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Expensed and Sweat Equity and the Macroeconomy†

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ABSTRACT

Expensed investments are expenditures financed by the owners of capital that increase future profits but, by national accounting rules, are treated as an operating expense rather than as a capital expenditure. Sweat investment is financed by worker-owners who allocate time to their business and receive compensation at less than their market rate. Such investments are made with the expectation of realizing capital gains when the business goes public or is sold. But these investments are not included in GDP. Taking into account hours spent building equity while ignoring the output introduces an error in measured productivity and distorts the picture of what is happening in the economy. In this paper, we incorporate expensed and sweat equity in an otherwise standard business cycle model. We use the model to analyze productivity in the United States during the 1990s boom. We find that expensed plus sweat investment was large during this period and critical for understanding the dramatic rise in hours and the modest growth in measured productivity.

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1. Introduction

A significant amount of business investment is not included in national accounts. Some of the unaccounted investment is *expensed* against profits. Expensed investments are expenditures financed by the owners of capital that increase future profits but, by national accounting rules, are treated as an operating expense rather than as a capital expenditure. Examples include research and development, advertising, and investments in building organizations. Some of the unaccounted investment is *sweat*. Sweat investment is financed by worker-owners who allocate time to their business and receive compensation at less than their market rate. Such investments are made with the expectation of realizing capital gains when the business goes public or is sold.

By not accounting for investments in expensed and sweat equity, the standard measure of productivity distorts the picture of what is happening in the economy during times when the importance of unmeasured investments is changing. The standard measure of aggregate productivity is gross domestic product (GDP) per hour worked. Output is understated by GDP because expensed and sweat investments are not accounted for in the U.S. Department of Commerce's Bureau of Economic Analysis (BEA) measure of product. This exclusion lowers profits and compensation in the BEA's measure of income by the amount of these investments. If the importance of these unaccounted investments relative to GDP remained constant over time, growth in GDP per hour would be equal to growth in actual output produced per hour worked. But, in the late 1990s, the relative importance of these investments varied a lot in the U.S. economy.

If macroeconomists were to look at the U.S. economy through the lens of a theory that abstracts from expensed and sweat equity, they would find the observations in the late 1990s puzzling. In the late 1990s, GDP grew rapidly. But hours grew even more rapidly implying weak labor productivity growth. The movements in total factor productivity (TFP), effective tax rates, and the Federal Funds rate are either too small or of the wrong sign to account for the dramatic changes in output and hours that occurred.

In this paper, we incorporate expensed and sweat equity into an otherwise standard model and use the model to analyze output and hours in the United States during the 1990s. The business sector in our model has two technologies available: one for producing final goods and services and one for producing intangible capital. Although most investment in expensed and sweat equity is intangible and not directly observable, the magnitudes of these investments can be inferred with the aid of growth theory and data from the U.S. national income and product accounts (NIPA). We find that this investment is large, particularly during the late 1990s when industry R&D grew rapidly and initial public offerings (IPOs) and company acquisitions boomed.[1] Our estimate of intangible (expensed plus sweat) investment in the business sector is a little over 0.03 GDP during the early 1990s, rising to over 0.08 GDP at the peak of the boom.

We conduct two tests of the theory. The first test is a check on the consistency of the equilibrium of our model. We use first order conditions of the model and observations from NIPA to determine allocations of factor inputs and TFPs across sectors. We then ask, If households in the model economy were confronted with these time paths for sectoral TFPs, would the model's behavior be close to the behavior of the U.S. economy? We find that it is.

The consistency test imposes a lot of discipline on the theory. To demonstrate this, we consider an alternative theory of the hours boom in the 1990s in which we posit that hours rose because of a reduction in labor distortions. In this case, we assume that TFPs in our two sectors change proportionally. Thus, there are the same number of free parameters in this alternative theory as the original. We find that labor distortions cannot account for

[1] Samuelson and Varian (2002) estimate industry R&D growth at 8.5 percent per year between 1994 and 2000. During the same period, gross proceeds of IPOs grew 22 percent per year and announced merger and acquisition volume grew 34 percent per year according to data from SDC.

the behavior of the U.S. economy in this period, in particular the boom in hours.

For the second test of our theory, we compare the model's prediction for factor incomes and capital gains to U.S. measures in NIPA and in the U.S. Flow of Funds (FOF), respectively. This test is demanding because neither the income data nor the capital gains data were used to infer our measures of sectoral TFPs. The incomes reported in the NIPA accounts do not include expensed and sweat equity. Thus, we need to compare them to our model's total incomes less intangible investments. The Flow of Funds reports *holding gains*, which is the difference between the end-of-period net worth and the sum of the beginning-of-period net worth and net investment. The holding gains of households, subtracting gains for real estate, should move with our model intangible gains during the 1990s period. We find that the model's predictions of both incomes and gains are in line with U.S. observations.

After testing the theory, we use it to get a more accurate picture of the U.S. economy in the late 1990s. In particular, we use our model to compare accounting measures for output, investment, and productivity with analogues that include expensed and sweat investment. Solow's (1987) remark that "you can see the computer age everywhere but in the productivity statistics" is pertinent for our findings. The model predicts lackluster productivity performance if accounting measures are used and a boom for productivity if expensed and sweat investments are included. From this, we conclude that ignoring these intangible investments gives a distorted picture of the U.S. economy in the late 1990s.

Our analysis deals directly with the criticism of Brynjolfsson and Hitt (2000), who argue that intangible investments "are not well captured by traditional macroeconomic measurement approaches." The traditional approaches they refer to are growth-accounting approaches such as that of Jorgenson and Stiroh (1999) and Oliner and Sichel (2000). Here, we explicitly model the intangible investments and use our theory to infer their size.

2. Standard Theory and the Prediction for Hours

We start with the standard growth model used in the study of business cycles. We derive a prediction for hours of work and show that it is grossly at odds with the fact that U.S. hours rose dramatically during the 1990s. We investigate the failure of the theory and use the failure to motivate an extension with expensed and sweat equity.

In the standard growth model, given initial capital stock k_0, the problem for the household is to choose consumption c, investment x, and hours h to maximize

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

subject to

$$c_t + x_t = r_t k_t + w_t h_t - T_t \tag{2.1}$$

$$k_{t+1} = [(1 - \delta) k_t + x_t]/(1 + \eta), \tag{2.2}$$

where variables are written in per capita terms and $N_t = (1 + \eta)^t$ is the population in t. Capital is paid rent r_t and labor is paid wage w_t. Capital depreciates at rate δ. The term T_t is the sum of all taxes less all transfers.

Firms in the economy use the following constant returns technology:

$$Y_t = A_t K_t^{\theta} H_t^{1-\theta} \tag{2.3}$$

to produce goods sold to the household. Capital letters in this case denote aggregates. The parameter A_t is the technology parameter that varies over time. The firms rent capital and labor at rates equal to the marginal products of capital and labor, respectively.

Finally, the goods market clears, that is $N_t(c_t + x_t) = Y_t$. Here, we assume that c includes both private and public consumption, and we assume that x includes both private and public investment.

Let τ_{ct} be the tax rate on consumption, and let τ_{ht} be the tax rate on wage income $w_t h_t$. The household's intratemporal condition, relating the marginal rate of substitution between consumption and leisure and the after-tax real wage, depends on these rates and can be written as

$$\frac{\psi(1+\tau_{ct})c_t}{1-h_t} = (1-\tau_{ht})(1-\theta)\frac{y_t}{h_t}, \tag{2.4}$$

where y_t is per-capita output. From the U.S. national accounts, we have data for total consumption c, output y, and the tax receipts needed to estimate tax rate τ_{ct} and τ_{ht}.[2] We solve for h_t, which is a function of current period observations, namely

$$h_t^{predicted} = \left[1 + \left(\frac{\psi}{1-\theta}\right)\left(\frac{1+\tau_{ct}}{1-\tau_{ht}}\right)\frac{c_t}{y_t}\right]^{-1}. \tag{2.5}$$

We compare this predicted series to the actual hours of work per-capita.[3]

In Figure 1, we plot predicted and actual per-capita hours of work, indexed so that 1990 equals 100. The predicted series is (2.5).[4] The difference between the series is striking. In the United States, hours per capita rose 8 percent between 1992 and 1999, more than 1 percent per year. The predicted series actually falls during this period, primarily because of a rise in τ_{ht}. To account for an 8 percent rise in hours in (2.5), the tax rate on hours would have had to fall 5 percentage points.

The fact that the series in Figure 1 do not track each other means that the intratemporal condition (2.4) does not hold.[5] If there is an error measuring either the output y or the labor input h, then we should expect a deviation in this condition. In the next section,

[2] The sources of national account data that we use are the Board of Governors (1945–2005) and the U.S. Department of Commerce (1929–2005). See Appendix A for more details. Tax rates are estimated as in Prescott (2004).

[3] The source of hours and population is the Bureau of Labor Statistics, Current Population Survey, and is described in detail in Prescott, Ueberfeldt, and Cociuba (2005).

[4] We set $\theta = 0.34$ and $\psi = 1.33$, but the results are not sensitive to these choices.

[5] There is also a deviation in the condition relating the marginal rate of substitution between consumption today and tomorrow and the marginal rate of transformation. But this intertemporal deviation is small in comparison to the intratemporal deviation.

we show evidence that suggests an error in measuring output resulting from unmeasured intangible investment being abnormally large.

3. The 1990s Boom

To motivate our extension of the growth model, we document changes that occurred in the U.S. economy that point us in the direction of increased intangible investment in the late 1990s. The first set of changes is related to the technology (or "high-tech") boom. During the 1990s, there was a large increase in industry R&D, IPOs, and mergers and acquisitions. The second set of changes is related to movements in factor inputs and incomes. The increase in hours occurred in certain occupations and factor incomes fell during the boom period.

In Figure 2, we plot total funding of R&D performed by industry reported by the National Science Foundation (1953–2003). Between 1994 and 2000, expenditures nearly doubled, rising from $107 billion to $198 billion. A lot of this investment is expensed by corporations and, thus, does not show up in either national product or national income. If the hours put in by researchers is counted, then productivity measures are distorted.

In Figure 3, we plot gross proceeds from IPOs compiled from Thomson Financial Securities Data Corporation (SDC) database.[6] Although there are fluctuations in the series, the trend is clear. there was much more IPO activity in the 1990s than there was in the 1980s. Associated with IPOs there typically is a large increase in the value of existing equity and therefore a jump in capital gains. Because these gains are not included in NIPA, NIPA incomes understate true income.

Other related evidence available from the SDC database is the volume of announced mergers and acquisitions. In Figure 4, we plot this volume for the period 1994–2003. The

[6] See also Table 1 in Ritter and Welch (2002).

volume rose from \$0.6 trillion in 1994 to \$3.4 trillion by 2000. As in the case of IPOs, if large payments to shareholders or worker-owners are made at the time a business is acquired, then NIPA measures of income understate true income.

