Tests of Price Sluggishness in the U.K.

Authors	K. Alec Chrystal, and Daniel L. Thornton
Working Paper Number	1984-019A
Creation Date	January 1984
Citable Link	https://doi.org/10.20955/wp.1984.019
Suggested Citation	Chrystal, K.A., Thornton, D.L., 1984; Tests of Price Sluggishness in the U.K., Federal Reserve Bank of St. Louis Working Paper 1984-019. URL https://doi.org/10.20955/wp.1984.019

Tests of Price Sluggishness in the U.K.

K. Alec Chrystal and Daniel L. Thornton
Federal Reserve Bank of St. Louis

84-019

In a paper published in the Economic Journal in September 1983, Alogoskoufis and Pissarides (AP) claim to be able to differentiate between "lags due to partial adjustments in the monetary sector, combined with continuous market clearing, and lags due (in addition) to sluggish price adjustment." We question this claim. In particular, we shall argue that there are theoretical problems with the framework they use and that the data cannot sustain their conclusions even if one accepts their framework.

Background

The issue seemingly at stake here is an important one. Indeed, it is a question that divides new classical equilibrium business cycle theory from its Keynesian or, indeed, monetarist precursors: can business cycles be modelled in a market clearing framework? Both sides admit that output and prices move in a cyclical way and, therefore, are autocorrelated (see, for example, Lucas 1977). Keynesians think of prices as sticky. New classical economists prefer to think of anything but prices as sticky--lagged information, irreversible lumpy investments, time taken in production. Both approaches can lead to difference equations in both output and prices that are consistent with the historical data. In this sense, they are observationally equivalent (Sargent 1976). This is important because it means that the evidence on the autocorrelation of prices (price sluggishness, as AP call it) alone is not sufficient for discriminating between these approaches to business cycle modelling.

This much is clearly understood by AP. However, they claim to be able to test for different 'sources of lags' without explaining clearly how their test overcomes the observational equivalence problem. Our conjecture is that they are really testing for the functional form which best captures the existence of such lags rather than identifying the sources of the lags themselves. This is not to say that the exercise is unimportant. The only danger is to claim discrimination which the data cannot, in principle, provide. Having raised this general caveat, however, we wish to address the substance of our comments to the AP model and its estimation.

The question at issue can be agreed to be the appropriate specification of the money demand/price level dynamics in a simple macro business cycle model. Money demand adjustment is important in reconciling output dynamics with price level dynamics for whatever approach to business cycles is being used. Slow adjustment of money demand could be sufficient to transform white noise shocks into autocorrelated price/output series, though it is not necessary.

Money Demand and Price Level Adjustment

The AP model consists of the following equations:

$$m_t^o - p_t^o = \alpha_0 + \alpha_1 y_t^d + \alpha_2 r_t + v_t = f(y_t^d, r_t, \alpha, v_t) \tag{1}$$

$$y_t^s = \beta_0 + \beta_1 T + \beta_2 y_{t-1} + \sum_{i=0}^{2} \beta_{3+i} \varepsilon_{t-i} + u_t = g(z, \beta, u_t) \tag{2}$$

$$m_t - p'_t = \mu(m^o_t - p^o_t) + (1-\mu)\ (m_{t-1} - p_{t-1}) \qquad (3)$$

$$p_t = \lambda\ p'_t + (1-\lambda)\ p_{t-1} \qquad (4)$$

$$y^s_t = y^d_t \qquad (5)$$

Where y is the log of real output, m is the log of sterling M3, r is the nominal interest rate, p is the log of the price level, ε is the unanticipated growth in m, T is a time trend and v and u are white noise errors.

Combining equations (1) - (5), results in

$$p_t = \lambda\mu f(g(z_t, \beta, u_t), r_t, \alpha, v_t) - \lambda(1-\mu)(m_{t-1} - p_{t-1}) + \lambda m_t + (1-\lambda)p_{t-1} \qquad (6)$$

The above system is unusual in that there are three prices; the long-run equilibrium price level, p^o, the actual price level, p, and the "market clearing" price level, p'. We do not understand the need for this confusing formulation.

