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Monetary Policy and Leading Indicators of Inflation in Sweden

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ABSTRACT: This paper derives a set of leading indicators of inflation for Sweden. It also discusses the developments leading to the adoption of the inflation targeting framework, and the changes in operational procedures entailed by it. The main findings are: (i) narrow money is the most powerful leading indicator of inflation; (ii) broad money and inflation expectations have significant predictive information on inflation; (iii) the output gap, interest rates and the credit aggregate have some predictive information on inflation, but this predictive information is confined to a shorter time horizon than either the monetary aggregates or inflation expectations; (iv) implied forward rates and their spreads with the spot rate have weak predictive information on inflation. The paper also discusses the types of feedback rules that can be derived for policy action on the basis of these results.

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Contents

I. Introduction

In Sweden, as in the case of the United Kingdom, inflation targeting emerged as a response to the collapse of the nominal exchange rate anchor in November 1992. The Riksbank's inflation target – consumer price inflation of 2 percent, with a tolerance range of +/- 1 percentage point – was announced on January 1993, but became operational only from 1995 onwards. This gap between announcement and effective implementation was to take account of the time lags between monetary policy action and its eventual impact on the final target. The targeted measure in Sweden is consumer price inflation, which includes both mortgage interest payments, and the effects of changes in indirect taxes and subsidies. Thus, the Riksbank chose a "headline" measure of inflation as its target, rather than some "underlying" measure, as has been the case in other countries with inflation targets – the U.K.'s targeted measure excludes mortgage interest payments, and New Zealand's makes special allowances for terms of trade shocks and changes in indirect taxes. The Riksbank's choice of consumer price inflation as the targeted measure was motivated by the public's familiarity with this measure, and the gains in credibility to be had from the transparency of the targeted measure. Moreover, the range around the central inflation target was perceived as partly playing the role of accommodating stochastic shocks. The Riksbank's monetary policy actions under this new framework – adapting the policy stance in response to changing forecasts of inflation – have been regularly reported and explained in its Inflation Reports, which have been published regularly since October 1993.

The main objective of this paper is to derive a set of leading indicators of inflation for Sweden. We use non-structural vector autoregressions for deriving these indicators. The paper discusses the methodological justification for the particular estimation procedure used, and also examines the way in which the results ought to be interpreted when it comes to implementing monetary policy in practice. The developments leading up to the adoption of inflation targeting as the framework for monetary policy are discussed, and the changes in operational procedures entailed by it are outlined. The concluding section examines the nature of the feedback rules that can be derived from our results, and the more general implications for monetary policy emerging from this study.

The main conclusions of this paper are the following. M0 contains, by far, the strongest predictive information on the targeted measure of inflation.[1] M3 also contains a high degree of predictive information on inflation. Both the monetary aggregates contain information about inflation sufficiently far into the future to allow the policy maker to respond to this information in a meaningful way. The credit aggregate has predictive information on inflation but mainly over a shorter time horizon. Both the output gap and inflation expectations have some predictive information on inflation, but the predictive information of the output gap is confined to a shorter time horizon than either the monetary aggregates or inflation expectations. The 3-month bill rate and the 5 year bond rate have some predictive information on inflation, but this information is confined to a very short time horizon, and hence, is not useful from an operational point of view. The nominal exchange rates – the Krona-Dollar, the Krona-Deutsche mark, and the trade-weighted nominal effective exchange rate – do not appear to contain predictive information on inflation that is of operational relevance. The implied forward rates, and their spreads with the spot rate, have only weak predictive information on inflation. The yield curve and the stock price index have no predictive information on inflation.

II. Swedish Experience With Monetary Policy

Before the Krona was allowed to float in November 1992, Sweden was on a fixed exchange regime through practically most of the period since the 1930s. Sweden participated in the multi-lateral systems (both Bretton Woods and the European Currency Snake) until 1977. It then pegged its currency unilaterally, first to a trade weighted basket of currencies, and then, in May 1991, to the ECU until the crisis broke out in late 1992. Despite being on a fixed exchange rate regime during this period, the commitment shown to the nominal anchor varied significantly over time. The Krona was devalued 5 times between 1976 and 1982 as Swedish inflation rates became incompatible

[1] The term inflation is used as a short-form for referring to consumer price inflation – the targeted measure – throughout the text.

with international levels. The commitment to the nominal anchor, however, became perceptibly stronger after 1982, and the Riksbank refrained from accommodating higher domestic inflation through further devaluations. The eventual forced float of the Krona in November 1992 occurred despite the extreme lengths to which the Riksbank went in trying to maintain the parity of the Krona – as evidenced by the episode of a 500 percent overnight interest rate in September 1992, and the large foreign exchange interventions conducted during the period of turbulence in European currency markets in 1992.[2] Thus, the floating of the Krona, and the decision to target inflation, shifted the framework for conducting monetary policy into uncharted terrain.[3]

The shift to inflation targeting also brought about changes in the operational procedures used for conducting monetary policy. While the Riksbank had periodically used sterilised interventions to stabilise the exchange rate in the short run, the main operational instrument used for regulating currency flows during the fixed exchange rate regime was the marginal rate. This was the Riksbank's overnight rate in the inter-bank market, and was determined by a pre-assigned supply function for borrowed reserves; i.e., based on an interest rate scale, increasing in discrete pre-determined steps with the level of bank borrowings. Given estimates of the demand for total reserves, the Riksbank adjusted the supply of non-borrowed reserves through open market operations to push banks to borrow at the desired level on the interest rate scale. Thus, the Riksbank's interventions in the currency market led to sizeable, automatic, and desired changes in the marginal rate, and this procedure proved particularly apt for defending the exchange rate parity. It allowed for the possibility of large adjustments to the marginal rate, without necessarily having to take recourse to prior announcements, in order to make domestic interest rates fall in line with the market's required return on Krona assets for maintaining the desired exchange rate parity. With the shift to inflation targeting, the effectiveness of the monetary policy framework warranted – from a credibility point of view – a system that would allow for relatively gradual, systematic, and transparent changes in interest rates in

[2] See Hörngren and Lindberg (1993) for a discussion of the history of fixed exchange rates in Sweden, and a detailed exposition of the events leading up to the floating of the Krona in November 1992.
[3] See Svensson (1995c) for a detailed discussion of how the framework for inflation targeting in Sweden was put together in practice.

response to perceived changes in the inflation outlook. Consequently, there was a change in operational procedures to a new interest rate policy system in June 1994. The repo rate replaced the marginal rate as the main operational instrument of the Riksbank, and the interest rate scale was replaced by the lending and deposit rates – which acted as upper and lower bounds to the corridor within which the repo rate could move. This new system formalized procedures in which gradual changes in the monetary stance required public announcements and prior justification.[4]

III. Inflation Targeting: Conceptual Issues

Inflation targeting, as the framework for conducting monetary policy, raises a number of conceptual issues that warrant discussion. One set relates to matters such as should inflation targeting be preferred to price level or nominal income targeting? How broad or narrow should the inflation target be? There is by now a fairly extensive literature on these issues, and where one stands in relation to them depends both on the choice of the preferred model of the economic process, as well as on the assessment of the type of stochastic shocks that the economy is likely to be subject to. For instance, inflation targeting is likely to be a preferred framework for monetary policy when demand shocks predominate, whereas nominal income targeting may be more apt when supply shocks are more frequent.[5] Yet another set of conceptual issues revolves around questions of whether inflation targeting is a better framework for controlling inflation than one based on a nominal exchange rate anchor, or having monetary aggregates as intermediate targets. Again, while there are differences of opinion in the literature, there has recently been a growing body of consensus about the difficulties entailed in sustaining nominal exchange rate anchors, and the ineffectiveness of relying

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[4] See Hörngren and Westman-Mårtensson (1991) and Sveriges Riksbank (1994) for detailed descriptions of the operating procedures for monetary policy in Sweden.

[5] A more detailed discussion of these issues can be found in Mankiw (1994), Fischer (1995), Leiderman and Svensson (1995), Svensson (1995b) and Baumgartner and Ramaswamy (1996). There, however, appears to be a consensus that inflation targeting provides a greater transparency for judging the actions of the Central Bank, and hence, may be preferable to nominal income targeting from a credibility point of view.

solely on monetary targets as the strategy for controlling inflation.[6] Thus, the support for inflation targeting – at least implicitly as the preferred framework by default – appears to have been growing recently.

An equally important conceptual problem, but one which has been less extensively explored in the literature, concerns the mechanics of implementing inflation targeting in practice. What sort of a model should be used for this purpose? A precondition for successful inflation targeting is obviously the capacity to predict inflation reasonably well over time horizons of operational relevance for policy action. The issue, then, revolves around the best way of doing this. When the purpose is essentially prediction, the choice of model – whether structural or non-structural[7], complex or simple – can be narrowed down to the one that forecasts better. However, when there is the additional objective of developing feedback rules that provide the basis for deciding how policy ought to respond to the inflation forecast, the criteria for choosing what kind of a model to use becomes more complex than in the pure forecasting case. There has been a tendency in practice with inflation targeting to opt for non-structural vector autoregressions – i.e., identify a set of indicators that has information on future inflation on the basis of tests of Granger causality, variance decompositions and impulse responses. Part of the reason for following this route is simply to do with forecasting; non-structural vector autoregressions do a relatively good job of providing information about future inflation. The other reason is that, given the lack of consensus over what the dominant channel of the transmission mechanism is, the choice of one particular structural model over another tends to become mired in controversy. An easy way out of this conundrum is to work with a non-structural model, and in this context, the information variable approach and the growing use of operational procedures based on interest rate rules help in

[6] See Svensson (1994) and Obstfeld and Rogoff (1995) for discussions of the difficulties with maintaining nominal exchange rate anchors. These arguments center around the problems of defending fixed exchange rates when the economy is subject to asymmetric real shocks in an environment characterized by nominal rigidities and an increasingly rapid international mobility of capital. Friedman (1996) outlines some of the practical difficulties of using monetary aggregates as intermediate targets. In fact, he suggests that countries which claim to have had money growth targets in the 1990s, have in practice used them as information variables.

