Journal of Applied Economics, Vol. VI, No. 2 (Nov 2003), 247-253

A NOTE ON BUSINESS CYCLE NON-LINEARITY IN U.S. CONSUMPTION

STEVEN COOK[*]
University of Wales Swansea

Submitted June 2000; accepted November 2001

The recently examined durability-asymmetry hypothesis of Cook (1999) is re-evaluated using the diagnostic tests of time deformation proposed by Stock (1987, 1988). An application of these tests to disaggregated data on U.S. consumers' expenditure provides further support for this hypothesis, with the findings given an economic interpretation in terms of variables evolving at differing speeds over different phases of the business cycle. Additionally, building upon the studies of Cover (1992), Karras (1996) and Rhee and Rich (1995), recent research by Arden *et al*. (2000) has shown the relaxation of the assumptions of linearity and symmetry typically employed in macroeconometric models to result in monetary policy having clear asymmetric effects on the economy. In particular it was shown that expansionary monetary policy as given by a reduction in the interest rate, has greater effects than contractionary policy (an increase in the interest rate), and that this becomes more apparent when the economy is in recovery rather than recession. The finding of non-linearity in U.S. consumption therefore has major implications for econometric modelling and policy analysis.

JEL classification codes: C12; E32
Key words: time deformation; asymmetry; non-linearity; consumers' expenditure

I. Introduction

In recent research Cook (1999) has explored the possibility of a positive

[*] I am extremely grateful to an anonymous referee, the co-editor Mariana Conte Grand and the editorial board for helpful comments which have improved the presentation of the paper. However, the usual disclaimer applies. Correspondence should be addressed to Steven Cook, University of Wales Swansea, Singleton Park, Swansea SA2 8PP, WALES, Tel: 44(0)1792 295168, Tel: 44(0)1792 295872, Email: s.cook@swan.ac.uk.

relationship between the durability of a good and the asymmetric, or non-linear, behaviour it exhibits. The theoretical motivation for the durability-asymmetry hypothesis was twofold. First, the analysis of Caballero (1993) had explained the behaviour of expenditure on consumer durables using a transactions cost model. In Caballero's model, expenditure on durables only returns to the time path suggested by the permanent income hypothesis when upper or lower trigger points are reached. It was argued by Cook (1999) that when the trigger points are distributed asymmetrically about the permanent income path, asymmetric behaviour will be exhibited. Second, as durable goods provide a stream of utility over time, it was argued that expenditure on durable goods is more closely related to the literature on investment rather than standard consumption theory. The analogy with investment supports the durability-asymmetry hypothesis as the 'option value of waiting' literature of Dixit (1992) and the endogenous delay model of Gale (1996) generate clear asymmetries in investment behaviour. To evaluate this hypothesis Sichel's (1993) tests of univariate business cycle asymmetry were applied to data on U.S. durable and non-durable consumers' expenditure. With significant asymmetry being found in durable goods alone, it was concluded that supportive evidence for the durability-asymmetry hypothesis had been derived.

The intention of this note is to re-evaluate the durability-asymmetry hypothesis using an alternative, recently proposed test. The test to be applied is the diagnostic test of time deformation due to Stock (1987,1988). Stock's time deformation tests are highly informative, allowing the hypothesis of economic variables evolving at different speeds during different phases of the business cycle to be tested.Via an application to the original data of Cook (1999) it will be seen that further supportive evidence for the durability-asymmetry hypothesis is provided.

An additional reason for interest in asymmetries and non-linearities is provided by the recent research of Arden *et al*. (2000). Following the work of Cover (1992), where positive and negative monetary shocks are shown to have differing effects on output in the US, a number of further studies have emerged also allowing the possibility of asymmetric effects within reduced form models. Examples of these include Karras (1996) for OECD economies, and Rhee and Rich (1995) also for the US. However, the research of Arden *et al*. (2000) extends this literature by incorporating asymmetries within structural

models. It is shown that the relaxation of the assumptions of linearity and symmetry typically employed in macroeconometric specifications leads to monetary policy having clear asymmetric effects. More precisely, it was found that the presence of non-linearities and asymmetries resulted in monetary policy having different effects depending upon (*i*) the sign of the monetary shock (expansionary or contractionary) and (*ii*) the phase of the business cycle the economy was in at the time of the shock (recovery or recession). In particular it was seen that the effects of expansionary monetary policy in the form of interest rate cuts are greater than those of contractionary monetary policy (increase interest rates). It was further found that the effects of expansionary monetary policy are greater when the economy is in recovery than when it is in recession. The discovery of asymmetry or non-linearity in consumers' expenditure therefore has major implications for both econometric modelling and policy analysis.