Consider the following alternative specification which gives three standard models as special cases and which, in its unconstrained form, is observationally equivalent to the AP model.

$$m^*_t - p^e_t = f(y^d, r_t, \alpha, v_t) \qquad (1')$$

$$m_t = \mu m^*_t + (1-\mu)m_{t-1} \qquad (3')$$

$$p_t = \lambda p^e_t + (1-\lambda)p_{t-1}, \qquad (4')$$

plus equations (2) and (5). Equation (1') makes the demand for nominal money, m^*_t, given the expected level of prices, p^e_t, equal the demand for real money balance. This equation explicitly recognizes that an individual's demand for real money is made operational through their demand for nominal money, given expectations of the price level. Equations (3') and (4') assume that nominal money and prices, respectively, follow partial adjustment processes. Equation (3') suggests that the nominal stock is accommodative to the demand for nominal money balances.

The price adjustment equation has a similar interpretation. The price level adjusts, in aggregate, to the difference between the actual and expected price level. If the price level that individuals expect differs from the preceding price level, then individuals attempt to adjust their nominal money holdings accordingly to satisfy their demand for real-balances given their expectations of price. This will result in a change in the price level even if there is no accommodation in the nominal money stock, i.e., $\mu=1$. An alternative interpretation of P_t^e in (1') and (4'), more in line with AP, is as the equilibrium price level. Notice, however, that this formulation requires only one notional price and one actual or observed price. The interpretation of (4') as adaptive expectations is, of course, inconsistent with rational expectations. It is, nonetheless, instructive to notice the functional equivalence of different approaches.

This model incorporates three common specifications as special cases. If $\lambda=\mu$, the result is the real adjustment model of Chow (1966). If $\lambda=1$, one obtains the nominal adjustment model of Goldfeld (1973, 1976). If $\mu=1$, the result is the price adjustment model of Walters (1967).

The other major difference between our formulation and AP's is in the demand for money adjustment. The real money adjustment, equation (3), is replaced with a nominal money adjustment, equation (3'). Our reason for making this change is important for interpretation of results. In the AP formulation, if money is exogenous, the parameter μ can only reflect the adjustment speed of prices (See Laidler, 1982, for discussion of this point). However, λ is the price adjustment speed. In our formulation μ is the adjustment speed of nominal money, which reflects the supply behaviour of the authorities and not the adjustment by actors of their portfolios.

It is true that AP have a money supply equation in their paper, however, this is entirely separable from the model and it in no way determines the adjustment speed of money. Rather it is used to forecast on the basis of information available no later than t-1 what the predetermined money stock will be in t. Indeed it is hard to reconcile contemporaneous nominal money supply adjustment with the 'surprise' supply curve, equation (2). There are two problems here. First, the contemporaneous innovations ('surprises') in the money supply are endogenous. So the aggregate supply curve is misspecified. Second, both m_t and p_t are endogenous in (6) so it is not a genuine reduced form and the choice of which variable to treat as the dependent variable is arbitrary.

As we shall see this issue of direction of normalization is crucial to the results. Reversal of normalization reverses the conclusion about adjustment speeds. It is also of economic importance. The bulk of the data period covers a regime of fixed exchange rates which suggests treating prices as exogenous and money as endogenous. The period of floating rates suggests the reverse.

We shall now show the problems associated with the implementation of both the AP model and our proposed alternative. These result from combining (1)-(5) or (1'),(2),(3'),(4') and (5). Estimates of these equations by OLS normalized on both m_t and p_t are given in table 1.[1/] The observational equivalence is clear from the OLS estimates. (This, of course, is not surprising since if any two of real money, prices or nominal money are allowed to adjust, then the complete adjustment process must be captured). Thus, these models cannot be distinguished from one another on statistical grounds in this form.

Each of the equations, however, is over-identified in the sense that there are more reduced form parameters than structural parameters. When these over-identifying restrictions are incorporated, the resulting equations can be differentiated. Estimates of the restricted equations are presented in table 2. The χ^2 statistics in table 2 are likelihood ratio tests of the over-identifying restrictions.[2/] These restrictions are rejected by the data in all four cases, suggesting that none of the equations is consistent with the data.[3/] The poor performance of these models is further evidenced by the fact that all four equations produced estimates of the adjustment parameters that are outside (in several cases, substantially outside) their theoretical limits.[4/]

In addition we tested the restrictions that $\mu=1$ and $\lambda=1$. The case where $\mu=1$ turned out to be the preferred formulation of AP (implying complete adjustment of real money balances within the year). The corresponding likelihood ratio statistics are presented in table 3.[5/] We find that when p_t is the left-hand-side variable, one cannot reject the hypothesis that $\mu=1$ in either model; however, when m_t is the left-hand-side variable the same hypothesis is easily rejected in both cases.[6/] The hypothesis $\lambda=1$ cannot be rejected where m_t is left-hand-side variable in our model, but in both AP equations and our price equation, it is soundly rejected. Thus, we see that the outcome of tests of price or money stock sluggishness are sensitive to both model specification <u>and</u> the normalization rule.