[7] Cooley and LeRoy (1985) showed that any restrictions imposed on a VAR model to achieve identification imply a particular economic structure. We use the term 'non-structural' for mechanical or atheoretical techniques, such as the Choleski decomposition, not based on economic theory.

providing the implicit theoretical justifications for this choice.[8]

In a recent article, Woodford (1995) has noted the pitfalls of uncritically using non-structural vector autoregressions as the primary tool for conducting monetary policy. While cognisant of the limitations of structural modelling arising from, for instance, the instability of the relationship between monetary aggregates and nominal activity, he argues that non-structural models have their own limitations – particularly when it comes to devising feedback rules. For example, suppose that the 3-month treasury rate predicts inflation well in a VAR, and this information is used for devising a feedback rule whereby the operational intervention rate of the monetary authority is raised every time that higher than average treasury bill rates are observed. Then, there is the strong possibility of unstable feedbacks due to the existence of a positive relationship, through the term-structure, between the operational rate and treasury bills. Hence, to avoid such unstable feedbacks when using information from non-structural VARs, monetary policy action needs to take into account the priors given by the understanding of structural economic relationships. We come back to this issue again in the concluding section of the paper.

This study takes cognisance of Woodford's critique, but is eclectic regarding the methodological debate itself. We believe that it is useful for the policymaker to have the additional information about leading indicators of inflation provided by non-structural vector autoregressions when implementing monetary policy, even if the procedures by which this information is obtained appear to be somewhat of a "black box". This is particularly the case when, as in Sweden, the monetary policy framework depends upon the monitoring of a number of monetary and financial variables for information on future inflation. It is useful, in this case, to have a more systematic idea of how reliable the indicators presented in the Inflation Reports have been in tracking future inflation, and tests of Granger causality, variance decompositions and impulse responses are particularly apt tools for this purpose. However, the way in which the monetary authority responds to this information – i.e., the nature of the feedback rules – will have to make use

[8] This is essentially the approach taken in the seminal papers by Bernanke and Blinder (1992) and Friedman and Kuttner (1992). See also, in this context, Mishkin (1995) and Baumgartner and Ramaswamy (1996) for a more detailed discussion of these issues.

of discretion. For instance, a signal of inflationary pressures provided by a leading indicator that is an expectational variable, will have to be treated differently for policy purposes from one that is provided by a leading indicator that is a non-expectational variable. Also, the weak information content of some indicators, such as, for instance, the implied forward rates, may partly reflect the fact that monetary policy has already used the information provided by these indicators. We shall return to a more concrete discussion of this issue later in the paper.

IV. Estimations

The procedure adopted for implementing the empirical tests is as follows. We estimate a series of Granger causality tests and variance decompositions for deriving the information that financial and monetary variables have on future inflation. The time dimension of these indicators – how far into the future do they contain information about inflation – is derived from the impulse-responses. We start with a series of bivariate Granger causality tests, where the estimated equations are of the form:

$$\Delta X_t = \alpha(L)\,\Delta X_{t-1} + \beta(L)\,\Delta Y_{t-1} + \varepsilon_t \qquad (1)$$

X is the final target variable. The set of target variables has been defined, for this exercise, as the consumer price index (denoted as CPI_S in the tables), the net price index (CPIN_S), the implicit GDP deflator (PGDP_S), and real GDP (GDP_S). The focus of the paper will be very much on the leading indicators of the consumer price index, since the inflation target is defined in terms of this measure. However, we also present the information that the indicator variables have on the other target variables for the sake of completeness.

Y is an element in the set of indicator variables, which for this exercise includes the output gap, i e the percentage deviations from trend, measured by a Hodrick-Prescott filter (GAP), narrow money – M0 (denoted M0_S in the tables), broad money – M3 (M3_S) in the tables, the credit aggregate (C2_S), the 5-year government bond rate (R5Y), the 3-month bill rate (R3M), the spread between the 5-year government bond rate and 3 month treasury bill rate – the yield curve (YLD), household inflation expectations (IEXP), the stock price index (SSMI), the nominal effective exchange rate (EE), the Krona-Deutsche mark exchange rate (DEM), the Krona-Dollar exchange rate (USD), the 1-year implied forward rate 12-months to settlement (T2), the 1-year implied forward rate 24-months to settlement (T3), and the 1-year implied forward rate 36-months to settlement (T4).[9] The forward rates have been calculated using the extended Nelson-Siegel method. For details see Svensson (1995a) and Dahlquist and Svensson (1993). Table 1 provides a more detailed description of all the variables used.[10]

The following set of data transformations were carried out for the estimations. First, an outlier adjustment procedure was implemented to take account, in particular, of the big spikes in interest rates in September 1992.[11] All target variables were seasonally adjusted; of the indicator variables, the monetary and credit aggregates were seasonally adjusted.[12] All target variables, the monetary and credit aggregates, the nominal exchange rates and the stock price index are in logs. The sample used for the estimations is quarterly data from 1972:2 to 1995:4. Data on implied forward rates are available only from 1984:1.

Augmented Dickey-Fuller tests, with the appropriate representation of the deterministic trend using the sequential procedure outlined in Holden and Perman (1994), have been used for selecting the order of integration. Most variables are found to be I(1) and thus stationary in first differences. One possible exception is the credit variable (C2_S) which could be interpreted as being I(2). Interest rates are generally found to be I(1). This result is however quite sensitive to the chosen sample period and is, theoretically, difficult to reconcile with a stationary inflation rate. We have therefore used the levels of interest rates rather than first differences[13]. The results of the unit root tests are presented in Tables 2.1 and 2.2. All variables except for the output gap,

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[9] The use of implied forward rates has been motivated by the need for additional indicators of longer term inflation expectations. The advantage with implied forward rates is that they allow for an easier separation of expectations between the short, medium, and long-term than the yield curve. Short term forward rates mainly reflects expectations of monetary policy. See Svensson (1995a) for details.

[10] All tables are presented at the end of the text.

[11] We used TRAMO, an ARIMA-model based outlier procedure, for detecting and removing outliers. See, Gomez and Maravall (1994b). See table 1.2 for details on the removed outliers.

[12] The seasonal adjustment procedure was implemented with SEATS, an ARIMA-model based procedure. See Gomez and Maravall (1994a).

[13] The results are not affected by using first differences.

the interest rate variables, and household inflation expectations have been first differenced to take care of stationarity considerations.[14] Since the results of the stationarity tests for interest rates are somewhat ambiguous, test results for both levels and changes of implied forward rates are included in table 7.

F-tests are first carried out for the null hypothesis of the non-Granger causality of the relevant indicator variable, and Table 3 presents the marginal significance levels (p-values) for the bivariate Granger causality tests for lag lengths of 1 to 8. The smaller these values, the stronger is the predictive content of the relevant indicator for the particular target variable under consideration.

The second set of tests involves the forecast error variance decompositions for bivariate vector autoregressions defined on the target variables and the financial and monetary indicators. The forecast error variance decompositions are calculated using the Choleski procedure for orthogonalising the VAR innovations, and identification is achieved through Sims' triangular ordering. The VAR is structured such that the financial or monetary indicators are last in order. The results are computed with 6 lags for the bivariate VAR (the results were not significantly different when the calculations were repeated with 4 and 8 lags). The forecast error variance decompositions for different forecast horizons are presented in Table 4; the higher these values, the stronger is the predictive content of the relevant financial or monetary variable for the particular target variable under consideration.

The results of the bivariate Granger causality tests reported in Table 3 indicate that M0 contains a high degree of predictive information on both inflation and underlying inflation. While M3 also contains information on both inflation and underlying inflation, this is less significant than the narrow monetary aggregate. The credit aggregate is just marginally significant for inflation, but contains strong predictive information on the GDP deflator. The

[14] Toda and Phillips (1994) made a comparative simulation study of the small sample properties of Granger causality tests in levels, differences, and in an error correction model for co-integrated systems. Their findings indicate that in small samples (less than 100), Granger causality tests that explicitly take co-integration into account could not outperform the conventional tests in levels and first differences, despite the absence of the usual asymptotic distributions. Moreover, there is the additional problem of the arbitrariness involved in choosing between multiple co-integrating vectors for multi-variable Granger causality tests. The strategy adopted in this paper is to test the robustness of the tests estimated in first differences on the basis of a decision rule outlined later on.

output gap contains a fairly high degree of predictive information on inflation. The 3-month bill rate, the 5-year bond rate and inflation expectations contain a limited amount of predictive information on inflation. The stock price index, the yield curve and all the nominal exchange rates – the nominal effective, the Krona-Deutsche mark and the Krona-Dollar do not have any predictive information on inflation in the bivariate Granger causality tests. The implied forward rates, as well as their spreads with the spot rates have only limited predictive information on inflation (the results for the implied forward rates are reported separately in Table 7).

