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PREDICTING THE MONEY MULTIPLIER

A case study for the U.S. and the Netherlands

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A Box–Jenkins model has been developed to predict the U.S. money multiplier. The forecasts are approximately 30% more accurate than those produced by the regression methods which Burger and others have used in recent work. Similar models are then applied to three different money multipliers for the Netherlands, taken from Korteweg's reformulation of the Brunner–Meltzer money supply scheme for this open economy. The results suggest that if the Dutch Central Bank invested more resources in the collection of data from the banks, then predictions could be made sufficiently accurate for use in the control of the money stock.

1. Introduction

The present paper discusses the degree of regularity of the money supply process in the U.S. and the Netherlands. This question has attracted increasing attention in recent years. Two reasons may be given:

(1) the growing awareness that monetary policy, if it is to be effective, should be directed towards controlling a monetary aggregate, rather than interest rates;

(2) the development of a theoretical framework, the 'Brunner–Meltzer money multiplier approach,' which has acted as a stimulus to research in the area.[1]

The characteristic equation in the Brunner–Meltzer description is

$$M = mB,$$

where:

M = one of the possible money stock concepts. Here we use the narrowly defined money stock (M_1), in agreeement with the American work with which we want to compare our results, and with Korteweg (1971, 1973) in his studies on the Dutch money supply process.

*The author is grateful to Pieter Korteweg for helpful advice and patient discussions. Martin M.G. Fase of De Nederlandsche Bank and Albert E. Burger of the St. Louis Fed. provided valuable comments on an earlier draft. The usual caveat applies.

[1]The seminal reference is Brunner and Meltzer (1964). The approach has been first introduced in the Netherlands by Korteweg (1971).

B = some measure of base money, often chosen in such a way that it can be used to describe Central Bank behaviour. One popular definition, used in the first part of this paper, is to put B equal to the net monetary liabilities of the Central Bank (plus coins, a liability of the government). These liabilities are held as currency by the (nonbank) public and as unborrowed reserves by the banks. In a fractional reserve banking system, bank reserves may serve as the basis for a multiple expansion of deposits. Because of this property, the Central Bank's monetary liabilities are sometimes referred to as 'high-powered money.'

m = the multiplication factor which represents this expansion.

The Brunner–Meltzer analysis has proved useful in organising discussion of money stock control. Suppose we know the desired value of M for the next period, then we may distinguish the 'political' problem – whether the Central Bank can control B through its open-market activities – from the 'technical' problem of forecasting the next period's multiplier. This paper is concerned with the last issue only.

Even the 'technical' question of predicting the multiplier may be approached in fundamentally different ways. Burger, Kalish and Babb (1971)[2] mention three methods:

(1) Definitional method – the multiplier is regarded as the quotient of M and B, and these magnitudes are predicted.
(2) Regression method – which is what they do themselves, using a single equation.
(3) Behavioural method – the multiplier is expressed as a function of various behavioural ratios, relating to currency, bank deposits, bank reserves and bank net foreign assets (see the introduction to section 3 of this paper). Each ratio depends on interest rates, policy instruments and other factors, which have to be predicted.

The method used in this paper comes under (2). A single equation is estimated with the special restriction that we only use past values of the multiplier m in the prediction formulae. That makes the analysis comparable with work done by researchers at the Federal Reserve Bank of St. Louis. At the same time it means that our study is subject to the same limitations as theirs:

(1) Multiplier predictability is no sufficient basis for a claim that the money stock can be technically controlled under present arrangements for reserve requirements, exchange rates, etc. Such a claim cannot be made without a full description of the money supply process and an economic analysis of its ultimate determinants.

[2]In what follows, the letters BKB refer to the three authors. All comments on the BKB method are also relevant to Burger (1972).

(2) We do not know whether multiplier predictability would have been different if predictions had actually been made each month. Presumably predictions would have influenced behaviour, but to what extent remains unknown.
(3) We cannot throw light on the question: What would have happened if Central Bank policies had been different?

As far as (3) is concerned, we should note that our study concerns two countries where the official aims of monetary policy were quite different over the periods under review. In the U.S., a decision to seek moderate expansion of the monetary aggregates and to give less priority to the control of interest rates was taken in early 1970 and abandoned again later that same year. It has been described as a 'revolutionary step, for the Federal Reserve had never before tried deliberately to control the money supply.'[3]

The situation in the Netherlands was different: 'Dutch monetary policy is directed towards influencing liquidity, i.e. the total money supply including those claims on money-creating institutions and the public sector which at a relatively short notice and in large amounts can be readily converted into money without much expense or loss (secondary liquidity).'[4] The Dutch Central Bank tries to influence this admittedly very broad monetary aggregate and is not primarily concerned with acting on a vector of interest rates or steadying money market conditions.

