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DISTRIBUTIVE AND DEMAND CYCLES IN THE US ECONOMY—A STRUCTURALIST GOODWIN MODEL

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ABSTRACT

There are regular counterclockwise cycles involving capacity utilization u (horizontal axis) and the labor share ψ (vertical axis) in the US economy since 1929. As in Goodwin's cyclical growth model, ψ can be interpreted as a Lotka–Volterra predator variable and u as prey. In a phase diagram, dynamics around the $\dot{u} = 0$ schedule respond to effective demand that econometric estimation (1948–2002) shows to be profit-led. Distributive dynamics around the $\dot{\psi} = 0$ curve demonstrate a long-term profit squeeze. Across cycles, the real wage and labor productivity grow at 0.57 per cent per quarter, holding the labor share broadly stable. Modeling the cycle in the (u, ψ) plane provides a parsimonious description of demand and distributive dynamics, consistent with the macroeconomics embedded in the work of Kalecki, Steindl, Goodwin and many subsequent authors.

1. INTRODUCTION

The relationship between effective demand and income distribution is a central issue in heterodox theories of social conflict. On the one hand, effective demand is expected to affect the functional distribution of income through cyclical fluctuations of the real wage and labor productivity. On the other hand, income distribution should influence consumption and investment expenditures through cyclical changes in the average propensity to save and in the rate of profit on fixed capital. The objective of this paper is to investigate these transmission mechanisms in the US economy. Figures 1 and 2 are capsule descriptions of the analysis. The first diagram shows annual

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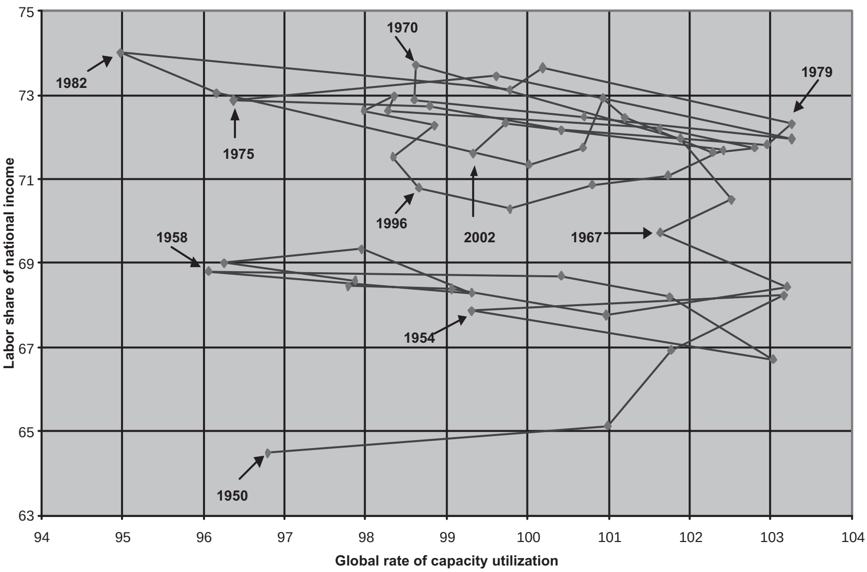

Figure 1. Demand fluctuations and income distribution in the US Economy, 1950–2002.
Labor share of income = 100 × (labor compensation/national income); global rate of capacity utilization = 100 × (real GDP/real potential GDP); real potential GDP = Hodrick–Prescott trend of quarterly real GDP, obtained with a smoothing parameter of 1600.
Source of data: US Bureau of Economic Analysis' NIPA tables 1.2 and 1.14 at http://www.bea.gov.

observations of the labor share ψ as broadly defined (vertical axis) and capacity utilization u (horizontal axis) from 1950 through 2002. To scale u around a value of one (or 100 per cent), capacity utilization is measured relative to potential output.

The trajectories in figure 1 follow negatively inclined counterclockwise spirals, with capacity utilization fluctuating by five to seven percentage points over a cycle, and the labor share by two or three points. There is an upward shift in the spirals in the late 1960s, due to the trends in government wages and supplemental labor payments.[1] Figure 2 presents the longer history

[1] The labor share is from the Bureau of Economic Analysis' NIPA table 1.2. Capacity utilization is based on NIPA table 1.14 and the Hodrick–Prescott methodology, with a smoothing parameter of 1600, is used to obtain the long-run trend of quarterly real GDP. There are numerous payments flowing towards households in the US economy. Just which should be called 'wages' is by no means clear. A broad definition of labor payments incorporates wages and salaries paid separately by the private sector and government, along with supplemental labor income (social security, health insurance and other benefits) paid by both. Government

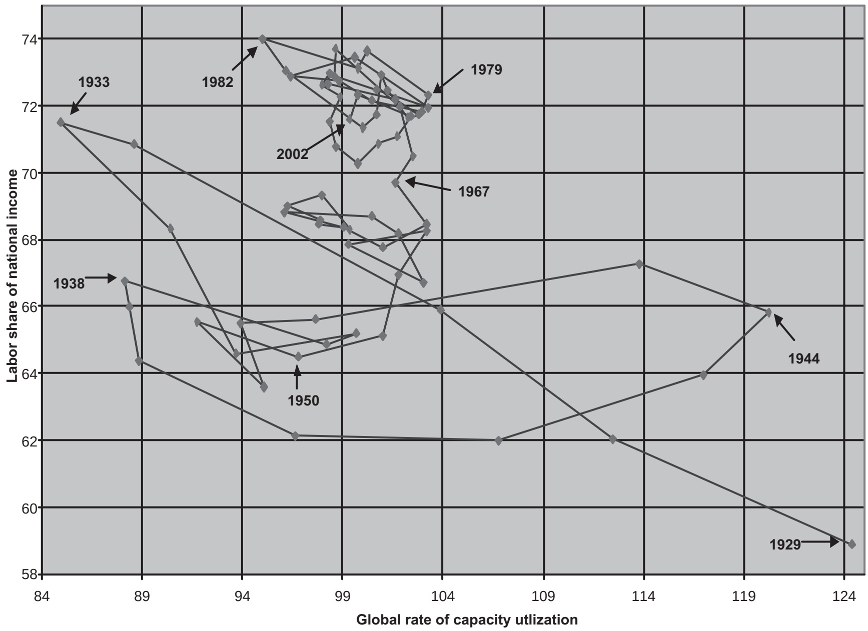

Figure 2. Demand fluctuations and income distribution in the US Economy, 1929–2002.
Labor share of income = 100 × (labor compensation/national income); global rate of capacity utilization = 100 × (real GDP/real potential GDP); real potential GDP = Hodrick–Prescott trend of annual real GDP, obtained with a smoothing parameter of 100.
Source of data: US Bureau of Economic Analysis' NIPA tables 1.2 and 1.14 at http://www.bea.gov.

beginning in 1929. With much wider fluctuations, the same general pattern holds. The significant exception is the decline in the labor share between 1944 and 1950 as both capacity utilization and wages fall off their wartime peaks.