The bivariate variance decompositions reported in Table 4 add support to the results of the bivariate Granger causality tests. M0 explains the forecast error variance of both inflation and underlying inflation well. M3 also has a relatively high degree of predictive information on inflation, as has the credit aggregate. The credit aggregate also has a high degree of predictive information for the GDP deflator, as was the case with the bivariate Granger causality tests. Inflation expectations contain a high degree of predictive information on inflation, but the output gap has relatively weaker predictive information. Both the 5-year bond rate and the 3-month bill rate have weaker predictive information on inflation as in the bivariate Granger causality tests. Implied forward rates, as well as their spreads with the spot rate, now contain a high degree of predictive information on inflation. This result is stronger than was the case with the bivariate Granger causality tests. The stock price index has almost no predictive information on inflation, but the yield curve appears to have some information. The bilateral exchange rates are again poor predictors of inflation, but the nominal effective exchange rate has some information on inflation.[15]

The next stage of the exercise is to test the robustness of the bivariate tests in a multi-variable set up. For the Granger causality tests, this involves estimating the following equations:

$$\Delta X_t = \alpha(L)\,\Delta X_{t-1} + \phi(L)\,\Delta Z_{t-1} + \beta(L)\,\Delta Y_{t-1} + \varepsilon_t \qquad (2)$$

[15] The statistical information that the nominal effective exchange rate has on future inflation in this exercise, as well as the following ones, need to be interpreted with caution for policy purposes. As will be discussed in detail later, the impulse-responses for the nominal effective exchange rates are of the wrong sign, so that the information provided by the Granger causality tests and variance decompositions are not useful from an operational point of view.

Again, X and Y are the target and indicator variables respectively. Z is a vector of control variables which are likely to contain information on the target variables. Z is defined as follows. For real GDP it includes the GDP deflator and the terms of trade. For all price variables, it includes real GDP and the terms of trade. The terms of trade variable serves to capture the effects of possible real external disturbances.[16] The results of the four variable forecast equations are given in Table 5. The same multi-variable set-up used for the Granger causality tests is also extended for calculating the forecast error variance decompositions. The ordering of these four variable VAR's for the multivariate variance decompositions always places the financial or monetary indicator as the last of the VAR variables in order to preclude biasing the results in favour of these indicators. The exercise is repeated for different lag lengths and the results are presented in Table 6.

The four variable Granger causality tests reported in Table 5 and 7 in most cases replicate the results of the bivariate case. M0 contains a high degree of predictive information on inflation. M3, the output gap, inflation expectations and the 5-year yield, contain a limited amount of predictive information on inflation. The credit aggregate has weak predictive information on inflation, but is highly significant for the GDP deflator. The 3-month bill rate does not appear to contain any information on inflation. The yield curve and stock prices contain no predictive information on inflation. The exchange rate variables once again do not have any predictive information on inflation. The implied forward rates and their spreads with the spot rate, have no predictive information on inflation (Table 7).

The results of the multi-variable variance decompositions indicate a relatively high degree of predictive power for M0. M3 and the credit aggregate explain the forecast error variance of inflation less well than in the case of the bivariate variance decompositions. Inflation expectations appear, as in the case of the bivariate variance decompositions, to contain relatively strong predictive information on inflation. The output gap, however, does not contain additional information not present in GDP itself. The 5-year bond

[16] The usual practice in estimating such non-structural VARs in studies of the U.S. economy has been to include commodity prices to capture exogenous shocks. But for a small open economy such as Sweden the terms of trade is likely be a more suitable variable for capturing external disturbances.

rate, the stock price index and the yield curve have very little information on inflation while the 3-month treasury bill rate has some information. Both the bilateral as well as the effective exchange rates fare poorly as leading indicators of inflation. In contrast to the bivariate case the 1 and 2 year implied forward rates now appear to have considerably less predictive information on inflation, but their spreads with the spot rate still contain some information (Table 7).

We conducted a set of robustness checks to test the stability of the Granger causality tests in differences. For the reasons discussed earlier, rather than use an error correction model for co-integrated systems, our approach for testing the robustness of the Granger causality tests in differences is by adopting the following decision rule. The null hypothesis of non-Granger causality is now rejected only if both the first differences and levels reject it for at least half of the calculated lag orders.[17] The results from this exercise once again indicate that the findings reported in the text are fairly robust – in particular, the monetary aggregates continue to be powerful leading indicators of inflation. The main differences are: (i) The predictive information contained in nominal exchange rates is stronger in the sequential testing procedure than was the case in the tests in first differences alone; however, as mentioned earlier, and discussed below, the nature of the predictive information contained in nominal exchange rates does not correspond to our structural priors about the relationship between nominal exchange rates and inflation; (ii) The output gap has marginally stronger predictive power in the sequential testing procedure than in tests of first differences alone; and (iii) Inflation expectations and the credit aggregate have somewhat weaker predictive power in the sequential testing procedure than in tests of first differences alone.[18]

The exercise so far has identified a set of variables that contain information in a statistical sense about future inflation. However, for these variables to be operationally useful as leading indicators, the time dimension matters. That is, we are interested in knowing whether movements in these financial and monetary indicators contain information about inflation sufficiently far into

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[17] This strategy is based on our interpretation of the simulation results reported in Toda and Phillips (1994). It appears that combining the results of the tests in first differences and levels as described in the text could reduce the distortions when the tests are carried out sequentially.

[18] Interested readers can obtain detailed tables of this set of tests from the authors.

the future (roughly in the range of 4 and 8 quarters), so that policy makers can operationally react to this information in a meaningful way. One way of arriving at judgements about the time dimension of the leading indicators is by estimating impulse-responses, which trace out the time path of the target variable in response to a one standard deviation shock to the monetary or financial variables. We take the horizons at which the impulse-response function is statistically significant as providing an approximate measure of the time dimension of the leading indicator.

Charts 1 and 2 show the impulse-response functions for variables which have been pre-selected as leading indicators on the basis of the Granger causality and variance decomposition exercises. Chart 1 shows that the impulse-response function for M0 is statistically significant between the 3th and the 9th quarters, reaching a peak in the 6th quarter. This, in turn, can be taken as an indication that movements in M0 contain information on inflation approximately 6 quarters ahead. This judgement is corroborated independently by cross correlations estimated between lagged M0 and inflation, which shows that the cross correlation coefficient is maximized when the lag on M0 is about 7 quarters. That is, we can infer that M0 contains information about inflation sufficiently far into the future for the policy maker to respond to movements in M0 in a useful way. The impulse response function for M3 is statistically significant between 4 and 7 quarters, attaining a maximum around the 6th quarter (Chart 1). That is, M3 is also a leading indicator that is of operational relevance for the policy maker. The impulse-response for the credit aggregate, in contrast, reaches its maximum in the 3rd quarter. Consequently, any monetary policy action that responds to the information provided by the credit aggregate is likely to spill over into a time horizon over which this aggregate ceases to have useful information.

The impulse-response for the output gap attains a maximum in the 4th quarter, while that for inflation expectations reaches a peak in the 4th and 8th quarters; both are in the borderline of being statistically significant at these respective time horizons (Chart 1). The longer lead time for inflation expectations makes it relatively more useful for operational purposes than the output gap, though this is subject to some qualifications (see below). The impulse-response for the nominal effective exchange rate is statistically significant in the 5th quarter. However, the impulse-response function is itself wrongly signed – i.e., a unit depreciation appears to lower the time path of inflation (Chart 1). This anomaly is also corroborated by the cross-correlations between inflation and the nominal effective exchange rate which are wrongly signed over most lag lengths. This rather implausible statistical result is not affected by the outlier correction procedure, which has removed the large devaluations from the sample. It may be the consequence of co-movements generated between inflation, a fixed exchange rate that was subject to repeated devaluations, and the policy stance following the devaluations.[19] Consequently, it is necessary to discount for policy purposes the statistical results showing the nominal effective exchange rate to be a leading indicator of inflation. The impulse-response for the 3-month bill rate is statistically significant in the 2nd quarter (chart 2). As will be discussed below, short rates are not useful as leading indicators from an operational point of view. The impulse responses for the implied forward rates, irrespective of time to settlement, are statistically significant only in the 3rd quarter. Implied forward rates are usually interpreted as expected future interest rates and thus contain inflation expectations over the relevant time horizon. Consequently, the predictive information contained in the implied forward rates is not of a form that can easily be used for deriving feedback rules for monetary policy action.

V. Conclusions and Policy Implications

Putting together the results of all these tests (see table 8), we have the following conclusions about leading indicators of inflation in Sweden. M0 contains, by far, the strongest predictive information on the targeted measure of inflation. M3 also contains a high degree of predictive information on inflation. Both monetary aggregates contain information about inflation sufficiently far into the future to allow the policy maker to respond to this information in a meaningful way. The credit aggregate has significant predictive information on inflation, mainly over shorter time horizons, but

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[19] This refers to the well known puzzle about Swedish wage behavior following large step devaluations. Workers repeatedly took real wage cuts following such devaluations to maintain the competitive position of Swedish industry, and this, together with the tight monetary stance following the devaluations, may account for the perverse statistical relationship between lagged changes in the nominal exchange rate and inflation to the extent that these periods of large step devaluations dominate the data sample. The results on the exchange rates may also be affected by the fact that the estimation period includes a shift from a fixed to a floating rate regime.

strong predictive information for the GDP deflator. Both the output gap and inflation expectations have some predictive information on inflation, but the predictive information of the output gap is confined to a shorter horizon than the monetary aggregates and inflation expectations. The 3-month bill rate has only weak predictive information on inflation, and this information is of too short a horizon to be useful from an operational point of view. The nominal exchange rates – the Krona-Dollar, the Krona-Deutsche mark, and the trade-weighted nominal effective exchange rate – do not appear to contain predictive information on inflation that is of operational relevance. The 5-year bond yield and the 1-year implied forward rate 12 months to settlement have weak predictive information on inflation. The yield curve and the stock price index have virtually no predictive information on inflation.

