Why Does Consumption Lead the Business Cycle?[*]

Yi Wen
Department of Economics
Cornell University, Ithaca, N.Y.
yw57@cornell.edu

Abstract

Consumption in the US leads output at the business cycle frequency. Standard RBC models predict the opposite. We show in this paper that the lack of an endogenous propagation mechanism that can support demand shocks is responsible for the discrepancy between RBC theory and data.

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1. Introduction

Standard RBC models driven by technology shocks predict that consumption lags both output and investment. Yet post-war US data show the opposite: at the business cycle frequency consumption leads output.

In this paper, I argue that the lack of a multiplier-accelerator like propagation mechanism that can support aggregate demand shocks without crowding out holds the key for standard RBC models' failure to explain the data. I demonstrate my point using an equilibrium business cycle model featuring capacity utilization and externalities. I show that the model is able to generate consumption that leads output, thanks to the multiplier-accelerator effect arising from of capacity utilization and externalities.

In what follows, I present the empirical puzzle in detail in section 2. I demonstrate my way of resolving the puzzle by RBC theory in sections 3 and 4. Caveats and concluding remarks are offered in sections 5 and 6 respectively.

2. The Puzzle

Applying the band-pass filter (Baxter and King, 1995) to post-war US data (1960:1–1996:3), I found that consumption leads output by one quarter and that investment lags output by one quarter at the business cycle frequency. The cross correlations among these series of cyclical components are reported in table 1, which shows that the strongest correlation between consumption and output occurs at lag $t-1$, whereas the strongest correlation between investment and output occurs at lead $t+1$.[1]

Standard RBC models cannot explain these stylized facts. Table 2 shows that the strongest correlation between consumption and output in the model of King, plosser and Rebelo (1988) occurs at lead $t+1$, and the same is also true for the time-to-build model of Keydland and Prescott (1982).[2] Such counter-factual predictions can also be revealed by impulse responses of the models to periodic technology shocks. Figure

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[1] The data used are US (1960:1 – 1988:4) real output (GDP), real total consumption and real business fixed investment (total fixed investment minus residential investment) filtered by the band-pass filter (Baxter and King, 1995) at the frequency interval of 6 to 40 quarters per cycle with 12 truncation points at each end of a time series.

[2] Through out the paper, the model statistics reported are always based on filtered simulated time series by the band-pass filter (see footnote 1). More specifically, I generate time series from a theoretical model with length of 146 quarters (the US sample size). I pass each series through the band-pass filter to isolate the business cycle components, and then compute the cross correlations. The numbers shown in tables1-3 are the mean and standard errors of these cross correlations based on 500 repeated simulations.

1, for example, clearly indicates that consumption in the KPR model lags output.[3]

The reasons for such discrepancy between the data and standard models are simple. The motive for consumption smoothing in a utility based optimization model implies that consumption comove with the capital stock (permanent income). At the same time, output and investment comove with transitory income (technology shocks). The capital stock, however, strongly lags investment because it is a weighted sum of past investment:[4]

$$\begin{aligned} k_t &= (1-\delta)k_{t-1} + i_{t-1} \\ &= i_{t-1} + (1-\delta)i_{t-2} + (1-\delta)^2 i_{t-3} + ... \end{aligned}$$

Consequently, consumption lags both output and investment in standard models.

If the permanent income theory of consumption is correct, it is then puzzling why we observe consumption leading the business cycle in data and lagging the business cycle in RBC models. It is tempting to think that sluggish investment adjustment may hold the key for explaining the puzzle. The idea is that if investment responds to technology shocks with a lag, it would then surely appear to lag output. This, however, does not necessarily render consumption to lead output.

The intuition is that when investment is slow to respond to technology shocks, consumption would be forced to absorb the impact of shocks. Although this helps to break the link between consumption and the capital stock at the impact period (namely, to prevent consumption from complete smoothing), it is not sufficient to resolve the puzzle because consumption would then appear to comove with output, rather than to lead output.