In what follows, we set up a dynamical model to study these oscillations in the (u, ψ) plane. We begin with a continuous-time theoretical specification and proceed to vector autoregressive (VAR) econometric estimation of effective demand and distributive equations for u and ψ that depend on lagged levels of the two variables. In standard phase diagram fashion, loci along

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wages tend to vary against the capacity utilization cycle, have an upward oscillating trend between 1950 and 1970 and a downward trend thereafter. Supplemental labor income trends upward from 4 per cent of the total in the 1950s to around 14 per cent in the mid-1990s with most of the growth prior to the mid-1980s. Wages paid by business vary pro-cyclically and their income share has a slight downward trend through the early 1980s. When all these contributions are combined, the real wage weakly varies pro-cyclically with u.

which $\dot{u} = du/dt = 0$ and $\dot{\psi} = 0$ (or $\Delta u = 0$ and $\Delta\psi = 0$ in discrete econometric time) can be interpreted as underlying the cycles.

Our modeling approach is similar to Goodwin's (1967) seminal analysis. The main differences are that we substitute the global rate of capacity utilization for the employment rate as a state variable, and assume that labor productivity growth varies during business fluctuations. Using the labor share enables us to investigate the dynamics of both the real wage and labor productivity. We chose the global rate of capacity utilization because, for the US economy, the ratio of effective to trend GDP is a very good proxy of the deviations of the unemployment rate and the capital–output ratio from their corresponding long-run trends. In other words, when the global rate of capacity utilization is 100 per cent, the unemployment rate and the capital–income ratio tend to be close to their long-run values, as shown in figure 3.[2]

2. THEORY

Long ago, Richard Goodwin (1967) arbitraged mathematical models of species competition from the 1920s (Lotka, 1925; Volterra, 1931) into economics, to set up a 'predator–prey' scenario involving distributive conflict between capitalists and workers. The workers, as it turns out, are the predators with economic activity and employment as the prey. A whole econometric literature followed in Goodwin's wake (e.g. Desai, 1973; Gordon, 1995; Goldstein, 1996). A general finding is that 'profit squeeze' cycles exist for the US economy. They are slightly damped and therefore repetitive. These findings are replicated here.

Along Marxist lines (Marglin, 1984), Goodwin assumed a fixed capital–output ratio and savings-determined investment. Since he wrote, a body of structuralist theory dealing with demand and distributive issues has emerged, inspired by the work of Michal Kalecki (1971) and Josef Steindl (1952). It bases the determination of output on effective demand, and distributive dynamics upon social forces. There are three major themes.

First, a long-run effective demand curve exists in the (u, ψ) plane, interpreted below as an equilibrium relationship along which $\dot{u} = 0$. A positive slope implies that demand is 'wage-led', reflecting the old left Keynesian idea that a powerful way to raise aggregate spending is to engineer a shift in the functional income distribution towards labor (a strategy pursued by Salvador Allende's government in Chile in the early 1970s, for example). With a strong

[2] All long-run trends were obtained through the Hodrick–Prescott filter with a smoothing parameter of 1600 for quarterly series, and 100 for annual series.

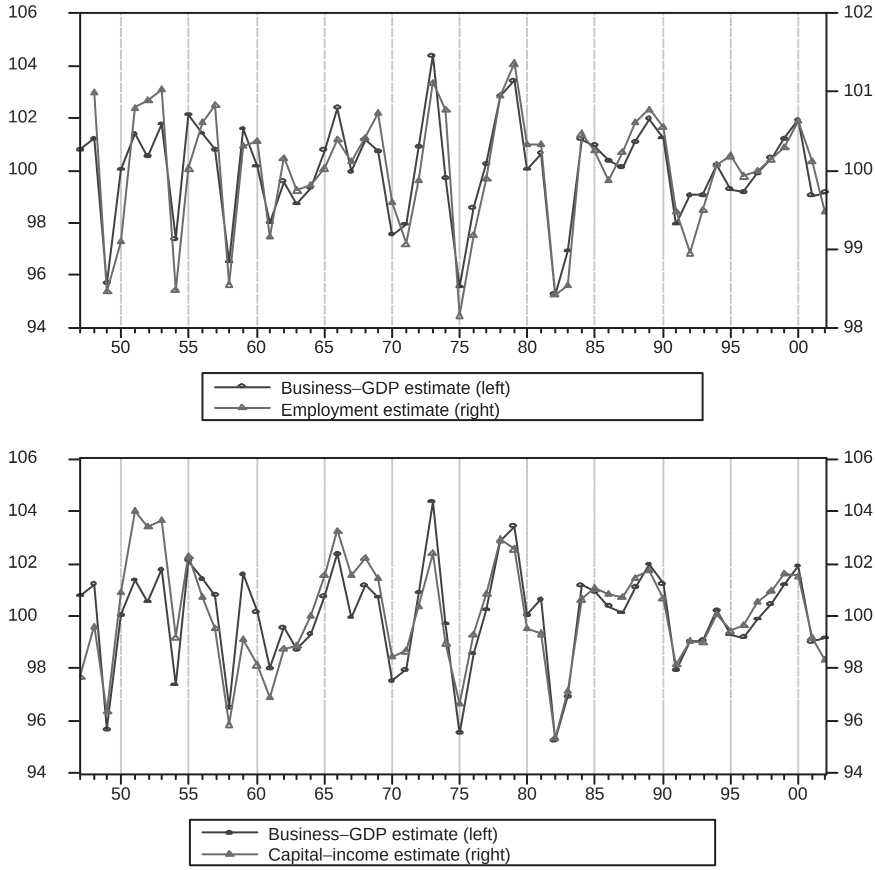

Figure 3. Fluctuations of the global rate of capacity utilization in the US economy according the real GDP of the business sector, the employment rate and the capital–income ratio.
All variables measured as the ratio of the effective series to its Hodrick–Prescott trend, with a smoothing parameter of 1600 for quarterly series (GDP and employment rate) and 100 for annual series (capital–income ratio). The GDP estimate was obtained from the US Bureau of Labor Statistics (series PRS84006043 at http://www.bls.gov). The employment-rate estimate was obtained from the unemployment rate of the civilian labor force estimated by the US Bureau of Labor Statistics (series LN14000000 at http://www.bls.gov, 1992 = 100). The capital–income index is the ratio of private and government fixed assets to GDP and it was obtained from the US Bureau of Economic Analysis (NIPA and Fixed-Assets tables 1.2 at http://www.bea.gov).

accelerator response of investment to higher workers' consumption, output expansion can be shown to be a possible response to the distributive shift.