The problem of normalization arises from the fact that these models are "incomplete." They are not genuine reduced forms. They have a contemporaneous endogenous variable on the right-hand-side (m in p equation; p in the m equation). The direction of normalization is arbitrary and, unhappily, the estimates of the adjustment parameters depend entirely upon it.

Conclusion

Alogoskoufis and Pissarides have claimed to provide evidence of price level sluggishness in the UK which is allegedly inconsistent with a market clearing approach to business cycles. It is doubtful that their evidence could in principle discriminate between market- and non-market clearing approaches on the basis of evidence of price level autocorrelation. More seriously, their evidence is marred by both theoretical and empirical inconsistencies. Their specification of real money demand and price adjustment does not make sense. Estimates of their equations imply that at least one of the two adjustment speeds is outside its theoretical bound, and the over-identifying restrictions implied by their model are rejected by the data. Finally, estimates of the speed of adjustment parameters and tests of these parameters are highly sensitive to whether the price level or money is selected as the dependent variable. Where money is treated as exogenous prices do the adjusting. But where prices are treated as exogenous money does the adjusting.

We do not claim to have a superior model to theirs. Indeed we show that similar problems are likely to be associated with a wide range of available formulations. However, we would suggest that no policy conclusions should be drawn on the basis of models which are rejected by the data, or which have radically different alternative interpretations.

Footnotes

1/ The data set was provided to us by David Demery, to whom we express our thanks. It is very similar to that used by AP. We were able to replicate their results closely. Variable definitions are exactly as in AP: y is GDP at factor cost in 1975 prices, m is sterling M3, p is the GDP deflator, 1975=100, and r is the 3-month Treasury bill rate. The current account balance, b, also was used to generate money surprises as in AP, though we do not report those estimates. All variables are in logs except r. We included 2 extra observations in our reported estimates for 1981 and 1982. However, the AP results were unchanged in all major respects by this addition.

2/ The over-identifying restrictions were imposed in the following fashion. The last two nonstochastic terms of the equation normalized in m_t were written as $\mu[(1/\lambda)p_t - ((1-\lambda)/\lambda)p_{t-1}] = \mu p_t^*$. The variable p_t^* was then created for values of λ, $(0 < \lambda < 1)$, at intervals of .01 and each of the resulting equations was estimated with ordinary least squares. In this way, maximum likelihood estimates of the parameters were obtained.

3/ AP indicate that they tested the over-identifying restriction of their equation and could not reject it.

4/ The constrained estimates of these parameters in our model are inside their bounds only because we limited our search to $\lambda, \mu \leq .99$. See footnote 2 above.

5/ For computational convenience, the hypothesis tests of table 3 were carried out on the unrestricted form of our model. These tests, however were carried out in the restricted form of the AP model. This is a test only of the extra restriction since the over-identifying restrictions have already been rejected. Also, note that the restriction $\lambda=1$ in the AP model <u>not only</u> requires that p_{t-1} be omitted from the equation but that the coefficient on m_t equal one.

6/ It is interesting to note that if one imposes the restriction that $\mu=1$ on the equations which normalize on p_t, then one obtains estimates of λ which are significant and close to the estimates reported by AP (page 624). Nevertheless, tests of the over-identifying restrictions are still rejected on a model where $\mu=1$. Notice also that the point estimate of μ is 39.5 in the AP model and yet one cannot reject the restriction that $\mu=1$. It would appear that μ is not estimated with much precision.

References

Alogoskoufis, G. and C.A. Pissarides, "A Test of Price Sluggishness in the Simple Rational Expectations Model: U.K. 1950-1980" Economic Journal, 93 (September 1983) 616-28.

Chow, G.C. "On the Long-run and Short-run Demand for Money," Journal of Political Economy, 2, LXXIV, April 1966, pp. 111-131.