Now, if 'ex-ante' predictions would have worked for two countries with such different monetary policies, some optimism about multiplier predictability could be justified. In the rest of this paper we show that accurate predictions were indeed feasible (of course it still remains an open question whether the multiplier is predictable for a reasonable range of Central Bank policies). In the first part, Box–Jenkins type models are developed for the U.S. multiplier. We compare both the methodology and the results with the regressions of the St. Louis researchers. The Box–Jenkins model performs about 30% better if we average the prediction errors over three-month periods. We let errors accumulate in this way because agreement seems to exist that month-to-month fluctuations within a quarter do not carry over into the real sector of the economy.

In section 3 of the paper slightly more involved Box–Jenkins models are applied to various multipliers for the Netherlands. The statistical discussion is much shorter: the same approach is used and the results are again better than those produced by an application of the St. Louis method. The conclusion is that in this country, with its highly open economy, accurate multiplier predictions would also have been possible.

[3]See Meigs (1972, p. 74).
[4]See Den Dunnen (1973, p. 288). Similar statements may be found in Holtrop (1972), for instance on p. 223: 'The essential instrument of policy . . . is their control over the creation of money.'

2. The multiplier in the U.S.

2.1. Existing studies

In his recent article, Levin (1973) has examined recent work on predicting the money multiplier. All studies use monthly data. Some employ an elaborate model of the financial sector of the U.S. economy in order to predict next month's multiplier. The researchers at the Federal Reserve Bank of St. Louis achieve equally good results with single-equation methods. Apart from the multiplier series itself, only one other variable is used.

The method used in this paper therefore lends itself to a comparison with the St. Louis work, since it follows the same principle of parsimony: it uses *only* earlier values of the multiplier to predict next month's value.

2.2. Outline of method used

The present work has been based on a method of time series analysis developed by Professors Box and Jenkins.

The analysis proceeds by the following steps:

(1) Decide whether the series is stationary in the mean (this of course is an economic, not a mathematical, problem). If it is not, try to achieve stationarity by taking differences (possibly more than once) and substitute the differenced series for the original one in the subsequent analysis.
(2) Use the autocorrelation function to choose a model for the series and to calculate preliminary values of the parameters.
(3) Find the 'best' parameters for the selected class of models.
(4) Analyze the success of the model, in particular by studying the residual errors.

2.3. Step-by-step account

2.3.1. Step 1: Differencing

Treating the data for seasonality. The data used (x_t) are monthly values for the multiplier, as published by the Federal Reserve Bank of St. Louis, for the 1962–1971 period. The first few months provide 'starting values;' a model is fitted to the remainder of the period. After that, prediction formulae are derived for various subperiods so that their post-sample predictions may be compared with the results obtained by BKB (1971) and by Burger (1972).

The 'raw' values are not adjusted seasonally before the model fitting starts. Burger, Kalish and Babb also use unadjusted monthly values throughout. They apply monthly dummies to deal with the very apparent seasonal pattern.

Box and Jenkins propose to apply a seasonal difference operator Δ_{12} instead. Its definition:

$$\Delta_{12}x_t = x_t - x_{t-12}.$$

The resultant series $\Delta_{12}x_t$ represents the errors we make in supposing that each multiplier is going to be equal to the value which occurred 12 months ago.

Is the multiplier series stationary? BKB do not discuss the question whether the nonseasonal series is stationary. Their prediction procedure appears to assume nonstationarity because they use values only over the last 36 months to predict the next multiplier. Knowledge of the development of the multiplier in the more distant past is not judged helpful. Now, *if* the series had a constant mean, an estimate of it, based on as many observed values as possible, might be expected to play a role in the prediction formula. The BKB method, with its regression lines drawn afresh each month, cannot be very efficient for a stationary series. So it seems fair to suppose that the St. Louis scholars implicitly assumed nonstationarity. More insight can be obtained by applying the 'normal' difference operator Δ to the series $\Delta_{12}x_t$. Inspection of the resulting series can now help to decide for or against stationarity of the seasonally corrected series using a criterion given by Christ (1966, p. 485):

> Raw economic data are appropriate to a world in which shifts come and last for just one period, . . . first differences of economic data are appropriate to a world in which shifts come and last forever.

In the 'first world' successive terms of $\Delta\Delta_{12}x_t$ should be negatively correlated (we make two errors: first in not predicting the sudden shift: then in failing to foresee that it will disappear). This should show up in a significantly negative value for r_1, the first autocorrelation. In the 'second world' the shift leads to only one single error in the month it takes place.

Table 1 shows that the first few autocorrelations of the series $w_t = \Delta\Delta_{12}x_t$ are quite small, which puts it in the 'second world.' Box and Jenkins, in their analysis of a series of sales data, point out that the operator $\Delta\Delta_{12}$ has greatly reduced the autocorrelations (also true in our case), and use this as a pragmatic justification for proceeding with $\Delta\Delta_{12}x_t$ instead of x_t.