Figures 5 and 6 are evidence from the U.S. national accounts that incomes were unexpectedly low during the boom period. In Figure 5, we plot average weekly hours of work for the noninstitutional population, aged 16 to 64 (the same number of hours as those in Figure 1). We also plot the wage rate corresponding to these hours, which is computed as follows. We take NIPA compensation and deflate it by the GDP deflator. We then detrend for population growth by dividing real compensation by this population. Finally, because there is technological growth, we divide the wage rate by the factor 1.02^t, where t indexes time. For all of the 1990s, NIPA real, detrended compensation per hour is below the 1990 level, despite the fact that there was a boom in hours.[7]

In Figure 6, we compare NIPA GDP and corporate profits, both deflated by the GDP deflator and detrended so that they do not grow with population or technology. We see that profits are falling (relative to trend) in the late 1990s when GDP, R&D, and capital gains are high.

Evidence in Figures 2 through 6 suggests that during the 1990s boom, business owners made large unmeasured investments and made large gains on those investments. If that is the case, we should see the rise in hours concentrated in certain groups of workers.

Using Current Population Survey (CPS) data, we find that the large increase in hours was concentrated among a small group of workers.[8] According to the survey data, per-capita hours for the noninstitutional population aged 16 to 64 rose 6.5 percent between

[7] In an earlier paper, we abstract from sweat equity and treat NIPA compensation as true labor income. Doing so understates the estimate of total intangible investment in both expensed and sweat equity. See McGrattan and Prescott (2005b).

[8] Here, we are referring to data compiled from the March supplement of the CPS survey. See www.ipums.org for more details.

1992 and 2000. Half of this increase was due to hours rising in a select group of occupations for workers with at least one year of college education. These occupations include most managers and proprietors, computer analysts, and certain financial occupations.[9] Our aim was to focus on occupations where many workers are making large unmeasured investments. Hours of the educated in these occupations accounted for only 10.3 percent of the hours in 1992, but rose 30 percent between 1992 and 2000. This change in hours contributed half of the overall change in hours.

We turn next to an extension of the standard theory described in Section 2.

4. A Theory of Expensed and Sweat Equity

In this section, we modify the standard growth model by including intangible investment. We start by describing the technology available to firms, the optimal firm size, and the aggregate production technology. The household problem remains the same except for an additional investment choice. We reexamine the theoretical prediction for hours and show that the theory can account for the puzzling U.S. observations during the 1990s.

A firm is characterized by the stock of its (unmeasured) intangible capital, K_u. This capital can be used for two activities. The first activity produces the composite output Y and the second produces intangible investment goods X_u.

Inputs of (measured) tangible capital K_m^i and hours H^i along with K_u produce an intermediate good Z^i via a standard constant returns to scale neoclassical production function f^i for $i \in \{1, 2\}$. In particular, the production functions are

$$Z^i = (K_m^i)^{\theta_i} K_u^{\phi_i} (H^i)^{1-\theta_i-\phi_i}, \quad i \in \{1, 2\}.$$

[9] Specifically, using data from IPUMS (www.ipums.org), we split workers into two groups: those with variable EDUCREC greater than or equal to 8 and variable OCC in the set {4, 7, 9, 13, 14, 15, 18, 21, 22, 34, 37, 64, 65, 229, 23, 24, 25, 225} and the remainder.

The quantity of Y produced is $g^1(Z^1)$, and the quantity of X_u produced is $g^2(Z^2)$. The functions g^i are increasing, initially strictly convex, then strictly concave, and satisfy $g^i(0) = 0$. The slope of the maximal tangent ray from the origin is A^i. The point of tangency is $\hat{Z}^i$. The margin of adjustment is the number of units operated, which is variable. The capital stock K_u can be split over firms through mergers, acquisitions, and spin offs. All production units that are operated will have the same K_u. This K_u will depend upon the relative prices of the three inputs. Production units of type i will be operated at level $\hat{Z}^i$ and produce $g^i(\hat{Z}^i)$.

The aggregate production technology is characterized by the two aggregate production functions:

$$y_t = A_t^1 (k_{mt}^1)^{\theta_1} (k_{ut})^{\phi_1} (h_t^1)^{1-\theta_1-\phi_1} \tag{4.1}$$

$$x_{ut} = A_t^2 (k_{mt}^2)^{\theta_2} (K_{ut})^{\phi_2} (h_t^2)^{1-\theta_2-\phi_2} \tag{4.2}$$

The important point is that k_u is an input to both production processes. Firms produce products using their intangible capital along with tangible capital and labor. Firms develop new brands, products, and patents *building* on their existing stocks of brands, products, and patents.

Given (k_{m0}, k_{u0}), the stand-in household maximizes

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

subject to

$$\begin{aligned} c_t + x_{mt} + q_t x_{ut} = {} & r_{mt} k_{mt} + r_{ut} k_{ut} + w_t h_t + Tr_t \\ & - \tau_{ct} c_t - \tau_{ht}(w_t h_t - (1-\chi) q_t x_{ut}) - \tau_{kt} k_{mt} - \tau_{xt} x_{mt} \\ & - \tau_{pt}\{r_{mt} k_{mt} + r_{ut} k_{ut} - \delta_m k_{mt} - \chi q_t x_{ut} - \tau_{kt} k_{mt}\} \\ & - \tau_{dt}\{r_{mt} k_{mt} + r_{ut} k_{ut} - x_{mt} - \chi q_t x_{ut} - \tau_{kt} k_{mt} \end{aligned}$$

$$- \tau_{pt}(r_{mt}k_{mt} + r_{ut}k_{ut} - \delta_m k_{mt} - \chi q_t x_{ut} - \tau_{kt}k_{mt}) - \tau_{xt}x_{mt}\}$$

$$k_{mt+1} = [(1-\delta_m)k_{mt} + x_{mt}]/(1+\eta) \tag{4.3}$$

$$k_{ut+1} = [(1-\delta_u)k_{ut} + x_{ut}]/(1+\eta). \tag{4.4}$$

As before, all variables are in per-capita units and there is growth in population at rate η. Consumption c includes both private and public consumption, and tangible investment x_m includes both private and public investment. The relative price of intangible investment and consumption is q_t. The rental rates for capital are denoted by r, and the wage rate for labor is denoted by w. Inputs are paid their marginal products.

The tax system in the model economy mimics the U.S. system. There are taxes on consumption τ_c, measured wages τ_h, tangible capital (that is, property) τ_k, investment τ_x, profits τ_p, and distributions τ_d. We use χ to denote the fraction of intangible investment financed by capital owners.[10] Note that $\chi q_t x_{ut}$ is expensed investment financed by the capital owners who have lower profits with increased investment. The amount $(1-\chi)q_t x_{ut}$ is sweat investment financed by workers who have lower compensation with increased investment.

Gross domestic product in the economy is the sum of total consumption (public plus private) and tangible investment (public plus private), which in per-capita terms is $y_t = c_t + x_{mt}$. Gross domestic income is the sum of labor income less sweat investment $w_t h_t - (1-\chi)q_t x_{ut}$, capital income less expensed investment $r_{mt}k_{mt} + r_{ut}k_{ut} - \delta_m k_{mt} - \chi q_t x_{ut}$, and capital consumption $\delta_m k_{mt}$.

4.1. Predictions for Hours

We showed that a key failure with the standard theory was evident in the intratemporal condition (2.4) which does not hold for U.S. time series. In the model with intangible

[10] The choice is irrelevant if there are no taxes. With taxes, the choice is all or none in the absence of risk which might optimally be shared between capital owners and worker owners.

investment, we have an analogous condition. For ease of comparison, first assume that there is no non-business sector. In this case, the intratemporal condition is

$$\begin{aligned}\frac{\psi(1+\tau_{ct})c_t}{1-h_t} &= (1-\tau_{ht})(1-\theta)\left(\frac{y_t}{h_{1t}}\right) \\ &= (1-\tau_{ht})(1-\theta)\left(\frac{y_t}{h_t}\right)\left(1+\frac{h_{2t}}{h_{1t}}\right) \qquad (4.5)\end{aligned}$$

where $h_t = h_t^1 + h_t^2$ and $\theta = \theta_1 + \phi_1$. Note that the real wage in the standard model was $(1-\theta)y_t/h_t$. Here, the real wage for work producing final goods and services is $(1-\theta)y_t/h_t^1$, reflecting the fact that some hours are spent producing intangible capital. Thus, we have the same expression as before except for the term h_t^2/h_t^1. If we do not account for this term, then we are not correctly measuring the productivity and, hence, the wage.[11]

If we do include a non-business sector, then the relevant condition is

$$\frac{\psi(1+\tau_{ct})c_t}{1-h_t} = (1-\tau_{ht})(1-\theta)\left(\frac{y_{bt}}{h_t^1}\right), \qquad (4.6)$$

where y_{bt} and h_t^1 is output and hours in production of final goods and services in the business sector, $h_t = h_t^1 + h_t^2 + \bar{h}_{nt}$ is total hours, h_t^2 is business hours in production of intangible capital, and $\bar{h}_{nt}$ is non-business hours assumed to be exogenous for our model household. Using (4.6), we have the following formulas for h_t^1 and h_t^2:

$$h_t^1 = \left(\frac{1-\theta}{\psi}\right)\left(\frac{1-\tau_{ht}}{1+\tau_{ct}}\right)\left(\frac{y_{bt}}{c_t}\right)(1-h_t) \qquad (4.7)$$

$$h_t^2 = h_t - h_t^1 - \bar{h}_{nt}. \qquad (4.8)$$

With observations on business value-added, consumption, total hours, non-business hours, and tax rates, we can directly infer the allocation of hours to production of final

[11] In standard sticky wage models, the condition (2.4) is replaced by a dynamic equation relating the nominal wage to a markup over expected future marginal rates of substitution between consumption and leisure. As McGrattan (2004) shows, however, the impact of monetary shocks in these models is tiny. Given the magnitude of these shocks for the United States during the 1990s, these models cannot account for the dramatic rise in hours and output.

goods and services and to production of new intangible capital. We know from the results in Figure 1 that movements in h_t^2 have to be sizable to be consistent with these observations. In Figure 7, we plot the ratio h_t^2/h_t using the expressions (4.7) and (4.8) with $\theta = 0.34$ and $\psi = 1.33$ and U.S. observations on tax rates, consumption, business value added, and total hours. As expected, there is a sizable increase starting in 1992. The fraction rises from 2.7 percent to 7.7 percent by 2000.

A large rise in hours to building intangible capital is consistent with the evidence presented in Section 3. This evidence suggests that increases in TFP, that were particularly high in certain activities, could have generated the 1990s boom. We explore this hypothesis next.

5. Tests of the Extended Theory

We have shown that growth theory, with unmeasured intangible investments explicitly modeled, can potentially resolve the puzzling observations during the U.S. 1990s boom. In this section, we determine if it in fact does resolve the puzzle by putting the theory to two tests.

The first test is a check on the consistency of the equilibrium of our model. We use a subset of equilibrium relations for the model to infer sequences for sectoral TFPs. We feed these sequences into the model and compare equilibrium outcomes with U.S. data. We find that the model does extremely well.

For the second test, we put the theory to a more demanding test and compare predictions of the model to observations that were not used when inferring paths for sectoral TFPs. In particular, we compare the models predictions for factor incomes and capital gains to analogues in the data.

Two first steps are needed to conduct the test. We have to revise the national accounts in light of our theory. We also have to choose parameters.

5.1. Revising Accounts

We start with the tedious but essential step of revising the national accounts. Four adjustments to the BEA accounts are necessary for consistency with our model. We provide an overview in this section and details in Appendix A.