Another tempting explanation is that the business cycle maybe actually driven by demand shocks (i.e., shocks that affect preferences) rather than by technology. It is well known, however, that taste shocks in standard general equilibrium models generate counter-cyclical investment due to the "crowding out" effect. In order for taste shocks to play a primary role in explaining the business cycle in the general

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[3] Since the model driven by conventional $AR(1)$ shocks cannot generate periodic movements to fully reveal the complete phase of a cycle, it makes sense to use periodic technology shocks to drive the model.

[4] The linear filter,

$$f(L) = 1 + (1-\delta)L + (1-\delta)^2 L^2 + ... = \frac{1}{(1-(1-\delta)L)},$$

is a backward phase shifter. E.g., see Harvey (1993) on the phase effect of linear filters.

equilibrium framework, features that can mitigate the crowding-out problem must also be incorporated.

It turns out that an multiplier-accelerator like endogenous propagation mechanism is the most essential to explain the lead-lag pattern of the business cycle. It is well known that output in the US economy has a hump-shaped impulse response pattern and that standard RBC models lack the propagation mechanism to generate that pattern (Cogley and Nason, 1995). Suppose that a model can generate hump-shaped dynamic responses for output, then output would appear to lag consumption provided that consumption's responses are monotonic or less hump-shaped. In order for consumption's responses not to be as hump-shaped as those of output, however, one needs shocks that can hit directly on consumption so as to trigger maximum consumption responses at the impact period. This suggests that demand shocks such as shocks to preferences are good candidates for such effects.

In the next section, I demonstrate my intuition by a general equilibrium model with an endogenous propagation mechanism. The model is the same as that used by Wen (1998) and by Benhabib and Wen (2000). In the model, variable capacity utilization and mild externalities in the production technology are allowed for. This gives rise not only to an "excessive" aggregate capacity that permits consumption demand shocks to boost investment with little "crowding out" effect, but also to an endogenous propagation mechanism that can generate hump-shaped dynamic responses for output and investment. I show that when the shocks are from consumers' preferences, the impulse responses of consumption are monotonic, hence the model can succeed in generating consumption that appears to lead output in each cycle.

Although the sources of shocks in the model are only from the demand side, the model is able to explain other stylized business cycle facts that are viewed as the defining features of the business cycle in the RBC literature, such as the positive comovement among consumption, investment, employment, and output; and the relative volatility orders among these variables.[5]

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[5] These aspects of the model's successes have been discussed by Benhabib and Wen (2000).

3. The Model

A representative agent chooses sequences of consumption $\{c_t\}_{t=0}^{\infty}$, labor supply $\{n_t\}_{t=0}^{\infty}$, capacity utilization rate $\{e_t\}_{t=0}^{\infty}$, and capital stock $\{k_{t+1}\}_{t=0}^{\infty}$ to solve:

$$\max \ E_0 \sum_{t=0}^{\infty} \beta^t \left(\log(c_t - \Delta_t) - a \frac{n_t^{1+\gamma}}{1+\gamma} \right)$$

such that

$$c_t + k_{t+1} - (1 - \delta_t) k_t \leq X_t \left(e_t k_t \right)^{\alpha} n_t^{(1-\alpha)}, \tag{3.1}$$

where Δ_t is a random variable representing taste shocks, and X_t in the production function is a measure of production externalities and is defined as the average output in the economy according to:[6]

$$X_t = \left[(e_t k_t)^{\alpha} n_t^{1-\alpha} \right]^{\eta}, \quad \eta \geq 0. \tag{3.2}$$

To have interior solutions for the rate of capacity utilization $e \in [0, 1]$ in the steady state, we follow Greenwood *et al.* (1988) by assuming that the capital stock depreciates faster when being used more intensively:

$$\delta_t = \frac{1}{\theta} e_t^{\theta}, \quad \theta > 1; \tag{3.3}$$

which imposes a convex cost structure on capital utilization.

