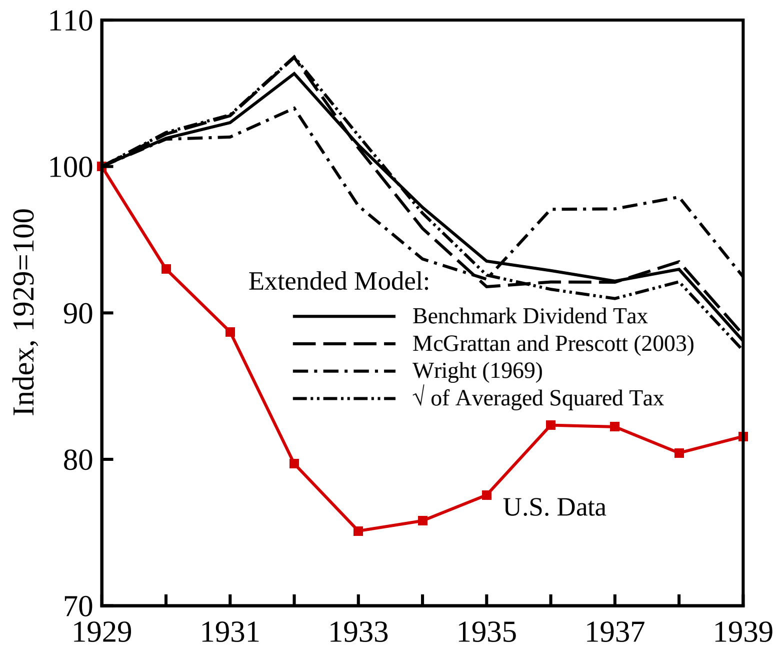

Figure 42. Detrended Real Consumption in the United States and Predictions of the Extended Model, 1929–1939

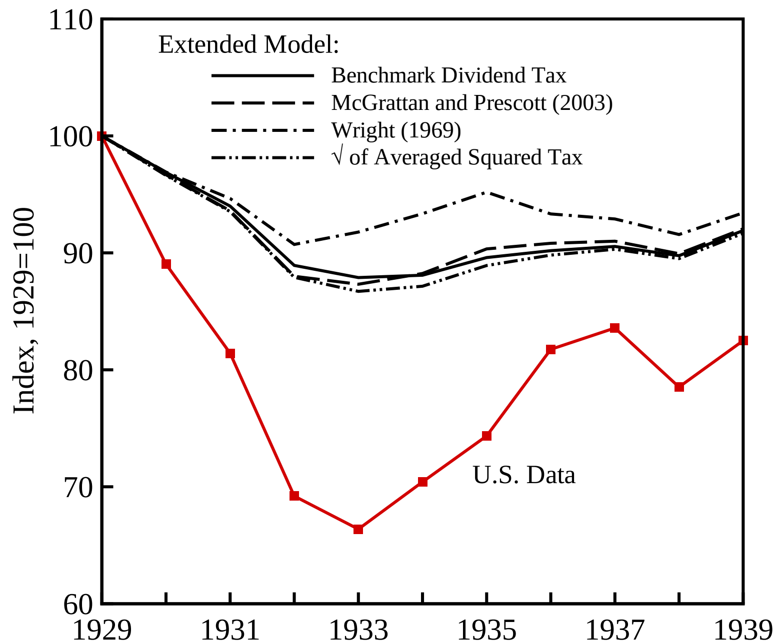

FIGURE 43. DETRENDED REAL GDP IN THE UNITED STATES AND PREDICTIONS OF THE EXTENDED MODEL, 1929–1939

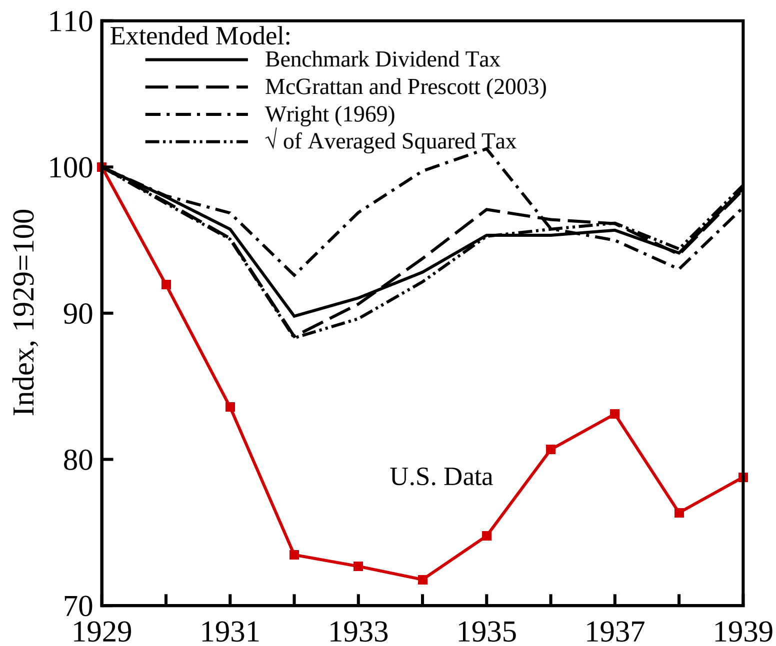

FIGURE 44. HOURS PER CAPITA IN THE UNITED STATES AND PREDICTIONS OF THE EXTENDED MODEL, 1929–1939

Figures 45–48.
Adding Exogenous Wedges in the Extended Model

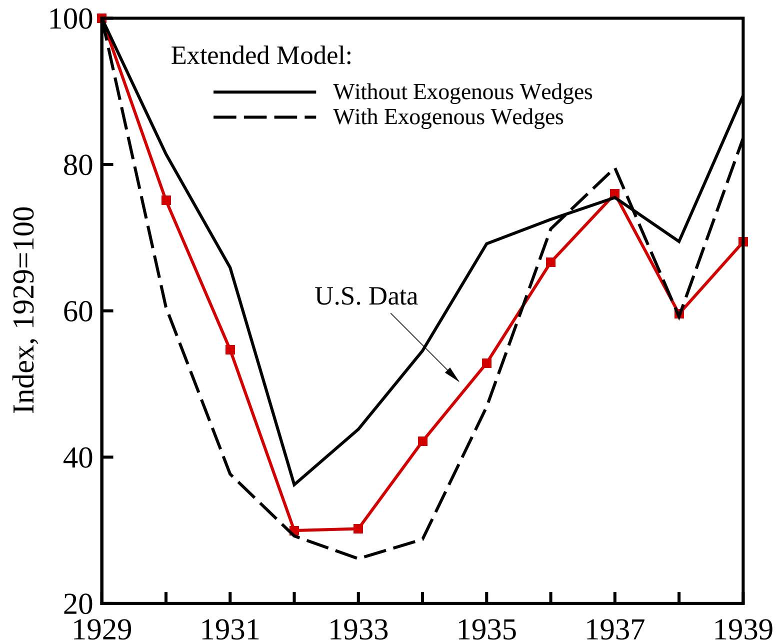

Figure 45. Detrended Real Investment in the United States and Predictions of the Extended Model, 1929–1939

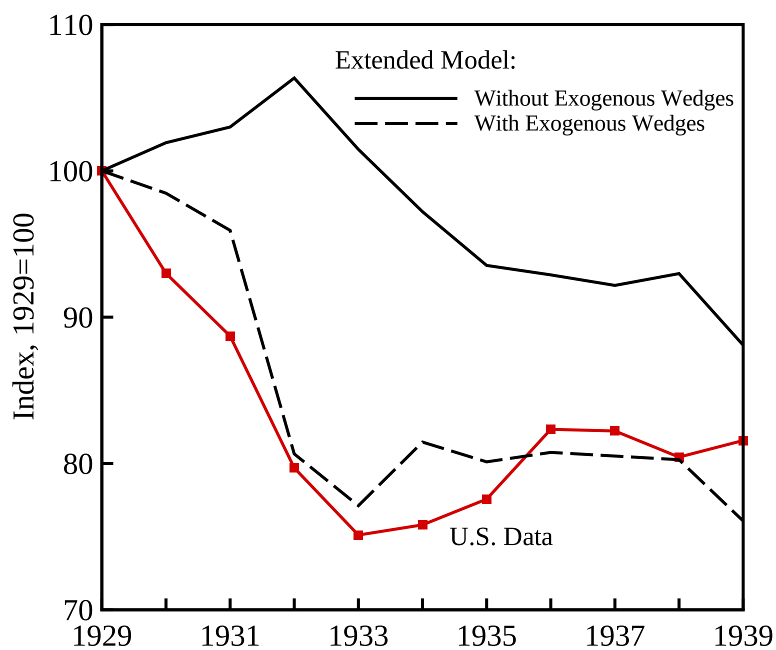

Figure 46. Detrended Real Consumption in the United States and Predictions of the Extended Model, 1929–1939