What are the policy implications of these results? There are two distinct but related issues that need to be discussed here. The first concerns the precise manner in which the policy maker should react to all this information – i.e., the nature of the feedback rules implied by the results. The second concerns monetary targeting. Do the powerful leading indicator properties of the monetary aggregates justify a role for monetary targeting?

At a broad level, the policy implications of this exercise are straightforward – they offer the policy maker additional information for conducting monetary policy. This additional information could, in fact, just be the corroboration of the results of structural models, or even of rules-of-thumb that were used in the past for conducting monetary policy. A more complex issue, in this context, is in deciding the weights to be given to the different leading indicators of inflation derived from our estimations. The purely logical approach, which is to weight the different indicators primarily by the strength of their forecasting power in these tests, has its pitfalls. This is best illustrated with two polar cases – the short interest rates and the nominal exchange rates. The fact that the Granger causality tests and variance decompositions indicate that short interest rates have predictive information on inflation, is not a sufficient condition for using them as leading indicators in practice. In addition to the fact that their forecasting horizon is short, the term-structure relationship between the operational rate and the bill rates will render the link between policy and indicator unstable in this particular case. In contrast, the absence of predictive information in the bilateral exchange rates, and the wrongly signed impulse-responses for the nominal effective exchange rate, do not necessarily constitute reasons for ignoring them completely in forming assessments about inflationary pressures. The results obtained from a period with fixed exchange rates, that were subject to repeated devaluations, and particular types of policy responses, may cease to hold in a period of floating exchange rates. The key to our assessments about the weights to be given to these leading indicators in practice will have to be conditioned, in both cases, by our understanding of the structural economic relationships between these variables. The estimations, of course, provide the crucial benchmark from which such assessments can begin to be quantified meaningfully.

This brings us to a more general point on this issue – how to distinguish between expectations and non-expectations based inflation indicators for policy purposes. Woodford (1994) has argued that indicators that are also proximate causes of inflation should be assigned a higher weight in practice than those that are primarily expectations based. The difference between these two cases is best illustrated with concrete examples. Consider, for instance, changes in the output gap; the impact of this is likely to be transmitted directly to inflation, and the path of inflation following the shock to the output gap is not affected by whether economic agents understand these economic relationships, or act upon that understanding. Changes in inflation expectations or implied forward rates, in contrast, impact on the path of inflation only in as much as economic agents understand these signals, and act upon them, as for instance, in the wage formation process. That is, the logic of this argument implies that we ought to assign a higher weight to the output gap in practice than what the Granger causality tests and variance decompositions indicate, and a relatively lower weight to inflation expectations than is indicated by the tests. Again, the estimations themselves provide a useful benchmark for making such assessments.

Does the powerful leading indicator properties of the monetary aggregates warrant a shift to monetary targeting? The answer is no, because the use of monetary aggregates as information variables is conceptually very different from using them as intermediate targets.[20] Using a monetary aggregate as an intermediate target presupposes a relatively stable relationship between money and nominal activity, and a clear understanding of the structural

[20] See, in this context, Friedman and Kuttner (1992) and Friedman (1996) for interesting discussions on this issue.

features of the transmission mechanism. The use of monetary aggregates as information variables is based on much less stringent conditions. If the relationship between the monetary aggregates and nominal activity changes, or is rendered unstable, as they have been repeatedly wont to by financial innovation, we just shift the focus to a different monetary aggregate, or drop them altogether and focus on other variables under inflation targeting. It is difficult to follow such a flexible strategy under intermediate targeting without weakening policy credibility significantly.

Table 1.1 Variable Definitions and Transformations

CPI_S	Consumer Price Index, seasonally adjusted, in logs	SCB	1970:1
CPIN_S	Net Price Index (CPI excluding changes in indirect taxes and subsidies), seasonally adjusted, in logs	SCB	1973:1
PGDP_S	Implicit GDP deflator, index seasonally adjusted, in logs	SCB	1980:1
GDP_S	Real GDP, SEK billions, base year 1991, seasonally adjusted by, in logs	SCB	1970:1
GAP	Output gap, percentage deviation from trend measured by a Hodrick-Prescott filter (smothing parameter = 6000), seasonally adjusted by the Riksbank	Rb	1970:1
M0_S	Notes and Coin outside banks, seasonally adjusted, in logs	Rb	1970:1
M3_S	M0 plus deposits and CD's at Swedish banks, seasonally adjusted, in logs	Rb	1970:1
C2_S	Domestic credit institutions' lending to the public, seasonally adj., in logs	SCB/Rb	1970:1
R5Y	5-year government bond rate 1979:1-1983:4 Issuing rate 1984:1-1995:4 Market rate	Rb	1979:1
R3M	Three-month interest rate 1972:1-1979:4 special deposits 1980:1-1983:2 Certificate of Deposits 1983:3-1995:4 Treasury bill	Rb Rb	1972:1 1972:1
YLD	R5Y - R3M		
T1	12 month spot rate	Rb	1984:1
T2	1-year implied forward rate 12 month to settlement	Rb	1984:1
T3	1-year implied forward rate 24 month to settlement	Rb	1984:1
T4	1-year implied forward rate 36 month to settlement	Rb	1984:1
T5	1-year implied forward rate 48 month to settlement	Rb	1984:1
T2_1	T2 - T1	Rb	1984:1
T3_1	T3 - T1	Rb	1984:1
T3_2	T3 - T2	Rb	1984:1
IEXP	Inflation expectations by households (survey)	SCB	1979:1
SSMI	Affärsvärdens generalindex, Stockholm Stock Index in logs	Rb	1970:1
EE	Nominal effective exchange rate (TCW) in logs	Rb	1970:1
DEM	Bilateral nominal exchange rate with the DEM in logs	Rb	1970:1
USD	Bilateral nominal exchange rate with the USD in logs	Rb	1970:1
TOT	Terms of trade (log of export price index minus log of import price index)	IMF	1972:1

Sources: SCB...Statistics Sweden, Rb...Sveriges Riksbank, IMF International Monetary Fund

All series are checked for outliers (and if one was detected also corrected) with TRAMO.

Seasonal adjustment was conducted with SEATS. For further details on that procedures see Gomez and Maraval (1994a,b).

Table 1.2: Results from Unit Root Tests and Outlier Detection

Variable	Conclusions based on the the unit root test procedure	Outliers detected and corrected by TRAMO: Number and type of outliers	Date of the outlier
CPI_S	I(1) without trend or constant	2 TC	1/1991 1/1990
CPIN_S	I(1) with constant or trend	0	
PGDP_S	I(1) with constant	1 AO	4/1990
GDP_S	I(1) with constant	1 AO	1/1980
GAP	I(0) without trend or constant	1 AO	1/1980
M0_S	I(1) with trend	1 AO	1/1995
M3_S	I(1) with trend	1 AO	3/1992
C2_S	I(1) / I(2) with trend	0	
R5Y	I(0) / I(1) with trend	0	
R3M	I(1) without trend or constant	1 AO	3/1992
T1	I(1) without trend or constant	1 AO	3/1992
T2	I(1) without trend or constant	0	
T3	I(1) without trend or constant	0	
T4	I(1) without trend or constant	0	
T5	I(1) without trend or constant	0	
IEXP	I(0) / I(1) with trend	0	
SSMI	I(0) / I(1) with trend	3 TC, AO, AO	4/1987 3/1992 2/1990
EE	I(1) / I(0) with trend	2 TC, AO	4/1982 3/1992
DEM	I(0) / I(1) with trend	2 TC, AO	4/1982 3/1992
USD	I(1) / I(0) with trend	1 AO	3/1992
TOT	I(1) without trend	0	

AO...additional outlier, TC...temporary changes

Possible explanations for outliers		Affected variables
1/1980	Labour market conflict	GDP_S, GAP
4/1982	Devaluation of the Krona	EE, DEM
4/1987	International stock market crash	SSMI
1/1990	Tax reform (VAT increase)	CPI_S
2/1990	High volatility in the stock market	SSM1
1/1991	Tax reform (VAT increase)	CPI_S
3/1992	Currency crisis and floating of the Krona	M3_S, R3M, T1, SSMI, EE, DEM, USD
3/1995	Change in tax refund date from 4th to 3rd quarter	M0_S