The first order conditions are given by

$$a n_t^{\gamma} = (1 - \alpha) X_t \left(e_t k_t \right)^{\alpha} n_t^{-\alpha}, \tag{3.4}$$

$$e_t^{\theta - 1} k_t = \alpha X_t e_t^{\alpha - 1} k_t^{\alpha} n_t^{1-\alpha}, \tag{3.5}$$

$$\frac{1}{c_t - \Delta_t} = \beta E_t \frac{1}{c_{t+1} - \Delta_{t+1}} \left[\alpha X_{t+1} e_{t+1}^{\alpha} k_{t+1}^{\alpha - 1} n_{t+1}^{1-\alpha} + 1 - \frac{1}{\theta} e_{t+1}^{\theta} \right], \tag{3.6}$$

$$c_t + k_{t+1} - (1 - \frac{1}{\theta} e_t^{\theta}) k_t = X_t \left(e_t k_t \right)^{\alpha} n_t^{(1-\alpha)}; \tag{3.7}$$

where the first equation indicates equilibrium in the labor market, the second equation indicates optimal utilization rate for capital at the margins, the third equation

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[6] See Baxter and King (1990).

is the standard intertemporal Euler equation for consumption and savings, and the last equation is the resource constraint. The exogenous shocks are specified as a stationary $AR(1)$ process in log:

$$\log \Delta_t = \rho_\Delta \log \Delta_{t-1} + \varepsilon_{\Delta t}. \tag{3.8}$$

4. Calibrated Analyses

The model is solved by log-linearization around the steady state. Benhabib and Wen (2000) show that the model generates hump-shaped impulse response functions for output when the externality parameter η is large enough to render the steady state a sink (indeterminate). Here we calibrate the model's parameters so that the steady state is a sink. More specifically, we set the capital's share $\alpha = 0.3$, the labor supply elasticity parameter $\gamma = 0$, the discount factor $\beta = 0.993$, the steady state ratio $\frac{\Delta}{c} = 0.1$. The depreciation parameter θ is chosen so that the steady stare rate of capital depreciation is 10% per year, and the externality parameter η is set to 0.11. To resolve indeterminacy, we set the initial investment level i_0 to its steady state value.[7]

Figure 2 shows the impulse responses of consumption and output to a taste shock ($\rho_\Delta = 0.9$). It indicates that consumption returns back to the steady state monotonically after the shock while output follows a hump-shaped path in converging back to the steady state. This suggests that if the economy is constantly disturbed by taste shocks, then consumption will appear to lead the business cycle. The cross correlations at various leads and lags at the business cycle frequency are reported in table 3. It shows that under taste shocks consumption leads output by $1-2$ quarters and investment lags output by 2 quarters.

Incidently, if technology shocks are permanent, then they can also produce consumption that leads output and investment in the capacity utilization model. This is so because when technology shocks are permanent, the maximum impact is absorbed by consumption, rendering consumption rise monotonically to a higher steady state. The response of output, however, remains hump-shaped in converging to a new steady state, thanks to the propagation mechanism under capacity utilization and externalities. Consequently, consumption appears to lead output (see table 3).

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[7] See Wen (1998) and Benhabib and Wen (2000) for more detailed calibrations.

Finally, to check that the model is able to explain also the stylized second moments of the US data often reported in the RBC literature, table 4 shows that the model does well along those dimensions.[8] In particular, it can match the relative volatilities of the US data well even in the case of taste shocks. This is amazing given that taste shocks can generate consumption that can be excessively more volatile than output. This does not happen in the model because production externalities render the real wage very smooth relative to employment. Since consumption comove with the real wage, it is smoother than output as well.

5. Caveats

There are two important caveats to my analyses. First of all, my analyses do not imply that the model studied in the paper is the only type of models that is capable of resolving the lead-lag puzzle. In fact, any model that can generate hump-shaped responses for output has the potential to resolve the puzzle, provided that the nature of shocks is such that they can exercise maximum impact on consumption so as to prevent consumption from mimic closely the cyclical movement of the capital stock (remember that the capital stock lags investment and output in general equilibrium models).

The second caveat is that aggregated investment in practice is often defined as the sum of residential investment and non-residential investment. The aggregate investment so defined does not lag output but appears to coincide with consumption instead. This is so, however, purely because residential investment strongly leads output. There is no inconsistence if business fixed investment is used as the measure. The intriguing question, however, is why residential investment leads the business cycle? I think the answer lies in that residential houses are essentially durable consumption goods, not capital goods. Hence, the question is akin to the puzzle addressed in the paper.