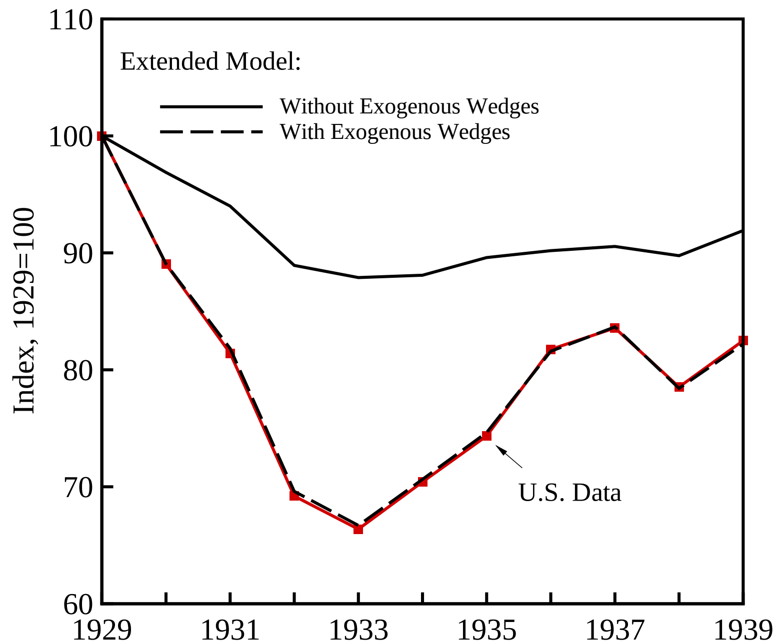

Figure 47. Detrended Real GDP in the United States and Predictions of the Extended Model, 1929–1939

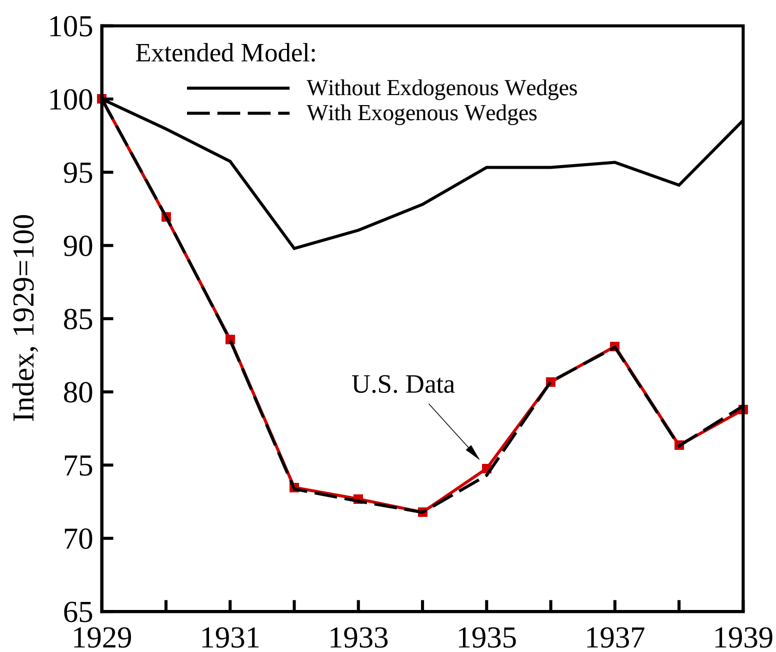

Figure 48. Hours Per Capita in the United States and Predictions of the Extended Model, 1929–1939

Figures 49–52.
Using Unfiltered Inputs in the Extended Model

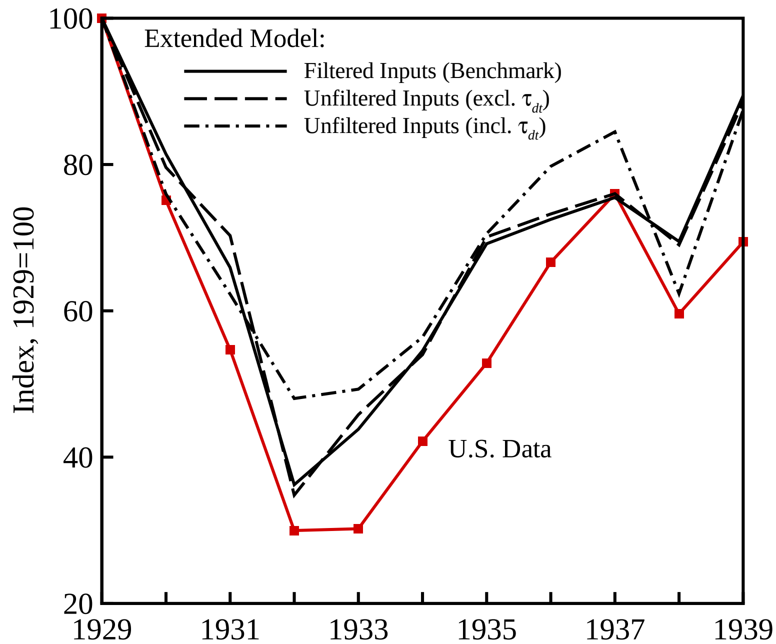

FIGURE 49. DETRENDED REAL INVESTMENT IN THE UNITED STATES AND PREDICTIONS OF THE EXTENDED MODEL, 1929–1939

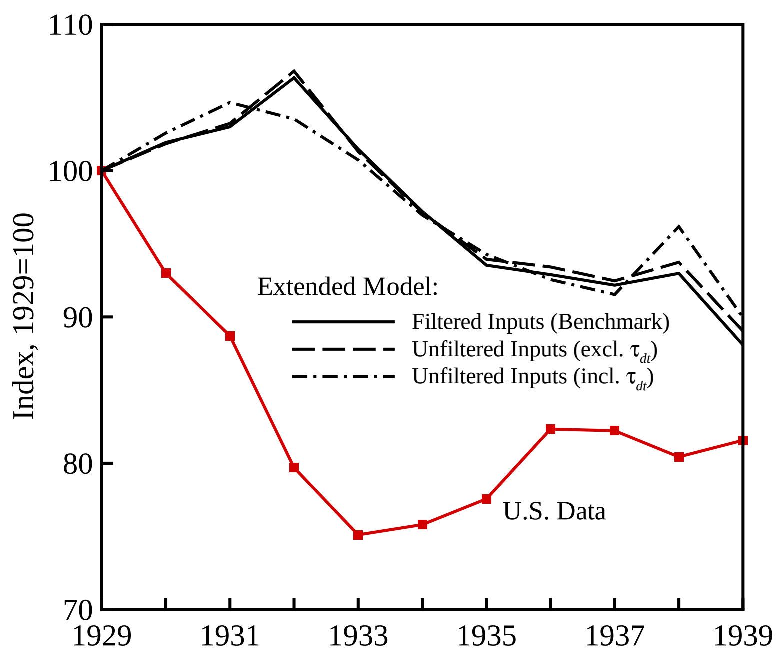

FIGURE 50. DETRENDED REAL CONSUMPTION IN THE UNITED STATES AND PREDICTIONS OF THE EXTENDED MODEL, 1929–1939

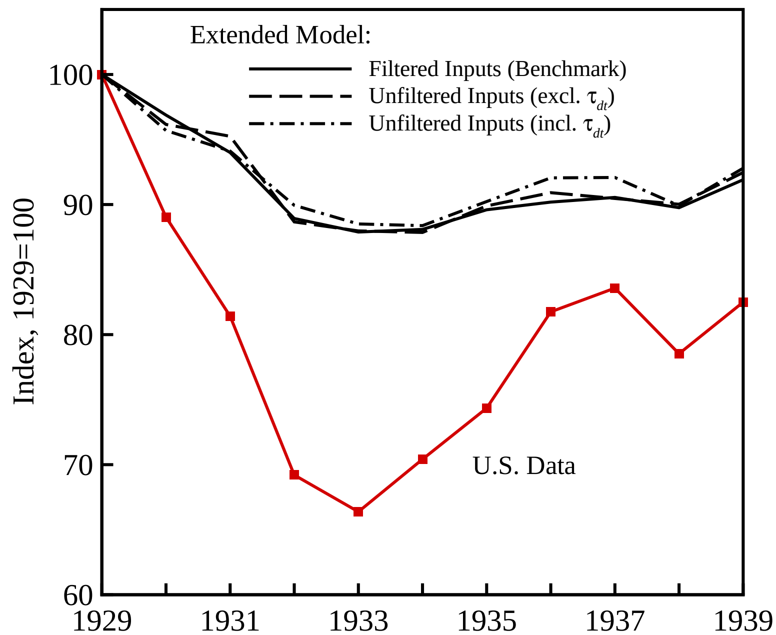

Figure 51. Detrended Real GDP in the United States and Predictions of the Extended Model, 1929–1939