First, our model output does not include consumption taxes as part of consumption and as part of value added, but NIPA GDP does. We subtract sales and excise taxes from taxes on production and imports and from personal consumption expenditures. A consequence of this is that, unlike NIPA, our accounts use producer prices rather than a mixture of producer and consumer prices.

Second, we treat some financial services included in NIPA as intermediate rather than as final and subtract them from GDP and from consumption services. Specifically, we subtract personal business expense for handling life insurance and pension plans from net interest and from personal consumption expenditures.

Third, our model treats expenditures on all fixed assets as investment. Thus, consumer durables are treated as an investment in the model accounts rather than as consumption expenditures. We introduce a consumer durable services sector in much the same way as an owner-occupied housing sector is introduced into NIPA. Households rent the consumer durables to themselves. A related adjustment is made for government capital.

Finally, and most importantly for the purposes of this paper, our model output includes intangible investment. Thus, total product in the model is the sum of intangible investment and gross domestic product (which is the same concept as NIPA GDP after the adjustments are made for consumption taxes, intermediate financial services, and consumer durables). On the income side of our model accounts, we add capital gains $q_t x_{ut}$ which offsets expensed investment $\chi q_t x_{ut}$ and sweat investment $(1-\chi)q_t x_{ut}$.

5.2. Parameters

Before comparing the model predictions to the data, we need to choose parameters. In this section, we report and motivate our choices.

For growth and interest rates, we use estimates based on U.S. trends. In particular, we set set the interest rate at 4.1 percent and the annual growth in population at 1 percent ($\eta = .01$). We also assume that there is growth in technologies so that per-capita GDP and its components grow at 2 percent annually. These choices imply $\beta = .98$.

Household preferences depend on the parameter ψ. We chose $\psi = 1.33$ in order to match the fraction of time allocated to work (in business and non-business) for the United States. This value implies that 27.5 percent of discretionary time is allocated to work.

Given that changes in tax rates on capital were modest during the 1990s, we hold these constant. We set $\tau_p = 0.35$ since most of the taxes on profits are corporate income taxes. We set the distribution tax to be $\tau_d = 0.15$, which is slightly less than our estimate in McGrattan and Prescott (2005a) for corporate distributions since noncorporate taxes are not taxed twice. We set $\tau_x = 0$ since depreciation allowances, investment tax credits, and investment taxes were negligible in the 1990s. Finally, we set the property tax rate at $\tau_k = 0.016$, which is consistent with NIPA non-sales taxes on production and imports.

We use the same series for the tax on consumption that we used for Figure 1. For the tax on labor we need to make one adjustment. Since we want to assume that τ_h is the tax rate on labor income excluding capital gains, we can either subtract the capital gain tax receipts from receipts or include capital gains income to taxable income before constructing our estimate of the tax rate.[12]

The share parameters and depreciation rates were chosen so that 1990 in the model simulations looked like 1990 in U.S. time series.[13] Our model, however, is designed to account for activity in the business sector. U.S. corporate and noncorporate business accounts for 75 percent of value added. We treat the remaining sector, which includes households, nonprofits, and government, as the "non-business" sector and treat investment, hours, and output in that sector as exogenous to households in our model. [14]

As a benchmark, we used the same technology for producing final goods and intangible capital. In this case, we found $\theta_1 = \theta_2 = 0.254$, $\phi_1 = \phi_2 = .087$, and $\delta_m = .04$ for the business sector technologies when we matched the model and data for 1990.

The final parameter to be set is χ, which is the fraction of intangible investment financed by capital owners. As we noted earlier, the only real ramification of this choice is for tax payments. But the evidence in Figures 5 and 6 suggests that some investment is being done by both shareholders and workers. As a benchmark, we chose 0.5 and then experimented with other values. The main effect of varying χ is a change in the effective tax rates on labor and capital.

5.3. A First Test

The first test of our theory can be summarized as follows. Are there paths of sectoral TFPs $\{A_t^1, A_t^2\}$ that imply an equilibrium of the model that is consistent with U.S. observations?

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[12] We do the latter using income data reported by the BEA. These data are reported in the table comparing NIPA personal income and the IRS's adjusted gross income.

[13] There is no way to determine δ_u. We chose 0 and experimented with other values to make sure our main results did not change.

[14] In Appendix A, we show specifically how we categorize business and non-business activity for U.S. national accounts.

If the answer is no, then this theory is not useful for predicting what was happening during the 1990s U.S. boom. If the answer is yes, then this theory is potentially useful for predicting the size of intangible investments and the patterns for actual output per hour.

Above we showed that the intratemporal condition relating the marginal rate of substitution to the after-tax wage rate gives us an expression for sectoral hours in terms of U.S. observations. If we had observations on all investments and capital stocks, we could use (4.1) and (4.2) to back out total factor productivities in the two sectors, feed these estimates of TFP into the model, and compute equilibrium responses of the household.

Since we do not have observations on all investments and capital, we have to use additional equilibrium relations to back out the sequences of TFPs. In Appendix B, we describe the steps used to derive sequences for A_t^1 and A_t^2. The main idea is to equate returns to capital in order to determine the sectoral allocation of capital stocks. The resulting sequences for TFPs are plotted in Figure 8 along with the standard measure of TFP: GDP divided by $K_{mt}^{.33} H_t^{.67}$, where K_{mt} is total measured capital and H_t is total hours. All series are real and relative to trend.

The standard measure falls slightly over the period but stays close to trend. The implied TFPs for the model with intangible investment, on the other hand, show large increases. In the sector producing final goods and services, the increase is about 6 percent. In the sector producing intangible capital, the increase is close to 17 percent.

We now take a second look at the U.S. data through the lens of the model with intangible investment. We feed in the series for TFP in Figure 8 implied by the model along with varying tax rates on market wages and consumption. In Figure 9, we display the results for total hours. The predicted and actual series track each other very closely. The model predicts that hours used to produce final goods and services actually fall somewhat. But, hours spent building intangible capital rise significantly, implying a large overall increase in hours.

In Figure 10, we display the results for measured labor productivity in the business sector. The model's prediction for business value added tracks the actual NIPA series closely. Thus, we also get a very close match with labor productivity. We also find a close match between model's total labor productivity (GDP per hour) and the measure for U.S. data.

The largest deviation between the model and U.S. time series is in the comparison of actual and predicted tangible investment. These series are plotted in Figure 11. The model prediction is sensitive to the choice of capital taxation which we fixed over the period. However, even with the assumption of constant capital taxes, the model does well in predicting the rise and fall of tangible investment.

How strong is this test?

If TFPs are backed out from first-order conditions of the household's problem, is the consistency test much of a test? Our answer is yes and best understood by considering the following alternative theory. An alternative theory for the 1990s is that a reduction in labor market distortions led to a large boom in hours. Consider the model of Section 2 with sectoral TFPs varying proportionally and τ_{ht} treated as unobserved parameters that capture all distortions on labor including but not exclusively those due to government taxation. If the sequence of τ_{ht} is chosen to satisfy the intratemporal first-order condition, then we have the same number of free parameters as our theory with different sectoral TFPs and τ_{ht} set equal to an estimate of the government tax rate.

We find that this alternative theory of reduced labor distortions is grossly at odds with U.S. data. To see this, note that (4.5) can be written as follows

$$\frac{\psi(1+\tau_{ct})c_t}{1-h_t} = (1-\tau_{ht})(1-\theta)\left(\frac{y_t+\bar{q}x_{ut}}{h_t}\right) \tag{5.1}$$

for this alternative theory, where the relative price q is fixed (because TFPs vary proportionally). In this equation we have two unobserved variables: τ_{ht} and x_{ut}. We can use (5.1) along with the intertemporal condition relating the marginal rate of substitution of consumption this period and next to the return on intangible capital to back out sequences of τ_{ht} and x_{ut}.

The resulting sequences for τ_{ht} and x_{ut} oscillate wildly. For example, the series for the labor distortion oscillates between 0 percent and 40 percent and displays little persistence. Such a pattern in inconsistent with the notion of reduced labor distortions and cannot generate an hours boom unless movements in capital tax rates and TFP are also oscillatory and offsetting.

We conclude from this section, that our consistency test is a strong test. Thus, we have confidence in the theory that increased growth in TFPs, especially in the sector producing intangible capital, resolves the puzzling U.S. observations during the 1990s.

5.4. A Second Test

Thus far, we have checked on the model's consistency using TFP sequences derived from the model's equilibrium relations. In this section, we consider an even more demanding test of the theory by comparing model predictions to observations not used to infer the TFP paths. In particular, we explore predictions for business wage compensation as measured in NIPA and for business capital gains as measured in the Flow of Funds. Neither series were used to derive our measures of TFPs.

To compare the model's prediction for NIPA wage compensation in the business sector, we need to construct wages as a national accountant would. A national accountant placed in the model economy estimates wage compensation in the business sector as follows: $w_t(h_t^1 + h_t^2) - (1-\chi)q_t x_{ut}$. In Figure 12, we plot this series along with the U.S. series.

Both are real series, detrended by 2 percent annually, and set equal to 100 in 1990. Relative to trend, both the model prediction and the actual wages are up nearly 8 percent in 2000 relative to the 1990 trend level. We should note that our choice of $\chi = .5$ is relevant for this prediction. The value of χ determines the level of taxation on expensed versus sweat equity, which affects the equilibrium measured compensation. Higher values of χ increase the value. We should note that allowing for variation in χ would imply a better fit of these curves. However, we do not have independent evidence of the financing of expensed and sweat equity.

Next, we compare model predictions to estimates of the increase in capital gains from expensed and sweat equity to U.S. household holding gains reported in the Flow of Funds accounts. Household holding gains reported in the U.S. Flow of Funds are the change in the net worth of households after accounting for net investment. If Flow of Funds accountants recorded holding gains for our model households, they would compute differences in the total value of businesses (for which the household is the residual claimant). The value of all businesses in t is

$$V_t = (1-\tau_{dt})(1+\tau_{xt})K_{m,t+1} + [\chi(1-\tau_{dt})(1-\tau_{pt}) + (1-\chi)(1-\tau_{ht})]q_t K_{u,t+1}, \quad (5.2)$$

where capital letters denote aggregates. The first term in (5.2) is the value of tangible capital and the second term is the value of intangible capital to the household. Notice that the price of intangible capital depends on χ since incomes to capital and incomes to labor are taxed differently.

The change in the value V does not exactly reflect the additional income in the model economy. The additional income is $q_t X_{ut}$ (in units of the final goods and services). However, during periods when there are large investments of intangible capital, the increase in holding gains, as defined in the Flow of funds, is a good approximation to the increase in intangible investment.

In Figure 13, we plot an estimate of U.S. real holding gains relative to GDP using data from the Board of Governor's Flow of Funds accounts and NIPA. To illustrate that the late 1990s and early 2000s were special, we show these estimates annually back to 1953. Starting in 1995, there is a significant break in the series. Prior to 1995 it averages around 6 percent of GDP. For the period 1995–2003, the average is 12 percent. A difference of 6 percent of GDP is large.

Because our theory does not provide any explanation for the huge swings in asset prices, we compare the model's predicted gains with the U.S. averages. We also have to make an adjustment for foreign gains because our model includes only domestic sectors. Since many domestic corporations have foreign subsidiaries, the value of the U.S. corporations includes equity from foreign capital, and the holding gains include gains from this foreign capital. We estimate the gain by assuming that the ratio of after-tax foreign corporate profits (excluding gains) to after-tax domestic corporate profits (excluding gains) is equal to the ratio of foreign to domestic holding gains. With this assumption, our estimate of foreign gains relative to total gains is approximately 23 percent on average for the period 1990–2003.