Table 2.1 Augmented Dickey/Fuller Unit Root Tests – Levels

	Trend included					No trend			No constant		
		(-20.7)	(-3.45)	(4.88)	(6.49)		(-13.7)	(-2.89)		(-7.9)	(-1.95)
	k	ρ_τ	τ_τ	Φ_2	Φ_3	k	ρ_μ	τ_μ	k	ρ	τ
CPI_S	18	0.57	0.38	151.57	22.74	18	-0.72	-2.93	12	0	0.02
CPIN_S	11	-0.44	-0.41	128.05	27.65	11	-0.92	-2.4	11	-0.02	-0.53
PGDP_S	4	-1.55	-0.88	65.8	6.5	6	-0.63	-1.85	3	0.07	2.22
GDP_S	7	-12.38	-2.97	7.97	2.79	8	-1.42	-1.86	8	0.03	2.78
GAP	7	-28.47	-3.85	3.62	5.48	7	-28.39	-3.86	7	-28.37	-3.88
M0_S	0	1.23	1.1	82.18	16.09	0	-1.19	-5.46	3	0.05	1.94
M3_S	14	-0.92	-0.41	50.03	13.06	14	-1.05	-2.35	12	0.03	0.97
C2_S	11	-6.1	-2.88	545.39	250.54	11	-0.14	-1.37	11	0.02	1.31
R5Y	2	-17.4	-3.77	6.13	9.3	4	-6.74	-1.56	4	-0.3	-0.58
R3M	4	-10.82	-2.44	2.21	3.31	4	-11.13	-2.64	6	-0.23	-0.24
YLD	1	-26.67	-4.87	7.83	11.88	1	-24.58	-4.59	1	-24.2	-4.61
T1	7	-10.65	-2.2	1.83	2.56	7	-7.46	-1.82	7	-0.43	-0.78
T2	2	-14.91	-3.33	3.03	4.34	3	-8.04	-2	9	-0.33	-0.53
T3	12	-32.53	-2.87	1.37	2.01	9	-5.59	-0.95	12	-0.31	-0.49
T4	12	-33.72	-3.06	3.88	5.87	9	-5.41	-0.9	12	-0.25	-0.43
T5	3	-26.14	-4.02	3.64	5.41	4	-11.19	-2.11	4	-0.55	-0.99
T2_1	0	-16.88	-3.11	2.08	3.19	0	-16.81	-3.13	0	-16.1	-3.08
T3_1	0	-14.28	-2.83	1.57	2.4	0	-14.09	-2.83	0	-13.91	-2.83
T3_2	7	-19.07	-1.82	2.04	3.13	7	-18.48	-1.8	7	-16.86	-1.71
IEXP	4	-17.22	-3.75	10.75	15.53	4	-2.28	-1.16	4	-0.82	-1.25
SSMI	7	-5.88	-2.12	11.92	10.13	7	-0.34	-0.46	7	0.31	1.72
EE	1	-12	-3.11	6.67	7.16	1	-0.45	-0.38	1	0.08	1.62
DEM	1	-21.22	-3.76	9.06	6.79	1	-0.52	-0.56	1	0.81	2.28
USD	7	-10.25	-3.26	7.59	11.21	7	-4.67	-2.29	7	0	-0.01
TOT	12	-5.72	-2.58	3.29	4.98	9	-3.34	-1.46	9	-2,53	-1.38

Table 2.2 Augmented Dickey/Fuller Unit Root Tests – First Differences

	Trend included					No trend			No constant		
		(-20.7)	(-3.45)	(4.88)	(6.49)		(-13.7)	(-2.89)		(-7.9)	(-1.95)
	k	ρ_τ	τ_τ	Φ_2	Φ_3	k	ρ_μ	τ_μ	k	ρ	τ
CPI_S	17	-74.65	-3.03	26.78	40.62	12	-13.38	-0.82	11	-2.88	-0.68
CPIN_S	11	-67.01	-2.41	31.88	48.39	10	-2.26	-0.2	10	-5.62	-1.42
PGDP_S	5	-38.95	-2.59	9.57	14.61	1	-28.86	-3.45	3	-5.25	-1.34
GDP_S	7	-99.14	-4.13	41.34	62.67	7	-86.52	-3.8	7	-40.41	-2.46
GAP	9	-142.01	-3.81	43.8	66.41	7	-132.41	-4.27	7	-132.48	-4.3
M0_S	0	-103.53	-10.43	34.34	52.03	2	-35.57	-2.7	2	-9.02	-1.44
M3_S	13	-96.16	-2.53	30.6	46.43	11	-33.43	-1.48	13	-8.56	-1.23
C2_S	10	-13.48	-2.07	16.87	25.48	10	-11.95	-1.86	10	-2.79	-1.17
R5Y	3	-67.53	-5.27	11.14	16.94	3	-66.17	-5.23	3	-66.19	-5.27
R3M	5	-101.03	-4.55	16.68	25.3	5	-93.55	-4.37	5	-93.27	-4.39
YLD	1	-69.09	-7.07	15.75	24.01	1	-68.72	-7.13	1	-68.69	-7.18
T1	6	-38.15	-2.18	7.65	11.77	8	-58.16	-2.2	6	-35.18	-2.17
T2	11	-56.47	-1.58	2.46	3.8	11	-57.94	-1.6	6	-60.26	-3.04
T3	11	-59.83	-1.56	3.26	5.04	11	-52.46	-1.43	11	-52.02	-1.62
T4	11	-52.29	-1.37	6.71	10.38	3	-59.46	-4.53	6	-69.28	-3.07
T5	3	-59.86	-4.48	12.12	18.6	0	-55.59	-8.19	3	-58.46	-4.5
T2_1	0	-55.6	-8.1	19.5	29.92	0	-50.06	-7.25	0	-55.58	-8.23
T3_1	0	-50.08	-7.17	15.07	23.13	4	-105.33	-4.6	0	-50.05	-7.33
T3_2	4	105.31	-4.53	25.81	39.68	3	-43.88	-2.8	4	-105.01	-4.65
IEXP	3	-44.41	-2.77	47.27	72.05	3	-43.88	-2.8	2	-64.94	-4.66
SSMI	6	-61.11	-3.03	18.1	27.43	6	-60.94	-3.06	6	-37.1	-2.36
EE	0	-74.67	-7.48	17.16	26	0	-74.11	-7.49	0	-70.33	-7.25
DEM	0	-83.8	-8.29	21.26	32.21	0	-83.81	-8.33	2	-61.83	-4.3
USD	6	-42.63	-2.16	19.64	29.78	6	-43.62	-2.25	6	-42.75	-2.25
TOT	4	-50.18	-1.95	15.39	23.5	4	-34.19	-1.46	11	-34.16	-1.48

Table 3: Information content of monetary indicators for inflation and real GDP growth (Granger causality tests)
Bivariate prediction equations for different lag length. Sample: 1972:02 - 1995:04

CPI_S

Lags	GAP	M0_S	M3_S	C2_S	R5Y	R3M	YLD	IEXP	SSMI	EE	USD	DEM
1	0.166	0.014	0.055	0.004	0.000	0.365	0.426	0.000	0.558	0.753	0.515	0.687
2	0.028	0.179	0.156	0.054	0.034	0.991	0.624	0.017	0.559	0.265	0.096	0.738
3	0.048	0.006	0.294	0.072	0.043	0.071	0.529	0.065	0.677	0.210	0.073	0.882
4	0.071	0.010	0.084	0.084	0.061	0.137	0.350	0.136	0.765	0.281	0.090	0.936
5	0.039	0.019	0.110	0.119	0.090	0.052	0.192	0.207	0.746	0.126	0.162	0.890
6	0.068	0.003	0.079	0.140	0.158	0.045	0.107	0.313	0.832	0.201	0.239	0.915
7	0.096	0.001	0.001	0.222	0.208	0.052	0.178	0.326	0.750	0.157	0.312	0.856
8	0.187	0.000	0.001	0.334	0.195	0.019	0.198	0.364	0.629	0.200	0.383	0.906

CPIN_S

Lags	GAP	M0_S	M3_S	C2_S	R5Y	R3M	YLD	IEXP	SSMI	EE	USD	DEM
1	0.317	0.000	0.267	0.003	0.000	0.624	0.523	0.000	0.420	0.877	0.704	0.601
2	0.058	0.005	0.239	0.119	0.032	0.872	0.864	0.001	0.568	0.752	0.986	0.485
3	0.008	0.013	0.372	0.388	0.232	0.716	0.237	0.035	0.828	0.549	0.940	0.778
4	0.015	0.035	0.195	0.417	0.299	0.759	0.148	0.141	0.852	0.664	0.400	0.806
5	0.027	0.124	0.340	0.452	0.216	0.438	0.170	0.246	0.904	0.140	0.438	0.502
6	0.012	0.010	0.295	0.219	0.251	0.419	0.073	0.374	0.824	0.201	0.556	0.658
7	0.040	0.025	0.001	0.422	0.238	0.220	0.033	0.557	0.370	0.206	0.712	0.462
8	0.065	0.008	0.002	0.506	0.120	0.157	0.105	0.580	0.503	0.294	0.719	0.531

PGDP_S

Lags	GAP	M0_S	M3_S	C2_S	R5Y	R3M	YLD	IEXP	SSMI	EE	USD	DEM
1	0.060	0.123	0.032	0.000	0.005	0.062	0.855	0.000	0.024	0.838	0.862	0.772
2	0.170	0.491	0.142	0.000	0.051	0.058	0.180	0.001	0.007	0.431	0.245	0.657
3	0.195	0.494	0.120	0.001	0.059	0.001	0.010	0.001	0.022	0.565	0.326	0.843
4	0.470	0.735	0.224	0.001	0.080	0.002	0.018	0.004	0.066	0.669	0.211	0.772
5	0.506	0.690	0.262	0.002	0.119	0.003	0.003	0.006	0.024	0.786	0.305	0.884
6	0.685	0.583	0.318	0.003	0.127	0.010	0.009	0.011	0.042	0.695	0.110	0.932
7	0.700	0.101	0.450	0.007	0.227	0.011	0.025	0.027	0.069	0.772	0.209	0.971
8	0.845	0.071	0.584	0.006	0.046	0.009	0.062	0.043	0.090	0.730	0.364	0.954

