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CHOICE OF MONETARY POLICY INSTRUMENTS IN A STOCHASTIC IS-LM MODEL: SOME EMPIRICAL REMARKS FOR THE NETHERLANDS

BY

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1 INTRODUCTION

In a seminal paper, Poole (1970) shows the choice of the monetary policy instrument in a stochastic IS-LM model to depend on the coefficients of the IS- and LM-curve and on the variances and covariance of the disturbances. Poole's analysis has been elaborated by *e.g.* Turnovski (1975) and, in the broader context of active discretionary monetary policy versus fixed growth rules, recently by Yoshikawa (1981). For a critical survey on monetary policy instruments and indicators see Friedman (1975).

An unfortunate aspect of the analysis of the instrument problem is that it does not lead to general statements and conclusions about which instrument to choose. The specification and the numerical parameter values of the model are of crucial importance. The problem is therefore mainly empirical.

This paper discusses the instrument problem, using empirical results on the IS-LM model for the Netherlands. The aim is to illustrate the sensitivity of the analysis for changes in specification of the model, and for changes in the value of a certain parameter when the others are held constant at realistic values. The study is restricted to the simple IS-LM model as investigated by Poole, and abstracts from the fact that the Netherlands is an open economy where under perfect capital mobility the scope for monetary policy may be dictated by the exchange rate regime (see *e.g.* Mundell (1963)). It also abstracts from the effects of estimation errors, or random variation in the coefficients of the model, and from the supposition that the policy regime may affect the specification of the model (see Revankar and Yoshino (1982)).

The estimates of the LM-curve are based on demand-for-money-studies, while the estimates of the IS-curve are drawn from Den Butter (1981). In

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view of the outcomes of these studies special attention is paid to the effects on the choice of the monetary policy instruments of

- the lag structure
- the incidence of so-called direct money transmission in the IS-curve.

2 THE FRAMEWORK

The equations of the IS-LM model are

$$\text{IS curve:} \quad Y = \alpha_0 + \alpha_1 R + \alpha_2 M + \alpha_3 Y_{-1} + \vec{\alpha}' \vec{ex}_Y + u \qquad (1)$$

$$\text{LM-curve:} \quad M = \beta_0 + \beta_1 R + \beta_2 Y + \beta_3 M_{-1} + \vec{\beta}' \vec{ex}_M + v \qquad (2)$$

where Y = real national income
M = real money stock (broadly defined)
R = nominal interest rate
$\vec{ex}_Y$ = exogenous explanatory variables in IS-curve
$\vec{ex}_M$ = exogenous explanatory variables in LM-curve
u, v = error terms where $Eu=Ev=0$, $Eu^2=\sigma_u^2$, $Ev^2=\sigma_v^2$ and $Euv/(\sigma_u\sigma_v) = \rho_{uv}$

The expected signs of the coefficients are $\alpha_1, \beta_1 < 0; \beta_2 > 0; \alpha_2, \alpha_3, \beta_3 \geqslant 0$. Both equations contain a Koyck-distributed lag allowing for partial adjustment of the actual value of the dependent variable to its desired or equilibrium value, with $(1-\alpha_3)$ and $(1-\beta_3)$ the fractions of adjustment per time unit. In the IS-curve the term $\alpha_2 M$ represents the effect of direct money transmission. In case $\alpha_2 = 0$ we have a IS-LM model where all monetary transmission takes place by way of the interest rate mechanism. The vector $\vec{ex}_Y$ includes price expectations with a coefficient equal to $-\alpha_1$ so that, in conformity with economic theory and Den Butter's (1981) specification, expenditure is determined by the real interest rate in the IS-curve.

Now suppose the authorities set a target level $\overline{Y}$ for the national income. They can either try to reach this target through an interest rate policy controlling R and letting the money stock be endogenously determined by the IS-LM model, or by means of a money stock policy, controlling the money supply and letting the interest rate be determined by the model. If the IS-LM model was not stochastic, *i.e.* if there were no error terms u and v, and if the authorities could control either R or M without any restrictions, the target could be perfectly met both by an interest rate and a money stock policy.

In a stochastic IS-LM model, however, the target will generally not be met. That instrument should be chosen by which the target can be approximated as closely as possible. We assume that the authorities seek to minimize the steady state variance about the target and hence choose

$$E(Y - \overline{Y})^2$$

as object function.