The question of stationarity, however, cannot be settled conclusively: 'it is impossible to test whether a series is stationary or not, given only a finite sample, as any apparent trend in mean *could* arise from an extremely low frequency.'[5]

In our case it is reasonable, however, to follow the statistical pointers in the direction of nonstationarity. We therefore apply the operator $\Delta\Delta_{12}$ and continue with the twice-differenced series $w_t = \Delta\Delta_{12}x_t$.

[5]See Granger (1964, p. 132).

Table 1

Autocorrelations of the series $w_t = \Delta\Delta_{12}x_t$.

nr. of lag	0	1	2	3	4	5
autocorr.	1.00	−0.07	0.00	0.19	−0.04	−0.12
nr. of lag		6	7	8	9	10
autocorr.		0.13	−0.11	−0.19	0.09	−0.21
nr. of lag		11	12	13	14	15
autocorr.		0.03	−0.29	−0.08	0.20	−0.03
nr. of lag		16	17	18	19	20
autocorr.		−0.08	−0.11	−0.03	−0.12	0.30
nr. of lag		21	22	23	24	25
autocorr.		−0.05	−0.21	0.14	−0.13	−0.05
nr. of lag		26	27	28	29	30
autocorr.		−0.08	−0.09	−0.07	−0.02	−0.12

2.3.2. Step 2: Selecting a model

The differenced series. The 107 terms of the series w_t have a mean of −0.00026 and a standard deviation of 0.0160. If the series is, for all purposes, equal to white noise, our analysis has to stop at this point and we cannot do better than to propose the prediction formula,

$$x_t = x_{t-1} + (x_{\tau-12} - x_{\tau-13}) + w_t,$$

with $E(w_t) = 0$. In words: take last month's multiplier. Add the change in the multiplier which occurred this time last year.

Table 3 shows that this 'naive model' already performs better than the far more complicated methods proposed by the St. Louis scholars. We shall see, however, that it is possible to improve upon this. The w_t series still possesses characteristics which distinguish it from white noise and make more sophisticated predictions possible.

When we compare the observed frequency distribution of the 107 available terms of the series w_t with those of a normal distribution with the same mean and standard deviation, it appears that there are 'too many' observations further than 2 s.d. away from the mean. These occurred in the following months: 66: 7, 67: 1, 67: 5, 67: 7, 69: 5 and 71: 1 (plus two months before 64: 1). A detailed economic analysis of the history of the multiplier, not attempted here, would have to concentrate on these months in particular.

We shall proceed to fit a model for the whole period, because separate estimates made for the subperiods 1963–1965 and 1968–1972 all gave very similar results. We therefore shall present coefficients, *t*-values, etc., for the model which covers the whole period, as these statistics do not seem to be unduly distorted by the 'unusual' behaviour of the series between mid 1966 and mid 1967.

'Autoregressive' and 'moving-average' models. Box and Jenkins propose two basic models to describe a stationary time series: 'autoregressive' (AR) and 'moving-average' (MA).

Table 1 shows that the autocorrelations do not die out in the slow and regular way we associate with autoregressive processes. We should therefore represent w_t by a MA process. The general form for an MA process of order q is

$$w_t = a_t - \theta_1 a_{t-1} - \theta_2 a_{t-2} - \theta_3 a_{t-3} - \ldots - \theta_q a_{t-q}.$$

(It has been assumed that the mean of the w_t is 0. In our case, the mean of the series, w_t, is only −0.00026. Had it been much larger, then it would have been necessary to take this into account.)

Which previous 'shocks' should be allowed an influence on w_t? First of all one would expect some delayed effects of the shocks that took place in the immediate past, i.e. a_{t-1} and a_{t-2}. Because the first few autocorrelations are all small, there is no need to go beyond a_{t-2}. The way in which the w_t series has been constructed implies that we should allow for a nonzero value of θ_{-12}. If θ_{-12} is put equal to 0, that means that any unexpected change which takes place in a given month becomes fully incorporated in the seasonal pattern of x_t from that moment onwards.

Choosing a model. The autocorrelation function of table 1 shows high values for r_{10} and r_{20}. That means that what happened 10 and 20 months ago on average has an important bearing on what happens now. Nevertheless, we do not include a_{-10} and a_{-20} in our model. No economic theory seems to exist which explains the particular importance of these lags. The fact that adjacent values of r_k, for instance r_9 and r_{11}, are not also larger than average, suggests that such an economic theory will not be developed either. If there were some delayed effect which took about 10 months, one should not expect it to be limited to exactly the tenth month; it should occur *around* that month instead, and that is not the case here. We thus limit ourselves to a_{-1}, a_{-2} and a_{-12} as candidates for inclusion in the model.

Similar decisions about the selection of the class of models retained for further analysis are taken in ordinary regression analysis, where one has to decide on the maximum number of parameters to describe a lag structure or on the *a priori* restrictions regarding the shape of an Almon lag structure.

The BKB procedure, however, lacks the transparency of both. No reasons are given why a simple moving average of the last three multipliers has been used, or why three years are used for the seasonal corrections instead of one year, two years or as many years as possible. That seems a stronger reason for calling the method 'dirty,'[6] than the fact that the predictions are based on a single equation, not on a full structural model.