In Figure 14, we show the U.S. average holding gains along with the estimated holding gains for the model. Both rise significantly in the late 1990s. The rise is coincident with the dramatic rise in hours. We conclude that the model passes this critical test.

6. Implications for Output, Productivity, and Investment

What does all of this mean for U.S. output, productivity, and investment? If some output is unmeasured relative to inputs, then GDP and productivity estimates are biased downward. If the mismeasurement is intangible investment, then the investment estimates are biased downward.

In Figure 15, we compare two predictions for output. The first is the model's prediction for gross domestic product, which includes consumption and tangible investment but excludes intangible investment. The second prediction is total output which includes intangible investment $q_t x_{ut}$. Both are detrended by 2 percent annually and set equal to 100 in 1990. The model predicts that GDP should have grown slightly faster than 2 percent per year between 1991 and 1997. But total output takes off starting in 1993. At the peak, in 1999, total output is far above trend whereas GDP is only slightly higher than the trend level of 1990.

In Figure 16, we compare two measures of labor productivity for the model: business value added divided by total business hours and total business output (value added plus intangible output) divided by total business hours. The first measure excludes intangible investment and the second includes it. Both are detrended by 2 percent annually and set equal to 100 in 1990. Notice how different the predictions are during this period. Measured labor productivity, which is what national accountants would record if put in our economy, shows a significant fall relative to trend prior to 1997 and then a sharp increase until 2000. But actual productivity shows that the economy is growing very quickly starting in 1993. These are very different predictions.

In Figure 17, we compare two measures of investment for the model: tangible investment and tangible plus intangible investment. Both are detrended by 2 percent annually and normalized to 100 in 1990. Between 1991 and 1999, tangible investment rose by almost 20 percent. Total investment, however, rose by more than 30 percent. Again, the predictions—with and without intangible investment—are very different.

In Figure 18 we display intangible investment as a share of total output. Total output is GDP plus intangible investment. The bottom line of our study is that it is large and increased significantly in the late 1990s. Hence, standard accounting measures do not highlight what was actually going on in the U.S. economy during this period.

7. Conclusions

Many business cycle analysts consider the 1990s to be a prime example that Federal Reserve policy has important consequences for the economy. This reasoning is typically made by a process of elimination: there is little change in TFP and tax rates, so changes in the economy must have been driven by monetary factors. As Mankiw (2002) lucidly summarizes, "No aspect of U.S. policy in the 1990s is more widely hailed as a success than monetary policy. Fed Chairman Alan Greenspan is often viewed as a miracle worker."

This paper takes a different perspective. We look at the data with the view that unmeasured investments are potentially important. In McGrattan and Prescott (2005a), we found that intangible capital was important for estimating the value of corporate equity. Here, we considered the impact of intangible capital on hours, output, and productivity. Our clues are the dramatic increase in hours that occurred before an increase in output and the large rise in capital gains at the end of the 1990s. Using data for the United States, we infer that sweat investment was large in the U.S. boom of the 1990s. We show that ignoring this investment leads to a very distorted view of the performance of the economy.

Appendix A. Model Accounts

In this appendix, we describe in more detail the adjustments that are made to the national accounts so that the accounts are consistent with our theory.

In Table A, part I, we construct our measure of domestic business value added. This measure is close to, but not exactly the same as, the sum of the value added of corporate business, sole proprietorships and partnerships, and other private business as defined in the NIPA tables. In our table, we note the source of these NIPA series. Two adjustments, made in line 20 and in line 25, imply that our estimate of domestic business value added is lower than NIPA's by an amount equal to .049 GDP. The first adjustment (line 20) removes the personal business expense for handling life insurance and pension plans from net interest. We treat these financial services included in NIPA as intermediate rather than as final. The second adjustment (line 25) removes sales tax from taxes on production and imports. Our model output does not include consumption taxes as part of consumption and as part of value added, but the BEA does.

In Table A, part II, we construct our measure of domestic non-business value added. This measure is close to, but not exactly the same as, the sum of value added of households, nonprofits, general government, and government enterprises. Three adjustments are made. We add depreciation of consumer durables (line 5), subtract sales taxes (line 24), and add imputed capital services for consumer durables and government capital (line 25). Adjustments for consumer durables are necessary because we include consumer durables with investment while the BEA includes durables with consumption. Services for government capital are included because the BEA does not impute any value to the service. We assume a rate of return equal to 4.1 percent which is an estimate of the return on other types of capital.

In Table, part III, we construct our measure of gross domestic product. The adjustments noted above are also included in product, so that income and product balance. We have also categorized tangible investment into business and non-business as in the case of incomes. That is, investments of corporations and noncorporate business are included with business investment, and investments of households, nonprofits, and government are included with non-business investment.

To be consistent, we also categorize hours from the Current Population Survey (CPS) as business or non-business. Using the March supplement (through www.ipums.org), we construct business hours as the sum of hours for the self-employed—both incorporated and unincorporated—and hours for private wage and salary workers less hours for employees in nonprofits. Because private wage and salary workers include employees at nonprofits, we use BEA data on compensation in nonprofits and, assuming an average wage rate equal to the economy wide average, we can infer hours for nonprofits. Hours in the non-business sector are found by subtracting business hours from the total. We use the hours from the March supplement sample to compute the fractions of hours in business and non-business. We multiply these fractions by total hours in the monthly CPS sample for our final series.

Table A. Revised National Accounts, Averages Relative to GDP, 1990–2003

I. Domestic Business Value Added

1	Domestic Business Value Added	0.700
2	Consumption of fixed capital	0.082
3	Corporate business (NIPA 7.5)	0.067
4	Sole proprietorships and partnerships (NIPA 7.5)	0.013
5	Other private business (NIPA 7.5)	0.003
6	Labor Income	0.469
7	Compensation of employees	0.421
8	Corporate business (NIPA 1.13)	0.382
9	Sole proprietorships and partnerships (NIPA 1.13)	0.036
10	Other private business (NIPA 1.13)	0.002
11	70% Proprietors' income with IVA and CCadj (NIPA 1.13)	0.049
12	Capital Income	0.149
13	Corporate profits with IVA and CCadj (NIPA 1.13)	0.073
14	30% Proprietors' income with IVA and CCadj (NIPA 1.13)	0.021
15	Rental income of persons with CCadj (NIPA 1.13)	0.006
16	Net interest and miscellaneous payments	0.022
17	Corporate business (NIPA 1.13)	0.014
18	Sole proprietorships and partnerships (NIPA 1.13)	0.012
19	Other private business (NIPA 1.13)	0.005
20	Less: Intermediate financial services[a] (NIPA 2.5.5)	0.009
21	Taxes on production and imports[b]	0.026
22	Corporate business (NIPA 1.13)	0.056
23	Sole proprietorships and partnerships (NIPA 1.13)	0.008
24	Other private business (NIPA 1.13)	0.002
25	Less: Sales tax (NIPA 3.5)	0.040

See footnotes at the end of the table.

Table A. Revised National Accounts (Cont.)

II. Domestic Non-business Value Added

1	Domestic Non-business Value Added	0.337
2	Consumption of fixed capital	0.099
3	Households	0.084
4	Excluding consumer durables (NIPA 7.5)	0.012
5	Consumer durables (FOF F10)	0.062
6	Nonprofits (NIPA 7.5)	0.004
7	General government (NIPA 7.5)	0.018
8	Government enterprises (NIPA 7.5)	0.003
9	Labor Income	0.154
10	Compensation of employees	0.154
11	Households (NIPA 1.13)	0.001
12	Nonprofits (NIPA 1.13)	0.042
13	General government (NIPA 1.13)	0.099
14	Government enterprises (NIPA 1.13)	0.012
15	Capital Income	0.083
16	Current surplus of government enterprises (NIPA 1.13)	0.001
17	Rental income of persons with CCadj (NIPA 1.13)	0.008
18	Net interest and miscellaneous payments	0.033
19	Households (NIPA 1.13)	0.031
20	Nonprofits (NIPA 1.13)	0.002
21	Taxes on production and imports[b]	0.004
22	Households (NIPA 1.13)	0.011
23	Nonprofits (NIPA 1.13)	0.001
24	Less: Sales tax (NIPA 3.5)	0.007
25	Imputed capital services[c]	0.038
26	Household, consumer durables	0.013
27	Government capital	0.025

See footnotes at the end of the table.

Table A. Revised National Accounts (Cont.)

III. Domestic Value Added and Product

1	Total Adjusted Domestic Income	1.043
2	Domestic Business Value Added	0.700
3	Domestic Non-business Value Added	0.337
4	Statistical Discrepancy	0.006
5	Total Adjusted Domestic Product	1.043
6	Private consumption	0.618
7	Personal consumption expenditures (NIPA 1.1.5)	0.678
8	Less: Consumer durables (NIPA 1.1.5)	0.083
9	Less: Intermediate financial services[a] (NIPA 2.5.5)	0.009
10	Less: Sales tax, nondurables and services (NIPA 3.5)	0.042
11	Plus: Consumer durable depreciation (FOF F10)	0.062
12	Plus: Imputed capital services[c]	0.013
13	Public consumption (NIPA 3.1)	0.179
14	Government consumption expenditures (NIPA 3.1)	0.154
15	Plus: Imputed capital services[c]	0.025
16	Business tangible investment[d]	0.112
17	Corporate gross private domestic investment (FOF F6)	0.092
18	Noncorporate gross private domestic investment (FOF F6)	0.020
19	Non-business tangible investment	0.134
20	Household	0.114
21	Excluding consumer durables (FOF F6)	0.036
22	Consumer durables (NIPA 1.1.5)	0.083
23	Less: Sales tax, durables (NIPA 3.5)	0.005
24	Nonprofits (FOF F6)	0.007
25	Government investment (NIPA 3.1)	0.033
26	Net exports of goods and services (NIPA 1.1.5)	−0.021

NOTE: IVA, inventory valuation adjustment; CCadj, capital consumption adjustment.

[a] Expense is for handling life insurance and pension plans.

[b] This category includes business transfers and excludes subsidies.

[c] Imputed capital services are equal to 4.1% times the current-cost net stock of government fixed assets and consumer durables goods.

[d] Ten percent of farm business is in corporate, with the remainder in noncorporate.

Appendix B. Deriving Total Factor Productivities

We start with observables.[15] Let x_{mt} be measured tangible investment, which is the sum of business tangible (x_{bt}) plus non-business tangible ($\bar{x}_{nt}$). We have sequences for all three tangible series. Let h_t be total hours, which is the sum of business hours $h_t^1 + h_t^2$ and non-business hours $\bar{h}_{nt}$. We have sequences for total business hours and non-business hours. Let y_{mt} be measured output (GDP) which is the sum of business output of production of final goods and services y_{bt} and non-business output $\bar{y}_{nt}$. We have sequences for all three of these output series. Finally, we have series for consumption, assumed to be the sum of private and public consumption, and for tax rates.