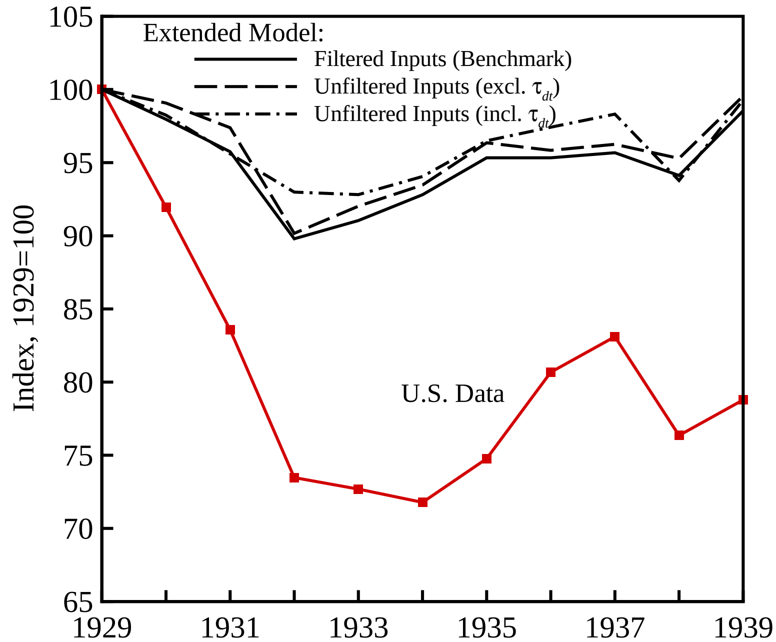

Figure 52. Hours Per Capita in the United States and Predictions of the Extended Model, 1929–1939

Figures 53–56.
Setting Policies Constant in the Extended Model

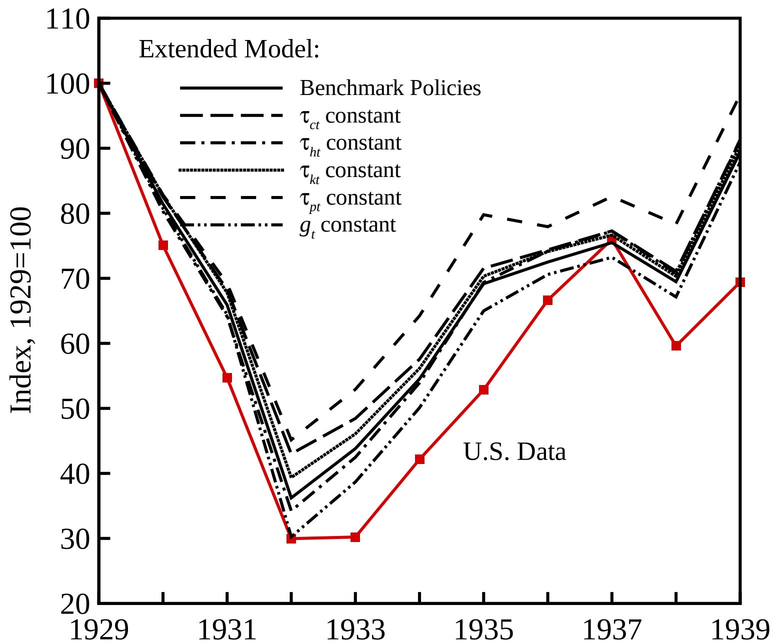

Figure 53. Detrended Real Investment in the United States and Predictions of the Extended Model, 1929–1939

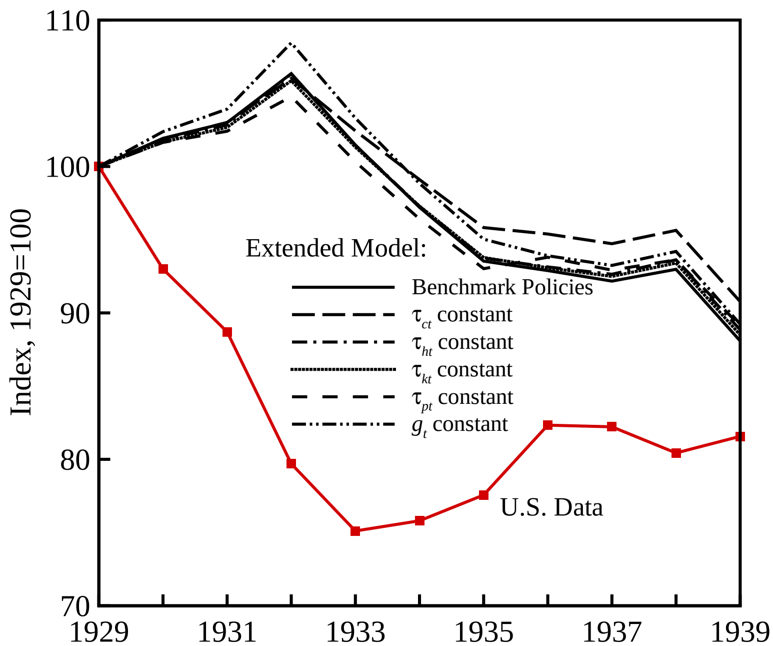

Figure 54. Detrended Real Consumption in the United States and Predictions of the Extended Model, 1929–1939

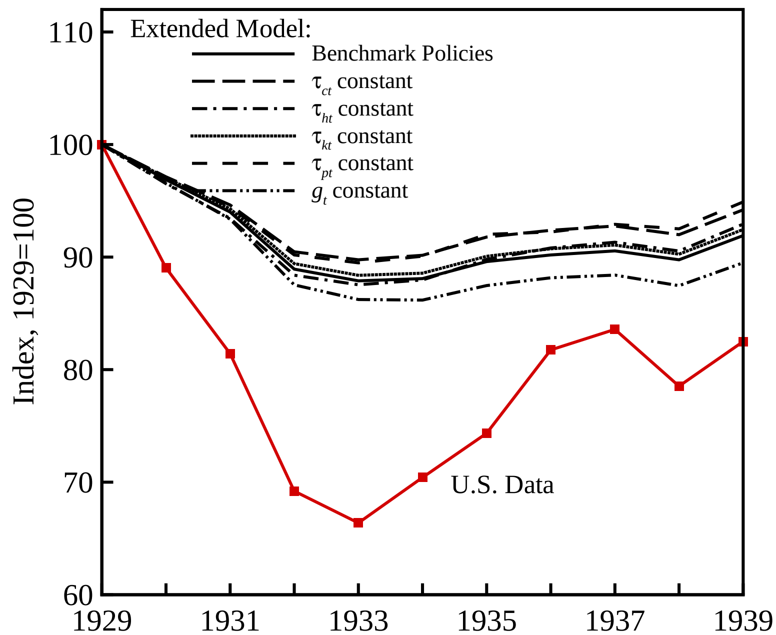

FIGURE 55. DETRENDED REAL GDP IN THE UNITED STATES AND PREDICTIONS OF THE EXTENDED MODEL, 1929–1939

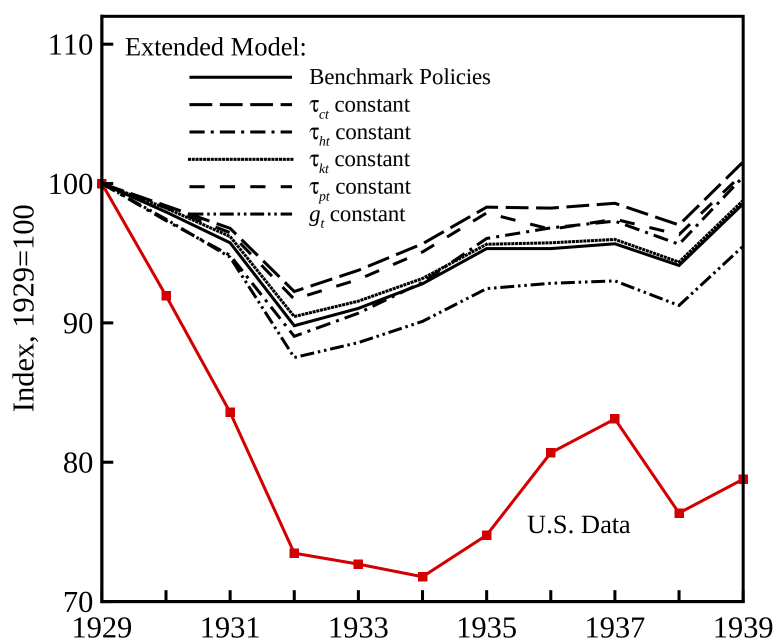

FIGURE 56. HOURS PER CAPITA IN THE UNITED STATES AND PREDICTIONS OF THE EXTENDED MODEL, 1929–1939

Figures 57–60.
Adding Estate Taxes to τ_k in the Extended Model

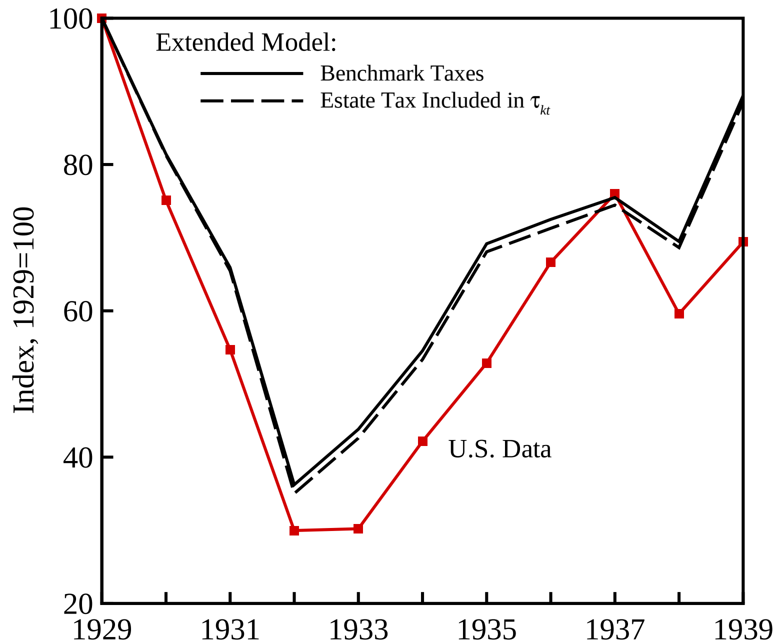

Figure 57. Detrended Real Investment in the United States and Predictions of the Extended Model, 1929–1939

