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1. Introduction

Consumer durables are widely thought to play a central role in the generation and propagation of business cycles. In fact, Mankiw [1985] has stated that "Understanding fluctuations in consumer purchases of durables is vital for understanding economic fluctuations generally."[1] Because the behavior of consumer durables differs so much from the behavior of other components of consumption, a large body of research has studied aspects of their behavior.[2] As enlightening as this body of research has been concerning the behavior of consumer durables in isolation, there is little research which attempts directly to evaluate whether consumer durables are important for fluctuations in aggregate economic activity. This paper seeks to fill this gap, by asking several related questions. First, are consumer durables potentially important as a source of shocks to the business cycle? That is: can shocks to consumers' desired stocks of consumer durables generate business cycles that resemble those identified by Burns and Mitchell [1946]? Second, do consumer durables represent an important propagation mechanism, by which temporary shocks to the economy can have long–lasting effects? Third, does this model overcome the "comovement problem" which plagues one–sector models?[3] Fourth, is the well–known volatility of consumer durables and investment due to endogenous mechanisms of the economy, or is it rather due to the fact that the shocks which impinge on the capital–producing sector are simply more volatile?

The paper is structured as follows. Section 2 presents a statistical overview of sectoral business cycles in the post–war United States. Section 3 develops a two–sector neoclassical model of a closed economy which is used to study the relationship between consumer durables and the business cycle. In this model, there are both durable and nondurable goods; the durable good can be used as a consumer good as well as an investment good. Section 4 describes the parameterization of the model. In section 5, we investigate whether consumer durables can <u>cause</u> business cycles, in the sense that an exogenous change in consumers' desired stocks of consumer durables leads to a typical business cycle response in the data. We find that this type of shock does not lead to a characteristic cyclic response along two important dimensions. First, output responses are very small and last only one period; second, investment and output move in opposite directions in response to this shock.

Section 6 explores the statistical properties of sectoral "Solow residuals" computed from the sectoral production functions as shifts in total factor productivity. While the properties of aggregate Solow residuals are well–documented, there is less information available concerning the behavior of sectoral Solow residuals. We find that the sectoral Solow residuals are positively correlated across sectors, with volatility of the Solow residuals being substantially higher in the durables industry. The data cannot reject the hypotheses that (i) the sectoral Solow residuals contain unit roots; and (ii) there is a cointegrating relationship between the sectoral Solow residuals.

Section 7 investigates the role of consumer durables in the propagation of business cycles; four questions are of particular interest. First, does the multi–sector nature of the model lead to stronger internal propagation mechanisms than in the one sector model? Second, do the intersectoral linkages that exist on both the production and consumption side provide a solution to the comovement problem? Third, what is the source of higher volatility in the durables sector? Fourth and finally, is the durability *per se* of consumer durables important for understanding business cycles? Section 8 concludes with a brief review of the paper's main results.

2. U.S. Sectoral Business Cycles

This section presents a statistical overview of sectoral fluctuations in the post–war U.S. data. The first two subsections discuss issues associated with the definition of sectoral outputs and consumptions; the last subsection describes the salient features of sectoral business cycles.

2.1 Sectoral outputs, factor inputs, and prices

The primary data source is a sectoral database which contains annual, post–war data on factor input, compensation, and output measures for thirteen SIC one–digit industries for the period 1948–1985.[4] Since we want to construct an aggregate economy with only two sectors, the first task is to assign each industry to a particular sector, depending on whether it produces predominantly durable or nondurable goods. Table 1 presents data taken from the 1972 input/output table for the United States. This table shows the breakdown, by industry, of output allocated to final consumption and investment.

Table 1 indicates that most industries are clearly recognizable as producing either consumption goods or investment goods. Industries that produce predominantly consumption goods are: agriculture; transport, communication, and utilities; wholesale and retail trade; finance, insurance, and real estate; and services. Based on these statistics, we define the output of "consumption good sector" (sector 1) as the total output of these sectors, plus manufacturing nondurables. Over the sample period the share of nondurables in total output has been rising, and currently is about 78%. The durable goods sector produces output which is used both as new capital goods and consumer durables. The mining and construction sectors have very low consumption shares, and therefore are allocated to the durables sector, together with manufacturing durables.[5]

Implicit price deflators were constructed for each sector, using 1982 as the base year. The relative price of durables in terms of nondurables is constructed as the ratio of the two sectoral implicit price deflators. Since Gordon [1990] has argued that the NIPA deflators are extremely inaccurate, especially for durable goods, we constructed an alternative measure of the relative price using Gordon's measure of the implicit price deflator for investment goods.[6] Figure 1–A plots the two relative price measures over time — there is a strong secular decline in the relative price of durables with the

Gordon measure, but not with the NIPA measure until about 1981. The cyclic movements in the two measures of the relative price are plotted in Figure 1–B (where the cyclic component is defined as the deviation from the Hodrick–Prescott [1980] trend line). The two measures are positively correlated (the correlation coefficient is 0.35), but the Gordon measure of the relative price is substantially more volatile.

Sectoral labor input is defined as total hours applied to production in that sector; capital input is the total sectoral capital stock. Sectoral investment was computed from the capital stock data assuming a depreciation rate of 7.1% per year (the computation of the depreciation rate is discussed in section 4 below). Nominal sectoral wages were computed as the weighted average of nominal compensation per manhour in the subsectors, with the weights being the current value of the sectoral output share accounted for by the particular subsector. Nominal wages were converted to sectoral real wages using the NIPA sectoral implicit price deflators.

The average value of labor's share in durables is 0.68, compared with 0.48 in nondurables (labor's share is computed as total worker compensation in a sector divided by aggregate sectoral output). The higher value of labor's share in durables primarily reflects the higher wage rate in durables, rather than higher labor intensity in this sector. In fact, capital–labor ratios in the two sectors are broadly similar at the beginning and end of the sample period, although durables were less capital–intensive than nondurables between 1960 and 1980.

2.2 Sectoral consumption

In the national income and product accounts, there are three main categories of consumption: nondurables, durables, and services. From these, we wish to construct aggregates for "nondurables" and "durables." One straightforward approach is to define nondurables as the sum of NIPA nondurables plus services, with durables defined as NIPA durables. However, one problem with this approach is that the NIPA measure of consumption services contains imputed rental on owner–occupied housing; i.e., it contains part of the service flow from consumer durables. (These "housing services" represent about 17% of NIPA nondurables plus services.) To construct a measure of purchases of nondurables, we added together NIPA nondurables plus services, then subtracted the imputed rental on owner–occupied housing.[7]

The NIPA measure of purchases of consumer durables does not include residential investment; i.e., additions to the stock of housing. We assume that completed housing units are occupied immediately, thus we measured purchases of new consumer durables as the sum of the NIPA measure of consumer durables purchases plus the net addition to the residential housing stock. The share of residential investment in this new aggregate for consumer durables is approximately 35%.[8]

With these new aggregates for consumer durables and nondurables, durables represent a larger average share of total consumption expenditure. Using the new aggregates, the average share of durables in total consumption expenditure is about 23%, compared with about 12% using the standard measures.

2.3 Sectoral Business Cycles

This subsection provides an overview of sectoral business cycles in the post–war United States. Table 2 presents statistics on cyclic volatility, persistence, and cross–correlation with output. The data were constructed as described in sections 2.1 and 2.2 above, and have been filtered with the Hodrick–Prescott [1980] filter.

Panel I summarizes cyclic volatility of sectoral outputs, factor inputs, consumption, wages and relative prices. All quantity variables are in own–goods units; wages are denominated in units of sectoral output. There are two relative prices: the NIPA measure and the Gordon measure, computed as described in Section 2.1 above. This table confirms that the production and purchases of durable goods exhibit much greater volatility than the production and purchases of nondurables; the volatility statistics for durables are about two to four times as high as for nondurables. Interestingly, real wages in the durables–producing sector are only twice as volatile as real wages in the nondurables sector, even though labor input in the durables sector is about four times as volatile as labor input in nondurables. The Gordon measure of the relative price is 60% more volatile than the NIPA measure.