A negative slope signifies 'profit-led' demand, which could result from higher investment stimulated by a bigger profit share and/or more exports due to increased international competitiveness resulting from lower unit labor costs (also indexed by ψ). Econometric evidence (e.g. Bowles and Boyer, 1995) suggests that demand in developed economies is profit-led. Because exchange rate devaluation cuts real wages and is often associated with output contraction in developing economies, their effective demand may typically be wage-led.[3]

Second, as will be shown below, one can similarly derive a long-run 'distributive' curve giving an equilibrium relationship between the labor share and capacity utilization. Its configuration depends on how real wage and labor productivity growth interact over the cycle. If it has a positive slope, the schedule along which $\dot{\psi} = 0$ could be called 'Marxist' or seen as demonstrating a profit squeeze in the sense that the profit share would fall if the level of capacity utilization were to rise along the curve. Subject to stability complications discussed below, a negative slope embodies 'forced saving' and could be called 'Kaldorian'.[4]

Third, the effective demand and distributive curves can be combined to generate a model of cyclical growth of the form that emerges from Goodwin's predator–prey formulation. Because by construction u and ψ vary in limited ranges, they can underlie a 2×2 system of differential equations that is generally stable and thereby straightforward to analyze.

Details follow for one particular specification. We first look at overall capacity utilization as an indicator of effective demand and then real wage and productivity dynamics on the side of distribution. Subsequently we take up behavior of the nominal wage and price levels, and the components of demand.

To model the output cycle as driven from the demand side, we treat capacity utilization u as a continuously differentiable function of time. Let X stand for output and Q for capacity, i.e. potential output. Then $u = X/Q$ and logarithmic differentiation gives the relationship

$$\hat{u} = \hat{X} - \hat{Q} \tag{1}$$

[3] The notions of wage- and profit-led demand trace to papers written independently by Rowthorn (1982) and Dutt (1984), who both acknowledge Steindl (1952) as a source of inspiration. Bhaduri and Marglin (1990) expand on their models and Blecker (2002) and Taylor (2004) provide recent literature reviews.

[4] Forced saving involves a distributive shift towards profits to generate saving to finance higher investment as effective demand rises in the long run. This mode of macro adjustment was proposed in the early 19th century or even before, and Kaldor (1956, 1957) was its main post-WWII exponent. Boddy and Crotty (1975) and Bowles *et al.* (1990) develop models of the US economy incorporating a profit squeeze.

with $\hat{u} = (\mathrm{d}u/\mathrm{d}t)/u = \dot{u}/u$ etc. As will be seen, behavioral assumptions about the components of this dynamic accounting identity can be used to generate cycles that are consistent with the relatively small changes quarter-by-quarter typically observed in macro time series for aggregate demand and distribution.

In heterodox macro models the growth rate of potential output is usually defined as a function of the growth rate of the capital stock, in the sense that capital is the scarcest factor in a capitalist economy. We adopt this approach here because, as shown in figure 3, changes in capacity utilization can be interpreted as the deviations of the income–output ratio from its long-run trend.

On the distribution side we have $\psi = \omega/\xi$ as the labor share, where $\omega = W/P$ is the real wage (with W and P as the nominal wage and price level, respectively) and $\xi = X/L$ is average labor productivity. The analog to (1) is

$$\hat{\psi} = \hat{\omega} - \hat{\xi} \tag{2}$$

This equation shows that ψ is determined over time by the bargain affecting the nominal wage W, pricing behavior by firms that sets P, and combined social and technological forces that impinge upon labor productivity growth.

In growth rate form and to reduce the analysis to two dimensions, the model can be restated in four equations based on capacity utilization and the labor share:

$$\hat{X} = \alpha_0 + \alpha_u u + a_\psi \psi \tag{3}$$

$$\hat{Q} = \beta_0 + \beta_u u + \beta_\psi \psi \tag{4}$$

$$\hat{\omega} = \gamma_0 + \gamma_u u + \gamma_\psi \psi \tag{5}$$

and

$$\hat{\xi} = \delta_0 + \delta_u u + \delta_\psi \psi \tag{6}$$

If we set $\phi_j = \alpha_j - \beta_j$ and $\theta_j = \gamma_j - \delta_j$, for $j = u$ and ψ, then substituting (3)–(4) into (1) and (5)–(6) into (2) gives reduced-form equations for u and ψ:

$$\dot{u} = u(\phi_0 + \phi_u u + \phi_\psi \psi) \tag{7}$$

and

$$\dot{\psi} = \psi(\theta_0 + \theta_u u + \theta_\psi \psi) \tag{8}$$

In the literature on dynamical systems (7) and (8) represent a population model analytically identical to the moose–wolf model of Tu (1988).[5] To find which variable is the 'moose' and which is the 'wolf' in our model, we have to determine the signs of the coefficients of the system, which in their turn depend on the economic assumptions about (3), (4), (5) and (6). To facilitate the exposition, let us examine each equation separately.

Beginning with (3), evidence presented below and elsewhere suggests that effective demand in the USA and other advanced countries is profit-led, so that $\alpha_\psi > 0$. There is a general consensus that the basic Keynesian stability condition $\partial \dot{X}/\partial X < 0$ is satisfied, or $\alpha_u < 0$. In words, given an increase in the labor share or in capacity utilization, the growth rate of income is expected to decelerate. In heterodox models the first effect is usually associated with the fall in the rate of profit brought by a higher labor share, whereas the second effect means that aggregate saving rises more rapidly than investment in response to an increase in u, braking an initial output expansion.

In (4), we assume that capacity Q is largely determined by the existing capital stock. Capital formation usually responds positively to both the level of economic activity and profitability, so that $\beta_u > 0$ and $\beta_\psi < 0$. The intuitive economic meaning of these assumptions is that, given the level of economic activity, an increase in the labor share reduces the global rate of profit and thereby investment demand. By analogy, given the functional distribution of income, an increase in capacity utilization raises the rate of profit and stimulates capital accumulation.

From $\alpha_u < 0$ and $\beta_u > 0$ it follows immediately that $\phi_u = \alpha_u - \beta_u < 0$, so $\partial \dot{u}/\partial u > 0$ in (7) and the differential equation is 'partially' stable in u.[6] From $\alpha_\psi < 0$ and $\beta_\psi > 0$ we cannot determine the sign of $\phi_\psi = \alpha_\psi - \beta_\psi < 0$ *a priori*. As will be seen in the next section, in the US economy it seems that, via the multiplier, the overall negative demand effect of a higher value of ψ tends to outweigh its specific effect on investment, $|\alpha_\psi| > |\beta_\psi|$, so that $\phi_\psi < 0$. Because of this, in both diagrams in figure 4, the 'Effective demand' schedule along which $\dot{u} = 0$ has a negative slope $\mathrm{d}\psi/\mathrm{d}u = -\phi_u/\phi_\psi$ in the (u, ψ) plane. Along the demand curve given by $\dot{u} = 0$, a higher labor share is associated with lower capacity utilization.[7]

[5] For an introduction to population models, see, for instance, Frauenthal (1980). A good introduction to the application of population models to economics can be found in Tu (1994) and Shone (1997).

[6] By partially stable we mean that the own partial derivative of $\dot{u}$ is negative, so that if the labor share remains constant, u tends to converge to its steady-state value in the long run.