Now, we are ready to use the model's equilibrium conditions. We use (4.7) and (4.8) to infer the allocation of hours within the business sector. Let $y_{ut} = q_t x_{ut}$. Equating wage rates implies

$$y_{ut} = \frac{(1-\theta_1-\phi_1)h_t^2}{(1-\theta_2-\phi_2)h_t^1} y_{bt}.$$

Given observables and $\{y_{ut}\}$, the sequences for k_{ut} and q_t are chosen to satisfy

$$y_{ut}/q_t + (1-\delta_u)k_{ut} = k_{ut+1}$$

$$\begin{aligned} & q_t(1/c_t)[(1-\chi)(1-\tau_{ht} + \chi(1-\tau_{pt})(1-\tau_{dt})]/(1+\tau_{ct}) \\ & \quad = \beta(1/c_{t+1})/(1+\tau_{ct+1}) \\ & \quad\quad [q_{t+1}((1-\chi)(1-\tau_{ht+1}) + \chi(1-\tau_{pt+1})(1-\tau_{dt+1}))(1-\delta_m) \\ & \quad\quad + (1-\tau_{pt+1})(1-\tau_{dt+1})(\phi_1 y_{bt+1} + \phi_2 y_{ut+1})/k_{ut+1}] \end{aligned}$$

given initial conditions for capital. Finally, we use the production technologies along with outputs, capital stocks, and hours to back out the time series for TFPs.

[15] For more details on how we construct the observable time series, see Appendix A.

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Figure 1

Total Hours of Work for the U.S. and the Model Without Intangible Investment, 1990–2003

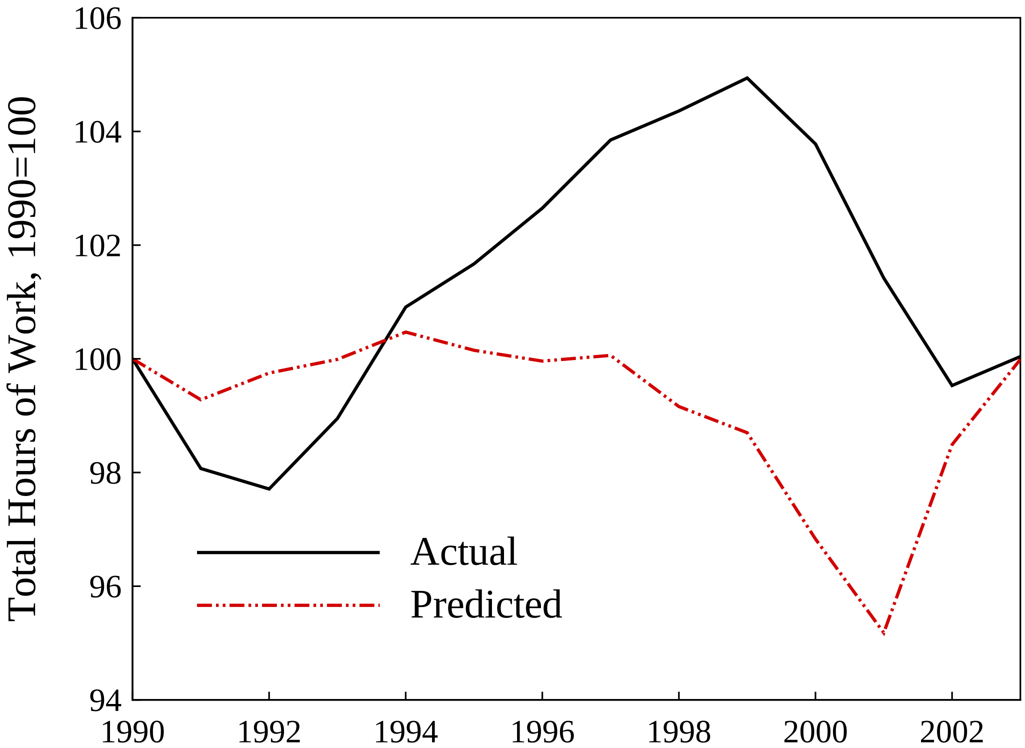

Figure 2

Total Research and Development Performed by Industry, 1990–2003

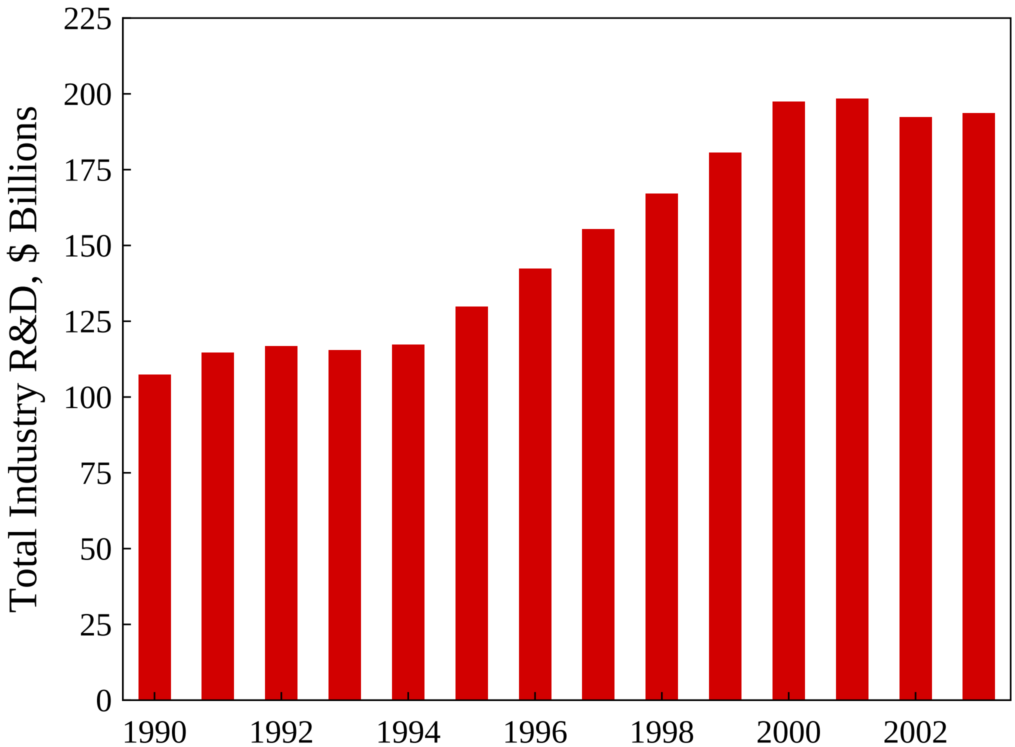

Figure 3

Gross Proceeds of IPOs, 1980–2001

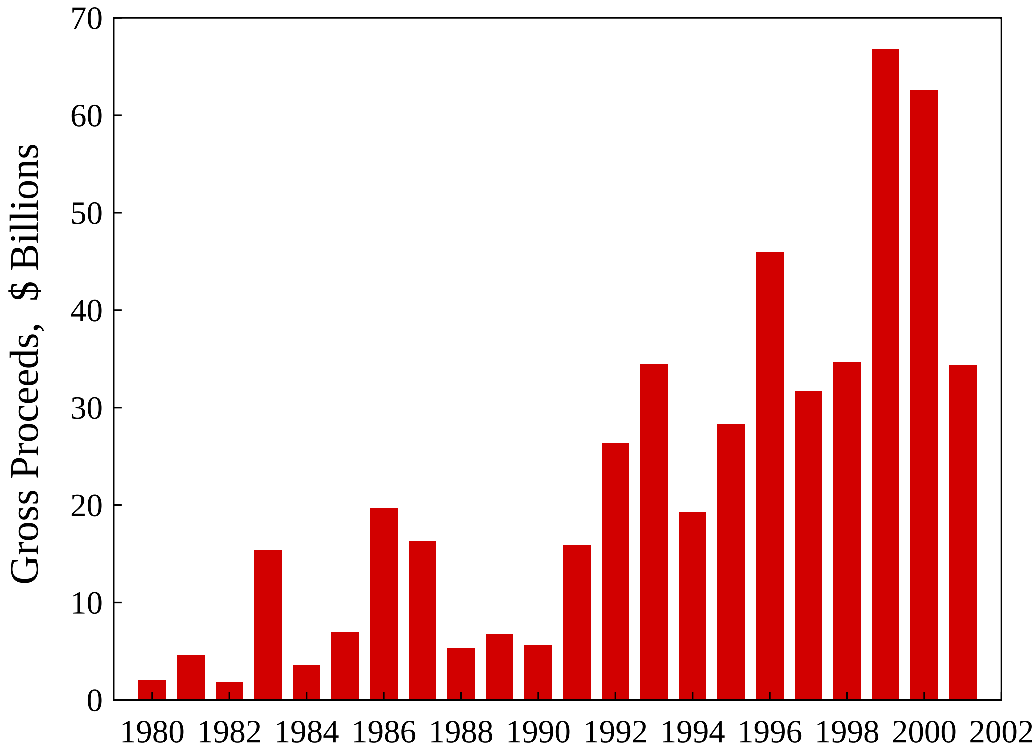

Figure 4
Announced Merger and Acquisition Volume, 1994–2003

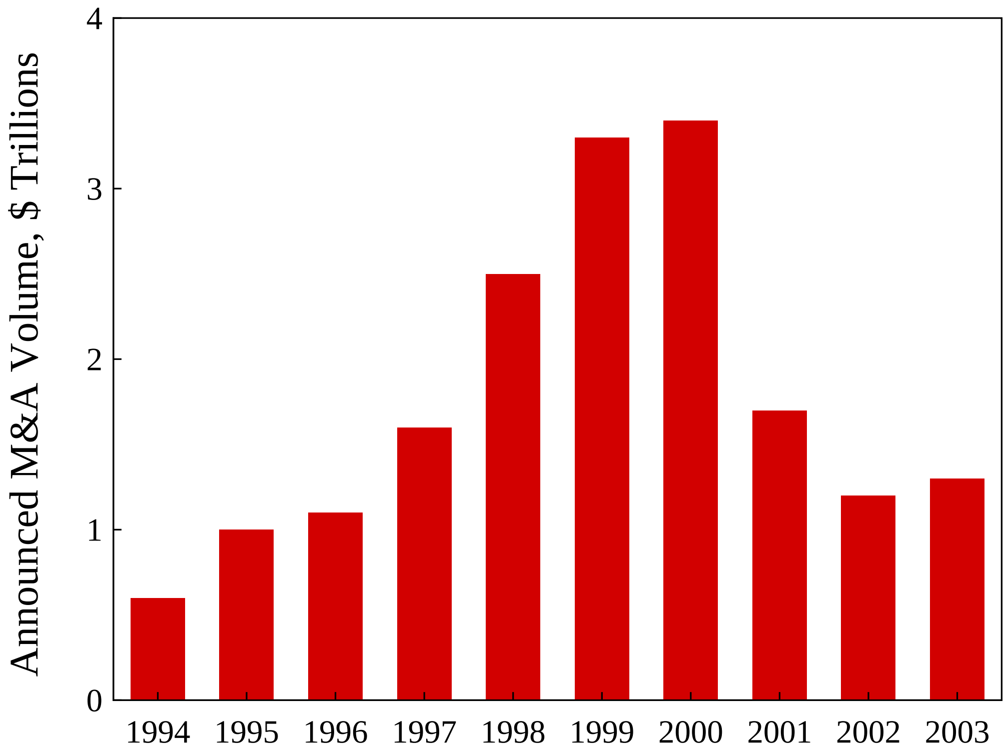

Figure 5

Average Weekly Hours of Noninstitutional Population 16–64 and NIPA Real, Detrended Compensation Per Hour, 1990–2003