Panel II of Table 2 gives a measure of persistence, computed as the first–order autocorrelation coefficient of the filtered data. There appears to be little difference across sectors in persistence, with the exception of consumption purchases and real wages. Purchases of nondurable consumption goods exhibit much higher persistence than purchases of durable consumption goods, while wage rate movements in nondurables are much less persistent than in durables. The Gordon measure of the relative price exhibits substantially less persistence than does the NIPA measure.

Panel III contains data on the contemporaneous correlations of the key aggregates within and across sectors. There is positive comovement across sectors in outputs, investments, labor inputs, and consumption purchases. Real wages are roughly uncorrelated across sectors, and also exhibit essentially zero correlation with own–sector output in either sector. Within each sector, real wages are negatively correlated with the labor input. The two relative price measures (the NIPA and Gordon measures) are positively correlated, but not strongly so (0.35). Finally, panel IV summarizes cross–correlations of sectoral output with various aggregates. Of interest here is the fact that sectoral investment and purchases of consumer durables lead sectoral output, although there is substantial contemporaneous correlation as well.

3. The Model

This section describes a two–sector, two–factor equilibrium model of a closed economy which we employ as a laboratory for studying sectoral business cycles. Sector 1 produces a nondurable, pure consumption good. Sector 2 produces the consumer durable and also produces the capital good used in both sectors. The two factors of production are homogeneous labor and capital. We follow Bernanke [1985] and Startz [1989] in specifying adjustment costs which are incurred in altering the stocks of consumer durables, although our specification differs from theirs in the details.

3.1 Preferences

The representative consumer receives utility from three sources: consumption of the nondurable consumer good, consumption of the service flow from the durable consumption good, and consumption of leisure. The nondurable consumption good is an aggregate of all the nondurable goods purchased by consumers; the major components are food, clothing, fuels, transportation, and medical care. The durable consumption good is an aggregate which includes the NIPA definition of durable goods (motor vehicles, furniture, stereos, televisions, boats, jewelry, and books), combined with the stock of residential housing. Let C_{1t} denote period t consumption of the nondurable consumption good and let C_{2t} denote consumption of the service flow from the durable consumption good. Define C_t^* as the following function of the two consumption goods:

$$C_t^* = \varphi(C_{1t}, C_{2t}) \tag{1}$$

where φ is homogeneous of degree one in C_1 and C_2, with $\partial\varphi/\partial C_j>0$ and $\partial^2\varphi/(\partial C_j)^2<0$ for j=1,2. The elasticity of substitution of good 1 for good 2 is denoted ζ_{12} with $0 \leq \zeta_{12} < \infty$. The service flow from the durable consumption good is assumed to be proportional to the stock of the durable consumption good, S_t:

$$C_{2t} = \nu\, S_t \quad , \quad \nu>0. \tag{2}$$

The representative consumer maximizes expected lifetime utility, given by:

$$U = E_0 \sum_{t=0}^{\infty} \beta^t \frac{1}{1-\sigma} \left[\left\{ C_t^* \, v(L_t) \right\}^{1-\sigma} - 1 \right] \qquad \sigma>0 \text{ and } \sigma\neq1,$$

$$U = E_0 \sum_{t=0}^{\infty} \beta^t \left\{ \log(C_t^*) + v(L_t) \right\} \text{ for } \sigma=1, \tag{3}$$

where β is the individual's subjective rate of time discount, and L_t denotes leisure.

3.2 Technology

The two final goods produced by the economy are: a perishable consumption good, produced in sector 1; and a capital good, produced in sector 2. Sector 2 provides new investment goods to both sectors and also produces the consumer durable. The two factors of production are homogeneous labor and capital. Both sectors require the use of both factors, although they may use them in different proportions. The two goods are produced via Cobb–Douglas production functions, as follows:

$$Y_{1t} = F_{1t}(K_{1t},N_{1t}) = A_{1t}(X_{K1t}K_{1t})^{\alpha_1} (X_{N1t}N_{1t})^{1-\alpha_1} \tag{4a}$$

$$Y_{2t} = F_{2t}(K_{2t},N_{2t}) = A_{2t}(X_{K2t}K_{2t})^{\alpha_2} (X_{N2t}N_{2t})^{1-\alpha_2} \tag{4b}$$

where K_{jt}, N_{jt} denote capital and labor used in producing sector j output at time t (j=1,2). A_{jt} denotes the stochastic component of total factor augmenting technical change in sector j at time t; A_{jt} may contain both permanent and temporary components. X_{ijt} denotes the level of the deterministic trend component of factor i augmenting technical change in sector j in period t; the X_{ijt} are assumed to grow at constant geometric rates, γ_{Xij} where we define $\gamma_Z \equiv Z_{t+1}/Z_t$. The following restrictions must be satisfied for the economy to display steady state growth (i.e., a situation in which one sector does not eventually represent all of GNP).[9] First,

$\gamma_{XK2} = 1$;

permanent technical change in the capital–producing sector must be purely labor–augmenting. Second, there may be capital–augmenting technical change in the nondurables sector, $\gamma_{XK1} > 1$, but the following restriction must be satisfied:

$$\frac{\gamma_{XN1}}{\gamma_{XK1}} = \gamma_{XN2} \quad .$$

In response to shocks to the economy, there will be reallocations of capital and labor across sectors. Although labor is assumed to be freely, instantaneously mobile across sectors, we assume that that adjustments in capital stocks are subject to convex costs of adjustment. Specifically, we assume that the stocks of productive capital in the two sectors and the stock of consumer durables evolve as follows. Letting I_{jt} denote gross investment in sector j in period t, and letting D_t denote purchases of new consumer durables, we assume the following:

$$K_{1,t+1} = (1-\delta_1)K_{1t} + \phi_K(I_{1t}/K_{1t})K_{1t} \tag{5}$$

$$K_{2,t+1} = (1-\delta_2)K_{2t} + \phi_K(I_{2t}/K_{2t})K_{2t} \tag{6}$$

$$S_{t+1} = (1-\delta_S)S_t + \phi_S(D_t/S_t)S_t \ , \tag{7}$$

where the adjustment costs function are assumed to satisfy $\phi_j>0$, $\phi'_j>0$, and $\phi''_j<0$, for j=K,S. Note that the adjustment cost function for consumer durables may differ from that for capital goods (although it is assumed to be the same for capital in the two output sectors), and depreciation rates may vary by type of capital.

3.3 Resource Constraints

Resource constraints for this economy are as follows. First, leisure plus hours of work in each of the two sectors cannot exceed the individual's allocation of time, which we normalize to 1:

$$N_{1t} + N_{2t} + L_t \leq 1 \quad . \tag{8}$$

Second, there are resource constraints for each of the two final goods. For the sector producing the pure consumption good, the constraint is:

$$C_{1t} \leq Y_{1t} \; . \tag{9}$$

For the sector producing the capital good, the constraint is:

$$D_t + I_{1t} + I_{2t} \leq Y_{2t} \; . \tag{10}$$

3.4 Restrictions on Long Run Growth

Preferences and technology have been restricted so that the economy will exhibit balanced growth in the steady state. Thus the following are stationary random variables: the ratio of consumption of the nondurable good to aggregate output; the ratio of purchases of durables to aggregate output; and the share of sector 2 output devoted to investment in each of the two sectors. These implications hold whether or not there exist deterministic or stochastic trends in the technology processes driving this model, and whether or not these trends are common across sectors.[10] Intuitively, the homotheticity of the preference specification implies that individuals desire to hold constant the shares of consumption of each of the two goods, as the economy grows. The technology side of the economy was constructed to make this "balanced growth" feasible. Because certain ratios are stationary in equilibrium, this model is rendered stationary by dividing these by the level of output in sector 2.

In the remainder of the paper, lowercase letters will be used to denote variables in the transformed economy. Since the "time constraint," (8), prevents labor or leisure from exhibiting deterministic growth in the steady state, these variables need not be transformed. In the transformed economy the only deterministic trend component that enters is γ_{XN2}, the growth rate of labor–augmenting technical change in the capital goods sector. This is also the deterministic trend component of capital in the two final goods sectors, and is the deterministic trend component of consumer durables. In what follows, therefore, we simply use γ to denote γ_{XN2}.