Following Turnovski (1975) let $\overline{R}$ and $\overline{M}$ be respectively the interest rate and money stock that correspond to the target or equilibrium level of income $\overline{Y}$. Given the value of $\overline{Y}$, $\overline{R}$ and $\overline{M}$ can be derived from

$$\overline{Y} = \alpha_0 + \alpha_1\overline{R} + \alpha_2\overline{M} + \alpha_3\overline{Y} + \vec{\alpha}'\vec{ex}_Y$$

$$\overline{M} = \beta_0 + \beta_1\overline{R} + \beta_2\overline{Y} + \beta_3\overline{M} + \vec{\beta}'\vec{ex}_M$$

Defining $y = Y - \overline{Y}$, $m = M - \overline{M}$ and $r = R - \overline{R}$, in case of an *interest rate* policy, the value of the interest rate that the authorities should select in order to minimize their object function $Ey^2 = E(Y-\overline{Y})^2$ is

$$\hat{r} = (-\alpha_2\beta_3 m_{-1} - \alpha_3 y_{-1})/(\alpha_2\beta_1 + \alpha_1)$$

which gives

$$C_r = (\sigma_u^2 + 2\alpha_2\rho_{uv}\sigma_u\sigma_v + \alpha_2^2\sigma_v^2)/(1 - \alpha_2\beta_2)^2 \qquad (3)$$

where C_r is the minimum of the object function in an interest rate policy regime.

In the case of no direct money transmission, *i.e.* $\alpha_2 = 0$, the formulas for $\hat{r}$ and C_r reduce to $\hat{r} = -(\alpha_3/\alpha_1)y_{-1}$ and $C_r = \sigma_u^2$. Hence, in this case, apart from the calculation of $\overline{R}$ and $\overline{M}$, the interest rate policy does not depend on the specification of the LM-curve and the actual level of income will only diverge from its target because of the random error in the IS-curve.

When the authorities pursue a *money stock* policy, they should set the money supply equal to

$$\hat{m} = (\alpha_1\beta_3 m_{-1} - \alpha_3\beta_1 y_{-1})/(\alpha_2\beta_2 + \alpha_1)$$

yielding

$$C_m = Ey^2 = (\beta_1{}^2\sigma_u{}^2 - 2\alpha_1\beta_1\rho_{uv}\sigma_u\sigma_v + \alpha_1{}^2\sigma_v{}^2)/(\beta_1 + \alpha_1\beta_2)^2 \tag{4}$$

as the minimum of the object function in a money stock policy regime. Now, the divergence of income from its target is independent of direct money transmission. Furthermore we see that C_r and C_m do not depend on the Koyck parameters α_3 and β_3 because the instrument values fully offset the lags in response. However, C_r and C_m are affected indirectly when, in case of constant long-term effects, the short-term effects vary with the adjustment speed.

3 ESTIMATES FOR THE IS-LM MODEL

In general we cannot assess whether C_r will be smaller than C_m, in other words, whether within this framework an interest rate policy will be preferable to a money stock policy or *vice versa.* Therefore we need realistic parameter values for the model. In order to determine these values, this paper uses empirical evidence of other studies rather than estimates of its own of the IS-LM model, hence avoiding estimation problems concerning simultaneity and cross-correlation of residuals.

With respect to the demand for money, a number of empirical studies is available for the Netherlands. The main findings, when using quarterly data and a log-linear specification, are:

$$\text{(LM-curve) } \beta_1 = -0.04,\ \beta_2 = 0.2 \text{ and } \beta_3 = 0.8$$

(see notably Fase and Kuné (1974) and Den Butter and Fase (1981)).

Recently I estimated an IS-curve for the Netherlands using quarterly data and a log-linear specification (see Den Butter (1981)). In the case of no direct money transmission ($\alpha_2 = 0$) I found (apart from the exogenous variables which are price expectations, government expenditure and a measure of world trade):

$$\text{(IS-curve a) } \alpha_1 = -0.016,\ \alpha_2 = 0 \text{ and } \alpha_3 = 0.2$$

and in the case of direct money transmission with the money stock representing the effects of wealth, availability of credit *etc.* in the expenditure equations:

(IS-curve b) $\alpha_1 = -0.01$, $\alpha_2 = 0.17$ and $\alpha_3 = 0$

We see that in the LM-curve the long-term interest rate elasticity of -0.2 is much larger than in both specifications of the IS-curve where it is -0.02 and -0.01 respectively. The speed of adjustment is slow in the LM-curve, fast in the IS-curve with no direct money transmission and immediate in the alternative specification of the IS-curve.