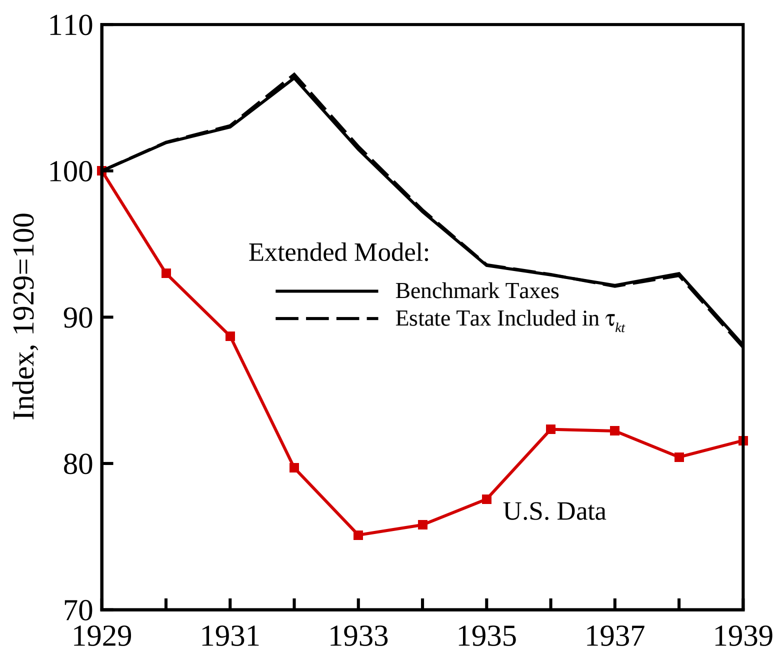

Figure 58. Detrended Real Consumption in the United States and Predictions of the Extended Model, 1929–1939

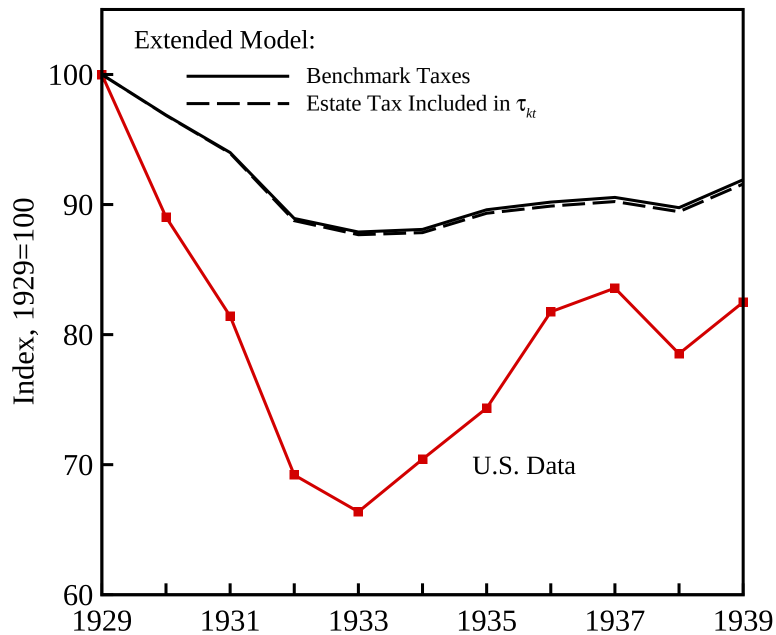

Figure 59. Detrended Real GDP in the United States and Predictions of the Extended Model, 1929–1939

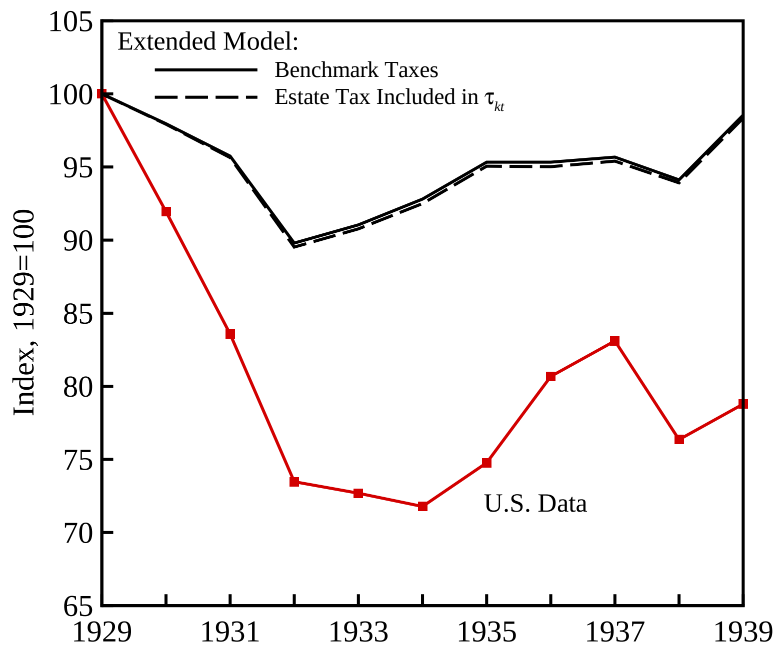

Figure 60. Hours Per Capita in the United States and Predictions of the Extended Model, 1929–1939

Figures 61–66.
Results for the Model with Non-Ricardian Households

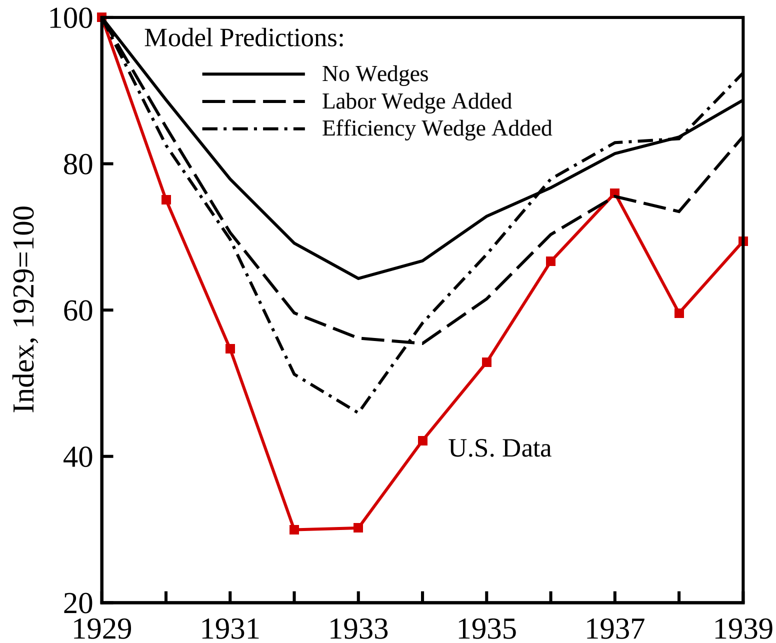

Figure 61. Detrended Real Investment in the United States and Predictions of the Non-Ricardian Model, 1929–1939

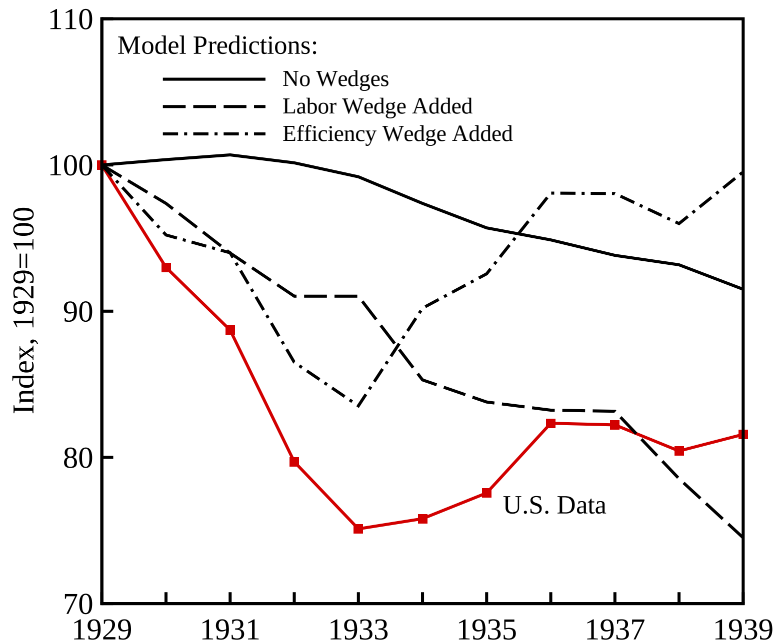

Figure 62. Detrended Real Consumption in the United States and Predictions of the Non-Ricardian Model, 1929–1939