The model is solved by forming a Lagrangian, constructing the first–order necessary conditions (the "Euler equations"), and then using numerical methods to find log–linear approximations to the decision rules that solve this system of equations. Specifically, we employ King, Plosser, and Rebelo's [1987] log–linear version of the general Euler equation approach to solving nonlinear dynamic models, as described in Baxter [1991].

4. Calibration

Since we wish to obtain quantitative predictions from our model, we must have numerical values for the key parameter values. For the most part, the model is calibrated from U.S. sectoral data constructed as described in Section 2 above. In a few instances we use parameters estimated in previous empirical studies. Table 3 provides an overview of the model parameterization discussed below.

4.1 Preferences

The parameter β determines the steady state level of the real interest rate in the economy. We choose β so that the annual real interest rate is 6.5%, following King, Plosser, and Rebelo [1988]. The parameter σ is the inverse of the elasticity of intertemporal substitution. Previous estimates using aggregate consumption data have yielded estimates of σ in the range .2 to 50. In particular, Mankiw [1985], Bernanke [1985], and Eichenbaum and Hansen [1990] have estimated this parameter for models incorporating consumer durables as well as nondurables. Neither Mankiw nor Bernanke could reject the hypothesis that consumer durables and nondurables enter the utility function in a separable fashion (in their specification, this implies σ=1). By contrast, Eichenbaum and Hansen reject the hypothesis that durables and nondurables enter separably in the utility function. We find that our model provides a better match to the data when individuals are somewhat more risk averse than the log case: our benchmark value of σ is 1.5.

There are three additional preference parameters that must be specified: (i) the steady–state shares of C_1 and C_2 as fractions of C^*; (ii) ζ_{12}, the elasticity of substitution of good 1 for good 2; and (iii) the own–elasticity of the marginal utility of leisure, ξ_{LL}.[11] The steady state shares of C_1 and C_2 were calibrated as the sample averages over the period 1948–1985, yielding $\theta_1 \equiv (C_1/C^*) = .785$ and $\theta_2 = 1 - \theta_1$. The other two parameters, ζ_{12} and ξ_{LL} are calibrated as follows. First, for the model to generate positive contemporaneous correlation of N_1 and N_2, as observed in the data, the two goods cannot be extremely good substitutes in consumption. Given our value for σ, the model generates realistic labor comovement for values of ζ_{12} between 0.5 and 2.5. We choose $\zeta_{12} = 1.5$ as our benchmark. Second, the elasticity ξ_{LL} primarily governs the aggregate labor supply response to shocks. Given our specification of utility and our parameterization of σ and ζ_{12}, there is a lower bound placed on the absolute value of ξ_{LL} which will deliver concavity of momentary utility. We set ξ_{LL} equal to –1.3, which is close to this bound.

4.2 Technology

Shares: For the two sectors in our economy, constructed as described in section 2.1 above, labor's share in each sector is computed as total worker compensation in a sector divided by total output in that sector. The average value of labor's share in durables is .68, and .48 in nondurables.

Ratio of average product: A second parameter necessary for solution of the model is the ratio of the average product of labor in sector 1 to the average product of labor in sector 2. Average product in each sector is computed as real output in that sector divided by total hours. The ratio of average product in sector 1 to average product in sector 2 has a mean of 0.84.

Depreciation rates: The depreciation rates for the two capital goods and the consumer durable were parameterized as follows. First, Bernanke [1985] reports an estimated quarterly depreciation rate for consumer durables of 5.06%, or an annual rate of 22%. However, residential capital accounts for about 35% of our measure of consumer durables, and houses depreciate much more slowly than (say) stereos. With a useful life of 27 years (according to the IRS), straight–line depreciation implies an annual depreciation rate for housing of 3.7%. The weighted–average depreciation rate for aggregate consumer durables is thus 15.6%.

For capital used in production, the July 1985 Survey of Current Business reported new computations of useful service lives for capital used in producing several categories of manufacturing durable and nondurable goods. The average lifespan of a machine in the durable goods sector is about 14 years. Translated to annual depreciation rates, assuming straight–line depreciation over the useful service life yields $\delta_K = 7.1\%$.

Adjustment costs: The adjustment cost functions were parameterized as follows. First, we assume that there are no adjustment costs incurred in maintaining the steady state levels of capital and consumer durables. Thus, in the steady state, $\phi_K(i_j/k_j) = i_j/k_j$ for j=1,2, and $\phi_S(d/s)=d/s$. Second, we assume that in the steady state Tobin's q (the ratio of the price of existing capital to the price of new capital) is one for both types of capital and the durable good. This implies that $\phi_K'(i_j/k_j) = 1$ for j=1,2, and $\phi_S'(d/s)=1$. Finally, we must specify the elasticities of (i_j/k_j) and (d/s) to movements in the appropriate relative price (i.e., the appropriate version of Tobin's q); we assume that this elasticity, denoted η, is the same across sectors. Calibrating this parameter is difficult, as there are no directly–applicable empirical studies that have estimated these elasticities. Since η primarily affects investment volatilities and cross–sector correlations of labor input and investment, these moments are used to restrict η. Thus we set $\eta = 200$, which implies very elastic adjustment of capital.

5. Shocks to Consumer Durables

This section investigates whether consumer durables are important for business cycles in the following specific sense: can an exogenous, permanent increase in consumers' desired stocks of durables (at given prices and interest rates) lead to a characteristic business cycle response in output, investment, labor supply, and consumption? Although the model of Section 3 does not explicitly contain preference shocks, this question may be answered by noting that the response of the economy to this shock will be identical to a standard, "transitional dynamics" exercise. Specifically, we answer this question by tracing out the response of the economy to a reduction in the stock of consumer durables by one unit relative to its initial, steady state value.

The responses are shown in Figure 2. Figure 2–A plots the response of purchases of consumer durables, investment in each sector, and output of the durables–producing industry. In response to the 1 unit increase in the desired long run stock of consumer durables, we find that purchases of durables increase on impact by about 0.6 units. Output of the durables–producing industry rises in response to the shock in the demand for consumer durables, but only very slightly (0.003 units). The primary effect of the shock to the stock of durables is to crowd out investment, especially in the nondurables industry. Investment in nondurables falls by about 0.40 units, while investment in durables falls by 0.20 units.

Consumption of the nondurable good rises on impact, which can be understood as follows. The demand shock in durables increases the marginal utility of consumption of both durables and nondurables, due to the nonseparability in utility. The stock of durables cannot be adjusted for one period, so consumers partially satisfy their current desire to consume by increasing purchases of nondurables in the impact period. After one period, the stock of durables has risen, and purchases of nondurables drop below their steady state level during the transition back to the steady state. Labor input in both sectors rises on impact, as does output of the nondurable good (as it must, since higher labor input cooperates with a predetermined capital stock). Wage rates in both sectors fall on impact, as does the relative price of durables in terms of nondurables.[12]

Along the transition path, from period 2 onward, output of both sectors is below steady state levels. This is true even though labor input is high in both sectors during the transition back to the steady state (while wages are correspondingly below the steady state). The reason is that the capital stock in both sectors has been depleted as a result of the decline in investment which took place in the impact period. From period 2 onward, therefore, we have a standard transitional dynamics situation in which the important force in the economy is the depleted capital stock. During this transition, therefore, investment in both sectors is above steady state levels (although the magnitudes are small).

Overall, this model predicts that shocks to consumer durables will fail to produce a characteristic business cycle response along two dimensions. First, shocks to durables do not induce a strong response of output in either sector. We found that shocks to durables have positive but very small impact effects on the outputs of both industries, but that after the impact period outputs of both industries are <u>below</u> steady state levels. Thus the shock to the demand for consumer durables does not generate the kind of persistence in output movements which is characteristic of business cycles. Second, the shock to durables induces a decline in investment (on impact) in both sectors while sectoral outputs increase. Along the transition path, investment is high while output is low; this negative comovement of investment with output is not typical of business cycles. However, this general effect seems likely to hold even in a model with more sectors, so long as the relevant sector produces both types of durable goods (for example, if the same industry produces engines for both cars and commercial trucks). When the demand for consumer durables rises, the increased demand will be accommodated by an increase in sectoral output combined with a decrease in investment.