In order to calculate (3) and (4) we also need values for the standard deviations and correlation of the disturbances in the IS-LM model. When taking the residuals of the Dutch demand-for-money function from Den Butter and Fase (1981) and the residual of both IS-curves from Den Butter (1981) the results are (for the reference period 1970:I–1976:IV):

(LM-curve)	$\sigma_v = 0.014$	
(IS-curve a)	$\sigma_u = 0.015$	$\rho_{uv} = -0.6$
(IS-curve b)	$\sigma_u = 0.012$	$\rho_{uv} = -0.9$

Since the model is specified in logarithms, the results indicate that on average 1.4% of the demand for money remains unexplained and 1.5% of total expenditure when no allowance is made for direct money transmission and 1.2% when it is. It is remarkable that by the change of specification in the IS-curve the negative correlation between the residuals of the IS- and LM-curves becomes much larger.

4 RESULTS FOR THE INSTRUMENT PROBLEM

Table 1 gives the results for the instrument problem for different sets of parameter values. The first row represents the IS-LM model with no direct money transmission while row 10 shows the outcomes for the model with the alternative specification of the IS-curve. In the in-between rows the effect of the specification change is investigated by altering the parameter values one by one. The odd rows 3-11 stand for the case when there would be immediate adjustment in the LM-curve.[1]

Table 1 shows that for all alternatives the variance about the target, which for the sake of interpretation is expressed as a percentage error, is smaller for the interest rate policy than for the money stock policy. The most striking

1 In case α_3 and/or β_3 is set equal to zero, the value of the variance(s) is adjusted correspondingly.

TABLE 1 – RESULTS FOR THE INSTRUMENT PROBLEM

	Parameter values									Results			
	α_1	β_1	α_2	β_2	α_3	β_3	σ_u	σ_v	ρ_{uv}	$100\sqrt{C_r}$	$100\sqrt{C_m}$	C_m/C_r	Q
1.	-0.016	-0.04	0	0.2	0.2	0.8	0.015	0.014	-0.6	1.50	1.75	1.36	23.15
2.	-0.02	-0.04	0	0.2	0	0.8	0.018	0.014	-0.6	1.80	2.08	1.34	22.73
3.	-0.02	-0.2	0	1.0	0	0	0.018	0.056	-0.6	1.80	1.98	1.21	4.55
4.	-0.02	-0.04	0.17	0.2	0	0.8	0.018	0.014	-0.6	1.73	2.08	1.45	21.95
5.	-0.02	-0.2	0.17	1.0	0	0	0.018	0.056	-0.6	1.74	1.98	1.30	3.77
6.	-0.01	-0.04	0.17	0.2	0	0.8	0.018	0.014	-0.6	1.73	1.93	1.25	23.00
7.	-0.01	-0.2	0.17	1.0	0	0	0.018	0.056	-0.6	1.74	1.89	1.17	3.95
8.	-0.01	-0.04	0.17	0.2	0	0.8	0.012	0.014	-0.6	1.11	1.40	1.52	23.00
9.	-0.01	-0.2	0.17	1.0	0	0	0.012	0.056	-0.6	1.19	1.32	1.23	3.95
10.	-0.01	-0.04	0.17	0.2	0	0.8	0.012	0.014	-0.9	1.03	1.45	2.00	23.00
11.	-0.01	-0.2	0.17	1.0	0	0	0.012	0.056	-0.9	0.65	1.39	4.58	3.95

differences are obtained when the correlation is altered from -0.6 to -0.9. This change appears to have a favourable effect on interest rate policy, especially in the case of a LM-curve with no adjustment lag (compare rows 8 to 10 and 9 to 11), but not on the money stock policy. On the other hand, when $\rho_{uv} = -0.6$ money stock policy is positively affected by speeding up the adjustment of the demand for money, while interest rate policy is not affected.

The effect of direct money transmission on the interest rate policy is favourable though rather small. As remarked in section 3, changing α_2 has no influence on money stock policy. However, this change of specification leads to a better fit for the IS-curve. For that reason both an interest rate policy and a money stock policy perform better in a IS-LM-model with direct money transmission.