2.3.3. *Step 3: Fitting the model*

Three models chosen. There are five possible MA models which contain at most two independent parameters:

$$w_t = a_t - \theta_1 a_{t-1}, \tag{1}$$

$$w_t = a_t - \theta_{12} a_{t-12}, \tag{2}$$

$$w_t = a_t - \theta_1 a_{t-1} - \theta_2 a_{t-2}, \tag{3}$$

$$w_t = a_t - \theta_1 a_{t-1} - \theta_{12} a_{t-12}, \tag{4}$$

$$w_t = a_t - \theta_1 a_{t-1} - \theta_{12} a_{t-12} + \theta_1 \theta_{12} a_{t-13}. \tag{5}$$

As r_{12} is the second largest in absolute value of the estimated autocorrelations, we should prefer models (2), (4) and (5) above. Assuming that model (2) describes the series w_t adequately, all autocorrelations r_k should be 0 for $k > 12$. Bartlett's formula [see Kendall and Stuart (1966, p. 432)] gives 0.104 for the approximate standard error of the estimated autocorrelations $r_k (k > 12)$. We have compared the frequency distribution of the estimated $r_{13}, r_{14}, \ldots r_{30}$ to a normal distribution with a mean of 0 and a s.d. of 0.104. The correspondence seems reasonable. Similar tests for models (4) and (5) lead to the same conclusion: the moving average models (2), (4) and (5) deserve further investigation.

Calculating the parameters. The maximum likelihood (ML) estimates are found by minimizing a sum of squared residuals $S = \sum a_t^2$.

The parameters for models (4) and (5) have been calculated with the Marquardt nonlinear least-squares algorithm including back-forecasting the series. It did not give any diffculties as regards convergence towards the optimum parameter values. A grid search, made for model (5) confirmed the impression that the S function is well-behaved for the multiplier models at hand.

The difference between models (4) and (5) on one side, and model (2) on the other is small (the absolute mean error – see below – for model (2) with $\theta_{12} = 0.50$ is 0.0113) but the assumption of some correlation between this month's value of w_t and last month's shock a_t is such a natural one that it seems defensible to retain the more complicated models (4) and (5). Model (4) happened to give slightly better results, both in terms of fit and as regards t-values. We therefore present results for model (4) only.

[6]See Federal Reserve Bank of Boston (1973, p. 57). The words are from Duesenberry.

$$x_t = x_{t-1} + (x_{t-12} - x_{t-13}) - \theta_1 a_{t-1} - \theta_{12} a_{t-12} + a_t$$

$\theta_1 = 0.131$ (0.081)
$\theta_{12} = 0.517$ (0.080)
Cov $(\theta_1, \theta_{12}) = -0.0009$
(standard errors in brackets)[7]
money multiplier U.S.
period: (1963: 2)–(1971: 12)
absolute mean error (A.M.E.): 0.0112
S.E.E.: 0.0149

The usual F-test on the joint distribution of both parameters rejects the null-hypothesis at the 1% level.

The terms in x represent the double differencing operation. The terms in a_{t-1} and a_{t-12} are included to open up a channel for the influence of previous shocks and for partial incorporation of such shocks in the permanent seasonal pattern. The last term (a_t) represents the unforeseen element in this month's multiplier (it has also been called 'shock term' or 'residual term'). If we replace this term by its expectation (which is zero), the formula above represents our prediction formula for the multiplier. The formula can be used for forecasts into the more distant future by putting all unknown a's equal to zero.

2.3.4. *Step 4: Tests on the residuals (see appendix)*

Table 2

Series	Value of r_{10}	Rank of r_{10} in the first 30 autocorr.
$w_t = \Delta_1 \Delta_{12} z_t$	−0.212	3
a_t	−0.257	1
Burger's final residuals	−0.307	2

[7]See Box and Jenkins (1970) for the calculation and interpretation of the standard errors.

2.4 Comparing the predictive power

For a fair comparison with the St. Louis results, ex ante forecasts are needed. We have estimated the model over the 35 months from 1963: 2 to 1965: 12 (the model fitted to the first 23 months resulted in coefficients which were unrepresentative in the sense that they differed markedly from the coefficients of the model fitted to the whole period). This model,

$$x_t = x_{t-1} + (x_{t-12} - x_{t-13}) - 0.176\, a_{t-1} - 0.773\, a_{t-12},$$

was used to generate forecasts for the years 1966–1971. A comparison with the work of the St. Louis researchers is presented in table 3.

Table 3
Summary statistics – ex-ante predictions.[a]

	Burger	Naïve method	Present study
mean absolute error in predicting next month's multiplier (% at annual rates)	5.8	5.6	5.1
quarterly average of the monthly errors – mean of their absolute values (% at annual rates)	1.31	1.07	0.84

[a]For the reason given by Levin, the percentage errors can be regarded both as errors in the predicted multiplier and as errors in the controlled money stock. All figures relate to the period 66: 1 to 71: 12.