Goldfeld, S.M. "The Demand for Money Revisited," Brookings Papers on Economic Activity, 3, 1973, pp. 577-638.

______. "The Case of the Missing Money," Brookings Papers on Economic Activity, 3, 1976, pp. 683-730.

Laidler, D.E.W. Monetarist Perspectives Phillip Allan, Deddington; Harvard University Press, Cambridge, Mass. 1982.

Lucas, R.E. "Understanding Business Cycles," Carnegie-Rochester Series on Public Policy, Volume 5 eds. K. Brunner and A.H. Meltzer, supplement to Journal of Monetary Economics 1977, 7-29.

Sargent, T.J. "The Observational Equivalence of Natural and Unnatural Rate Theories of Macroeconomics," Journal of Political Economy, 84, June 1976, 631-40.

Walters, A.A. "The Demand for Money - The Dynamic Properties of the Multiplier," Journal of Political Economy, 75, 1967, pp. 293-298.

Table 1:

Independent Variables	Our model		AP model	
	m_t	p_t	p_t	m_t
m_t		.197 (1.01)	.197 (1.01)	
m_{t-1}	1.142* (11.44)	.055 (0.22)		
p_t	.244 (1.01)			.244 (1.01)
p_{t-1}	-.247 (1.43)	.665* (9.89)	.719* (3.21)	.896* (3.85)
$m_{t-1} - p_{t-1}$			.055 (0.22)	1.142* (11.44)
$\hat{\varepsilon}_t$	1.252* (5.84)	-.227 (0.73)	-.227 (0.73)	1.252* (5.84)
$\hat{\varepsilon}_{t-1}$	.869* (3.27)	-.725* (2.94)	-.725* (2.94)	.869* (3.27)
$\hat{\varepsilon}_{t-2}$	.278 (1.25)	-.347 (1.81)	-.347 (1.81)	.278 (1.25)
r_{t-1}	-.571 (1.41)	.524 (1.44)	.524 (1.44)	-.571 (1.41)
Trend x 10^{-2}	.796* (1.96)	.490 (1.28)	.490 (1.28)	-.796* (1.96)
Const.	-1.167* (2.06)	-1.193* (2.42)	-1.193* (2.42)	-1.167* (2.06)
$\bar{R}^2$	.999	.999	.999	.999
S.E.	.028	.025	.025	.028

Absolute values of t-statistics in parentheses.
*indicates significance at 5 percent level.

Table 2:

Independent Variables	Our model		AP model	
	m_t	p_t	p_t	m_t
m_t			.008	
			(0.05)	
m_{t-1}	1.200*			
	(11.20)			
p_t				.013
				(0.49)
p_{t-1}		.751*	.992*	.987*
		(14.03)	(5.68)	(3.62)
$m_{t-1} - p_{t-1}$			.308	1.159*
			(1.45)	(9.83)
$\hat{\epsilon}_t$	.911*	-.636	.180	.896*
	(4.32)	(0.40)	(0.79)	(4.21)
$\hat{\epsilon}_{t-1}$	.280	-.503*	-.416*	.368
	(1.25)	(2.77)	(2.22)	(1.49)
$\hat{\epsilon}_{t-2}$	-.123	-.108	-.159	-.112
	(0.58)	(0.63)	(0.94)	(0.52)
r_{t-1}	-.170	.389	.329	-.243
	(0.38)	(1.04)	(0.90)	(0.53)
Trend x 10^{-2}	.291	-.133	-.110	.273
	(1.19)	(0.65)	(0.55)	(1.11)
Const.	-1.109	-1.406*	-1.782*	-.876
	(1.85)	(4.68)	(4.567)	(1.32)
χ^2	12.150*	7.179*	4.377*	11.144*
$\bar{R}^2$	.998	.998	.998	.998
S.E.	.033	.027	.027	.034
λ	.990	.249	.008	76.723
μ	-.200	.990	39.500	-.159

Absolute value of t-statistics in parentheses.
*indicates significance at the 5 percent level.

Table 3: Chi-square Test Statistics

Our model	Null Hypothesis $\lambda=1$	$\mu=1$
m_t	2.808	61.134*
p_t	51.420*	.072
AP model		
p_t	27.004*	2.980
m_t	14.036*	49.990*

*significant at the 5 percent level.