[7] It should be noted that the theoretical model shown in figure 4 is specified in continuous time, whereas the econometric model of the next section will be specified in discrete time. Since we are highlighting the qualitative aspects of the model, we chose to work with continuous time when discussing theoretical issues to facilitate the analysis.

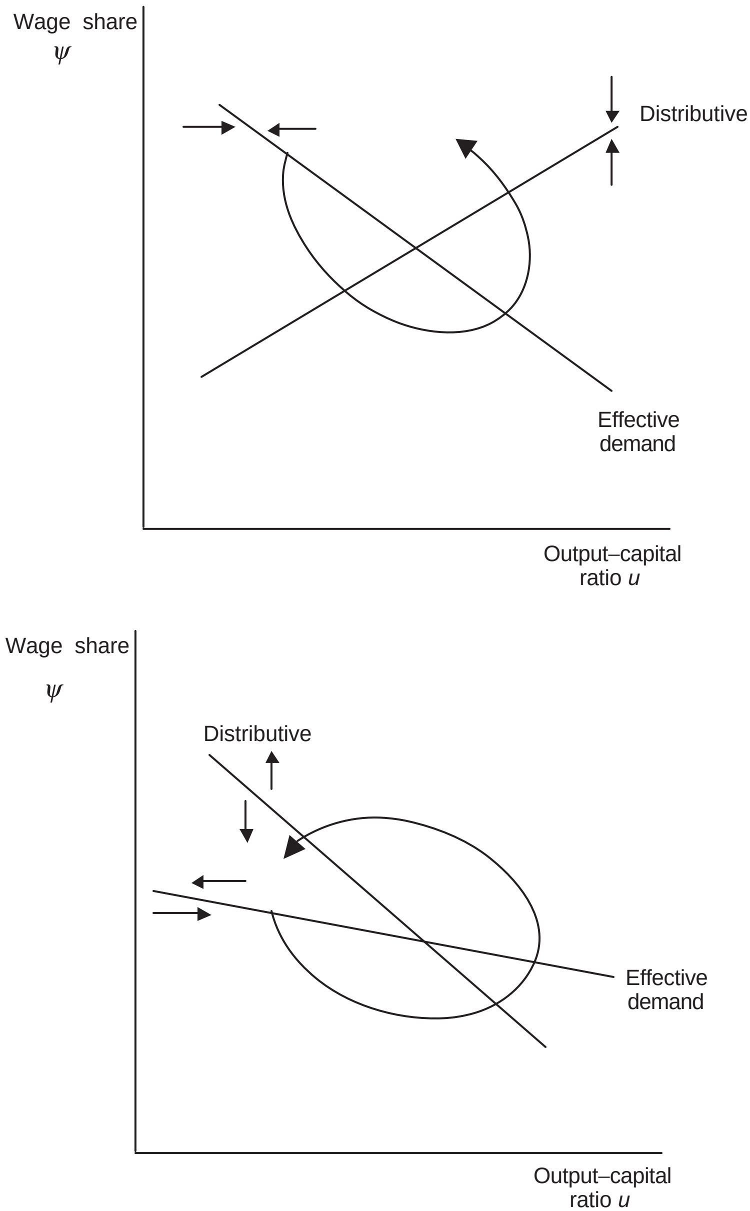

Figure 4. A structuralist Goodwin model, with stable (upper) and unstable (lower) wage share dynamics.

The story about the 'Distributive' curve along which $\dot{\psi} = 0$ is tangled. In the USA the real wage rises in line with productivity across cycles, thereby holding ψ rather stable when it is averaged over long periods. During the course of one cycle, the counterclockwise oscillations in figures 1 and 2 suggest that $\psi = \omega/\xi$ falls in the beginning of an expansion, as labor productivity grows faster than real wages. Eventually real wage growth catches up and overcomes productivity growth, making ψ rise at the end of an expansion. By analogy the opposite holds during a recession and, overall, labor-share cycles are maintained through expansions and recessions.

Focusing on the two components of the labor share, the econometric results reported below suggest that the (detrended) price level responds positively to lagged levels of ψ as an indicator of unit labor cost and negatively to lagged u via a mildly counter-cyclical aggregate mark-up. Both responses are weak so that P is relatively stable over the cycle. In other words, shifts in the real wage ω are largely driven by the (again detrended) money wage W. As it turns out, W responds positively to both state variables but more strongly to ψ than u. So cyclical real wage dynamics are principally driven by money wage reactions to changes in the labor share. The bargaining interpretation would be that, given the level of economic activity, a high labor share is a sign of high market power for labor at the macro level, in the sense that workers are able to obtain a high real wage in relation to their productivity. In terms of (5), the interaction between nominal wages and prices indicate that $\gamma_u > 0$ and $\gamma_\psi > 0$ in the US economy.

Similar observations apply to labor productivity $\xi = X/L$. We know already from the demand side of the model that X tends to fall when ψ increases. The econometric results below suggest that ξ reacts positively to lagged values of both u and ψ, i.e. $\delta_u > 0$ and $\delta_\psi < 0$ in (6). As with the real wage, the ψ effect is stronger. It can be positive only if L falls more than X when ψ rises. This pattern must be interpreted along cyclical lines. During a downswing in u, ψ tends to increase. A positive *lagged* response of ξ to ψ is then consistent with a rise in productivity during and after the cyclical trough—the observed pattern.

Equation (6) can be interpreted as an aggregate technological function in the sense that changes in capacity utilization lead to productivity gains at the firm level, as well as shifts in the composition of employment at the macro level. In short, because of technological, scale and composition effects, labor productivity growth is a positive function of capacity utilization. It also responds positively to an increase in the labor share because a reduction in the rate of profit leads firms to adopt labor-augmenting innovations. At the macro level, the latter involves changes both in sectoral productivity indexes and in the level and composition of employment and production.

Combining (5) and (6) we have $\gamma_u > 0$ and $\delta_u > 0$ so that the sign of $\theta_u = \gamma_u - \delta_u$ cannot be determined *a priori*; the same holds for $\theta_\psi = \gamma_\psi - \delta_\psi$. For the US economy the positive effects of both u and ψ on the real wage seems to be stronger than those on productivity. An immediate implication is that $\theta_u >$ and $\partial\hat{\psi}/\partial u < 0$, i.e. there is a short-run profit squeeze. Translating the VAR econometric difference equation presented below into differential equation language, it will also be true that $\partial\hat{\psi}/\partial\psi < 0$ in (8); that equation is partially stable. However, during the period 1955–70 the regression results suggest that $\delta_\psi \ll 0$, with productivity growth responding strongly to increases in the profit share and making $\theta_\psi > 0$ so that $\mathrm{d}\hat{\psi}/\mathrm{d}\psi > 0$ as well. A possible rationale is that higher profits stimulate investment sufficiently to bring productivity-improving innovations rapidly into operation.