GDP_S

Lags	GAP	M0_S	M3_S	C2_S	R5Y	R3M	YLD	IEXP	SSMI	EE	USD	DEM
1	0.008	0.002	0.428	0.268	0.704	0.028	0.016	0.325	0.866	0.498	0.150	0.804
2	0.014	0.011	0.125	0.611	0.741	0.104	0.016	0.794	0.180	0.359	0.163	0.885
3	0.013	0.014	0.176	0.879	0.846	0.105	0.015	0.798	0.426	0.357	0.222	0.749
4	0.004	0.032	0.253	0.908	0.713	0.129	0.033	0.460	0.049	0.555	0.238	0.842
5	0.004	0.044	0.142	0.811	0.499	0.153	0.055	0.247	0.085	0.297	0.261	0.528
6	0.002	0.094	0.219	0.854	0.357	0.137	0.058	0.299	0.084	0.212	0.348	0.277
7	0.001	0.021	0.270	0.835	0.306	0.159	0.102	0.478	0.058	0.028	0.306	0.060
8	0.009	0.009	0.491	0.578	0.644	0.451	0.477	0.695	0.067	0.244	0.352	0.290

All series except GAP, IEXP and the interest rate variables are in first diffferences. The numbers in the table are marginal significance levels (p-values) of F-tests for the H_0 of non-Granger causality of a monetary indicator. For regressions including the series CPIN_S and PGDP_S the sample starts 1975:02 and 1982:02 respectively; with the series R5Y, R3M, and IEXP the sample starts 1981:02, 1974:02 and 1981:02 respectively.

Table 4. Forecast Error Variance Explained through Different Monetary Indicators
Bivariate VAR Model of order 6. Sample: 1971:04 - 1995:04

CPI_S

Steps	GAP	M0_S	M3_S	C2_S	R5Y	R3M	YLD	IEXP	SSMI	EE	USD	DEM
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	3.0	0.0	2.7	1.6	0.0	0.5	6.9	2.1	0.5	0.1	1.5	0.1
4	6.2	4.3	3.2	6.3	11.1	6.4	10.0	3.8	1.6	4.8	5.0	0.8
8	11.1	15.8	20.1	9.7	10.0	8.6	12.8	12.9	3.2	15.1	8.6	3.4
12	12.5	23.0	24.9	16.3	10.5	12.3	14.9	21.0	3.1	17.6	9.6	4.0
24	12.8	34.4	29.3	30.5	11.1	20.7	15.5	32.1	3.1	18.6	10.0	4.2

CPIN_S

Steps	GAP	M0_S	M3_S	C2_S	R5Y	R3M	YLD	IEXP	SSMI	EE	USD	DEM
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	1.8	3.2	0.2	0.3	0.0	0.0	2.5	1.0	1.1	0.1	0.3	0.4
4	8.7	6.1	2.9	4.8	3.3	0.3	8.1	2.8	1.1	1.2	0.6	0.4
8	12.8	20.2	10.9	5.2	7.0	1.7	14.9	11.4	1.7	10.3	4.7	3.9
12	13.4	25.0	11.1	12.7	7.1	3.5	15.7	16.9	1.6	11.6	5.6	4.4
24	13.3	33.7	11.8	29.2	6.9	7.7	16.6	25.6	1.5	13.8	7.0	5.0

PGDP_S

Steps	GAP	M0_S	M3_S	C2_S	R5Y	R3M	YLD	IEXP	SSMI	EE	USD	DEM
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	2.8	3.4	9.5	21.8	0.0	9.1	13.6	5.5	19.3	1.3	1.0	0.9
4	5.1	6.7	9.3	33.8	11.0	17.6	17.6	12.4	20.0	1.6	8.2	0.9
8	8.2	15.7	10.5	38.4	10.4	18.2	20.3	21.8	27.7	3.0	8.8	1.3
12	8.1	16.0	10.8	42.3	10.6	18.3	21.9	22.9	30.4	3.1	10.9	1.3
24	9.1	16.8	10.7	48.4	11.0	18.6	22.2	26.2	31.2	3.1	11.8	1.3

GDP_S

Steps	GAP	M0_S	M3_S	C2_S	R5Y	R3M	YLD	IEXP	SSMI	EE	USD	DEM
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	2.3	8.2	1.8	0.5	2.2	0.5	0.1	3.1	0.2	0.0	2.3	0.1
4	3.8	8.4	3.3	0.7	13.0	8.9	5.4	3.2	3.7	5.1	6.1	2.0
8	6.2	12.6	6.6	2.1	17.8	8.9	10.6	6.6	10.8	7.9	7.6	7.5
12	6.2	13.0	7.0	2.6	18.4	9.2	11.1	6.9	10.9	8.1	7.6	7.6
24	6.1	13.4	7.1	3.0	18.9	9.3	11.3	7.0	10.9	8.1	7.6	7.6

All series except GAP, IEXP and the interest rate variables are in first diffferences. For regressions including the series CPIN_S and PGDP_S the sample starts 1974:04 and 1981:04 respectively; with the series R5Y, R3M, and IEXP the sample starts 1980:04, 1973:04 and 1980:04 respectively. The orthogonalization method is Choleski decomposition with the monetary indicator last in the ordering.

Table 5: Information content of monetary indicators for inflation and real GDP growth (Granger causality tests)
Four variable prediction equations for different lag length. Sample: 1972:03 - 1995:04

CPI_S

Lags	GAP	M0_S	M3_S	C2_S	R5Y	R3M	YLD	IEXP	SSMI	EE	USD	DEM
1	0.045	0.020	0.051	0.002	0.000	0.433	0.574	0.000	0.572	0.429	0.711	0.401
2	0.022	0.089	0.178	0.047	0.042	0.933	0.821	0.010	0.596	0.212	0.059	0.690
3	0.064	0.004	0.249	0.044	0.025	0.111	0.776	0.020	0.657	0.281	0.061	0.914
4	0.336	0.030	0.129	0.124	0.131	0.438	0.242	0.072	0.960	0.713	0.085	0.952
5	0.117	0.046	0.210	0.276	0.139	0.468	0.257	0.165	0.806	0.505	0.181	0.827
6	0.093	0.035	0.291	0.270	0.271	0.403	0.181	0.328	0.939	0.567	0.272	0.851
7	0.103	0.004	0.054	0.226	0.361	0.546	0.296	0.418	0.805	0.719	0.424	0.897
8	0.456	0.013	0.028	0.283	0.536	0.102	0.130	0.321	0.801	0.712	0.615	0.920

CPIN_S

Lags	GAP	M0_S	M3_S	C2_S	R5Y	R3M	YLD	IEXP	SSMI	EE	USD	DEM
1	0.074	0.000	0.196	0.001	0.000	0.786	0.758	0.000	0.518	0.612	0.916	0.989
2	0.589	0.002	0.313	0.129	0.051	0.883	0.982	0.001	0.423	0.901	0.977	0.578
3	0.333	0.013	0.464	0.211	0.157	0.743	0.164	0.002	0.722	0.691	0.992	0.825
4	0.268	0.050	0.349	0.169	0.305	0.787	0.145	0.004	0.785	0.401	0.039	0.745
5	0.599	0.129	0.344	0.170	0.809	0.425	0.287	0.033	0.778	0.172	0.027	0.586
6	0.787	0.188	0.583	0.073	0.743	0.324	0.339	0.110	0.612	0.267	0.053	0.736
7	0.798	0.183	0.016	0.092	0.520	0.554	0.251	0.161	0.457	0.663	0.182	0.845
8	0.965	0.273	0.027	0.168	0.359	0.554	0.343	0.313	0.378	0.460	0.190	0.881

PGDP_S

Lags	GAP	M0_S	M3_S	C2_S	R5Y	R3M	YLD	IEXP	SSMI	EE	USD	DEM
1	0.116	0.096	0.033	0.000	0.006	0.052	0.948	0.000	0.025	0.516	0.672	0.488
2	0.473	0.513	0.130	0.000	0.059	0.004	0.051	0.004	0.033	0.469	0.146	0.657
3	0.729	0.674	0.049	0.001	0.101	0.001	0.028	0.007	0.067	0.594	0.123	0.723
4	0.530	0.864	0.271	0.000	0.268	0.004	0.019	0.013	0.110	0.612	0.194	0.651
5	0.228	0.897	0.486	0.000	0.132	0.005	0.037	0.041	0.124	0.880	0.363	0.862
6	0.102	0.912	0.523	0.001	0.091	0.011	0.072	0.043	0.342	0.939	0.107	0.928
7	0.088	0.749	0.434	0.005	0.075	0.034	0.147	0.093	0.522	0.847	0.217	0.928
8	0.003	0.567	0.488	0.000	0.040	0.024	0.251	0.077	0.669	0.424	0.431	0.783

GDP_S

Lags	GAP	M0_S	M3_S	C2_S	R5Y	R3M	YLD	IEXP	SSMI	EE	USD	DEM
1	0.020	0.004	0.080	0.551	0.334	0.078	0.023	0.547	0.537	0.390	0.163	0.650
2	0.020	0.021	0.107	0.950	0.317	0.015	0.018	0.650	0.220	0.141	0.384	0.224
3	0.009	0.087	0.209	0.862	0.097	0.003	0.004	0.579	0.392	0.135	0.205	0.252
4	0.007	0.163	0.502	0.923	0.411	0.018	0.010	0.593	0.082	0.300	0.287	0.454
5	0.021	0.143	0.601	0.938	0.400	0.089	0.059	0.269	0.102	0.570	0.407	0.831
6	0.033	0.059	0.681	0.900	0.134	0.128	0.063	0.353	0.073	0.748	0.360	0.952
7	0.045	0.030	0.710	0.969	0.166	0.302	0.149	0.260	0.152	0.187	0.614	0.396
8	0.003	0.164	0.572	0.863	0.484	0.702	0.496	0.348	0.431	0.315	0.223	0.607

All series except GAP, IEXP and the interest rate variables are in first diffferences. The numbers in the table are marginal significance levels (p-values) of F-tests for the H_0 of non-Granger causality of a monetary indicator. For regressions including the series CPIN_S and PGDP_S the sample starts 1975:02 and 1982:02 respectively; with the series R5Y, R3M, and IEXP the sample starts 1981:02, 1974:02 and 1981:02 respectively.