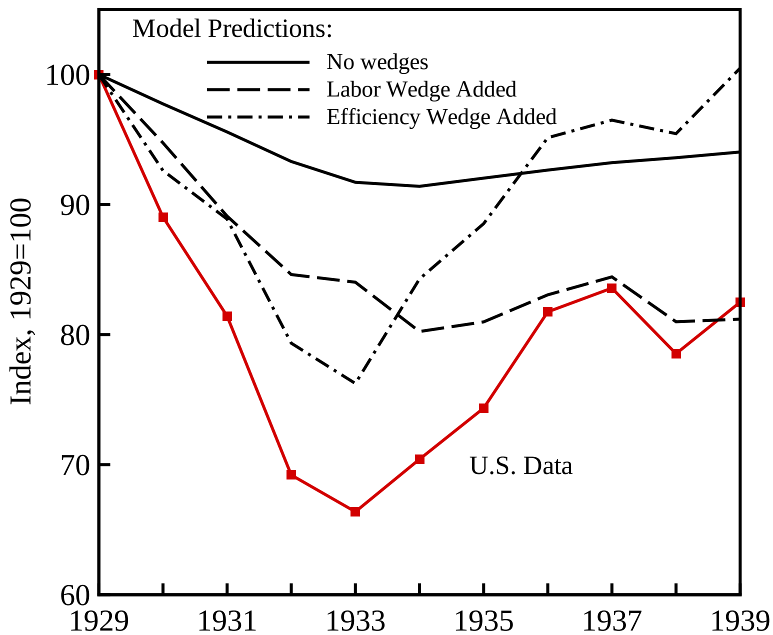

Figure 63. Detrended Real GDP in the United States and Predictions of the Non-Ricardian Model, 1929–1939

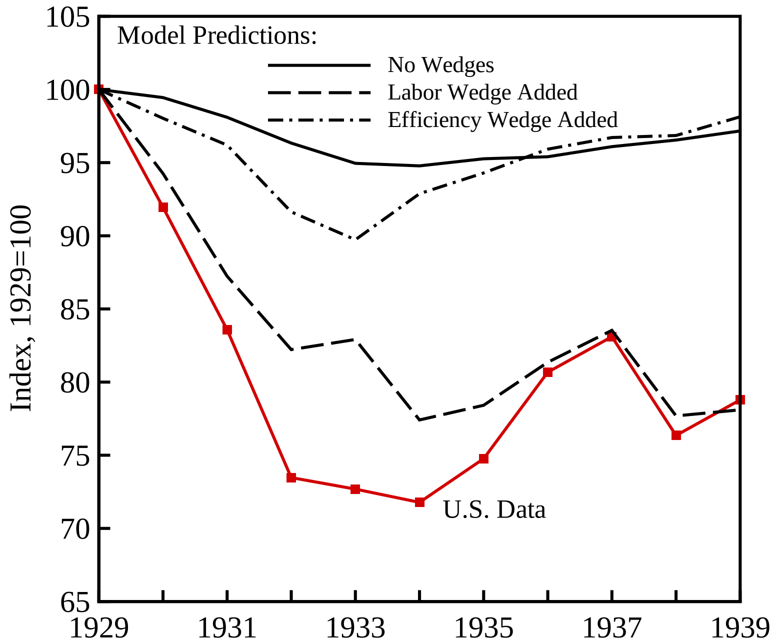

Figure 64. Hours Per Capita in the United States and Predictions of the Non-Ricardian Model, 1929–1939

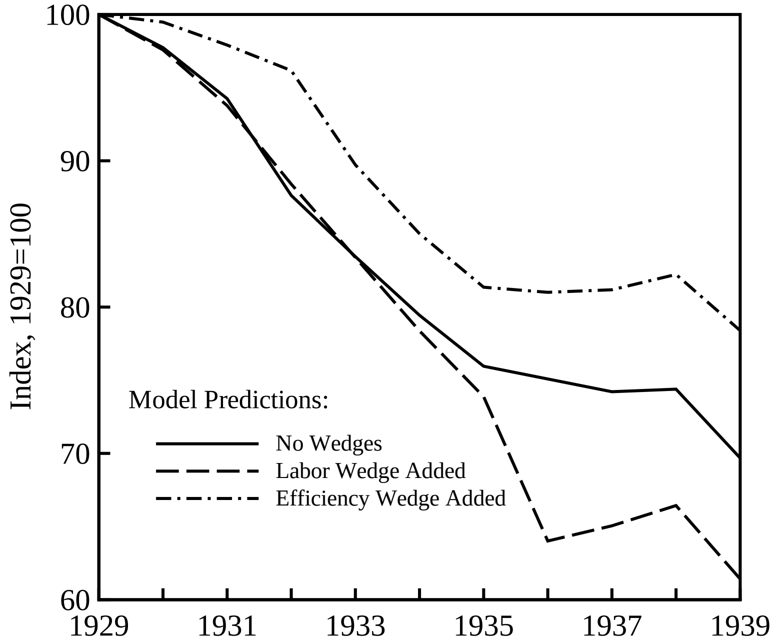

Figure 65. Detrended Consumption of the Ricardian Households in the Non-Ricardian Model, 1929–1939

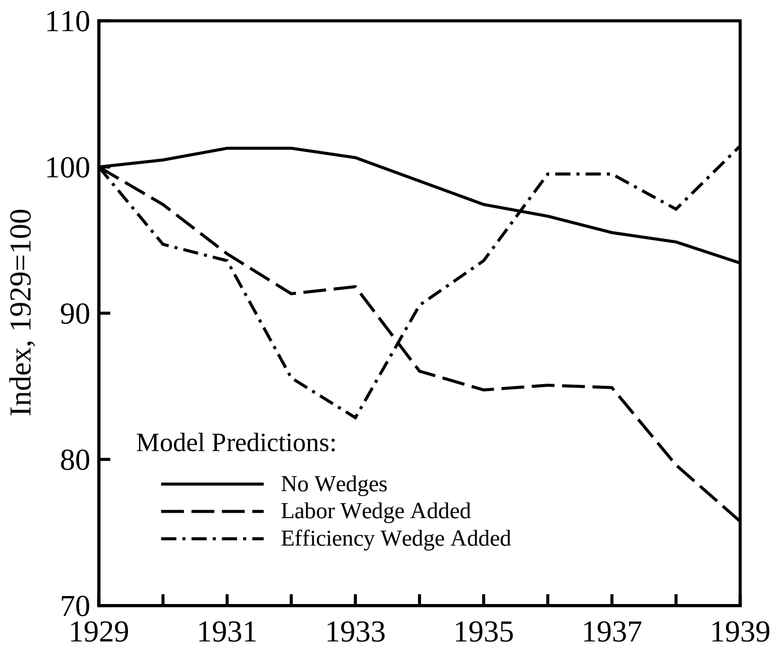

Figure 66. Detrended Consumption of the Non-Ricardian Households in the Non-Ricardian Model, 1929–1939

Figures 67–70.
Results for the Model with Intangible Capital, 1929–1939

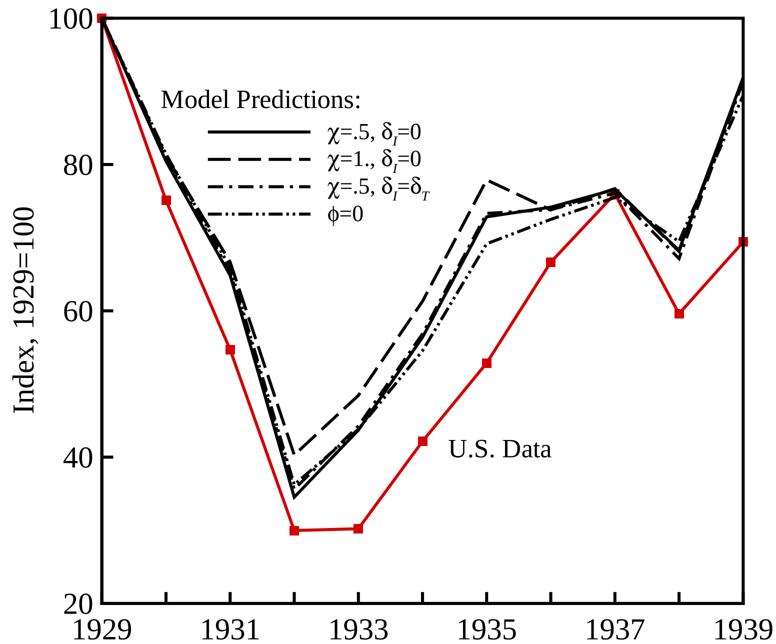

Figure 67. Detrended Real Investment in the United States and Predictions of the Model with Intangible Capital, 1929–1939