Levin gives special attention to the 1970–1971 period. To enable a further comparison over these 24 months, a model was also estimated for the 83 months from 1963: 2 to 1969: 12. Results for the quarterly average of the monthly errors are now as follows.

BKB, as updated by Levin:	1.11%	
Burger (1972):	0.94%	
Naïve model:	0.85%	
Box–Jenkins model, as used for table 3:	0.71%	ex ante
Box–Jenkins model, fitted to the 1963–1969 period:	0.69%	ex ante
ex post predictions with the model fitted to the whole period:	0.70%	

Note: once again, all errors have been multiplied by 4 to provide errors on an annual basis.

In these comparisons we follow Levin and put emphasis on the 'mean absolute quarterly errors,' i.e. the errors which would be made if we let monthly errors accumulate on a three-month basis. There the present method performs approximately 30% more accurately than the regressions of the St. Louis researchers. The reason why will become clear if we compare the first two autocorrelations of the final residuals. This is done in table 4.

Table 4
Autocorrelations of final residuals.

	r_1	r_2
Burger	0.32	0.21
present method	0.00	−0.03

The correction for autocorrelation which both BKB and Burger apply does not seem to have worked too well; successive errors tend to accumulate rather than to offset each other (they estimate ρ, the first autocorrelation coefficient, of the residuals and add $\rho \times$ (previous error) to this month's estimate. Table 4 shows r_1 and r_2 of the residuals which remain *after* this correction. One may doubt whether autocorrelation can be taken care of in this way: shifts in the constant term of the St. Louis regressions influence the Durbin–Watson coefficient (from which the autoregressive parameter ρ is estimated) to such an extent that ρ sometimes changes from positive to negative from one month to the next.

2.5. Comparing the two methods

We conclude section 2 by summarizing some differences between the methods used by Burger c.s. on the one hand and Box and Jenkins on the other. Success in predictions may be the final criterion (and the present method has done better in that respect too) but a claim could also be made for the methodological superiority of the Box–Jenkins algorithm.

St. Louis scholars	present method
nonstationarity assumed	problems of stationarity can be investigated
mechanical method, no rationale given	refinement of 'naïve' methods

St. Louis scholars	present method
predicts one month ahead only	can also predict 2 or more months ahead
confidence intervals for the predictions very hard to derive theoretically	theory of confidence intervals exists
unsystematic treatment of autocorrelation	autocorrelation studied at all stages of the development of the algorithm
residuals hardly suitable for detailed historical analysis	series w_t and final residuals can be used for investigation of special periods.

3. Money multipliers for the Netherlands

3.1. *Definitions*

Our discussion of the Dutch money multiplier has to start with a decision on which measure to use for the monetary base. In his recent paper, Korteweg (1973) analyses three different bases, each of which is connected to the money supply M by a corresponding multiplier. They are defined as follows.

	sources	uses
B	$G+SK+RL$	$C+R$
B^a	$G+SK$	$C+R-RL$
B^r	$G'+SK'$	$C+R-RL+NFA$

3.2. *Notation*

B	monetary base
B^a	'adjusted' monetary base
B^r	'redefined' monetary base
C	currency
G	gold and foreign currency stock of the Central Bank
G'	national stock of monetary reserves, defined as $G+IMF+NFA$
IMF	Dutch IMF position
NFA	net foreign assets of the banking sector
R	bank reserves
RL	discounts and advances extended to the banking system by the Central Bank
SK	amount of government liabilities net of the government's current account plus real assets minus capital accounts, held by the Central Bank
SK'	$SK-IMF$

3.3. *Comparing the multipliers*

The 'uses' side of the definitions clearly shows the differences between the three measures of the monetary base. To get the adjusted base we subtract borrowed reserves. The same step is taken by the American students of the money supply, when they construct the 'net source base' or the 'nonborrowed base.'

The argument for the second correction, the adding of NFA, is that in an open economy banks have an alternative to borrowing from the Central Bank: they can borrow from foreign credit markets. With a more-or-less fixed exchange rate, as was the case during most of the reference period, the Central Bank will be obliged to purchase or sell whatever amount of foreign currency the banking system supplies or asks.

We have developed prediction formulae for the three different multipliers, corresponding to B, B^a and B^r. The multipliers are defined in table 5, which also gives their mean and range.

Table 5

A comparison of three money multipliers (1957–1972).[a]

	definition	mean	range
m_1	M/B	2.17	1.83–3.05
m_2	M/B^a	2.21	1.83–3.10
m	M/B^s	1.90	1.35–2.49

[a]*Notes:* m_2 corresponds to the multiplier m, used in work on the U.S.