The upper diagram in figure 4 corresponds to the case where $\partial\hat{\psi}/\partial\psi < 0$. The Distributive curve slopes upward so that there is a profit squeeze. The two-equation system is dynamically stable and can also demonstrate cyclical behavior.[8] The damped instability case is illustrated in the lower diagram. The slope of the Distributive curve is $\mathrm{d}\psi/\mathrm{d}u = -(\partial\hat{\psi}/\partial u)/(\partial\hat{\psi}/\partial\psi)$ and is negative when $\partial\hat{\psi}/\partial\psi > 0$. For the determinant of the Jacobian of (7) and (8) to be positive (thereby ruling out a saddlepoint), the Distributive curve has to cross the Effective demand curve from above. As shown, starting from a low point for u along the Effective demand schedule, the two variables may follow a counterclockwise spiral around the equilibrium point: predator–prey dynamics again.

Finally, although it does not appear to be empirically relevant in the USA, a stable forced saving/Kaldorian Distributive schedule would have $\partial\hat{\psi}/\partial\psi < 0$ and $\partial\hat{\psi}/\partial u < 0$. The Distributive curve would have a negative slope. A profit-led (negatively sloped) Effective demand schedule would have to cut it from above for the overall system to be stable.[9]

[8] In the upper diagram, convergence will be oscillatory (the equilibrium point is a 'focus') instead of direct (a 'node') if the discriminant $(\mathrm{Tr}J)^2 - 4\mathrm{Det}J$ of the Jacobian is negative so that the eigenvalues are complex. The (discrete-time) econometric results in the following section suggest that this condition is likely to be satisfied.

[9] Skott (1989) sets out a theoretical model for a similar system based on: (1) a locally stable, downward-sloping locus for the employment ratio e (horizontal axis, with ψ on the vertical axis) so that employment expansion is profit-led as it is for Goodwin; and (2) a faster response of $\hat{X}$ than $\hat{Q}$ to a fall in ψ with a negative relationship between u and ψ emerging from a short-run output supply function acting through the macro balance relationship. We thus have $\partial\dot{e}/\partial e < 0$ and $\partial\dot{\psi}/\partial\psi < 0$, with overall stability possible because a higher value of e reduces supply growth by inducing greater labor militancy. The dynamics resembles the lower diagram of figure 4.

3. EVIDENCE FOR THE USA

To our knowledge, the model just sketched has not been estimated as a full system.[10] Here we present an initial attempt. For purposes of estimation, it is preferable to work with the labor share of the *business* sector only (instead of the broad measure appearing in figures 1 and 2), for at least two reasons. The quarterly series is reliably stationary, because it does not incorporate the trending elements of supplemental income and government wages. Second, price/quantity data are not readily available for the non-business sector.

Capacity utilization is measured as the ratio of observed to potential business sector product in percentage points. Quarterly potential output is calculated using the standard Hodrick–Prescott filter (with a smoothing parameter of 1600); results are much the same on the CBO (Congressional Budget Office) definition. The quarterly labor share is measured as an index number (1992 = 100), constructed from BLS (Bureau of Labor Statistics) series on the business sector implicit price deflator, hourly wages and product per hour. On these definitions, a counterclockwise cycle persists in the (u, ψ) plane beginning in 1947. Applying the Hodrick–Prescott filter to both variables suggests that movements in capacity utilization lead those of the labor share throughout most of the post-World War II (WWII) period—predator is led by prey. The upper and lower diagrams of figure 5 show the effective and long-run fluctuations of capacity and the labor share, respectively.

Before we proceed, recall that u is defined as the ratio of effective to H–P-trend GDP. By construction the long-run value of u is 100 per cent, which corresponds to the points at which the employment rate and the capital–output ratio are close to their long-run values. In other words, we can map the fluctuations shown in figure 5 to the employment × labor share and the capital–income × labor-share planes.

For decomposition analysis,[11] we can write $u_t = c_t + i_t + n_t + g_t$ at time t, with the four demand components being consumption c_t, investment i_t, net exports n_t and government spending g_t measured relative to potential GDP. Implicitly, the demand composition of total and business sector GDP are assumed to correlate closely.[12]

[10] Gordon (1995) probably came closest, although he used the profit rate as a distributive indicator and did not focus on cyclical patterns. See also Harvie (2000) for evidence on Goodwin cycles in 10 industrialized economies.

[11] The Appendix presents the methodology to decompose the aggregated VAR coefficients, estimated for the dynamics of u and ψ, into their distributive and demand components. For a more detailed description, see Barbosa-Filho (2004).

[12] For instance, c should be equal to C_B/Y_B, where C_B and Y_B are the consumption and potential output of the business sector, respectively. Because the NIPA data do not give us C_B, we define $c = C/Y$ where C and Y are the total consumption and potential output of the economy.

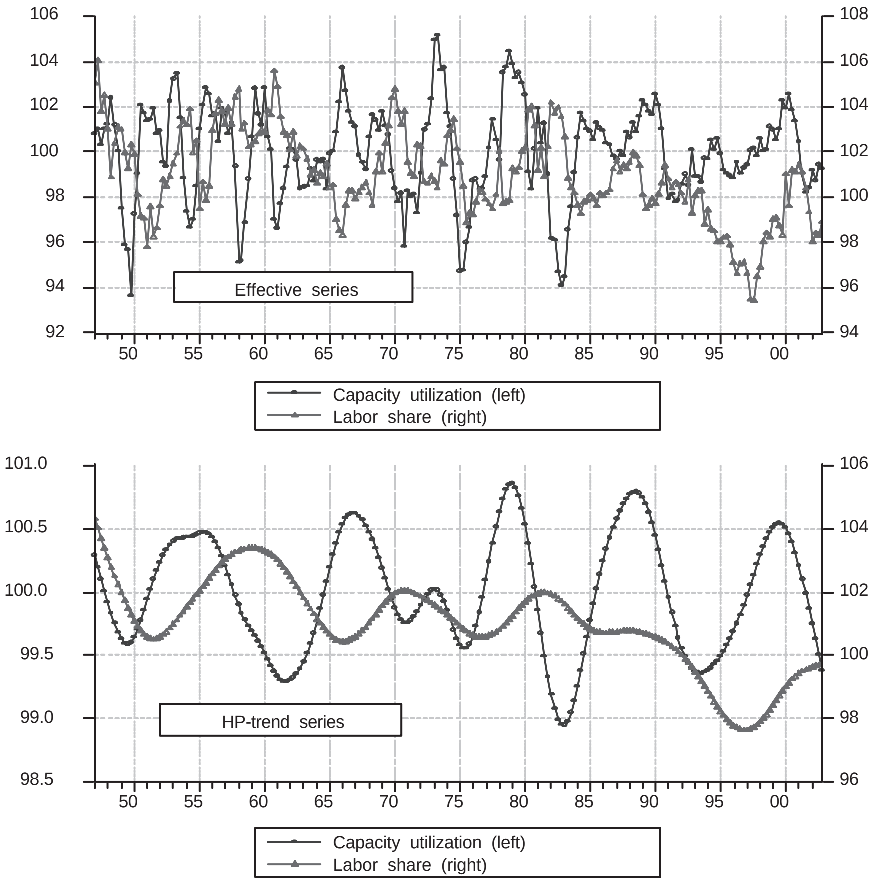

Figure 5. Demand fluctuations and income distribution in the business sector of the US economy: 1947–2002. The upper shows the effective series and the lower diagram the corresponding Hodrick–Prescott (HP) trends.