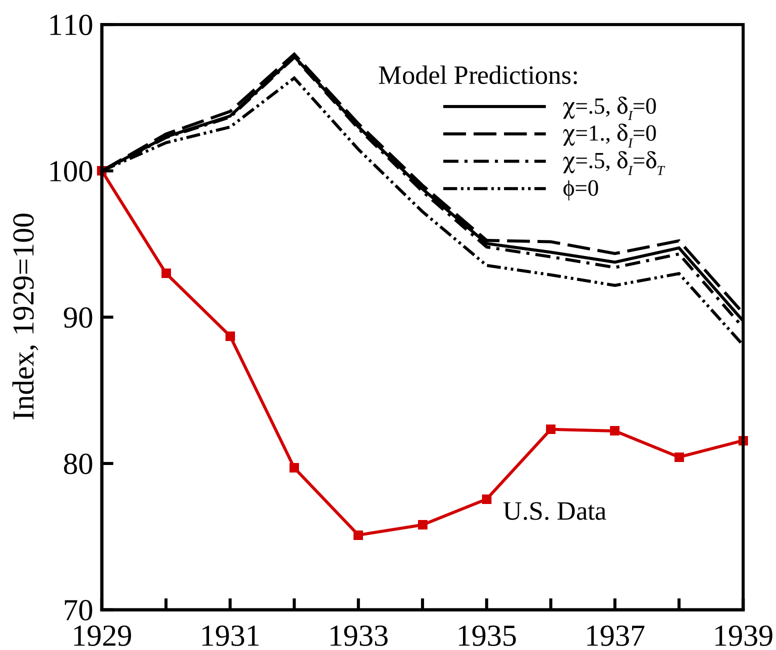

Figure 68. Detrended Real Consumption in the United States and Predictions of the Model with Intangible Capital, 1929–1939

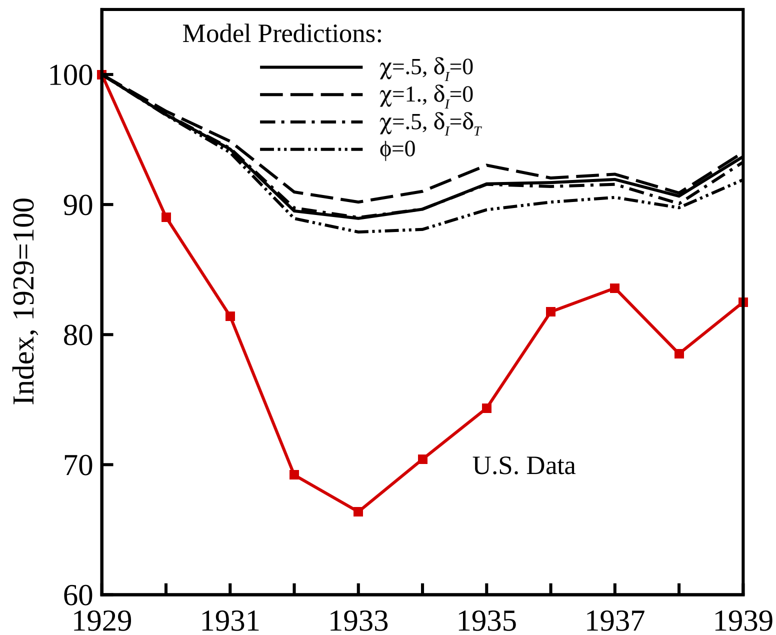

Figure 69. Detrended Real GDP in the United States and Predictions of the Model with Intangible Capital, 1929–1939

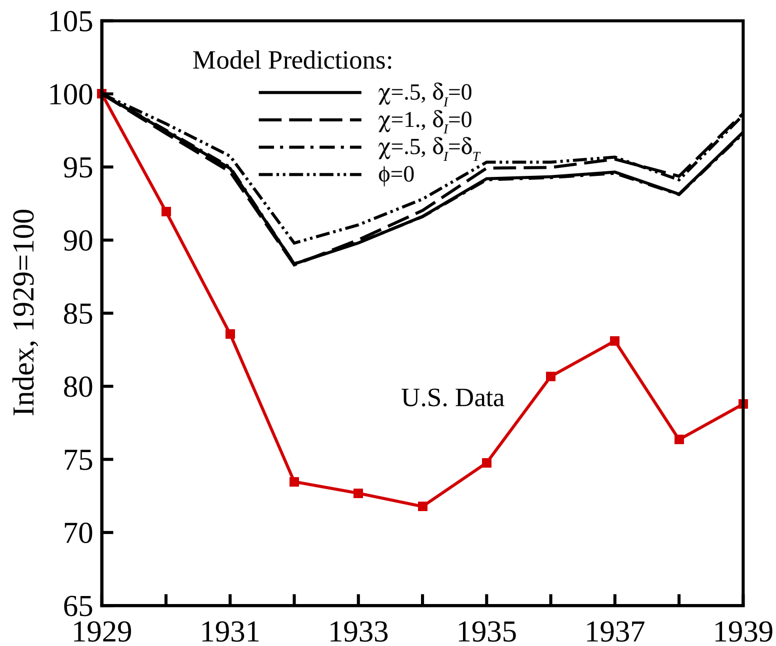

Figure 70. Hours Per Capita in the United States and Predictions of the Model with Intangible Capital, 1929–1939

Figures 71–72.
U.S. Individual Income Tax Rates, 2000–2010

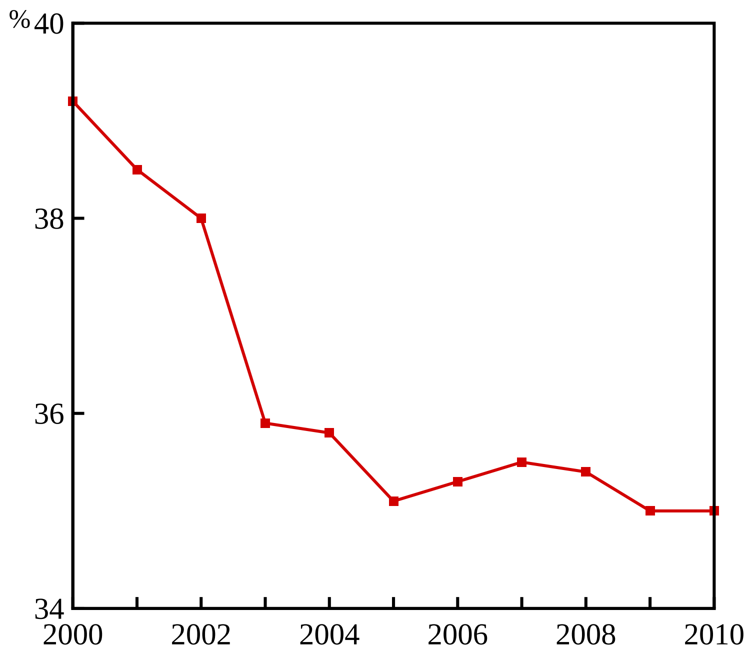

Figure 71. Average Marginal Tax Rates on Labor Income in the United States, 2000–2010

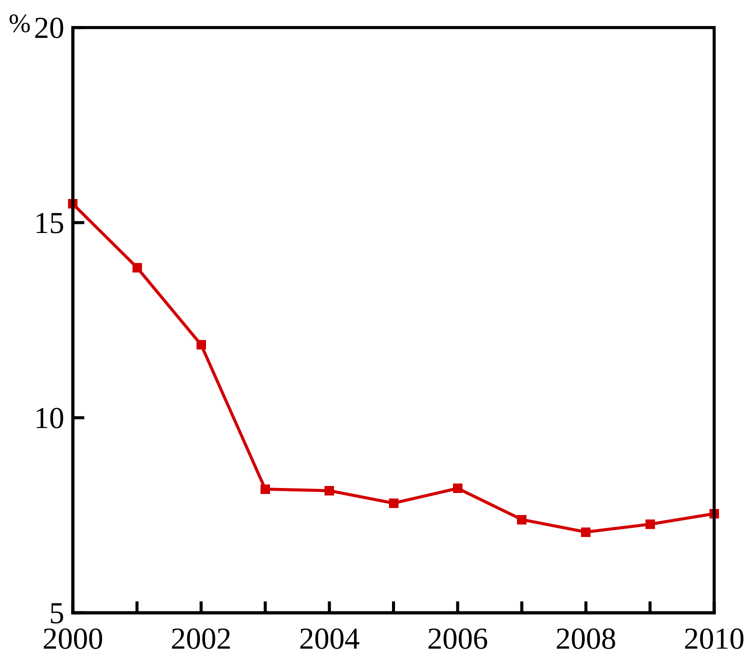

Figure 72. Average Marginal Tax Rates on Dividend Income in the United States, 2000–2010