6. Sectoral Solow Residuals

"Solow residuals" are movements in output that cannot be attributed to movements in factor inputs. These shifts in total factor productivity have received a great deal of attention, recently, as the primary driving process for "real business cycle" models of the aggregate economy. For example, it is well known that the univariate process for the aggregate Solow residual is highly persistent, and may contain a unit root. This section explores the statistical properties of sectoral Solow residuals, while focusing on several specific questions. First, are the average growth rates of productivity similar across sectors? Second, are business–cycle fluctuations in total factor productivity closely related across sectors? Third, do sectoral Solow residuals appear to contain unit root components and, if so, does a cointegrating relationship exist between these variables?

6.1 Measuring sectoral Solow residuals

Computing the sectoral Solow residuals requires data on labor and capital shares in total output. We have assumed that production functions are Cobb–Douglas and constant–returns–to–scale. Letting α_j denote capital's share in sector j, the sectoral Solow residuals are defined in standard fashion as movements in output that cannot be explained by movements in factor inputs:

$$SR_{jt} = \log(Y_{jt}) - \alpha_j \log(K_{jt}) - (1-\alpha_j)\log(N_{jt}) \quad ; \; j=1,2.$$

Figure 3 plots growth rates of the sectoral Solow residuals. This plot shows that the Solow residuals are positively correlated across sectors, and that productivity growth in durables is more volatile than in nondurables. Table 4 provides summary statistics on these measures of sectoral productivity. Productivity growth has proceeded at a higher average rate in the durables sector, growing at 5.0% per year compared with average growth of 4.4% per year in nondurables. This table also confirms the visual impressions from Figure 3 that (i) productivity growth in durables is more volatile and less persistent than in nondurables, and (ii) there is substantial positive correlation between productivity growth in durables and nondurables (the correlation coefficient is 0.69). The next subsection investigates the time series properties of the sectoral Solow residuals in more detail.

6.2 Time series properties of sectoral Solow residuals

Univariate autoregressions of the Solow residuals suggest the presence of unit roots. Table 5 reports the results of two tests for difference stationarity of the sectoral Solow residuals: (i) the augmented Dickey–Fuller test; and (ii) the J(p,q) test proposed by Park [1990a]. The null hypothesis of difference stationarity is not rejected under either test for any of the series. The next question is whether there is a common stochastic trend in the sectoral Solow residuals. Park's [1990b] canonical cointegrating regression approach was used to estimate the cointegrating vector for durables and nondurables. Table 6 contains the test results. The data strongly support the hypotheses that there is a single stochastic trend shared by the two sectors, and that the cointegrating vector is [1,–1]. Further, the sectoral Solow residuals appear to be deterministically cointegrated, which means that the difference between the deterministic trend growth rates across the two sectors is not statistically significant.

Since the Solow residuals in the two sectors are difference stationary and appear to be cointegrated, the stochastic process for the sectoral Solow residuals is estimated as:

$$\begin{bmatrix} \Delta SR_{1t} \\ SR_{1t} - SR_{2t} \end{bmatrix} = \begin{bmatrix} k_1 \\ k_2 \end{bmatrix} + \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \begin{bmatrix} \Delta SR_{1,t-1} \\ SR_{1,t-1} - SR_{2,t-1} \end{bmatrix} + \begin{bmatrix} u_{1t} \\ u_{2t} \end{bmatrix} \qquad (12)$$

where ΔSR_{jt} denotes the growth rate of the Solow residual in sector j in period t. Estimates were obtained by running two OLS regressions, and the results of this estimation are reported in Table 7. To explore the dynamic properties of these estimates, Figure 4 plots the impulse response of sectoral Solow residuals to a shock in productivity in each sector. Figure 4 shows that each of the sectoral Solow residuals contains permanent and temporary components. Following the impact period, the Solow residual in the sector receiving the shock declines over time, while the Solow residual rises in the other sector. In the nondurables sector, about 60% of a typical shock is permanent, while this figure is only 40% in the durables sector. In each case, the transitory part of the shock is highly persistent — half of the transitory component of the shock is still present after ten years.

7. Productivity Shocks and Sectoral Business Cycles

The real business cycle research program has discovered that the standard, one–sector neoclassical model is capable of reproducing many important business–cycle regularities when driven by aggregate Solow residuals. Although this approach is highly controversial, the fact remains that this model does surprisingly well along many dimensions when it is driven by an exogenous productivity process with the same time series properties possessed by aggregate Solow residuals.

The one–sector model nevertheless has several empirical shortcomings; two of the most important are as follows. First, the model does not contain a strong internal propagation mechanism. For the model to produce sustained fluctuations in output, consumption, investment, etc., the shocks to the model must themselves be sustained over time. Second, the one–sector model is unable to produce realistic comovement in output and labor supply across different locations. This finding was first documented by Rebelo [1989] who studied a multi–location, one–sector real business cycle model. He found that the model predicted negative correlation of labor inputs across locations unless the correlation of the productivity shocks across locations exceeded about 0.98. Baxter and Crucini [1991,1992] obtain similar results in their open economy versions of the one–sector model. Recently, Benhabib, Rogerson, and Wright [1991] stressed a third shortcoming of the one–sector model — namely, that hours of work devoted to production of consumption goods was negatively correlated with hours of work devoted to production of investment goods.

The two–sector model with consumer durables may be able to improve the predictions of the standard neoclassical model along all three dimensions. First, the fact that consumer durables behave essentially as a capital good provides an additional source of endogenous propagation. Changes in the stock of consumer durables that occur in response to shocks will naturally persist over time since consumer durables depreciate slowly. Second, the comovement problem may be mitigated by the fact that the sectors are linked in two ways. On the consumption side, the two goods are not perfect substitutes as in Rebelo [1989] and Baxter and Crucini [1991,1992]. There is a further linkage on the production side, where production of the nondurable good requires the durable good as input. Third, because of the linkages on both the consumption and production sides of the model, hours of work in the two sectors may be positively correlated over the business cycle.

This section evaluates the ability of the two–sector model to generate "realistic" business cycles, where the central business cycle regularities are those reported in Section 2. In particular, we investigate whether the multi–sector character of the model improves the model's propagation and comovement properties, when the parameterized model is driven by the estimated process for sectoral Solow residuals, as reported in Table 7.

7.1 Business cycles in the two–sector model

This section evaluates the extent to which the two–sector model reproduces the key qualitative features of sectoral business cycles, as described in Section 2. Table 8 provides statistics summarizing the model's predictions for sectoral volatility, persistence, and comovement. Panel I of this table compares cyclic volatility in the model to that in the data. The model predicts that output, investment, hours, and consumption purchases are more volatile in durables than in nondurables, as is true in the data. For sectoral outputs, the model predicts volatility statistics that are close to those found in the data. In the case of investment, predicted volatility in each sector is low relative to the data, although the model does capture the general feature that investment in nondurables is about half as volatile as investment in durables. Predicted volatility of consumer durables purchases is also low, relative to the data, but is correctly predicted to be substantially more volatile than purchases of nondurables.[14]

The predicted volatility of hours in each sector is too low; however, the volatility of hours in durables is predicted to be about ten times as high as in durables, compared with only about four times as high in the data. Wages are correctly predicted to be about twice as volatile in durables, compared with durables, although the levels of volatility are somewhat too high in the model. The volatility of the relative price is lower in the model relative to the data, and is much closer to the NIPA measure than the Gordon measure.

In terms of persistence of movements in macro aggregates, (measured as the first–order serial correlation coefficient), the model generally predicts higher persistence than is found in the data, as shown in panel II of Table 8. The one exception is purchases of consumer durables, where the model matches the (low) persistence in the data almost exactly. Nevertheless, the internal propagation mechanisms of this two–sector model are no stronger than those of the one–sector model. When the model is driven by productivity shocks with zero first–order serial correlation, output, consumption, investment, and labor supply also display approximately zero persistence (these results are not in the table).

The contemporaneous correlation structure of the model is presented in panel III of Table 8. In many respects, the model does a good job of matching the correlations found in the data. First, within each sector, the model predicts that hours, investment, and consumption purchases are positively correlated with output, as is true in the data. Second, and more importantly, the model correctly correctly predicts that the cross–sectoral correlations of output, investment, hours, and consumption purchases are positive. Thus the sectoral interdependencies built into the model do solve the "comovement problem."[14] In particular, the model predicts that hours of work devoted to producing consumption goods are positively correlated with hours of work devoted to producing investment goods, a phenomenon which Benhabib, et al. [1991] have argued is an important feature of business cycles.