The above analysis assumes that the authorities can control the instruments of monetary policy accurately. In the case of the interest rate and the money stock as policy instruments it is more realistic to assume that the actual value of the instrument will deviate from its desired optimal value by a random error. Then

$$r = \hat{r} + w_1 \qquad\qquad m = \hat{m} + w_2$$

where w_1 and w_2 are random errors with variances $\sigma_{w_1}^2$ and $\sigma_{w_2}^2$. This uncertainty in setting the instrument values will, of course, add to the variance of income about the target. The contribution to C_r is

$$(1 - \alpha_2\beta_2)^{-2} \left\{(\alpha_2\beta_1 + \alpha_1)^2 \sigma_{w_1}^2 + \text{covariances}\right\}$$

and to C_m

$$(\beta_1 + \alpha_1\beta_2)^{-2} \left\{(\alpha_2\beta_1 + \alpha_1)^2 \sigma_{w_2}^2 + \text{covariances}\right\}$$

Neglecting the covariances we see that an interest rate policy is affected more by this uncertainty than a money stock policy if

$$\sigma_{w_1}/\sigma_{w_2} \geqslant Q = (1 - \alpha_2\beta_2)/(\beta_1 + \alpha_1\beta_2)$$

The values of Q for the alternative parameter values are given in the last column of table 1. They show that in this respect a money stock policy will only outperform an interest rate policy if the percentual error when fixing the interest rate is more than 20 times as large as when fixing the money stock. In case of immediate adjustment in the demand-for-money function the critical ratio is reduced to about 4.

In practice, however, the monetary authorities in the Netherlands have never pursued an interest rate policy. The interest rate is not regarded as a reliable instrument for macro-economic policy, since it does not allow a target value to be fixed independently of money market conditions and foreign interest rates. In terms of the above analysis it means that the variance of w_1 will be very large compared to the variance of w_2, as the money stock can be controlled with reasonable accuracy.

5 CONCLUSIONS

This paper reports the results for the instrument problem in a stochastic IS-LM model with realistic parameter values for the Netherlands. An interest rate policy appears to be slightly preferable to a money stock policy. Given the small interest rate elasticities, this result seems somewhat at variance with intuition, especially in case of a direct money transmission in the IS-curve. One would expect this mechanism to be favourable for a money stock policy, but in fact it favours the interest rate policy. These seemingly incompatible outcomes are an immediate consequence of the choice of the variance around the target as the only criterion for selecting the policy instrument. It is assumed that, apart from a random error, in each period the instruments can instantaneously be set equal to any desired value. This is an unrealistic assumption in particular in a small open economy, where the scope for variation of the interest rate is limited by foreign interest rates. Moreover the criterion does not account for trade-offs between the interest rate and money stock policies. In fact, a money stock policy is much more efficient when direct money transmission takes place, while the efficiency of an interest rate policy is hardly affected by direct money transmission. Table 2 illustrates that in

TABLE 2 – LONG-TERM IMPACT MULTIPLIERS FOR IS-LM MODEL
($\beta_1 = -0.2; \beta_2 = 1.0; \alpha_3 = \beta_3 = 0$)

	No direct money transmission	Direct money transmission	
	$\alpha_1 = -0.02$ $\alpha_2 = 0$	$\alpha_1 = -0.02$ $\alpha_2 = 0.17$	$\alpha_1 = -0.01$ $\alpha_2 = 0.17$
(1) dY/dM	0.10	0.25	0.20
(2) dY/dR	-0.05	-0.07	-0.05
(1)/(2)	-2	-3.6	-4

the long run a 1% change in the income target involves a 10% change in the money stock in case of no direct money transmission but only a 4 to 5% change in case of direct money transmission. With respect to the interest rate it would require changes of about 20% in both cases. Yet, when accepting the variance around the target as criterion, this paper shows that the size of the variances and covariance of the disturbances in the IS-LM model is of much greater importance to the choice of the monetary policy instrument than the specification of the model, its parameter values and the adjustment lags.

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Summary

CHOICE OF MONETARY POLICY INSTRUMENTS IN A STOCHASTIC IS-LM MODEL: SOME EMPIRICAL REMARKS FOR THE NETHERLANDS

This paper investigates the sensitivity of the choice of the monetary policy instrument for changes in the specification and the parameter values of the IS-LM model, using empirical results for the Netherlands.