6. Conclusion

Conventional wisdom may be well-positioned in arguing that demand shocks are the primary cause of the business cycle (e.g., see Blanchard, 1993, and Cochrane,

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[8] The point that demand shocks can explain many standard features of the business cycle in a model with capacity utilization and externalities has been forcefully documented recently by Benhabib and Wen (2000).

1994). However, as the above analyses also showed, it is not so much the sources of the impulse as the fundamental propagation mechanism where the crux lies – for without the endogenous propagation mechanism that generates hump-shaped dynamic responses for output, neither supply nor demand shocks can generate the correct lead-lag patterns for consumption to match the US data.

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Table 1. Correlations with y_t at Business-cycle Frequency

(U.S. Sample)

	$t+4$	$t+3$	$t+2$	$t+1$	t	$t-1$	$t-2$	$t-3$	$t-4$
$c_{t\pm j}$	.005	.273	.539	.760	.900	.934	.861	.698	.477
$i_{t\pm j}$	.537	.755	.888	.913	.823	.633	.340	.107	$-.143$

Table 2. Correlations with y_t at Business Cycle Frequency

(Standard errors in brackets)

A. KPR Model

	$t+4$	$t+3$	$t+2$	$t+1$	t	$t-1$	$t-2$	$t-3$	$t-4$
$c_{t\pm j}$	.551	.706	.829	.861	.759	.526	.226	$-.061$	$-.274$
	(.038)	(.019)	(.005)	(.002)	(.001)	(.001)	(.008)	(.020)	(.027)
$i_{t\pm j}$	$-.032$	.238	.566	.851	.989	.926	.701	.411	.154
	(.042)	(.032)	(.012)	(.001)	(.000)	(.001)	(.013)	(.038)	(.056)

B. Time-to-build Model

	$t+4$	$t+3$	$t+2$	$t+1$	t	$t-1$	$t-2$	$t-3$	$t-4$
$c_{t\pm j}$	.411	.578	.755	.877	.874	.710	.427	.107	$-.161$
	(.054)	(.035)	(.013)	(.002)	(.001)	(.0005)	(.003)	(.015)	(.025)
$i_{t\pm j}$	$-.009$	.267	.595	.871	.993	.912	.675	.382	.131
	(.042)	(.030)	(.010)	(.001)	(.000)	(.001)	(.015)	(.039)	(.055)

Table 3. Correlations with y_t at Business Cycle Frequency

A. Taste Shock ($\rho_\Delta = 0.9$)

	$t+4$	$t+3$	$t+2$	$t+1$	t	$t-1$	$t-2$	$t-3$	$t-4$
$c_{t\pm j}$	$-.192$	$-.060$	.126	.333	.510	.613	.634	.593	.513
	(.098)	(.072)	(.038)	(.015)	(.009)	(.010)	(.011)	(.015)	(.022)
$i_{t\pm j}$	.843	.925	.967	.963	.916	.829	.724	.613	.503
	(.002)	(.001)	(.001)	(.001)	(.006)	(.021)	(.045)	(.074)	(.101)

B. Permanent Technology Shock

	$t+4$	$t+3$	$t+2$	$t+1$	t	$t-1$	$t-2$	$t-3$	$t-4$
$c_{t\pm j}$	$-.069$	.070	.253	.443	.593	.662	.653	.591	.511
	(.105)	(.072)	(.038)	(.017)	(.012)	(.011)	(.010)	(.014)	(.022)
$i_{t\pm j}$	.864	.924	.950	.937	.891	.810	.717	.622	.529
	(.003)	(.002)	(.001)	(.003)	(.012)	(.031)	(.057)	(.084)	(.108)

Table 4. Conventional Moments

σ_c/σ_y	σ_i/σ_y	σ_n/σ_y	$corr(c,y)$	$corr(i,y)$	$corr(n,y)$
US Economy (1960:1 - 1996:3)					
0.65	4.01	1.07	0.91	0.89	0.85
Model (Taste Shock)					
0.27	3.85	0.95	0.56	0.98	0.99