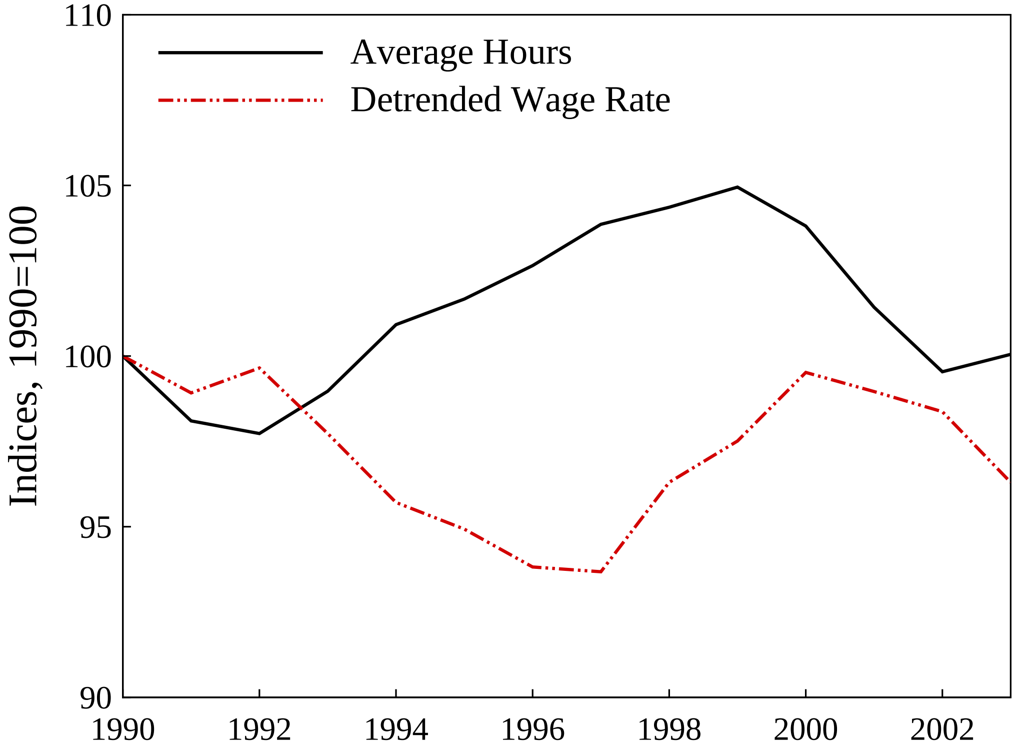

Figure 6

NIPA Real, Detrended GDP and Corporate Profits, 1990–2003

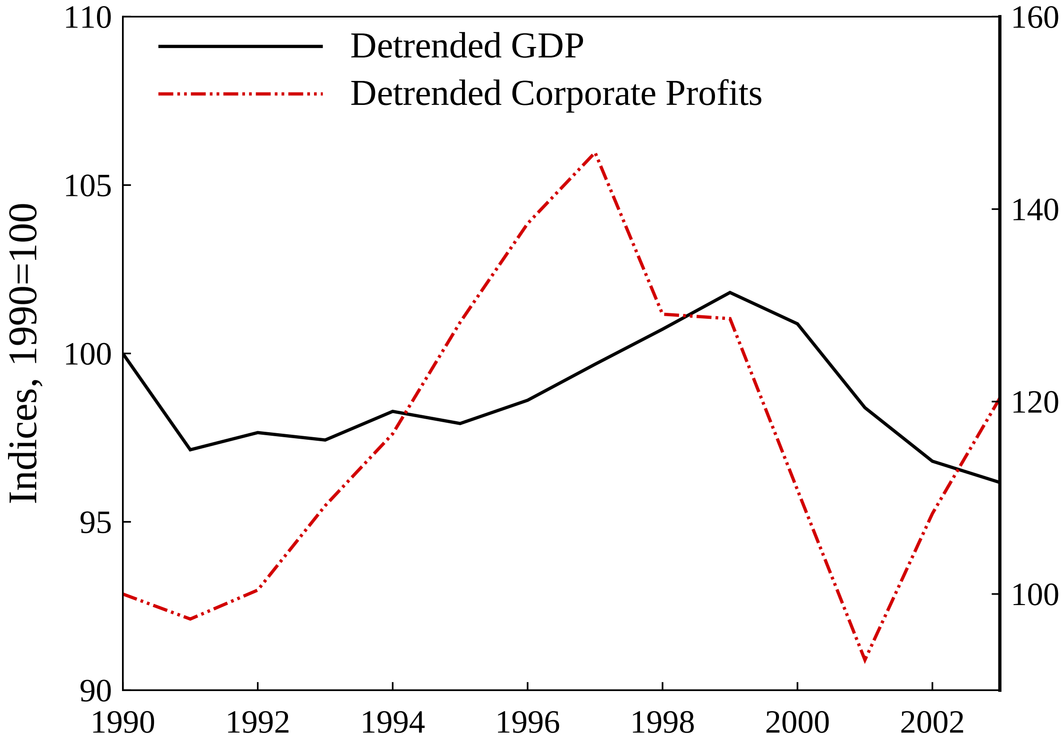

Figure 7

Fraction of Hours Spent in Production of Intangible Capital for the Model with Intangible Investment, 1990–2003

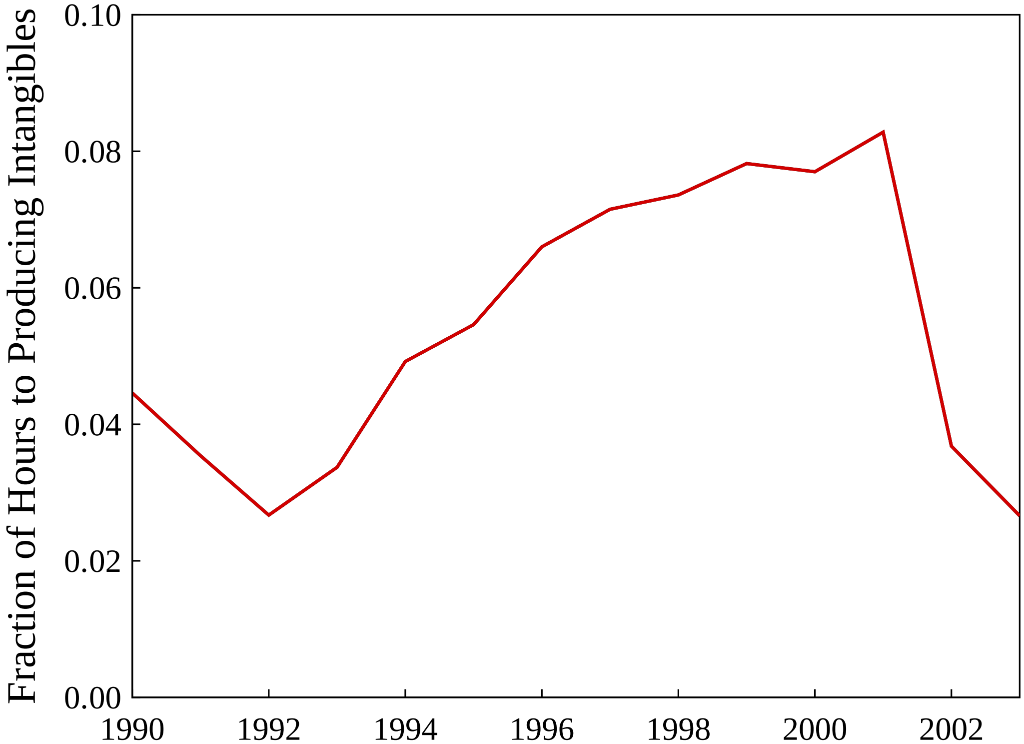

Figure 8

TFP for U.S. and Model with Intangible Investment

All real and detrended, 1990–2003

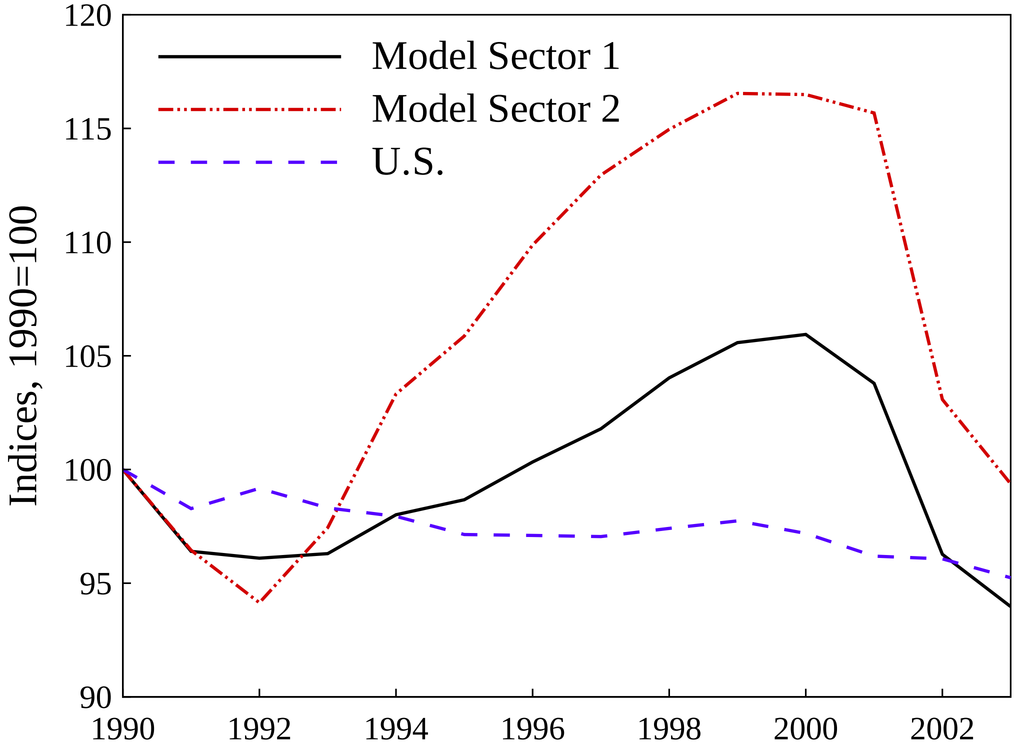

Figure 9
Per-capita Hours for U.S. and Model with
Intangible Investment, 1990–2003