Labor-share index = (business labor compensation per hour)/[(business price deflator) × (business output per hour)], all series calculated with 1992 = 100; global rate of capacity utilization = 100 × (real business output)/(real potential business output); real potential business output = Hodrick–Prescott trend of real business output, obtained with a smoothing parameter of 1600.

Source of data: Bureau of Labor Statistics' productivity and costs series at http://www.bls.gov.

To impose a linear decomposition of ψ into its components, regression equations have to be specified for $\ln \psi$ to obtain the determinants of the distributive curve. More precisely, define $f(\psi_t) = \ln \psi_t - \ln \overline{\psi}$ where ψ_t is the labor share at time t and $\overline{\psi}$ is its sample mean. For sample values close to the mean, we have

$$\ln\psi_t - \ln\bar{\psi} \approx f(\bar{\psi}) + (1/\bar{\psi})(\psi_t - \bar{\psi}) = (\psi_t/\bar{\psi}) - 1$$

This is an approximate linear relationship between ψ and $\ln\psi$, which in turn decomposes as $\ln\psi = \ln W - \ln P - \ln\xi$, parallel to the additive breakdown of aggregate demand into its components presented above.

Measured in index number form, variations in ψ slightly exceed those of u over cycles. Both series are stationary at the 1 per cent level of significance on Augmented Dickey–Fuller tests.[13]

To have the explanatory variables expressed in the same functional forms, the regression equations were estimated for u and ψ to analyze the demand curve, and for $\ln u$ and $\ln\psi$ to analyze the distributive curve.[14] In both cases the distributive-demand dynamics were studied using an off-the-shelf VAR model of the form

$$\mathbf{y_t} = \boldsymbol{\mu} + \boldsymbol{\eta}\mathbf{t} + \sum_{\mathbf{j=1}}^{\mathbf{L}} \mathbf{F_j y_{t-j}} + \mathbf{e}_t$$

where $\mathbf{y}_t = [\psi_t\ u_t]'$ in the 'demand' VAR and $[\ln\psi_t\ \ln u_t]'$ in the 'distributive' VAR; $\boldsymbol{\mu}$, $\boldsymbol{\eta}$ and $\mathbf{F}_j$ are coefficient matrices of appropriate dimensions; and, by construction, $\mathbf{e}_t$ is vector of white-noise disturbances.[15]

To define the lag structure of the model, we set eight quarters as the maximum length and computed Akaike and Schwarz information criteria for all specifications. The results indicated that two is the best lag length.[16] Table 1 summarizes results of the distributive and demand VAR models for the

[13] The Augmented Dickey–Fuller tests were performed with zero to seven lagged differences and no trend in the estimated equations for both variables. To have the same sample for all lag specifications, the tests were applied to the 1949–2002 sample. At 1 per cent and 5 per cent of statistical significance, the unit-root null was rejected for u and ψ in all lag specifications, respectively. It should be noted that, because both state variables are stationary by construction (u = 100 in the long-run and $0 < \psi < 1$), the linear VAR specification automatically produces convergence to one, and only one equilibrium point.

[14] The linear approximation around the sample means allows us to map the level results into the log-level results and vice versa.

[15] The path from the data generating process of the state variables to the estimable VAR model involves four methodological assumptions, namely: (1) we can work with the marginal density function of the variables under study; (2) such a function can be approximated by a linear function; (3) the parameters of such a function are time invariant; and (4) the derived disturbances are normally distributed.

[16] The Akaike and Schwarz information criteria were calculated for 1949–2002 to have the same sample in each lag specification. The lowest Schwarz criterion was obtained with two lags, whereas the Akaike criteria with two and three lags were practically the same and lower than in all other lag specifications.

Table 1. Estimated coefficients for capacity utilization and the labor share, 1948–2002

	Constant	*Trend*	$u(-1)$	$u(-2)$	$\psi(-1)$	$\psi(-2)$	*Steady state* $\mathrm{d}\psi/\mathrm{d}u$
$\boldsymbol{u}$	**37.4275**	**−0.0013**	**1.2042**	**−0.4862**	**0.3031**	**−0.3931**	**−3.1334**
c	54.9465	0.0232	0.3820	−0.1443	−0.1253	−0.0473	
i	−13.4468	0.0010	0.8021	−0.3931	0.1924	−0.3060	
n	12.8739	−0.0176	−0.2143	0.1489	−0.1553	0.1059	
g	−16.9461	−0.0079	0.2344	−0.0977	0.3912	−0.1458	
	Constant	*Trend*	$\ln u(-1)$	$\ln u(-2)$	$\ln \psi(-1)$	$\ln \psi(-2)$	*Steady state* $\mathrm{d}\ln\psi/\mathrm{d}\ln u$
$\ln \psi$	**−1.2780**	**0.000**	**0.0461**	**0.1365**	**0.7128**	**0.1919**	**1.9166**
$\ln \mathrm{W}$	9.0715	0.0150	0.7266	−0.5300	1.3955	0.3757	
$\ln \mathrm{P}$	4.2386	0.0093	−0.4176	0.2684	−0.3398	0.4958	
$\ln \xi$	6.1109	0.0057	1.0981	−0.9349	1.0226	−0.3121	
$\ln \omega$	4.8329	0.0057	1.1442	−0.7984	1.7354	−0.1202	

period 1948–2002. The wage, price and productivity variables increase over time so all equations were estimated including trends. All coefficients were jointly significant according to the standard tests and the capacity utilization and labor-share equations had adjusted R^2 of 0.75 and 0.83, respectively.[17]

Through the lags, capacity utilization responds positively to its own past values and negatively to the labor share. From the first row in table 1, the equation for u can be rewritten as

$$u_t - u_{t-1} = 37.4275 + (1.2042 - 1)u_{t-1} - 0.4862u_{t-2} + 0.3031\psi_{t-1} - 0.3931\psi_{t-2}$$

so that Δu_t has an overall negative response of (1.2042 – 1) – 0.4862 = –0.282 to the two lagged values of u. The implied long-run multiplier of 1/0.282 = 3.546 has a plausible magnitude.

In formal terms, one of the necessary stability criteria for an autoregressive model with two lags is that the absolute value of the sum of coefficients on lagged values must be less than one.[18] From table 1, this requirement is satisfied for the u process: 1.2042 – 0.4862 = 0.718 > 1. Perhaps more intuitively, at a steady state it will be true that $u_t = u_{t-1} = u_{t-2}$ and $\psi_t = \psi_{t-1} = \psi_{t-2}$, so that $u_t - u_{t-1} = 0$. The implied slope of the steady-state effective demand curve is $\mathrm{d}\psi/\mathrm{d}u$ = (1 – 1.2042 + 0.4862)/(0.3031 – 0.3931) = –3.1334, as shown in the table.