More problematic are the model's predictions for the behavior of wages and relative prices. Here, the model's predicted correlations do not generally line up well with the data. In particular, the model predicts a strong positive correlation between sectoral wage rates and sectoral output, while these are roughly uncorrelated in the data. In the case of wage rates, this may be due to the fact that real wages as measured in the NIPA are not a good measure of the contemporaneous marginal product of labor, for reasons expounded by a number of authors. Or, the model may omit important sources of shocks which operate on the "demand side," such as government spending shocks or preference shocks (although the analysis of section 5 suggests that preference shocks cannot be the sole source of business cycles; see also the analysis of preference shocks in Baxter and King [1991]). Of the two data–based measures of the relative price, the model exhibits a better fit with the Gordon measure.

Finally, Panel IV of Table 8 presents the cross–correlations of the key macro aggregates with sectoral output. Although the model correctly predicts that purchases of durables are strongly correlated with output of durables both contemporaneously and also at the first lag, the highest correlation in the model is contemporaneous while in the data, the highest correlation is at the first lag (i.e., durables "lead the cycle"). This phenomenon also holds with respect to the investment–output relationship within each sector. Otherwise, the model's predictions for these cross–correlations seem roughly in line with the data.

7.2 The causes of sectoral volatility

Why is the durables sector more volatile than the nondurables sector, both in the model and in the data? Is this phenomenon due to the higher volatility of shocks to durables, or is it an endogenous economic response? To investigate this question, we set the innovation variance in the durables sector equal to that in the nondurables sector, while preserving the cross–sectoral correlation of the shocks (this involves reducing by about one–half the standard deviation of the shocks to durables). Table 9 presents sectoral volatility statistics for this case. Evidently, reducing the volatility of shocks in durables reduces the volatility of both sectors, but understandably reduces volatility more in the durables sector. Nevertheless, volatility in the durables sector exceeds volatility in nondurables, although by about half the level obtained in the benchmark parameterization. Thus we conclude that about 50% of the higher volatility found in the durables sector is due to the endogenous mechanisms of the economy — notably the investment accelerator which operates both on consumer durables and investment goods. The remaining 50% is due to the fact that the shocks which impinge on the durable–goods industry are simply more volatile.

7.3 Is durability important?

Is the durability, *per se*, of consumer durables important for the character of business cycles in this two–sector model? In particular, does the durability of this consumption good increase the persistence of the model's response to shocks? To answer this question, we set the depreciation rate of consumer durables at 100% (per year) and recomputed the model's predictions as reported in Table 8. It was striking how little difference this change made to the model's predictions; the only notable alterations were as follows. First, with 100% depreciation, the volatility of consumer durables dropped from 5.04% per year to 3.62%. At the same time, the persistence of consumer durables increased from 0.38 to 0.75 (with 100% depreciation, persistence is approximately the same for consumer durables and nondurables), while investment volatility in the durables sector increases from 9.44% to 11.21%. Finally, the cross–sector correlation of labor inputs drops from 0.79 to 0.01. Aside from these changes, the model's predictions are largely insensitive to the depreciation rate for consumer durables.

8. Conclusions

This paper studied the properties of sectoral business cycles in the post–war United States, with the specific aim of evaluating the role of consumer durables in the generation and propagation of business cycles. Toward this end, we developed a two–sector neoclassical model of a closed economy, and used this model as a laboratory for studying the interaction of consumer durables and business cycles.

We investigated whether consumer durables could act as a business cycle impulse by studying the response of the economy to an exogenous increase in consumers' desired stock of consumer durables. This experiment failed to generate a characteristic business cycle response along two key dimensions. First, an increase in the demand for consumer durables led to an increase in output of both sectors, but only in the impact period — and the magnitude of the response was extremely small. After the initial period, output in both sectors fell below steady state levels. Thus this type of demand shock did not lead to the type of persistent movement in output that is characteristic of business cycles. Second, sectoral investments and outputs moved in opposite directions in every period: investment fell on impact, and was above its steady state level along the transition path. This negative correlation of investment with output is not characteristic of business cycles.

Next, we measured sectoral Solow residuals and investigated their time series properties. We found that these "productivity shocks" are more volatile and less persistent in the durables–producing industry. Statistical tests suggested that the Solow residuals in the two sectors contain unit roots, and are cointegrated.

When the two–sector model is driven by the estimated process for the sectoral Solow residuals, it is capable of broadly replicating the observed patterns of cyclic volatility. More importantly, there is no "comovement problem" in this model: the model correctly predicts positive cross–sectoral comovement of outputs, investments, and labor inputs. However, the model has more difficulty replicating the business cycle properties of wage rates and relative prices.

We investigated the source of the higher volatility in the durable goods industry, and found that roughly half of the higher volatility in the durable goods industry is due to the the higher volatility of productivity shocks in that industry, with the remaining half due to the endogenous accelerator mechanism. Finally, we investigated whether the durability, *per se*, of consumer durables was important for business cycles generated by the model. Somewhat surprisingly, we found that the model's predictions were largely insensitive to the depreciation rate for consumer durables, except for the volatility and persistence of consumer durables themselves.

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Endnotes

[1]Mankiw [1985], page 353, paragraph 2.

[2]One branch of this literature investigates whether the life cycle/permanent income hypothesis holds with respect to consumer durables. A second line of inquiry asked whether purchases of consumer durables responded strongly to changes in interest rates, as one would expect of a capitalistic good. A third direction was recently pursued by Caballero [1990,1991], for whom consumer durables represent an interesting laboratory for studying the implications of theories of stochastic aggregation.

[3]The "comovement problem" is the strong tendency for the one–sector, multi–location (or multi–country) model to generate negative comovement of labor input and investment across locations unless the shocks are extremely highly correlated across the different locations.

[4]This dataset is documented in Shapiro [1987].

[5]Net exports account for a large percentage of the final output of some sectors, such as mining and some durable manufactures. Unless foreign use patterns differ from those in the U.S. (in terms of the allocation between consumption and investment) a large share of net exports does not require any change in our sectoral allocation of these industries.

[6]Specifically, we used the time series listed in column 6 of Table 12.4, page 541.

[7]Real aggregates were obtained by first computing nominal aggregates and then deflating by the implicit price deflator for that category of consumption purchases.

[8]To be consistent, one should construct a measure of GNP that would remove the imputed service flow from owner–occupied housing. For the statistics presented in section 3.3, we found that there was little or no difference in the statistics depending on the measure of output used. This is probably due to the fact that the imputed service flow from housing is a very smooth series, basically resembling a loglinear trend. The HP filter which was applied to the data removes this type of trend.

[9]These restrictions can be derived by following the procedures outlined in the King, Plosser, and Rebelo [1987].

[10]The details are contained in an Appendix which is available upon request.

[11]The parameter ν does not affect any of the dynamic properties of the model, which is fortunate since it would be difficult or impossible to estimate this parameter. We arbitrarily set ν=0.20.

[12]The decline in the relative price of durables in response to an increase in the demand for durables is rather counterintuitive. In fact, the relative price of durables would rise in response to this shock if the two goods were very poor substitutes in consumption (however, in this case the model predicts negative comovement across sectors in labor input and investment).

[13]The failure of the model to match the volatility statistics for durables is largely due to the failure of the data to fit neatly into the two–sector structure we have imposed on it. If the sectoral structure of the model were an accurate description of the data, the accounting identity $Y_2 = D + I_1 + I_2$ would imply that the standard deviation of detrended output was equal to $\sigma_{Y2} = (var(s_D D + s_{I1} I_1 + s_{I2} I_2)^{1/2})$ which is not true of the sectoral data. In fact, σ_{Y2} is much smaller than the value given by the right–hand–side of this expression. Thus there is no parameterization of the model that can match all the volatility statistics in the data, since the model satisfies the above condition by construction. The failure of the data to satisfy this condition could be due to one of the following: (i) net exports and government expenditure are important components of sectoral output; (ii) some output of durables is used for nondurables, or conversely, some output of our "nondurables" sector is actually used as consumer durables or investment goods; or (iii) the model has no role for inventories.