Table 6. Forecast Error Variance Explained through Different Monetary Indicators
Four variables VAR model of order 6. Sample: 1971:04 - 1995:04

CPI_S

Steps	GAP	M0_S	M3_S	C2_S	R5Y	R3M	YLD	IEXP	SSMI	EE	USD	DEM
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	0.0	0.4	0.7	0.3	0.4	1.3	3.4	6.0	0.3	0.1	2.6	0.5
4	0.2	4.9	1.3	3.8	6.5	5.3	5.5	7.1	1.2	1.8	3.7	0.5
8	1.3	21.4	14.2	6.8	7.3	9.9	7.3	13.1	2.5	5.7	4.7	1.1
12	2.8	29.5	17.7	10.6	7.1	13.7	7.5	21.2	4.0	5.6	4.5	1.9
24	4.3	40.9	19.8	18.4	7.0	18.2	8.0	33.4	5.0	6.3	4.4	2.8

CPIN_S

Steps	GAP	M0_S	M3_S	C2_S	R5Y	R3M	YLD	IEXP	SSMI	EE	USD	DEM
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	0.1	4.9	0.0	0.5	0.4	0.0	0.0	10.5	2.7	0.0	0.0	0.3
4	0.3	7.0	1.2	4.4	1.8	0.6	2.9	10.7	2.6	0.5	0.9	0.2
8	0.4	19.0	6.6	4.6	7.2	4.8	6.6	13.9	4.1	5.7	3.4	2.2
12	1.1	22.4	6.6	7.9	8.4	7.4	7.8	19.2	5.2	6.1	3.8	2.8
24	1.4	31.5	6.1	15.1	9.2	10.8	9.6	26.5	5.9	7.1	3.6	4.1

PGDP_S

Steps	GAP	M0_S	M3_S	C2_S	R5Y	R3M	YLD	IEXP	SSMI	EE	USD	DEM
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	1.2	1.9	11.5	28.2	1.6	12.4	5.0	3.4	14.6	4.3	2.9	3.7
4	3.1	4.0	11.6	32.9	9.5	17.4	9.6	9.3	17.2	4.3	9.2	4.2
8	4.6	18.8	10.9	35.8	8.3	18.0	9.7	17.6	22.6	7.7	14.5	4.0
12	5.5	20.2	10.3	41.1	8.5	16.7	9.7	18.9	33.8	9.8	20.8	4.6
24	6.6	20.1	10.3	42.1	8.6	16.1	9.8	19.8	34.2	10.3	22.9	4.8

GDP_S

Steps	GAP	M0_S	M3_S	C2_S	R5Y	R3M	YLD	IEXP	SSMI	EE	USD	DEM
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	5.4	14.9	0.7	0.0	1.8	0.0	0.4	7.8	0.1	0.1	1.5	0.5
4	4.3	20.3	3.0	2.4	9.9	15.2	10.4	7.4	5.6	5.5	6.7	4.1
8	5.8	23.4	3.7	6.8	12.0	14.8	12.4	14.3	23.5	10.8	10.2	6.3
12	5.3	23.3	3.9	8.1	11.7	14.2	12.3	14.5	24.8	11.3	12.0	6.3
24	5.5	23.4	4.2	9.4	12.0	14.4	13.0	14.6	25.6	11.3	12.0	6.4

All series except GAP, IEXP and interest rate variables are in first diffferences. For regressions including the series CPIN_S and PGDP_S the sample starts 1974:04 and 1981:04 respectively; with the series R5Y, R3M and IEXP the sample starts 1980:04, 1973:04, and 1980:04 respectively. The orthogonalization method is Choleski decomposition with the monetary indicator last in the ordering.

Table 7 Implied Forward Rates

Information content of monetary indicators for inflation and real GDP growth (Granger causality tests)
Bivariate prediction equations for different lag length. Sample: 1986:01 - 1995:04

CPI_S

Lags	T1	T2	T3	T2_1	T3_1	DT1	DT2	DT3
1	0.006	0.003	0.014	0.696	0.563	0.108	0.834	0.577
2	0.062	0.046	0.102	0.107	0.524	0.129	0.739	0.705
3	0.196	0.090	0.180	0.117	0.585	0.022	0.253	0.344
4	0.115	0.165	0.291	0.162	0.576	0.045	0.428	0.498
5	0.098	0.255	0.310	0.218	0.780	0.023	0.300	0.348
6	0.073	0.383	0.384	0.027	0.064	0.039	0.473	0.450
7	0.040	0.559	0.541	0.055	0.100	0.036	0.421	0.483
8	0.015	0.687	0.680	0.135	0.218	0.018	0.689	0.739

Forecast Error Variance Explained through Different Monetary Indicators
Bivariate VAR Model of order 6. Sample: 1985:03 - 1995:04

CPI_S

Steps	T1	T2	T3	T2_1	T3_1	DT1	DT2	DT3
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	1.2	3.6	2.6	26.5	15.8	5.5	3.2	1.9
4	14.8	20.5	19.1	25.1	15.5	13.3	14.7	13.1
8	17.2	22.8	20.2	31.9	23.5	17.4	15.1	11.9
12	17.5	25.0	23.7	35.6	26.3	17.5	15.2	12.2
24	17.7	26.1	24.7	35.2	25.0	17.1	15.6	12.4

Information content of monetary indicators for inflation and real GDP growth (Granger causality tests)
Four variable prediction equations for different lag length. Sample: 1986:01 - 1995:04

CPI_S

Lags	T1	T2	T3	T2_1	T3_1	DT1	DT2	DT3
1	0.009	0.001	0.004	0.316	0.882	0.391	0.354	0.968
2	0.275	0.063	0.172	0.163	0.675	0.107	0.411	0.624
3	0.261	0.082	0.170	0.281	0.837	0.110	0.138	0.178
4	0.546	0.351	0.574	0.527	0.912	0.277	0.425	0.458
5	0.155	0.294	0.381	0.750	0.893	0.246	0.449	0.396
6	0.131	0.292	0.307	0.187	0.168	0.233	0.562	0.465
7	0.209	0.481	0.488	0.132	0.234	0.437	0.466	0.438
8	0.261	0.575	0.766	0.028	0.036	0.263	0.715	0.787

Forecast Error Variance Explained through Different Monetary Indicators
Four variables VAR model of order 6. Sample: 1985:03 - 1995:04