Figures 73–76.
Results for the Model with Intangible Capital, 2004:4–2011:1

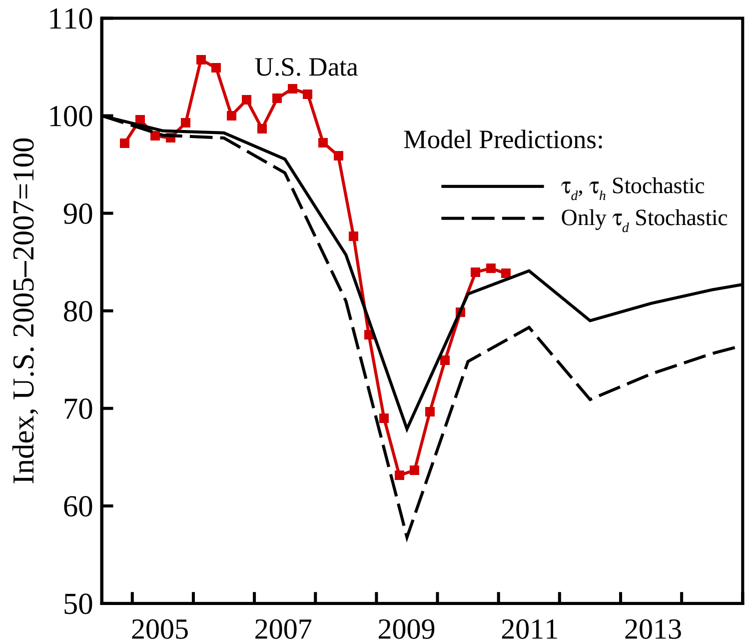

Figure 73. Detrended Real Tangible Investment in the United States and Predictions of the Model with Intangible Capital, 2004:4–2011:1

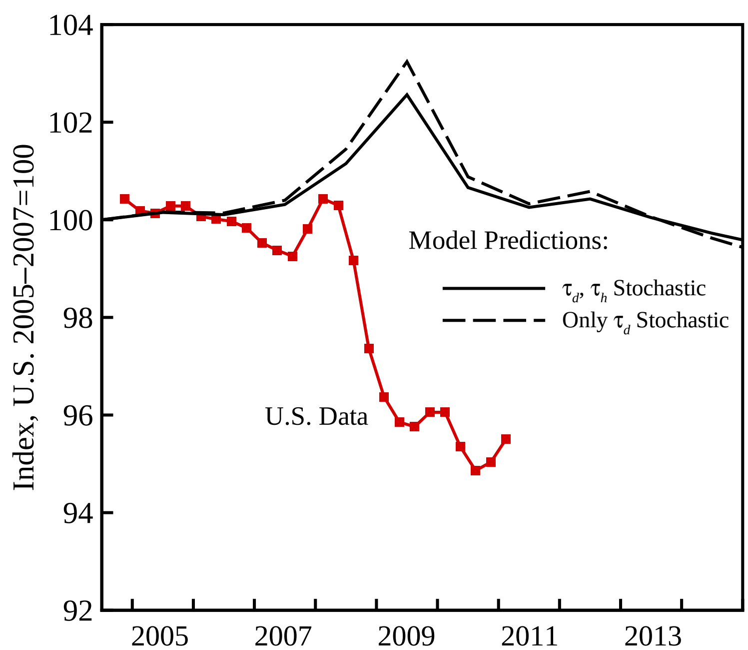

Figure 74. Detrended Real Consumption in the United States and Predictions of the Model with Intangible Capital, 2004:4–2011:1

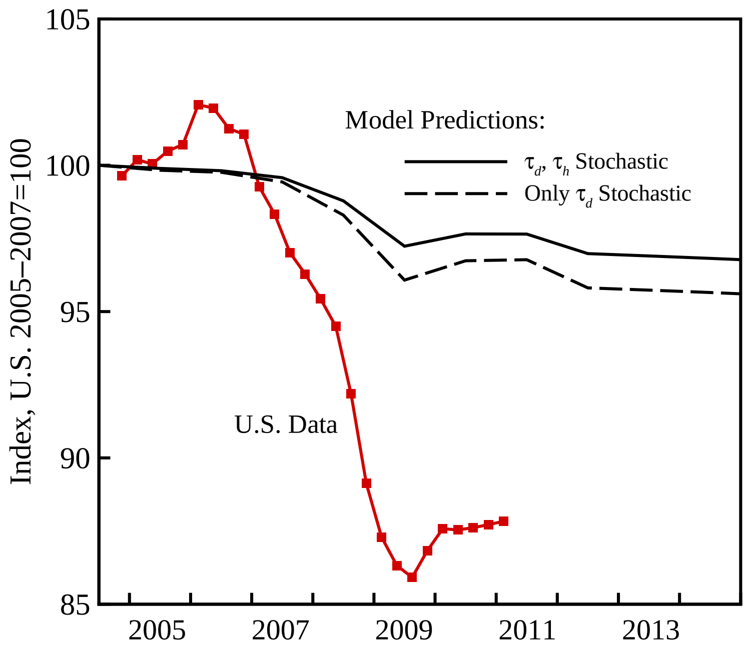

Figure 75. Detrended Real Business Value Added in the United States and Predictions of the Model with Intangible Capital, 2004:4–2011:1

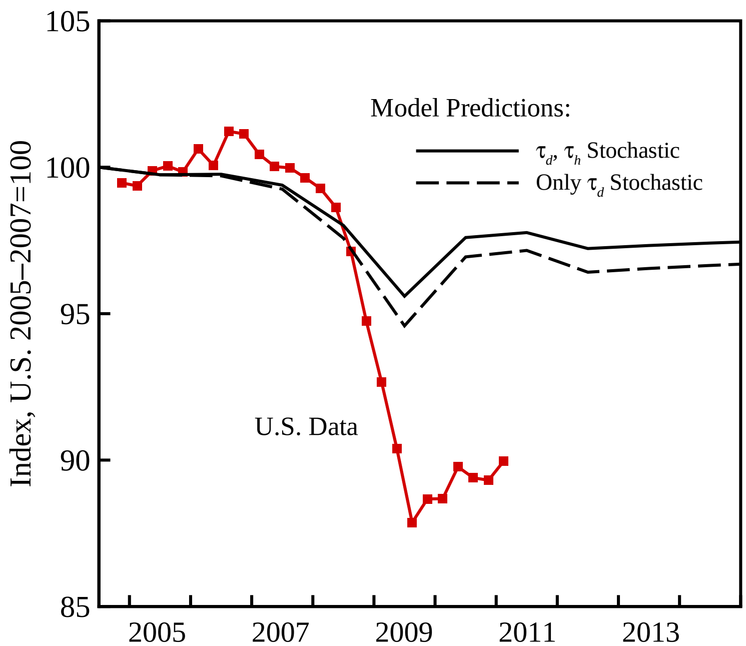

Figure 76. Business Hours Per Capita in the United States and Predictions of the Model with Intangible Capital, 2004:4–2011:1

Figures 77–82.
Results for the Model with Intangible Capital, 1990–2003

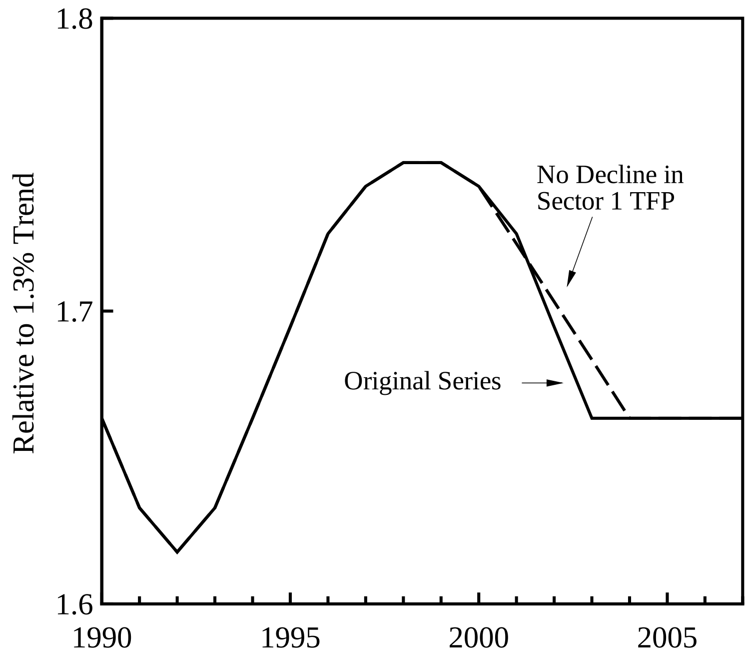

Figure 77. TFP in the Final Goods and Services Sector in Two Versions of the Model with Intangible Capital, 1990–2003

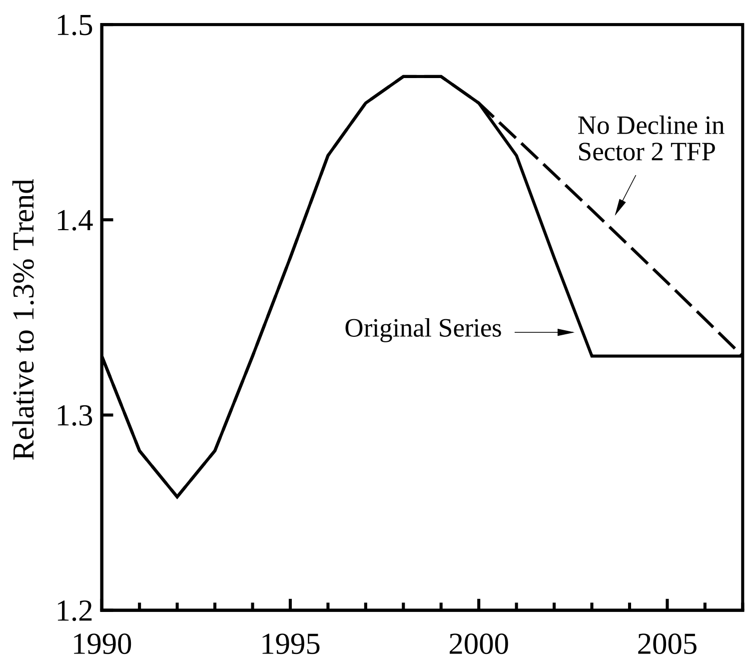

Figure 78. TFP in the Intangible Investment Sector in Two Versions of the Model with Intangible Capital, 1990–2003