[14]See also a recent paper by Reynolds [1992] which studies a two–good, open economy model with production and consumption linkages. She also finds that the multi–sector character of the economy is central to resolving the comovement problem.

TABLE 1

Sectoral Output by Final Use

Industry	Consumption (%)	Investment (%)
Agriculture	100.0	0.0
Mining	24.4	75.6
Construction	0.0	100.0
Manufacturing	56.9	43.1
Transportation, Communication, & Utilities	92.4	7.6
Wholesale and Retail Trade	93.2	6.8
Finance, Insurance, and Real Estate	97.8	2.2
Services	99.8	0.2

Entries computed as follows: of the total sectoral output allocated to consumption plus capital formation, this table shows the percentage allocated to each use.

Source: 1972 Input-Output Table of the United States, Department of Commerce.

TABLE 2

Sectoral Business Cycles in the Postwar U.S.

I. Cyclic Volatility

(percent per year)

Variable	Nondurables	Durables
Output	1.77	5.63
Investment	7.03	15.14
Hours	1.55	5.97
Capital stock	1.75	2.84
Consumption purchases	1.77	8.86
Wages	1.09	2.14
Relative price: NIPA		2.96
Relative price: Gordon		5.00

II. Persistence

(first-order serial correlation)

Variable	Nondurables	Durables
Output	0.42	0.49
Investment	0.53	0.60
Hours	0.32	0.46
Capital stock	0.88	0.82
Consumption	0.56	0.39
Wages	0.12	0.64
Relative price: NIPA		0.65
Relative price: Gordon		0.37

Note: Output, consumption, and wages are defined in own-goods units. "Relative price: NIPA" is computed from the implicit price deflators for the sectoral aggregates computed from Shapiro's dataset. "Relative price: Gordon" is computed using Gordon's deflator for investment goods as the durable goods price index.

TABLE 2, cont'd.

III. Contemporaneous Correlations

	Y:nd	Y:d	I:nd	I:d	H:nd	H:d	C:nd	C:d	W:nd	W:d	P:N	P:G
Output: nd	1	.77	.50	.54	.88	.74	.69	.42	-.12	-.09	-.11	-.36
Output: d		1	.41	.69	.82	.94	.58	.20	-.29	-.09	-.11	-.47
Inv: nd			1	.38	.37	.19	.73	.65	.02	.33	-.54	-.19
Inv: d				1	.44	.59	.40	.40	-.02	-.30	.20	-.18
Hours: nd					1	.87	.57	.12	-.38	-.14	-.13	-.52
Hours: d						1	.46	-.02	-.32	-.27	.09	-.51
Cons'n: nd							1	.57	.03	.24	-.30	-.22
Cons'n: d								1	.37	.33	-.28	.23
Wages: nd									1	.06	.30	.53
Wages: d										1	-.84	-.08
Rel. P: N											1	.35
Rel. P: G												1

standard error = 0.17

All variables as defined in the note to Panel I of this table.

TABLE 2, cont'd.

IV. Cross correlation with sectoral output

A. Nondurables

Correlation(Variable(t), output(t-i))

Variable	i = 2	i = 1	i = 0	i = -1	i = -2
Investment	-0.30	-0.06	0.50	0.81	0.31
Hours	-0.13	0.48	0.87	0.15	-0.18
Consumption	-0.05	0.19	0.69	0.69	0.24
Wages	0.27	-0.07	-0.13	0.24	0.14
Relative P: NIPA	0.51	0.14	-0.10	-0.31	-0.36
Relative P: Gordon	-0.17	-0.51	-0.36	-0.00	0.17

B. Durables

Correlation(Variable(t), Output(t-i))

Variable	i = 2	i = 1	i = 0	i = -1	i = -2
Investment	-0.09	0.25	0.69	0.71	0.11
Hours	0.10	0.61	0.93	0.26	-0.21
Consumption	-0.20	-0.29	0.21	0.64	0.27
Wages	-0.19	-0.01	-0.00	0.12	0.12
Relative P: NIPA	0.34	0.01	-0.19	-0.27	-0.21
Relative P: Gordon	0.18	-0.08	-0.41	-0.41	-0.07

TABLE 3

MODEL PARAMETERIZATION

Parameter	Description	Value
β	subjective rate of time discount	0.98
σ	coefficient of relative risk aversion (inverse of intertemporal elasticity of substitution)	1.50
θ_1	preference parameter for expenditure shares	0.785
ζ_{12}	elasticity of substitution of C_1 for C_2	1.50
ξ_{LL}	own–elasticity of marginal utility of leisure	–1.30
ν	service flow from stock of consumer durables	0.20
s_{N1}	labor's share in sector 1 (nondurables)	0.48
s_{N2}	labor's share in sector 2 (durables)	0.68
	average product ratio (sector 1 to sector 2)	0.84
δ_K	depreciation rate of capital (% per year)	7.10
δ_S	depreciation rate of consumer durables (% per year)	15.60
η_K	elasticity of (i/k) with respect to Tobin's q	200.00
η_S	elasticity of (d/s) with respect to Tobin's q	200.00

TABLE 4

SUMMARY STATISTICS FOR SOLOW RESIDUALS

(growth rates of annual data, 1948–1985)

	mean: % per year	std. dev.: % per year	first–order autocorrelation
Nondurables	4.39	2.56	0.51
Durables	5.03	3.26	0.19

Correlation between nondurables and durables: 0.69

TABLE 5

TESTING FOR UNIT ROOTS IN THE SECTORAL SOLOW RESIDUALS

I. Augmented Dickey–Fuller test:

$$\Delta SR_{jt} = \text{constant} + \alpha SR_{j,t-1} + C(L)\ \Delta SR_{j,t-1} + u_{jt}$$

	$\hat{\alpha}$	s.e.($\hat{\alpha}$)	p–value	order of C(L)
Nondurables	0.034	0.007	>.99	0
Durables	0.017	0.010	>.99	0

II. Park's J(p,q) test:[1]

	J(1,2)	J(1,3)	J(1,4)	J(1,5)	J(1,6)
Nondurables	9.59	13.51	30.73	110.14	110.61
Durables	3.62	3.97	17.99	27.38	31.55
Critical values for test statistic					
1% level:	.000086	.011	.055	.012	.210
10% level:	.0093	.120	.290	.455	.660

1 The null hypothesis of difference–stationarity is rejected if the test statistic is smaller than the critical values. The critical values shown were obtained from Park and Choi [1988].

TABLE 6

COINTEGRATION TESTS FOR SECTORAL SOLOW RESIDUALS

I. Estimation of the cointegrating vector [1,–α] from the regression[1]

$$SR_{2t} = \text{constant} + \alpha SR_{1t} + u_t$$

	$\hat{\alpha}$	s.e.($\hat{\alpha}$)	p–value
CCR estimate	1.08	0.02	0.0004

II. Test for deterministic cointegration[2]

	$\chi^2(1)$	p–value
test statistic:	0.26	0.61

III. Test for stochastic cointegration[3]

	H(1,2)	H(1,3)	H(1,4)	H(1,5)
Test statistic:	1.50 (0.22)	2.94 (0.23)	2.96 (0.40)	3.28 (0.51)

Notes:

1. See Park [1990a].
2. See Park and Ogaki [1989].
3. See Park [1990a].

TABLE 7

STOCHASTIC PROCESS FOR SOLOW RESIDUALS

$$\Delta SR_{1t} = \underset{(0.030)}{-0.012} - \underset{(0.173)}{0.072}\,\Delta SR_{1,t-1} - \underset{(0.040)}{0.025}\,(SR_{1,t-1}-SR_{2,t-1})+u_{1t}$$

$$(SR_{1t}-SR_{2t}) = \underset{(0.046)}{-0.050} - \underset{(0.262)}{0.184}\,\Delta SR_{1,t-1} + \underset{(0.061)}{0.932}\,(SR_{1,t-1}-SR_{2,t-1})+u_{2t}$$

Implied variance–covariance matrix for innovations to sectoral Solow residuals:

$$\Sigma = \begin{bmatrix} (1.152\text{x}10^{-2})^2 & 2.241\text{x}10^{-4} \\ 2.241\text{x}10^{-4} & (2.518\text{x}10^{-2})^2 \end{bmatrix}$$

correlation between u_1 and u_2: 0.77

Notes:

1. Annual data, 1948–1985.
2. Standard errors in parentheses.

TABLE 8

Business Cycles in the Two-Sector Model

I. Cyclic Volatility

(percent per year)

Variable		Nondurables	Durables
Output	model	1.72	4.80
	data	1.77	5.63
Investment	model	5.52	9.44
	data	7.03	15.14
Hours	model	0.20	1.98
	data	1.55	5.97
Capital stock	model	1.61	2.01
	data	1.75	2.84
Consumption purchases	model	1.72	5.04
	data	1.77	8.86
Wages	model	1.64	2.97
	data	1.09	2.14
Relative price (output measure)	model	NA	2.26
	NIPA	NA	2.96
	Gordon	NA	5.00

TABLE 8, cont'd.