Over the sample period, effective demand is profit-led. With both u and ψ normalized around unity, a three-percentage point decrease in the index for the labor share along the demand curve would result in a rise of about one point in capacity utilization.

The labor share responds positively to past values of capacity utilization and itself. The overall response of $\Delta \ln \psi_t$ and $\ln \psi_{t-1}$ and $\ln \psi_{t-2}$ is –1 + 0.7128 + 0.1919 = –0.0953, so the difference equation for $\ln \psi$ is partially stable. The steady-state slope of the distributive curve $\mathrm{d}(\ln \psi)/\mathrm{d}(\ln u)$ is 1.9166, signaling a profit squeeze. A one-percentage point increase in capacity utilization along the distributive curve would lead the profit share to fall by approximately two points.

Figure 6 gives a feel for the overall dynamics of the system for the 1954–2002 period. With the trivial time trend in u shown in table 1

[17] According to the econometric results, we can reject the null hypotheses that capacity does not Granger cause the labor share and vice versa at 0.03 per cent of statistical significance.

[18] Let ϕ_{u1} and ϕ_{u2} be respectively the coefficients on the first and second lagged values, the necessary and sufficient stability condition is that the two autoregressive coefficients lay in the 'stability triangle' defined by the inequalities $\phi_{u1} + \phi_{u2} < 1$, $\phi_{u1} - \phi_{u2} > -1$ and $\phi_{u2} > -2$, as shown by Hamilton (1994, ch. 1).

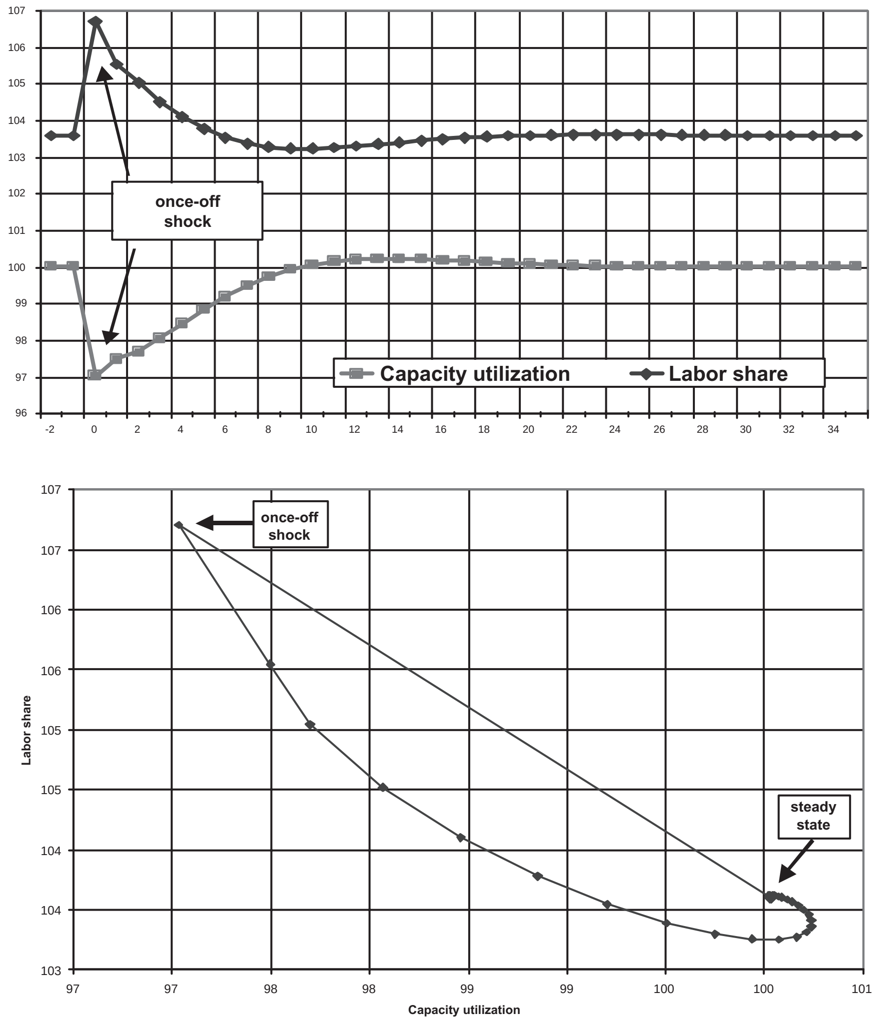

Figure 6. Model response to a combination of a –3 per cent shock to capacity utilization and a +3 per cent shock to the labor share, applied to the 1954–2002 model of the US economy.

eliminated,[19] steady-state values of the variables are $u = 99.14$ and $\psi = 103.99$. In both diagrams, a once-off −3 per cent shock is applied to steady-state u and +3 per cent to steady-state ψ, to approximate the bottom of a normal cycle. The upper diagram shows the expected counterclockwise pattern. The

[19] The trend is due to the sharp increase in consumption from 1970 through 1985 and will probably die out as the sample grows longer.

Table 2. Slopes of effective demand and distributive curves for subperiods, 1948–2002

Period	*Effective demand* $d\psi/du$	*Distributive* $d \ln \psi/d \ln u$
1948–2002	−3.1334	1.9166
1954–2002	−2.7867	1.9964
1948–1970	−2.0362	3.6253
1954–1970	−1.4337	−6.2525
1971–2002	−6.9026	1.1591

lower diagram shows that the state variables return close to the steady state after eight quarters (and cycle in the vicinity thereafter).

Table 2 presents the slopes of the effective demand and distributive curves for the 'Golden Age' period that began after WWII and ended in the early 1970s, and thereafter. A convenient breakpoint is the year 1970, which contained the trough of an NBER business cycle. The initial year is alternatively 1948 or 1954 (the latter a trough year that omits the immediate post-WWII and Korean War periods).[20]

Over both 1948–2001 and 1954–2001, demand is profit-led and there is a profit squeeze. Before 1970, the demand effect is stronger (a two-percentage point decrease in ψ would make u increase by one point or more in the long run), and weakens during 1971–2001. Further sample splits suggest that demand may have shifted to being wage-led during the 1970s but was profit-led in the preceding and following decades.[21] However, the number of observations per decade is too low to make a solid case.

During 1954–70, the distributive curve takes a negative slope and the difference equation for $\ln \psi$ is locally unstable as in the lower diagram of figure 4.

Otherwise, the qualitative characteristics of the economy are described by the upper diagram in figure 4. It follows that distributive shocks favorable to labor (upward shifts of the distributive curve) lead to a temporary increase in the labor share at the expense of a reduction in capacity utilization; and that positive demand shocks (upward shifts of the demand curve) lead to temporary increases in capacity utilization and the labor share. Along the

[20] The Chow breakpoint test indicates a structural break in the capacity equation in the end of 1970 at 2.5 per cent statistical significance.