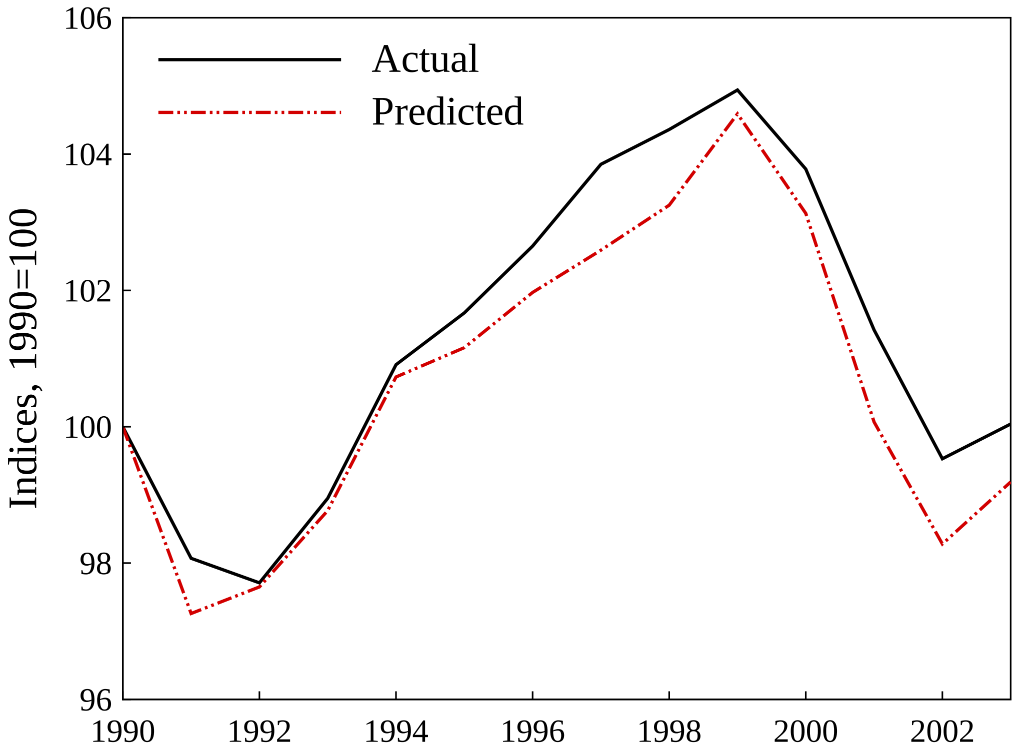

Figure 10

Business Labor Productivity for U.S. and Model with Intangible Investment, Both real and detrended, 1990–2003

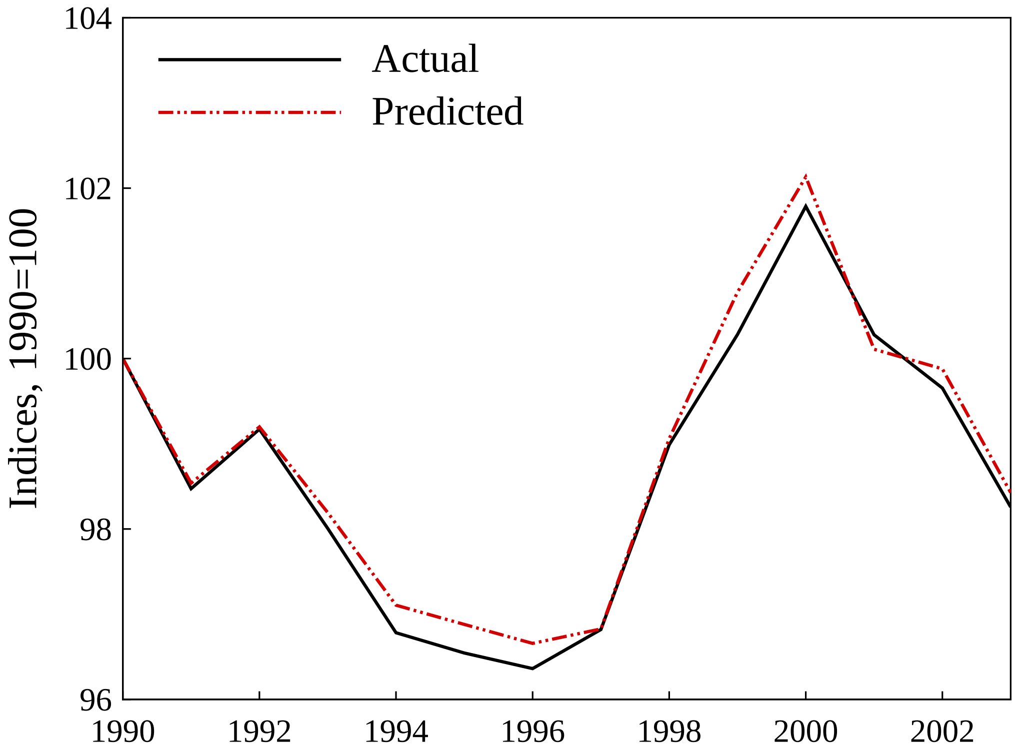

Figure 11

Tangible Investment for U.S. and Model with Intangible Investment, Both real and detrended, 1990–2003

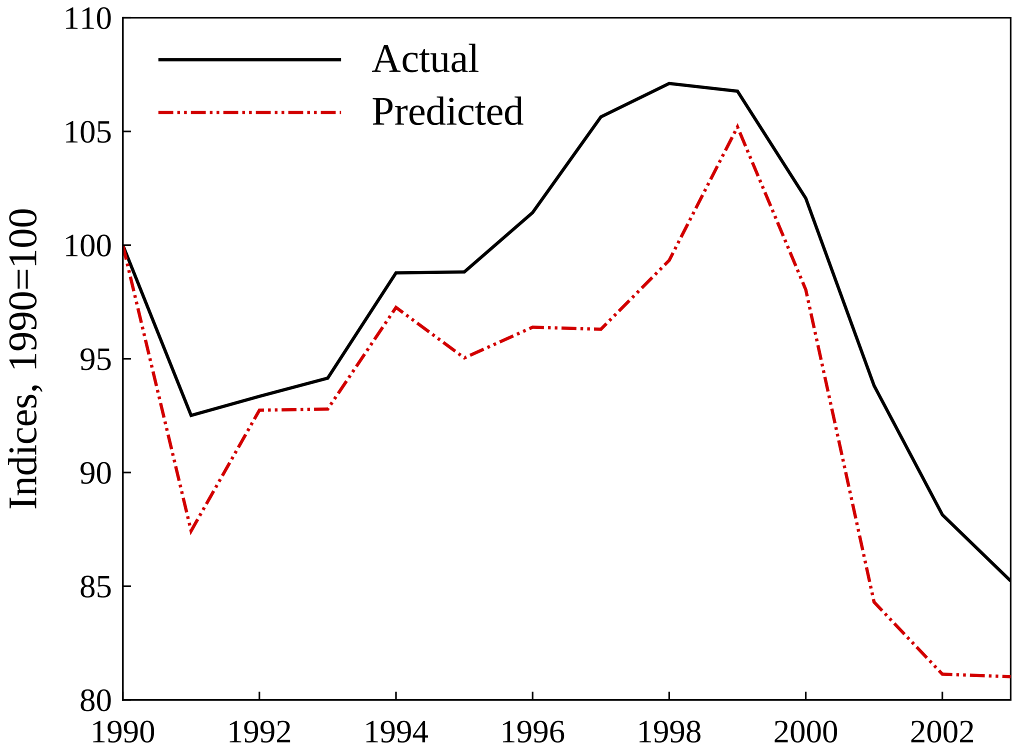

Figure 12

Compensation Less Sweat Investment for U.S. and Model with Intangible Investment, Both real and detrended, 1990–2003

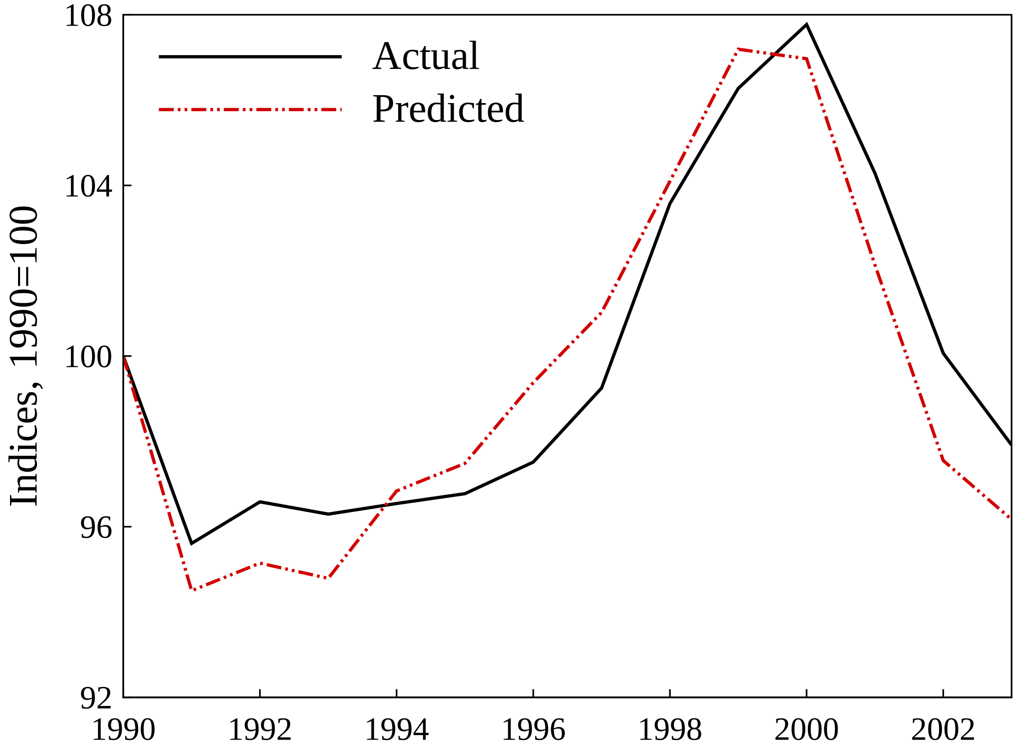

Figure 13

U.S. Household Real Holding Gains Relative to GDP
(Excluding Real Estate), 1953–2003

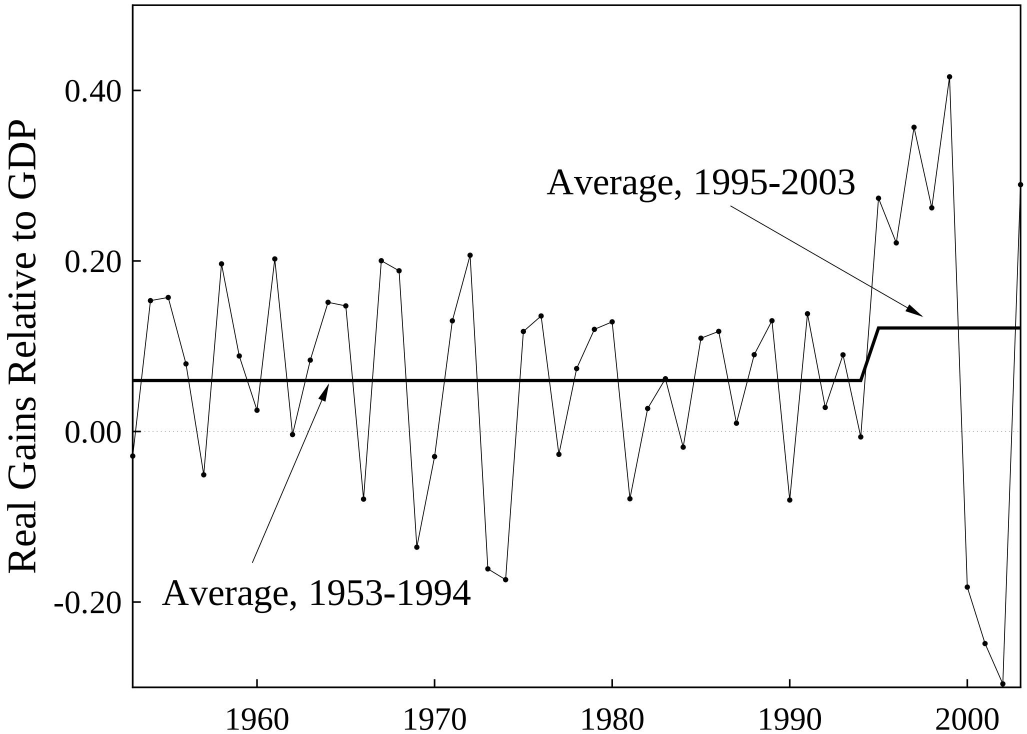

FIGURE 14

U.S. and Model Household Real Holding Gains Relative to GDP (Excluding Real Estate), 1990–2003