Three multipliers may be expressed in terms of certain proportions which indicate the behaviour of banks and the public:

$$m_1 = \frac{1}{k(1-c+t)+c},$$

$$m_2 = \frac{1}{(k-b)(1-c+t)+c},$$

$$m = \frac{1}{(k+a-b)(1-c+t)+c}.$$

The notation is as follows:

D = public's demand deposits,
T = public's time and savings deposits,
a = $NFA/D+T$ = bank net foreign asset ratio,
b = $RL/D+T$ = bank borrowing ratio,
c = C/M = currency ratio,
k = $R/D+T$ = bank reserve ratio,
t = T/M = time and savings deposit ratio.

For the derivations, based on the balance sheets of the Central Bank, the rest of the banking sector and the public, we refer to Korteweg (1973). He calls the proportions a, b, c, k and t the '*proximate* determinants' of the money supply. They, in turn, are determined by the '*ultimate* determinants,'examples of which are: current and expected interest and inflation rates, national income, human and nonhuman wealth and Central Bank instruments. The latter particularly influence a, b and k which describe the bank's behaviour. The other ratios c and t, which indicate the public's preferences, tend to be less changeable in the very short run, which is what matters here since we are trying to predict month-to-month changes in the multiplier. A comparison of the expressions for the three multipliers makes it clear that if we choose to describe the money supply process by

$$M = m_2 B^a, \qquad (m_2 \text{ a function of } k, c, t \text{ and } b),$$

or

$$M = m B^r, \qquad (m \text{ a function of } k, c, t \text{ and } a, b),$$

bank behaviour is reflected to a greater extent in the multiplier than if we had used the formulation with m_1. An analysis of bank behaviour in the Netherlands, which covers the period we study here, has been made by Korteweg in the paper already referred to above. It is an illustration of the fruitfulness of the multiplier approach for describing the proximate determinants of the money supply process and analysing the ultimate determinants (interest rates etc.) of the money supply; and, as discussed in the introduction, for money stock control.

In the last area the Brunner–Meltzer analysis helped to distinguish two problems: (1) can B (also, *which* B?) be controlled by the monetary authorities? (2) can m be predicted with sufficient accuracy? Until the first of these questions has been answered, it is impossible to prefer one multiplier to the other two, which is why we study all three.

The multiplier approach also shows the way to progress beyond merely concluding that m_2 is more variable than m_1 and m less variable than m_2. We can now point to the negative correlation between k and b (that makes the variation of $k-b$, part of m_2, greater than the variation of k, part of m_1) and to the negative correlation between $k-b$ and a (that makes the variation of $k-b$ larger than that of $(k-b)+a$, part of m). The relations between the proportions a, b, etc., form a subject for economic analysis, as in Korteweg's paper.[8] Here, we wished only to indicate that such an analysis, not attempted here, is directly related to our statistical findings about multiplier variability through the Brunner–Meltzer description of the money supply. We now proceed to operate on the three time series for Holland in much the same way as in section 2. The four steps mentioned there are taken again, but important differences appear, due to different properties of the series analysed.

3.4. Special characteristics of the Dutch data

3.4.1. No seasonal differencing needed

With the Dutch multiplier series, nothing is gained by a seasonal differencing operation. This is because the Dutch series show a much less distinctive seasonal pattern. In fact, the Dutch Central Bank publishes only nonseasonally corrected data for the money stock and its components, and with the autocorrelations at lag 12[9] for the once differenced series Δm_1, Δm_2 and Δm at 0.22, 0.16 and 0.26 respectively there seems to be no need to construct seasonally adjusted measures. The distinctive seasonal pattern in the American multiplier is brought about by:

(1) a stable seasonal pattern in C (currency),
(2) a stable but different seasonal pattern in D (demand deposits),
(3) large and stable values for $R-RL$ (unborrowed reserves).

In the Netherlands almost the opposite holds: weak seasonal patterns in C and D and small but highly variable values for unborrowed reserves. (In the U.S. a month-to-month change in $R-RL$ which is of the order of magnitude of 1% of the base B is exceptional; in Holland changes amounting to 4–5% are quite frequent.) All this results in a very weak seasonal pattern.

3.4.2. Only end-of-month values available

The only data available for the Netherlands which relate to the multiplier are measures of the money stock and its components, taken on the last working-day of the month. This contrasts with the U.S. situation, where the trend has

[8] The picture is somewhat different from Korteweg (1973) as he uses yearly average data instead of monthly values.

[9] A high value would mean that values for the same month in subsequent years are closely related. That is what one would expect with a strong seasonal pattern. The value of r_{12} for the American end-of-month data (see below for the reason why these are used now) is 0.71.

been to concentrate on daily average series in accordance with one of the recommendations of the Ad Hoc Committee on Money Supply Statistics in 1959. As becomes clear from the Burger–Balbach (1972) article,[10] the reason for this shift in emphasis towards averages was the growing extent to which money stock data were needed in making policy decisions.

The importance of this difference in the data may be judged from table 6. The top line gives the monthly and quarterly errors for our model fitted to the U.S. series. For the bottom line, a new multiplier series was used, based on end-of-month data.