CPI_S

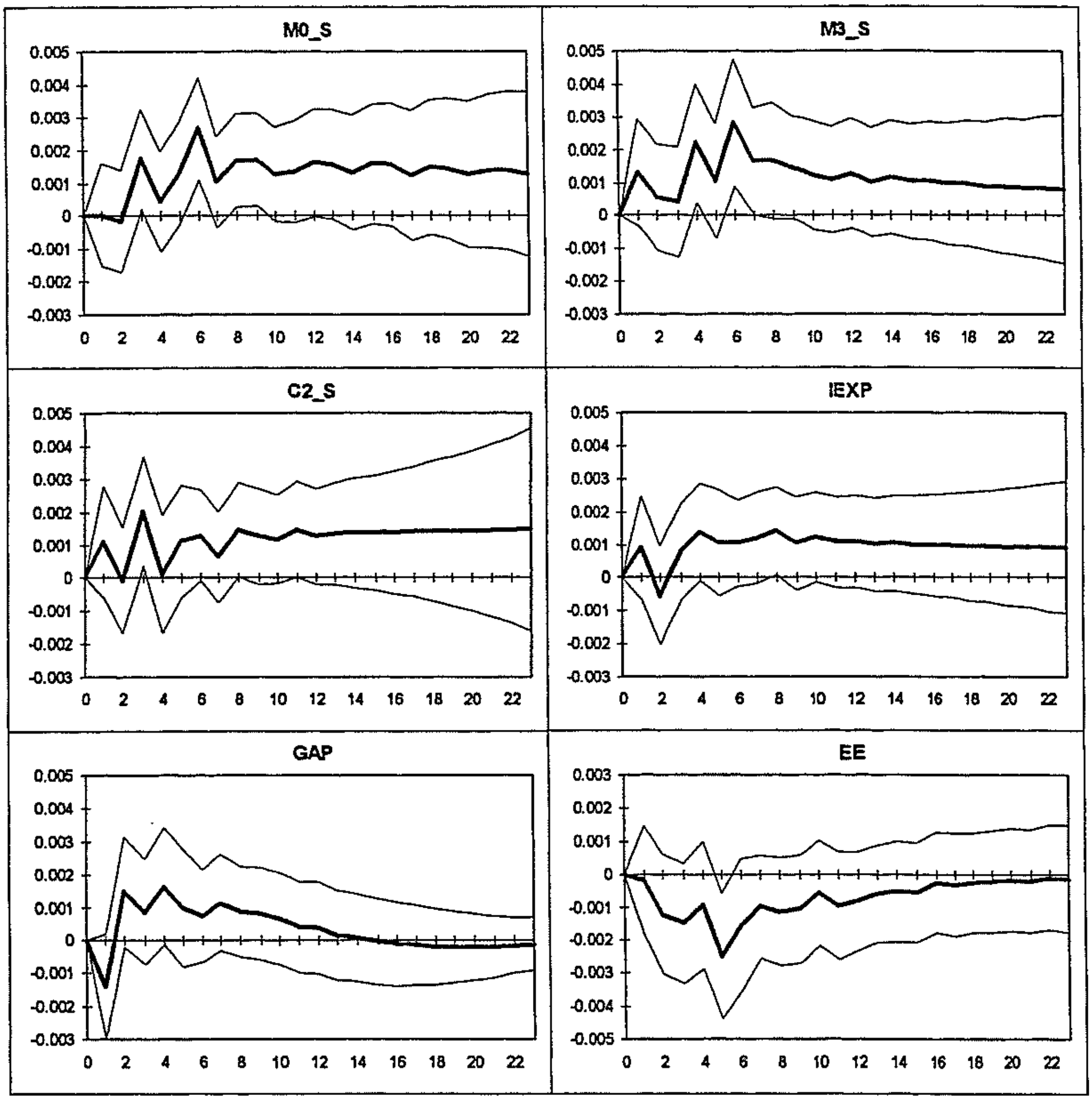
Steps	T1	T2	T3	T2_1	T3_1	DT1	DT2	DT3
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	1.1	0.1	0.2	20.0	15.4	1.3	0.6	1.7
4	2.9	4.8	3.4	16.8	11.8	8.0	4.2	6.4
8	8.6	5.4	5.5	17.0	15.1	13.4	4.8	6.6
12	9.2	5.3	5.4	16.3	15.7	17.0	6.5	7.8
24	8.6	5.4	5.1	15.0	14.3	16.2	6.7	8.1

Table 8 Predictive Power of Monetary Policy Indicators on Inflation
(Qualitative Results: Summary)

Indicators	Bivariate Granger Causality	Bivariate Variance Decomposition	Multi-variable Granger Causality	Multi-variable Variance Decomposition	Approximate Time Horizon
M0_S	Strong	Strong	Strong	Strong	Second Year
M3_S	Medium	Strong	Weak	Medium	Second Year
C2_S	Weak	Strong	Weak	Medium	First Year
GAP	Strong	Weak	Weak	None	First Year
IEXP	Weak	Strong	Medium	Strong	Second Year
R5Y	Medium	Weak	Weak	Weak	First Year
R3M	Weak	Weak	None	Medium	First Year
T2	Weak	Medium	None	Weak	First Year
T2_1	None	Strong	None	Medium	First Year

Chart 1 Impulse-Response functions
(Bivariate VAR models with lag order 6)

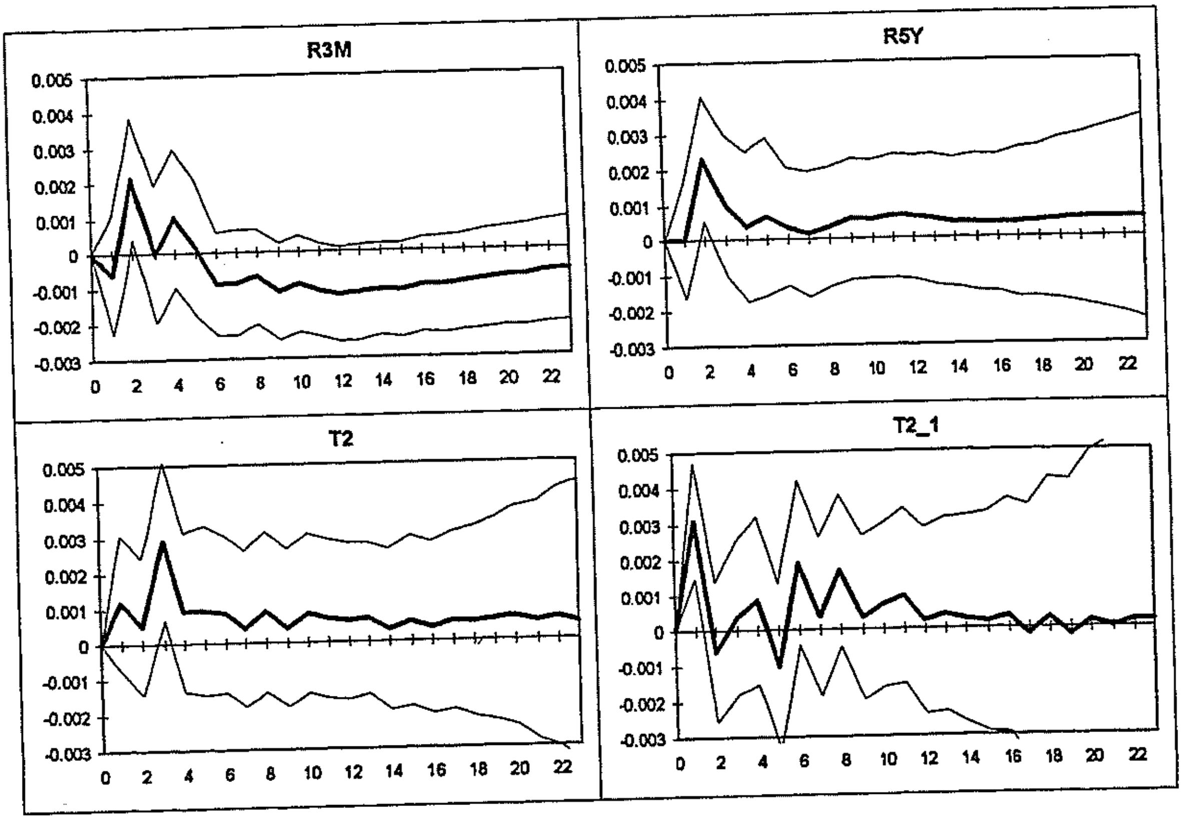
Response of CPI_S to an impulse in the indicator variable



Thin lines represent +/- 2 standard error bands calculated with Monte Carlo simulations

Chart 2 Impulse-Response functions
(Bivariate VAR models with lag order 6)

Response of CPI_S to an impulse in the indicator variable



Thin lines represent +/- 2 standard error bands calculated with Monte Carlo simulations

Appendix: Holden and Perman unit root test procedure

The problem with unit root tests is that the distribution of the test statistic is not invariant to either the true data generating process or the estimated equation used in the test. Whether a linear trend or a constant is or should be included in the equation is often crucial for the results. Another problem is that these tests generally have very low power. Discriminating between different models can therefore be difficult.

The test procedure used in this paper follows that outlined by Holden and Perman (1994). They suggest using the joint tests of Dickey and Fuller (1981) in combination with the standard ADF-tests. See below for an outline of Holden and Perman's sequential test procedure. The ADF test results reported in table 2 are both the usual t-statistics (τ) and the standardised bias, where the test statistic is $\rho = T(\alpha - 1)$ and T is the number of observations.

Step 1. Estimate the following equation: $y_t = \mu + \beta t + \alpha \; y_{t-1} + \sum_{i=1}^{k} \gamma_i \Delta y_{t-i} + \varepsilon_t$

Step 2. Use the Φ_3 statistic to test $H_0{:}(\mu, \beta, \alpha) = (\mu, 0, 1)$ vs. $H_A{:}(\mu, \beta, \alpha) \neq (\mu, 0, 1)$
If the null hypothesis is rejected go to Step 3. If the null hypothesis is not rejected go to Step 5.

Step 3. Test $(\mu = 1)$ using the t-statistic from step 1, with critical values from the standard normal tables. If the null hypothesis is not rejected we conclude that β is non-zero and α is one. If the null hypothesis is rejected go to step 4.

Step 4. Use a conventional t-statisitc to decide whether β equals zero or not. If the null hypothesis is accepted we conclude that the series is a stationary series without trend. If the null hypothesis is rejected we conclude the series is a stationary series with a linear trend. In either case we can test the hypothesis concering the parameter μ in a conventional manner.

Step 5. Use a t-statisitic to test $(\mu = 1)$, assuming β is zero so that non-standard critical values are required. Assuming this t-statisitc provides the verification we seek we proceed to Step 6.

Step 6. Perform a Φ_2 test for $(\mu, \beta, \alpha) = (0, 0, 1)$. If Φ_2 leads us to conclude that μ is zero we conclude that the series is a random walk without drift. Oherwise the series is a random walk with drift. In either case case we can proceed to step 7.

Step 7. Estimate the following equation (β restricted to zero) :

$$y_t = \mu + \alpha \; y_{t-1} + \sum_{i=1}^{k} \gamma_i \Delta y_{t-i} + \varepsilon_t$$

by using the Φ_1 statisitc to test the null hypothesis of a unit root and zero drift.

Source: Holden and Perman (1994) p. 64-65 table 3.2. Minor changes in notation have been made by the authors.

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