II. Persistence

(first-order serial correlation)

Variable		Nondurables	Durables
Output	model	0.76	0.76
	data	0.42	0.49
Investment	model	0.69	0.41
	data	0.53	0.60
Hours	model	0.53	0.77
	data	0.32	0.46
Capital stock	model	0.96	0.92
	data	0.88	0.82
Consumption purchases	model	0.76	0.38
	data	0.56	0.39
Wages	model	0.81	0.78
	data	0.12	0.64
Relative price	model	NA	0.79
	NIPA	NA	0.65
	Gordon	NA	0.37

TABLE 8, cont'd.

III. Contemporaneous Correlations

	Y:nd	Y:d	I:nd	I:d	H:nd	H:d	C:nd	C:d	W:nd	W:d	P:N	P:G
Output: nd	1	.58 / .77	.45 / .50	.39 / .54	.45 / .88	.35 / .74	1 / .69	.47 / .42	.99 / -.12	.71 / -.09	-.20 / -.11	-.20 / -.36
Output: d		1	.58 / .41	.83 / .69	.75 / .82	.96 / .94	.58 / .58	.87 / .20	.52 / -.29	.98 / -.09	-.91 / -.11	-.91 / -.47
Inv: nd			1	.03 / .38	.03 / .37	.46 / .19	.45 / .73	.11 / .65	.46 / .02	.62 / .33	-.48 / -.54	-.48 / -.19
Inv: d				1	.91 / .44	.87 / .59	.39 / .40	.98 / .40	.30 / -.02	.77 / -.30	-.79 / .20	-.79 / -.18
Hours: nd					1	.79 / .87	.45 / .57	.85 / .12	.35 / -.38	.68 / -.14	-.63 / -.13	-.63 / -.52
Hours: d						1	.35 / .46	.86 / -.02	.27 / -.32	.88 / -.27	-.97 / .09	-.97 / -.51
Cons'n: nd							1	.47 / .57	.99 / .03	.71 / .24	-.20 / -.30	-.20 / -.22
Cons'n: d								1	.39 / .37	.83 / .33	-.81 / -.28	-.81 / .23
Wages: nd									1	.66 / .06	-.14 / .30	-.14 / -.53
Wages: d										1	-.84 / -.84	-.84 / -.08
P: NIPA											1	1 / .35

Notes:

1. P:N denotes NIPA relative price; P:G denotes relative price using Gordon's index for investment goods as the durable goods price.

2. In each cell, the top number is the Hodrick-Prescott filtered model prediction and the bottom (shaded) number is computed from the filtered data.

TABLE 8, cont'd.
IV. Cross correlation with sectoral output

A. Nondurables
Correlation(Variable(t), output(t-i))

Variable	i = 2	i = 1	i = 0	i = -1	i = -2
Investment	0.14	0.36	0.58	0.48	0.48
	-0.30	-0.06	0.50	0.81	0.31
Hours	-0.15	0.06	0.45	0.29	0.27
	-0.13	0.48	0.87	0.15	-0.18
Consumption (purchases)	0.63	0.76	1.00	0.76	0.63
	-0.05	0.19	0.69	0.69	0.24
Wages	0.68	0.79	0.99	0.77	0.63
	0.27	-0.07	-0.13	0.24	0.14
Relative P: NIPA	0.12	-0.07	-0.20	-0.20	-0.27
	0.51	0.14	-0.10	-0.31	-0.36
Relative P: Gordon	0.12	-0.07	-0.20	-0.20	-0.27
	-0.17	-0.51	-0.36	-0.00	0.17

B. Durables
Correlation(Variable(t), output(t-i))

Variable	i = 2	i = 1	i = 0	i = -1	i = -2
Investment	-0.02	0.24	0.83	0.71	0.52
	-0.09	0.25	0.69	0.71	0.11
Hours	0.36	0.67	0.96	0.78	0.56
	0.10	0.61	0.93	0.26	-0.21
Consumption (purchases)	0.16	0.36	0.87	0.71	0.49
	-0.20	-0.29	0.21	0.64	0.27
Wages	0.58	0.79	0.98	0.72	0.45
	-0.19	-0.01	-0.00	0.12	0.12
Relative P: NIPA	-0.40	-0.69	-0.91	-0.73	-0.53
	0.34	0.01	-0.19	-0.27	-0.21
Relative P: Gordon	-0.40	-0.69	-0.91	-0.73	-0.53
	-0.07	-0.41	-0.41	-0.08	0.18

TABLE 9

The Sources of Cyclic Volatility

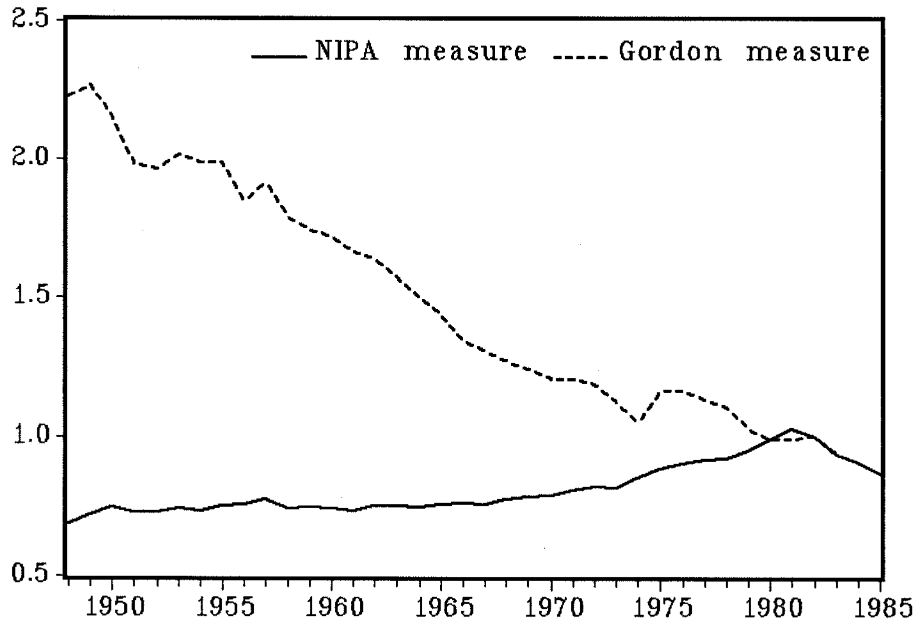
(standard deviations, percent per year)

Variable	Model variant	Nondur's.	Durables
Output	benchmark	1.72	4.80
	equal var's.	1.48	2.17
Investment	benchmark	5.52	9.44
	equal var's.	2.47	3.99
Hours	benchmark	0.20	1.98
	equal var's.	0.14	0.81
Capital stock	benchmark	1.61	2.01
	equal var's.	0.76	0.89
Consumption purchases	benchmark	1.72	5.04
	equal var's.	1.48	2.02
Wages	benchmark	1.64	2.97
	equal var's.	1.37	1.45
Relative price	benchmark	NA	2.26
	equal var's.	NA	0.91

Note: The benchmark model is parameterized as in Table 3 with variance-covariance of shocks given by the fixed labor share case in Table 7. The equal variance model sets both sectors' innovation variances equal to the innovation variance in nondurables used in the benchmark case, and preserves the contemporaneous correlation of the sectoral shocks.