To achieve its objective this note will proceed as follows. In the following section the notion of time deformation and diagnostic tests for its presence will be outlined. Section III will present the results of the application of this test to data on U.S. consumer durables and non-durables, with section IV concluding.

II. Time Deformation

Stock (1987) introduces the notion of time deformation models which are based upon the distinction between an economic, or operational, time scale (s) within which variables evolve, and the calendar time scale from which observations are drawn (t). A continuous latent process evolving in economic time, $\xi(s)$, is then related to the observation of this process in calendar time by $s = g(t)$. A variable of interest, x_t, observed at discrete points in calendar time can then be related to the latent process by:

$$x_t = \xi\,(g(t)) \tag{1}$$

Despite the novelty of the above framework, the use of alternative time scales does have a precursor in the phase averaging procedures employed at the National Bureau of Economic Research. The use of phase averaging,

where data are averaged across different phases of the business cycle, has a long history with Burns and Mitchell (1946) and Friedman and Schwartz (1982) being early and more recent applications of this approach. In contrast to phase averaging, the two forms of time scale transformation considered here are based upon the use of Neftci's (1984) switching, or indicator, variable. The first form, cyclical expansion/contraction, relates to changes in the variable of interest. For cyclical expansion-contraction the relevant indicator variable, z_t, is defined as:

$$z_t = \begin{cases} 1 & if \quad \Delta x_t \geq 0 \\ \\ 0 & if \quad \Delta x_t < 0 \end{cases} \tag{2}$$

where x_t in this instance represents each of the consumption series in turn. The second form of time scale transformation, cyclical growth expansion/ contraction, relates to changes in the variable of interest in relation to its average rate of change. For cyclical growth expansion/contraction the relevant indicator variable, z^*_t, is defined as:

$$z^*_t = \begin{cases} 1 & if \quad \Delta x_t \geq \overline{\Delta x} \\ \\ 0 & if \quad \Delta x_t < \overline{\Delta x} \end{cases} \tag{3}$$

These forms of time deformation therefore consider asymmetry or non-linearity arising due to different speeds of evolution during recessionary and recovery periods. For cyclical expansion/contraction, the possibility of differing behaviour is permitted when the variable of interest is either increasing or decreasing over the business cycle. For growth expansion/ contraction, the differing behaviour is permitted depending upon whether current growth is above or below a long-run average growth rate.

Despite the computationally demanding nature of the estimation of time deformation models (see Stock, 1988), it is relatively straightforward to implement diagnostic tests for the presence of time deformation. When the variables of interest possess stochastic trends, Stock (1987) proposes the use of the following models:

$$\Delta x_t = \mu + \lambda\, \Delta x_{t-1} + \sum_{i=1}^{\tau} \alpha_i \left(z_{t-i} - \overline{z} \right) + \sum_{i=1}^{\tau} \beta_i \left(z_{t-i} - \overline{z} \right) \Delta x_{t-i} + \varepsilon_t \qquad (4)$$

$$\Delta x_t = \mu^* + \lambda^* \Delta x_{t-1} + \sum_{i=1}^{\tau} \alpha_i^* \left(z_{t-i}^* - \overline{z^*} \right) + \sum_{i=1}^{\tau} \beta_i^* \left(z_{t-i}^* - \overline{z^*} \right) \Delta x_{t-i} + \varepsilon_t^* \qquad (5)$$

with the presence of time deformation examined via significance testing of the coefficients (α_i, β_i) and (α^*_i, β^*_i). The relevant null hypotheses, H_0: $\alpha_i = \beta_i = 0$ in (4) and H^*_0: $\alpha^*_i = \beta^*_i = 0$ in (5), are that time deformation is not present.

III. Results

The data used in this note are the same seasonally adjusted, quarterly observations in 1992 dollars from 1959(1) to 1998(1) of U.S. consumers' expenditure on durables and non-durables employed by Cook (1999).[1] The notation *cd* and *cnd* will therefore represent the natural logarithms of the durables and non-durables series respectively. Before presenting the results of testing for time deformation, it was noted in the previous section that regressions of the form of (4) and (5) are appropriate when the variables under analysis have stochastic trends. Application of fifth order Augmented Dickey-Fuller tests confirmed the findings of Cook (1999) that both *cd* and *cnd* are I(1) processes.[2]

The results obtained from applying the models (4) and (5) to the consumption data are given in Table 1. Reported in this table are the asymptotic marginal significance levels (p-values) for the F-tests of the significance of the cyclical expansion/contraction coefficients (α_i, β_i) and the cyclical growth expansion/contraction coefficients (α^*_i, β^*_i). Given that the data used are quarterly, two alternative lag lengths of one and four periods (τ = 1, 4) were chosen for the functions of the switching variables z_t and z^*_t. The results show that time deformation of the cyclical expansion/contraction form is present for durables using both lag lengths, with the results for the longer lag length being highly significant. This is the only evidence of time deformation, as durables do not exhibit time deformation of the cyclical growth form and non-durables display no evidence of time deformation of either form.