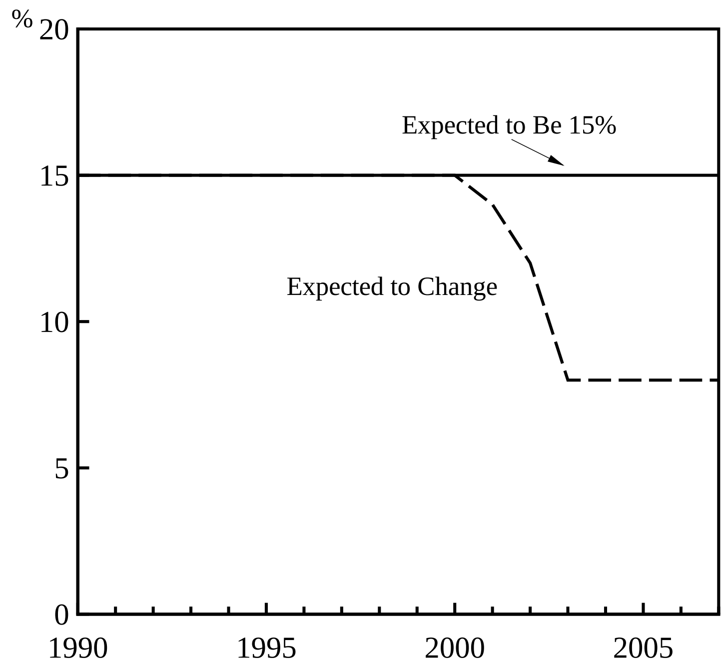

Figure 79. Tax Rate on Dividend Income in Two Versions of the Model with Intangible Capital, 1990–2003

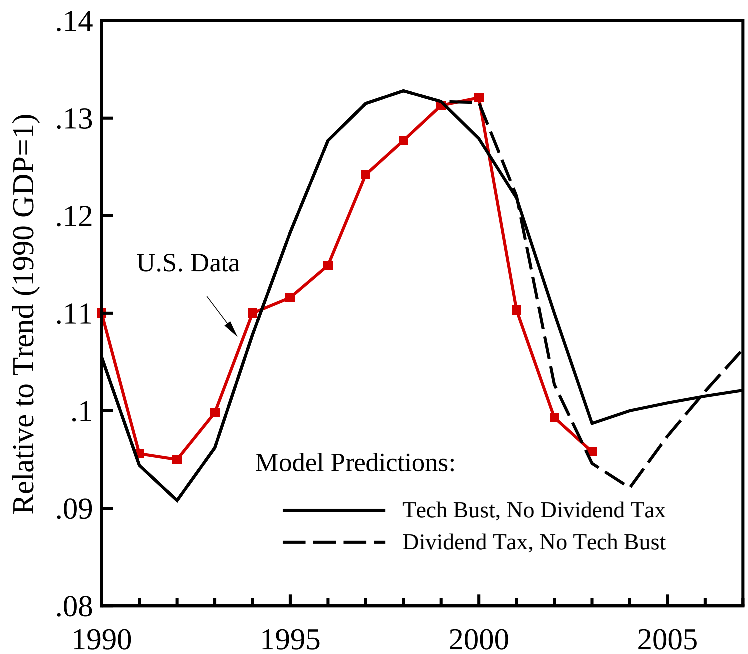

Figure 80. Detrended Real Business Investment in the United States and Predictions of the Model with Intangible Capital, 1990–2003

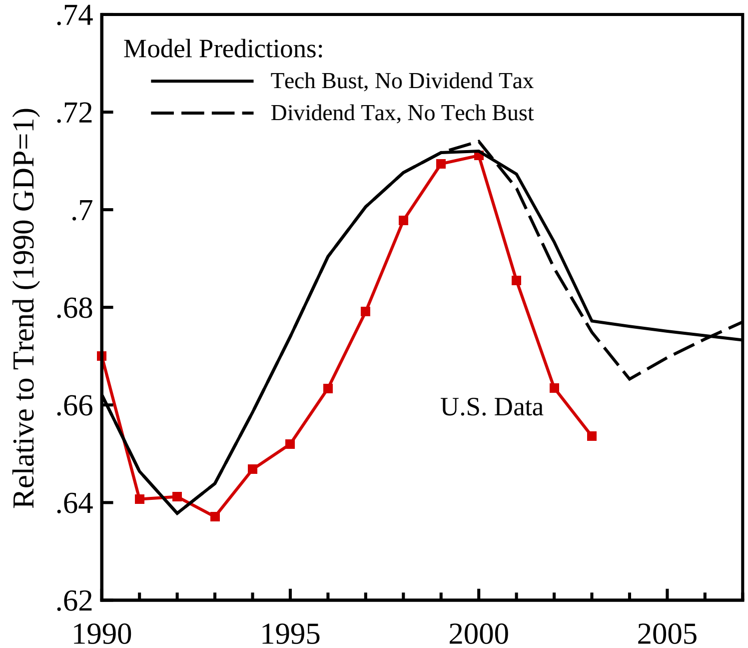

Figure 81. Detrended Real Business Value Added in the United States and Predictions of the Model with Intangible Capital, 1990–2003

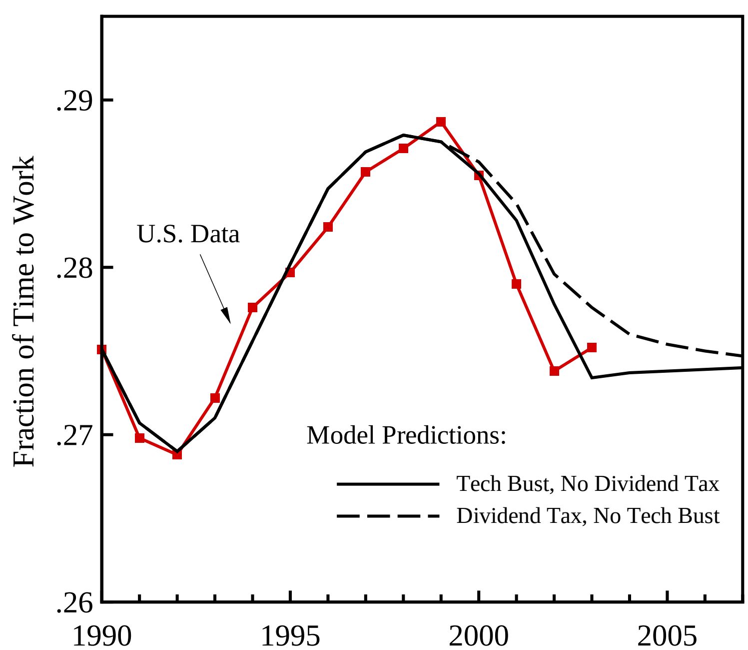

Figure 82. Hours Per Capita in the United States and Predictions of the Model with Intangible Capital, 1990–2003

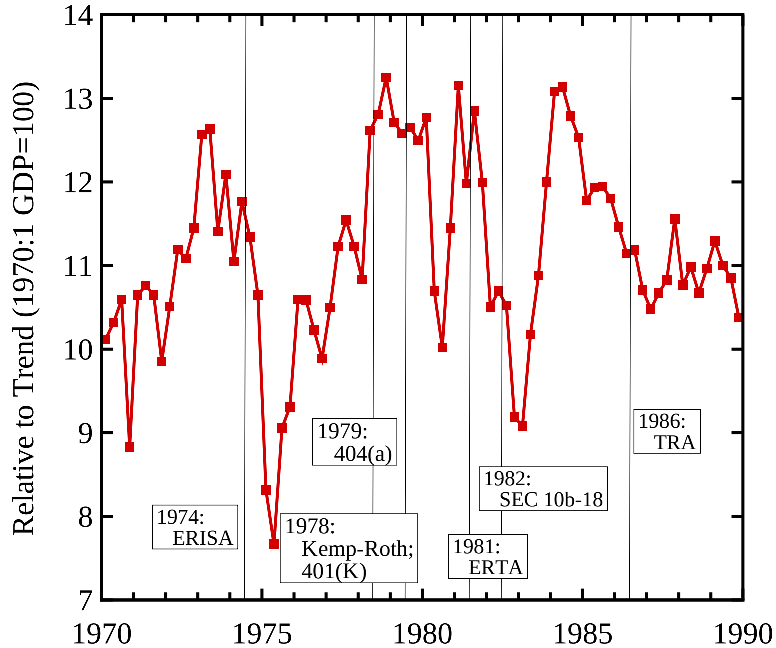

Figure 83. Detrended Real Business Tangible Investment in the United States and Major Policy Changes, 1970–1990