FIGURE 1

A. RELATIVE PRICE OF DURABLES TO NONDURABLES



B. CYCLIC COMPONENT OF RELATIVE PRICE

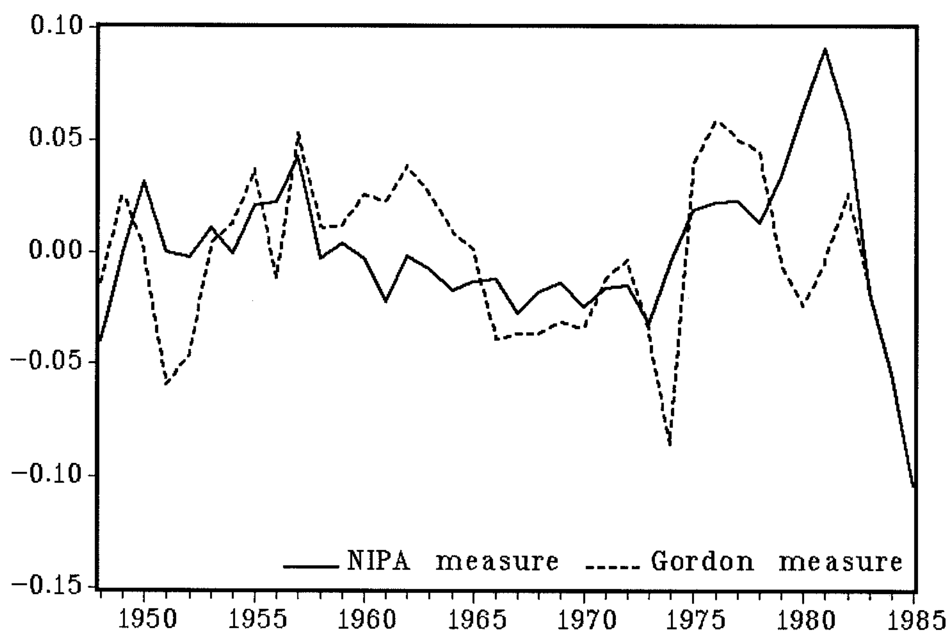


Fig. 2: Increase in desired stock of consumer durables

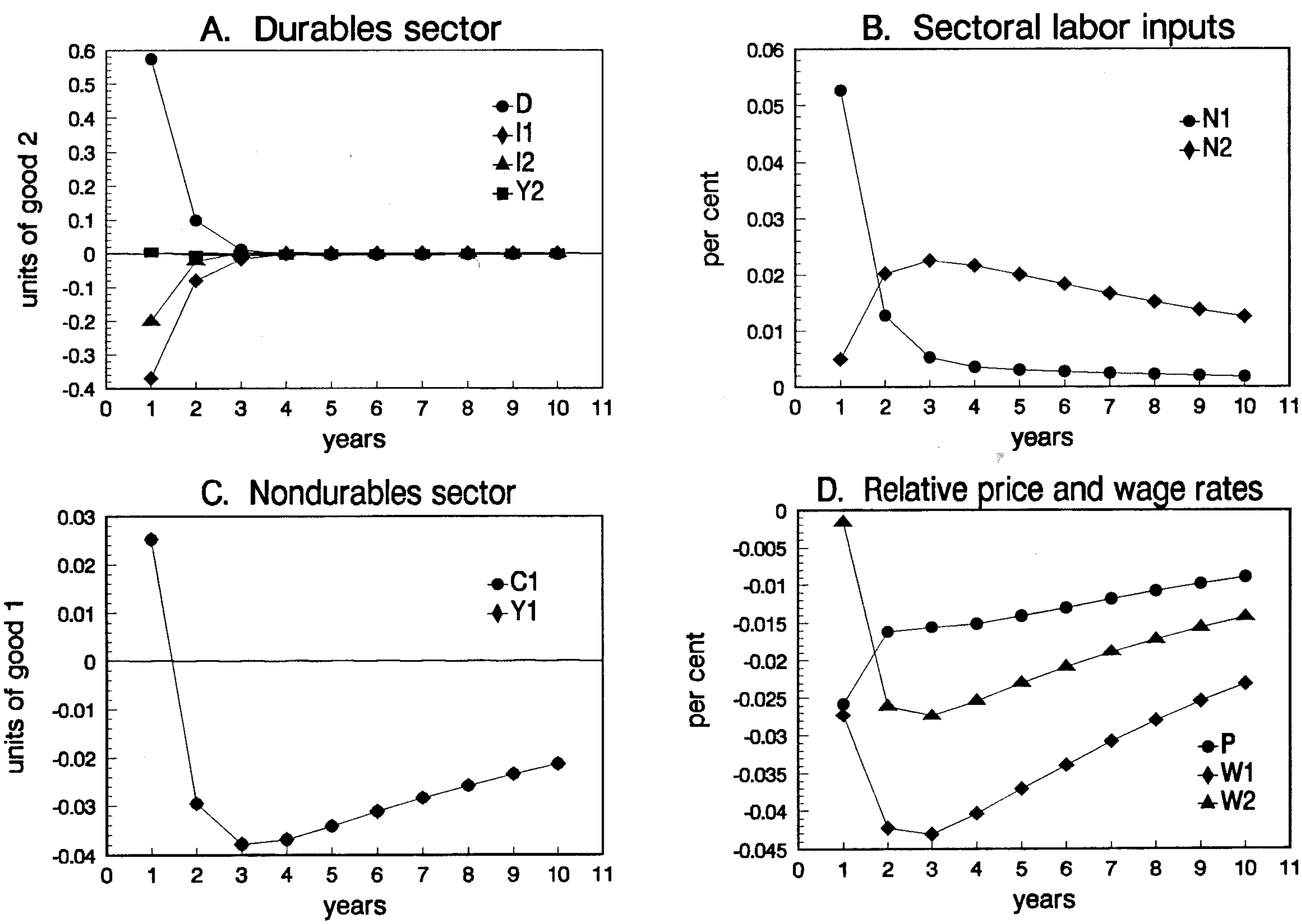


FIGURE 3

GROWTH RATES OF SECTORAL SOLOW RESIDUALS

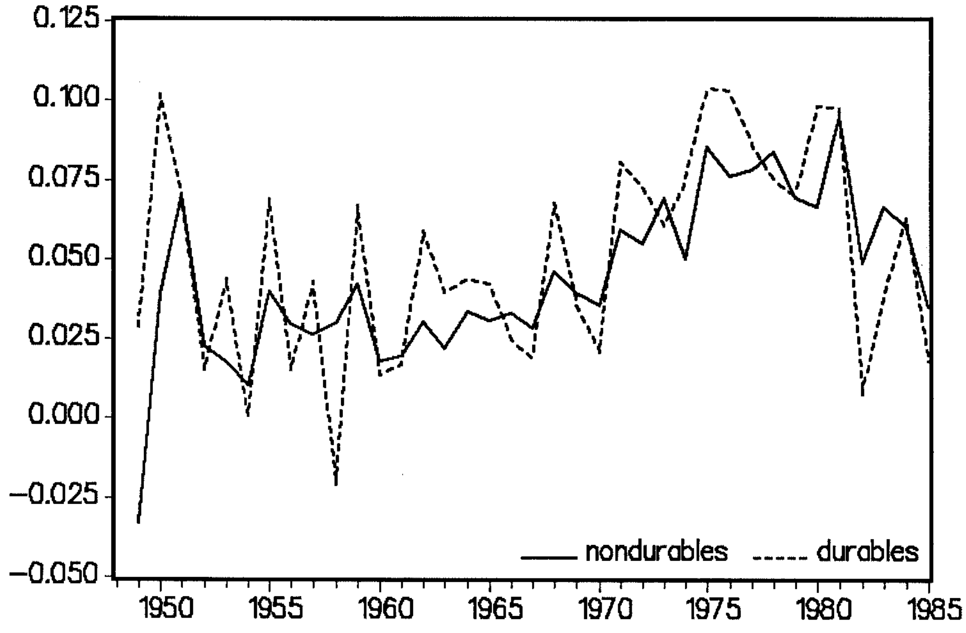


Figure 4: Shocks to sectoral productivity