[1] Datastream codes USCNDURBD and USCNNONDD.

[2] Application of these unit root tests replicated the results reported in Cook (1999).

Table 1. Time Deformation Tests

	Asymptotic marginal significance levels			
	z_t		z^*_t	
	$\tau = 1$	$\tau = 4$	$\tau = 1$	$\tau = 4$
cd_t	0.0263*	0.0078**	0.2801	0.1763
cnd_t	0.9241	0.0714	0.3351	0.5263

Notes: * denotes significance at the 5% level. ** denotes significance at the 1% level.

Therefore with positive results found for durables alone, the durability-asymmetry hypothesis is re-confirmed and given an interpretation in terms of variables evolving at different speeds during recessionary and recovery periods.

IV. Conclusion

In this note the recently proposed positive relationship between the durability of consumer goods and the asymmetric behaviour they exhibit has been re-evaluated. In contrast to the previous study which applied the tests of business cycle asymmetry proposed by Sichel (1993), diagnostic tests of time deformation have been employed as they are more informative of the source of any asymmetry detected. In an application to U.S. consumers' expenditure on durables and non-durables, previous findings of excessive asymmetry in durables have been supported, and in doing so an interpretation has been provided for them in terms of variables evolving at differing speeds during recessionary and recovery periods. Recent studies such as Arden *et al*. (2000), Cover (1992), Karras (1996) and Rhee and Rich (1995) have shown asymmetries to have a major impact on the influence of economic policy. In particular, Arden *et al*. (2000) shows that the relaxation of the symmetry and linearity assumptions typically imposed in macroeconometric specifications leads to clear asymmetries in the effects of monetary policy, both in terms of the sign of the shock (positive or negative) and the phase of the business cycle at the time of the shock (recovery or recession). In light of these studies, the present findings of asymmetry and non-linearity have major implications for both econometric modelling and policy analysis.

References

Arden, R., Cook, S., Holly, S. and P. Turner (2000), "The Asymmetric Effects of Monetary Policy: Some Results from a Macroeconometric Model," *The Manchester School* **68**: 419-441.

Burns, A.F. and W.C. Mitchell (1946), *Measuring Business Cycles*, New York, National Bureau of Economic Research.

Caballero, R.J. (1993), "Durable Goods: An Explanation for their Slow Adjustment," *Journal of Political Economy* **101**: 351-384.

Cook, S. (1999), "Cyclicality and Durability: Evidence from U.S. Consumers' Expenditure," *Journal of Applied Economics* **2**: 299-310.

Cover, J. (1992), "Asymmetric Effects of Positive and Negative Money Supply Shocks," *Quarterly Journal of Economics* **107**: 1261-1282.

Dixit, A. (1992), "Investment and Hysteresis," *Journal of Economic Perspectives* **6**: 107-132.

Friedman, M. and A.J. Schwartz (1982), *Monetary Trends in the United States and United Kingdom: Their Relation to Income Prices and Interest Rates, 1867-1975*, Chicago, University of Chicago Press.

Gale, D. (1996), "Delay and Cycles," *Review of Economic Studies* **63**: 169-98.

Karras, G. (1996), "Are the Output Effects of Monetary Policy Asymmetric?," *Oxford Bulletin of Economics and Statistics* **58**: 267-278.

Neftci, S.N. (1984), "Are Economic Series Asymmetric over the Business Cycle?," *Journal of Political Economy* **92**: 307-328.

Rhee, W. and R. Rich (1995), "Inflation and the Asymmetric Effects of Money on Output Fluctuations," *Journal of Macroeconomics* **17**, 683-702.

Sichel, D. (1993), "Business Cycle Asymmetry: A Deeper Look," *Economic Inquiry* **31**: 224-236.

Stock, J.H. (1987), "Measuring Business Cycle Time," *Journal of Political Economy* **95**: 1240-61.

Stock, J.H. (1988), "Estimating Continuous Time Processes Subject to Time Deformation: An Application to Post-War GNP," *Journal of the American Statistical Association* **83**: 77-85.