Table 6

Two kinds of data.[a]

	monthly absolute mean error	quarterly errors
U.S. – based on monthly average of daily data	4.8	0.87
U.S. – based on data for last day of month	11	2.2

[a]*Notes*: period: 1964: 1–1971: 12. Errors expressed as a percentage at annual rates.

The net source base corresponds exactly to the base used by Burger. For the money stock we could use only the tables 'Details of Deposits and Currency' in the *Federal Reserve Bulletin*. This table gives the money stock for the last Wednesday of each month, but in June and December Call Report data are used. Except on call dates, the figures are partly estimated, according to the *Bulletin*, and they appear to differ in minor respects from the daily average series. Once again the data have not been seasonally adjusted. The table shows that in the U.S. the multiplier based on end-of-month data is more than twice as irregular as the one previously calculated.

3.4.3. *Greater variability in 1969–1972*

The degree of variability increases significantly for all three multipliers near the end of the period under review. The change may be located in the second half of 1969 and is illustrated in table 7. The standard deviations of $\Delta m_1, \Delta m_2$ and Δm were calculated for the years 1957–1968, and the table indicates how many values were greater than 3 times the corresponding s.d.

[10]See also Meigs (1972, p. 328).

Table 7

Number of values greater than 3 × standard deviation over 1957–1968.

	Δm_1	Δm_2	Δm
1957–1968 (143 values)	1	1	0
1969–1972 (48 values)	4	7	5

The reasons for this change of character in the multiplier series fall outside the scope of this paper. Students of the Dutch financial system often stress the growth of retail banking in the second half of the sixties, but the beginning of that development should certainly be dated two or three years *before* 1969.[11] Our prediction algorithm (see below) generates forecasts of average quality for 1966, 1967 and 1968 and deteriorates sharply only in 1969. The reasons why cannot be derived through the present nonstructural, two-country analysis.

3.5. *Models with three parameters*

The models for the Dutch multiplier series differ from the models fitted to the U.S. data in that a term in a_{t-2} has been added. It is economically quite plausible that unexpected events maintain an influence on the multiplier not only one but also two months later and the high values of r_2 (c.f. $r_2 = 0.00$ for the U.S. multiplier) show that it is worthwhile to add this term to the models. Our results for the 1957–1968 period (143 observations) are given in table 8.

Table 8

Multipliers for the Netherlands.[a]

	A.M.E.	S.E.E.
m_1: $x_t = x_{t-1} - 0.56\, a_{t-1} + 0.22\, a_{t-2} + 0.17\, a_{t-12} + a_t$ (0.082) (0.082) (0.072)	0.032	0.041
m_2: $x_t = x_{t-1} - 0.52\, a_{t-1} + 0.14\, a_{t-2} + 0.14\, a_{t-12} + a_t$ (0.083) (0.084) (0.075)	0.036	0.045
m : $x_t = x_{t-1} - 0.31\, a_{t-1} + 0.04\, a_{t-2} + 0.38\, a_{t-12} + a_t$ (0.077) (0.076) (0.070)	0.030	0.039

[a]*Notes*: Estimated standard deviations are printed below each coefficient. The usual F-test on the joint distribution of all three parameters rejects the null hypothesis at the 1% level for each equation. Mean values of Δm_1, Δm_2, Δm are 0.002, 0.002 and 0.003, so no correction for the mean needed to be made. The values of $143\ \Sigma_1^{30}\, r_k^2$ are 29.0, 23.5 and 24.7. Comparison with the χ^2 table for 27 degrees of freedom gives no ground for questioning the models.

[11]Van Loo, in his econometric study of the monetary sector of the Dutch economy, also gives 1967 as the year in which changes in the financial sector 'gathered momentum.' see Van Loo (1974, p. 92).

All experiments with subperiods of these 12 years gave very similar results.[12] Models fitted to the complete 16-year period have a different sign for the term in a_{t-2}. They are less interesting because they refer to 12 years from a certain time series plus another 4 years from a series with rather different characteristics. The coefficient of a_{t-12} is now positive. This is one consequence of using a series which has not been differenced seasonally. We now begin by expecting this month's value to be equal to last month's and then proceed to make our forecast more sophisticated by including terms in a_{t-1}, a_{t-2}, etc. Suppose that just a year ago the multiplier made an unexpected jump. If part of that is a new aspect of the weak (but nonetheless existing) seasonal pattern, we should add such a part of the error made at the time to this month's forecast. The formulae should thus contain a_{t-12} with a positive coefficient.

3.6. *Predictions for the Netherlands*

Table 9 shows summary statistics for the Dutch multipliers. Apart from the naïve and Box–Jenkins models, we have also calculated forecasts with the St. Louis method. These are available from April 1960 onwards. Because our Box–Jenkins models have three parameters (against two for the U.S. multiplier), we need a longer period for the estimation of the prediction formulae. Ex ante predictions could be made from 1963 onwards.