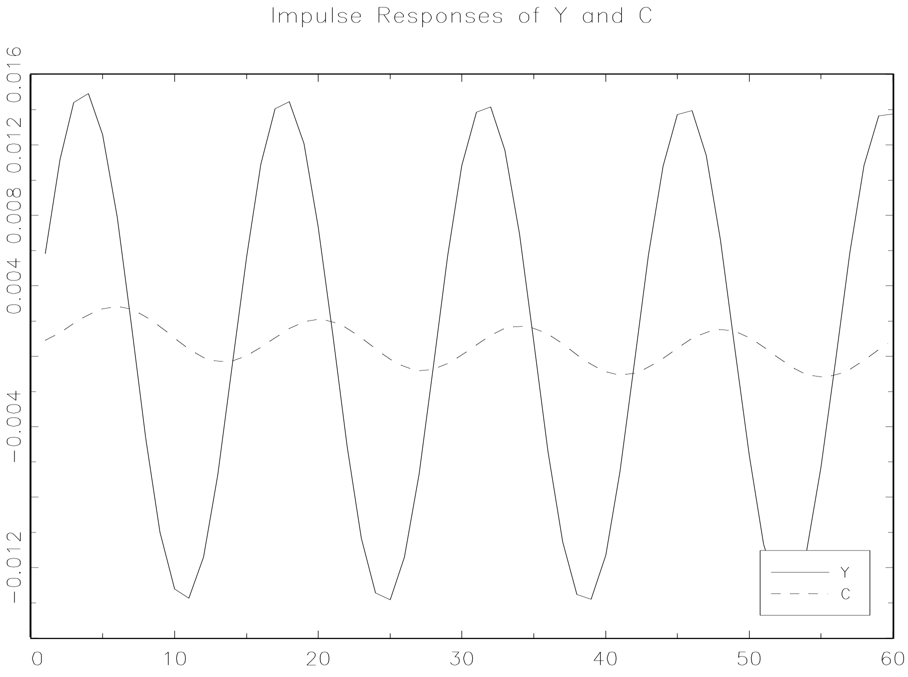

Figure 1. Cyclical Movement of Consumption and Output in the KPR Model.

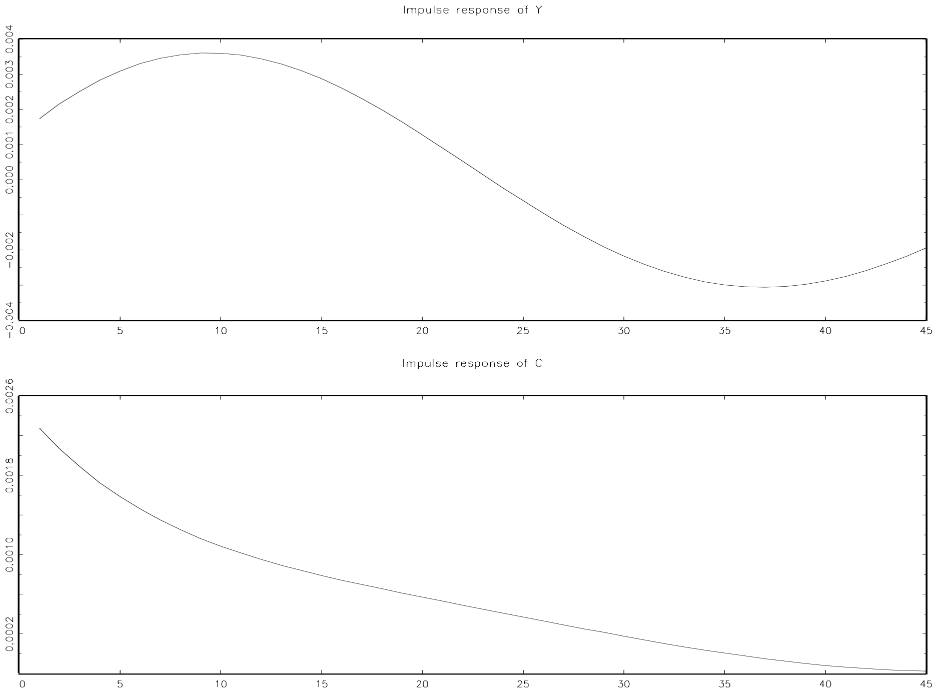

Figure 2. Impulse Responses of Consumption and Output under Taste Shocks.