[21] Blecker (2002) suggests that the Reagan fiscal package may have pushed the economy in a profit-led direction during the 1980s.

lines of figure 6, convergence to a 'new' long-run intersection of the Effective demand and Distributive curves would be oscillatory.

As discussed above, it is possible to use VAR estimation subject to adding-up restrictions to express the demand components of u and the price/productivity components of $\ln \psi$ as functions of lagged values of these two variables. The results of these reduced-form estimates are also shown in table 1.

The estimated coefficients suggest that, during the period under analysis, c_t, or the ratio of private consumption to potential GDP, had a positive trend and was pro-cyclical.[22] Investment i_t also varied pro-cyclically. Net exports n_t had a downward trend and responded negatively to both capacity utilization and the labor share (interpreted as an index of labor costs). Government spending g_t also had a negative trend, and responded positively to u and ψ. In the aggregate, the profit-led components predominated and, by construction, there was a trivial overall trend in u (see footnote 13).

Trends are stronger in the logs of W, P and ξ. The real wage increases at approximately 0.57 per cent per quarter in 1948–2002, due to trend money wage growth outstripping the trend in the price level. Labor productivity growth also grows at 0.57 per cent, stabilizing the labor share.

The coefficients for $\ln \omega$ and $\ln \xi$ are consistent with the descriptions above for the long period 1948–2001. As already noted, during 1954–70, the sum of the coefficients on $\ln \psi$ in the productivity equation is -1.18, giving rise to discrete-time oscillation similar to the continuous-time dynamics illustrated in the lower diagram of figure 4. Local instability of the difference equation for the predator variable $\ln \psi$ is offset by stable adjustment of the prey $\ln u$ in the overall dynamic scheme.

The nominal wage responds positively over two lags to capacity utilization, along Phillips curve lines, and also responds positively to the labor share. The price level responds counter-cyclically to capacity utilization and (over two lags) is largely unaffected by unit labor costs as measured by ψ.

4. CONCLUSIONS

There are rather regular counterclockwise cycles involving capacity utilization u (horizontal axis) and the labor share ψ (vertical axis) in the US

[22] Net lending by households, or their savings less investment, varies counter-cyclically, consistent with the econometric result (Taylor, 2004).

economy after WWII. In Lotka–Volterra terms, χ can be interpreted as a predator variable and u as prey.

The cycles can be rationalized in phase diagram terms as being driven by dynamics around schedules along which $\dot{u} = 0$ and $\dot{\psi} = 0$. The former can be interpreted in terms of effective demand—specifically demand that responds negatively to ψ or is profit-led. The latter can be interpreted in distributive terms—along the distributive equilibrium line the labor share rises along with capacity utilization or the functional distribution is subject to a profit squeeze.

Econometric results suggest that all components of demand contribute to its profit-led character. Real wage and labor productivity dynamics over the cycle are the main driving force behind the distributive profit squeeze. Across cycles, both the real wage and labor productivity grow at about 0.57 per cent per quarter, holding the labor share broadly stable.

Modeling the cycle in the (u, ψ) plane provides a parsimonious description of demand and distributive dynamics that is consistent with the view of macroeconomics embedded in the work of Kalecki, Steindl and many subsequent followers.

APPENDIX

Estimating demand components and wage and price responses

The VAR model for u and ψ can be written as

$$\mathbf{y_t} = \mathbf{\Gamma x_t} + \mathbf{e_t} \tag{A1}$$

where naturally $\mathbf{\Gamma} = [\boldsymbol{\mu}\ \boldsymbol{\eta}\ \mathbf{F_1}\ \mathbf{F_2}]$ and $\mathbf{x'_t} = [1\ \ t\ \ \mathbf{y'_{t-1}}\ \ \mathbf{y'_{t-2}}]$. The ordinary least squares and maximum likelihood estimator of Γ (Hamilton, 1994) is given by:

$$\mathbf{\Gamma} = \left(\sum_{\mathbf{t=1}}^{\mathbf{T}} \mathbf{y_t x'_t}\right)\left(\sum_{\mathbf{t=1}}^{\mathbf{T}} \mathbf{y_t x'_t}\right)^{-1} \tag{A2}$$

Let $\mathbf{z'_t} = (\psi_t\ c_t\ i_t\ g_t\ n_t)$ be the vector containing the labor share and the demand–potential output ratios that add up to u_t. The 'demand' VAR implicit in the equation for u in (A1) is given by the following regression:

$$\mathbf{z_t} = \mathbf{\Pi w_t} + \mathbf{v_t} \tag{A3}$$

where $\mathbf{\Pi}$ is a 4×12 coefficient matrix and $\mathbf{w'}_t = [1\ t\ \mathbf{z'}_{t-1}\ \mathbf{z'}_{t-2}]$. In other words, the demand VAR is a regression of the labor share and the demand components on their past values, a constant and a time trend. In relation to (A1), the crucial difference is that (A3) breaks u in its four components.

By analogy with (A2), the ordinary least squares and maximum likelihood estimator of Π is

$$\hat{\mathbf{\Pi}} = \left(\sum_{t=1}^{T} \mathbf{z}_t \mathbf{w}_t'\right)\left(\sum_{t=1}^{T} \mathbf{w}_t \mathbf{w}_t'\right)^{-1} \tag{A4}$$

By definition:

$$\mathbf{x}_t = \mathbf{G}\mathbf{w}_t \tag{A5}$$

where G is a 6×12 matrix of constant terms that maps $\mathbf{w}_t$ into $\mathbf{x}_t$. Substituting (A5) in (A2) and after some algebraic operations, we obtain

$$\hat{\mathbf{G}} = \mathbf{H}\hat{\mathbf{\Pi}}\mathbf{F} \tag{A6}$$

where

$$\mathbf{H} = \begin{bmatrix} 1 & 1 & 1 & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 \end{bmatrix} \tag{A7}$$

and

$$\mathbf{F} = \left(\sum_{t=1}^{T} \mathbf{w}_t \mathbf{w}_t'\right)\mathbf{G}'\left[\mathbf{G}\left(\sum_{t=1}^{T} \mathbf{w}_t \mathbf{w}_t'\right)\mathbf{G}'\right]^{-1} \tag{A8}$$

The purpose of (A6) is to find how each ‘aggregate’ coefficient of the first line of (A1) can be decomposed in terms of the ‘disaggregated’ coefficients of the first four lines of (A3). In other words, the purpose is to know how much of each aggregate demand coefficients comes from consumption, investment, net exports and government expenditures. Given the sample values of $\boldsymbol{w}$, $\boldsymbol{F}$ is a matrix of fixed weights and the decomposition of the aggregated demand results is implicit in the right-hand side of (A6).

By analogy, the same method can be applied to the decomposition of the ‘aggregate coefficients’ of the labor-share equation, provided that we use logs instead of levels to assure that the wage, price and productivity variables add up to the labor-share variable.

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