We may compare the predictions of the naïve model to the St. Louis and the Box–Jenkins predictions over the 6 years (1963–1968) for each of the three multipliers. In 15 out of 18 cases, the Box–Jenkins prediction does better than the naïve one, which is significant at the 99% level with a sign-of-differences test. The St. Louis method predicts poorly (this remains true if we consider the whole period). Over the last four years (1969–1972) the ex ante Box–Jenkins predictions still outperform the naïve model, but the difference is not significant. In the table we present the results for the naïve model, in line with our emphasis on the break in the series in 1969. The naïve model does better than the Box–Jenkins models as regards the quarterly average of the monthly errors. The reason is simple. The expected value of the quarterly average error depends both on the expected monthly error and on the first two autocorrelations of the error series. Fitting the Box–Jenkins models reduces the monthly errors (a gain over the naïve model) and reduces the absolute value of r_1 and r_2 (a loss over the naïve model because r_1 and r_2 are large and negative for all three series Δm_1, Δm_2 and Δm). The second of these effects happens to be stronger than the first.

It would be possible to fit a Box–Jenkins model which does not minimize the squared sum of the residuals, but which minimizes the squared sum of the

[12] Multiplicative models did – on the whole – slightly less well than the additive models for which results are reported in the text. Differences were not large. Mixed AR–MA models did distinctly worse.

Table 9

Prediction errors for Holland.

	m_1	m_2	m
Absolute monthly errors (% at annual rates)			
1957–1968			
naïve model	21.7	23.9	23.4
ex post	18.9	21.2	21.1
1963–1968			
naïve model	18.4	21.0	20.7
ex ante predictions	17.9	19.5	19.4
ex post model for 1957–1968 period	16.4	19.2	18.5
St. Louis method	19.1	21.0	23.1
1969–1972			
naïve model	25.8	40.2	33.7
Quarterly average of monthly errors (% at annual rates)			
naïve model, 1958–1968	2.69	2.95	3.52
naïve model, 1969–1972	3.52	5.85	5.12

After division by a factor, derived from table 6, to obtain an indication of ex ante prediction errors if calculated from monthly averages of daily data (% at annual rates)		Average of the three Dutch multipliers	U.S. multiplier
Monthly	1963–1968	8	4.8
	1969–1972	15	
Quarterly	1963–1968	1.3	0.9
	1969–1972	2	

quarterly errors. This remains an empty mathematical exercise until more is known about the Central Bank loss function (which depends inter alia on unwanted changes in the level of the money stock, aberrations from the long-run growth rate of M and the cost of controlling the base). More information would also be needed about the availability and quality of successive estimates of the money stock for each month.

The bottom part of table 9 gives some hypothetical errors. We have assumed that the proportion shown in table 6 between prediction errors for the two kinds of U.S. data would hold also for the Netherlands.[13] The figures show that multiplier predictability would have been reasonable for the 1963–1968 period. More economic analysis of the final years is called for.

[13] The Dutch data relate to the last day of each month; the U.S. data are for the last Wednesday. How large a difference this makes to the multipli

4. Final remarks

(1) A complete model of the financial sector would not have been necessary to predict the U.S. multiplier with sufficient accuracy. The Box–Jenkins technique can do the job on the basis of previous observations from the multiplier series.

(2) If proper data were available, the same conclusion could have been drawn for the Netherlands over the years 1957–1968. With such data – based on daily figures for at least the major banks – it would be easier to analyse the 1969–1972 period. Now we can only conclude that for the first 12 years of the period under review it would have been possible to make accurate predictions for the multiplier in this small, open economy with a currency in which large short-term capital movements take place.

(3) The analysis nowhere contradicts the impression given by Korteweg's work that the Brunner–Meltzer approach to the money supply process is a useful tool for a country like Holland.

Appendix: Step 4: Tests on the residuals

The 107 residuals have a mean of -0.00037 and a standard deviation of 0.0144. The frequency distribution of the residuals is very much like that of a normal distribution with the same mean and s.d. An (approximate) χ^2 test on $\sum_1^{30} r_k^2$ gives a value of 44.2 which lies between the 5% significance level (41.3) and the 2% level (45.4). The hypothesis that the a_t are an uncorrelated white noise series should thus be rejected.

Particularly striking is the large value for r_{10}. As table 2 shows, this can hardly be a case of spurious correlation.

The St. Louis scholars have used a completely different method, but r_{10} stands out among their correlation coefficients as well. Closer study of the series w_t shows that the high value of r_{10} is caused for about 50% by the correlation between March–September 1966 and January–July 1967. All proposed methods of the multiplier perform very poorly over these two groups of months and their errors are always in opposite directions.

The multipliers reflect in their way what happened during and immediately after the short period of highly restrictive monetary policy which ended in November 1966. We submit therefore that a precise economic analysis of the history of the monetary base and the money supply will be more helpful in understanding the pattern of the residuals a_t than 'mechanical' attempts to fit a more complicated model to the series w_t.

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