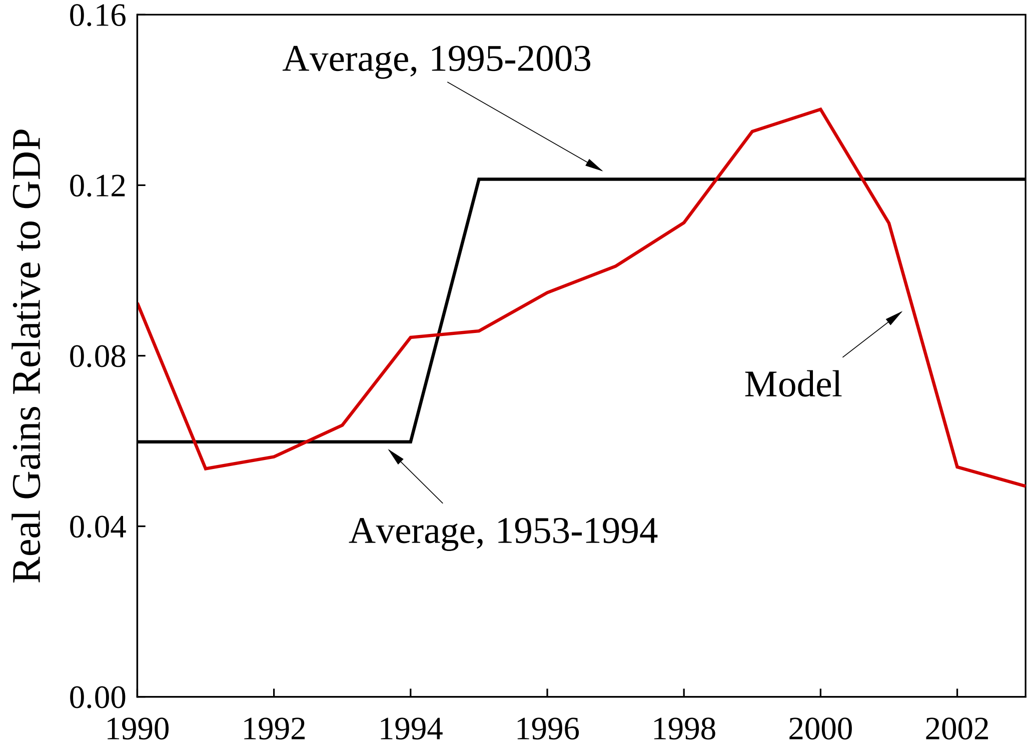

FIGURE 15

Output for the Model, With and Without Intangible Investment, Both real and detrended, 1990–2003

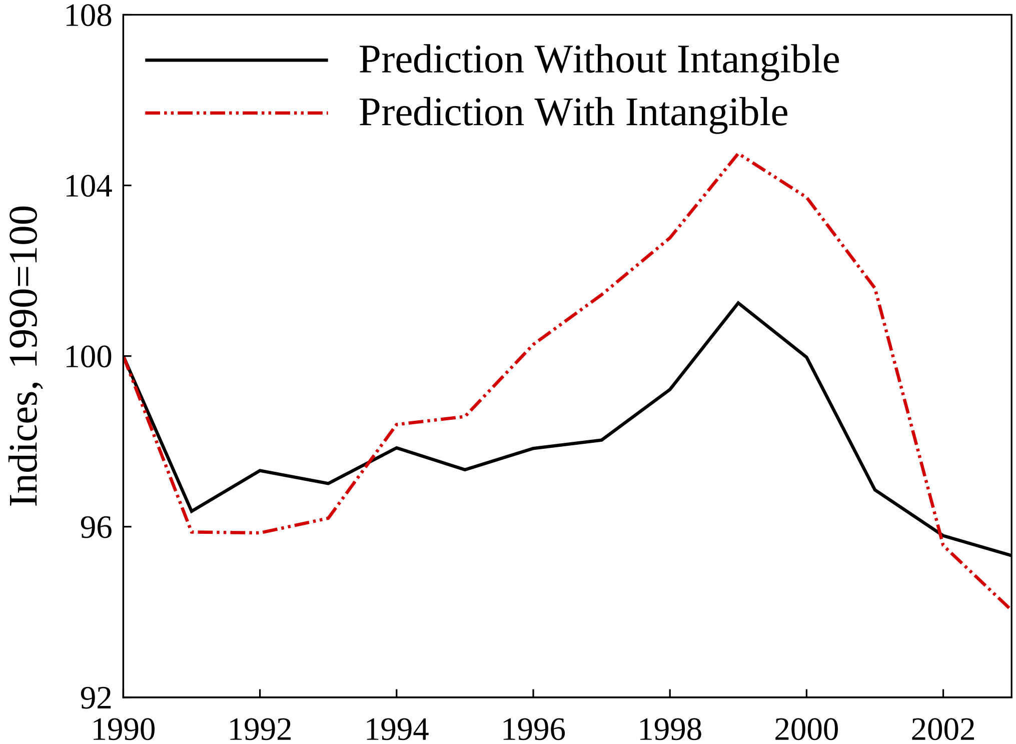

Figure 16

Business Labor Productivity for the Model, With and Without Intangible Investment, Both real and detrended, 1990–2003

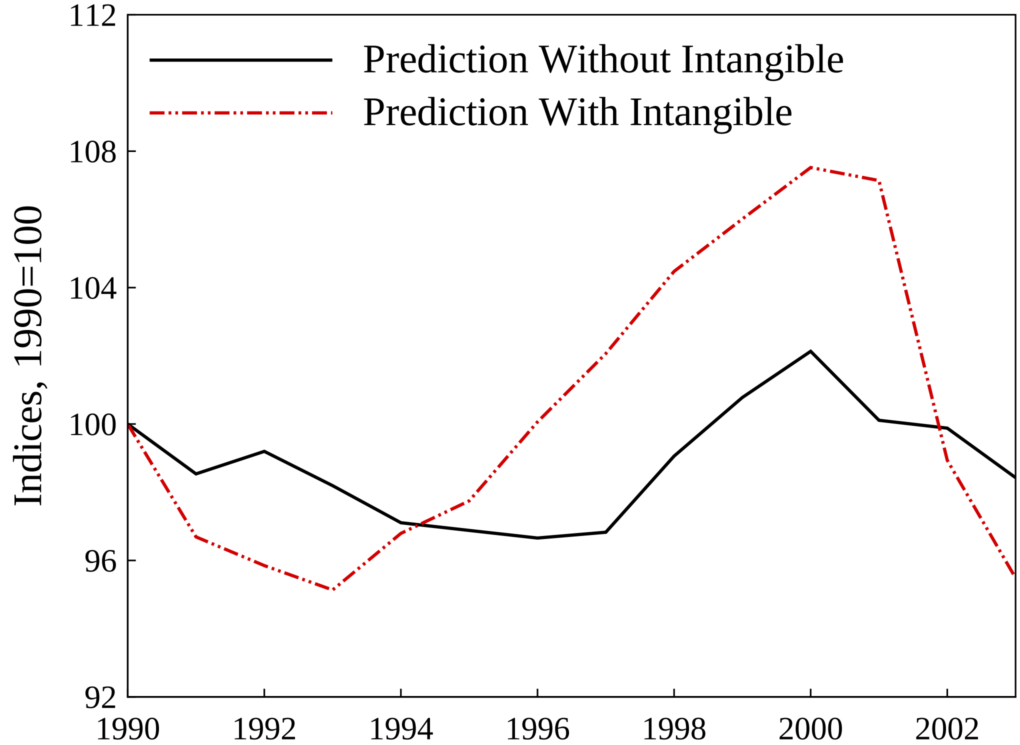

Figure 17
Investment for the Model, With and Without Intangible Investment, Both real and detrended, 1990–2003

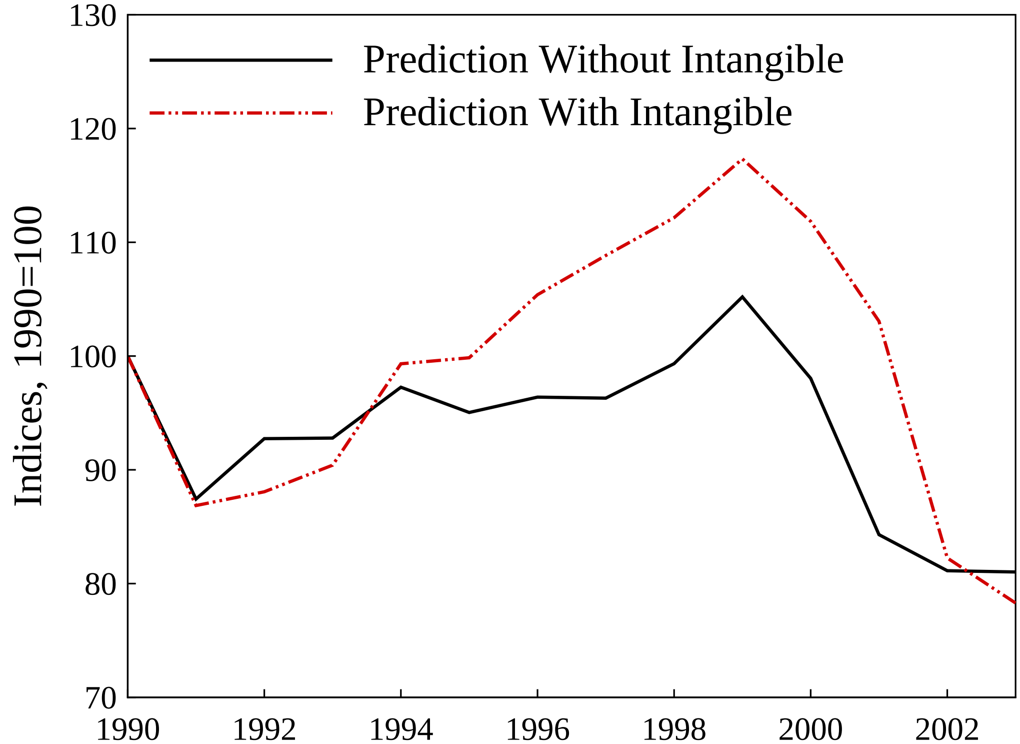

Figure 18
Model Intangible (Expensed plus Sweat) Investment
Relative to Total Output, 1990–2003