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Abstract

We analyze the issue of the impact of multiple breaks on monetary neutrality results, using a long annual international data set. We empirically verify whether neutrality propositions remain addressable (and if so, whether they hold or not), when unit root tests are carried out allowing for multiple structural breaks in the long-run trend function of the variables. It is found that conclusions on neutrality are sensitive to the number and location of breaks. In order to interpret the evidence for structural breaks, we introduce a notion of deterministic monetary neutrality, which naturally arises in the absence of permanent stochastic shocks to the variables.

Keywords: Deterministic and Stochastic Neutrality and Superneutrality of Money, Unit Roots, Structural Breaks, Resampling Methods.
JEL Classification: C15, C32, E51, E52

Resumen

Este artículo analiza el impacto de cambios estructurales múltiples sobre resultados de neutralidad monetaria, utilizando una base de datos internacional. Investigamos empíricamente si las proposiciones de neutralidad pueden ser verificables (y si lo son, si se mantienen o no), cuando las pruebas de raíz unitaria se aplican permitiendo cambios estructurales múltiples en la función de tendencia de largo plazo de las variables. Encontramos que las conclusiones sobre neutralidad son sensibles al número de cambios y a su localización en la muestra. Para interpretar la evidencia de cambios estructurales, introducimos una noción de neutralidad monetaria determinística, que surge naturalmente en ausencia de choques estocásticos permanentes en las variables.

Palabras Clave: Neutralidad y súper neutralidad monetaria determinística y estocástica, Raíces unitarias, Cambios estructurales, Métodos de remuestreo.

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1 Introduction

Several empirical studies demonstrate the prevalence of (infrequent) parameter variation in the trend function of macroeconomic time series, and analyze the impact of such structural breaks on unit root testing. The common conclusion is that neglected breaks tend to induce non rejection of the unit root hypothesis.[1] Similar problems could arise when testing relevant hypotheses such as monetary neutrality. In particular, neglecting breaks could bias the results of tests of monetary neutrality that rely on the time series properties of money and income, such as those proposed by Fisher and Seater (1993).

Serletis and Koustas (1998) argue that the issue of whether long-run monetary neutrality (LRN) results hold under the presence of structural breaks -an issue that has not been resolved yet in the literature- depends on how big shocks are treated. If they are treated like any other shock, then there is no need to account for them in interpreting neutrality results. If, on the other hand, they are regarded as (infrequent) big shocks that need to be accounted for, then conclusions on neutrality may change, because such shocks may induce lower orders of integration for output and money. Fisher and Seater (1993) (henceforth, FS) use the convention that if a variable is stationary around a *linear* trend then it is treated as trend-stationary, that is, integrated of order zero. Extending FS's idea, one can say that if a variable is stationary around a *broken* trend then it is also integrated of order zero. This is precisely the interpretation followed by Serletis and Krause (1996), and Serletis and Koustas (1998). Under their approach, however, the number of structural breaks allowed in the deterministic trend function is fixed to one. This selection may not be inconsequential.[2]

In this paper, we analyze precisely the issue of the impact of multiple breaks on monetary neutrality results. To the best of our knowledge there is no evidence of the effects of structural breaks on monetary neutrality tests available in the literature. By allowing for broken trend functions we uncover the presence of structural breaks which alter (reduce) the order of integration of money and output, therefore modifying conclusions on LRN and long-run super neutrality (LRSN). We utilize the same data set as Noriega (2004), i.e., long annual data on real output and monetary aggregates for Argentina (1884-1996), Australia (1870-1997), Brazil (1912-1995), Canada (1870-2001), Italy (1870-1997), Mexico (1932-2000), Sweden (1871-1988), and the UK (1871-2000) (The cases of Denmark and the U.S are not analyzed

[1] Empirical examples with macro time series can be found in Perron (1989, 1992, 1997), Lumsdaine and Papell (1997), Ohara (1999), Mehl (2000), Noriega and De Alba (2001), and Gil-Alana (2002); Perron and Vogelsang (1992), Culver and Papell (1995), and Aggarwal et.al. (2000) for real exchange rates; Raj (1992) and Zelhorst and Haan (1995), for real output; Clemente, et. al. (1998) for interest rates, among others.

[2] In a recent paper, Arestis and Biefang-Frisancho Mariscal (1999) conclude that "...unit root tests that do not account sufficiently for the presence of structural breaks are misspecified and suggest excessive persistence"(p.155). See also Perron (2003).

in this paper, since evidence in Noriega (2004) suggests that both money and output are integrated of order zero).

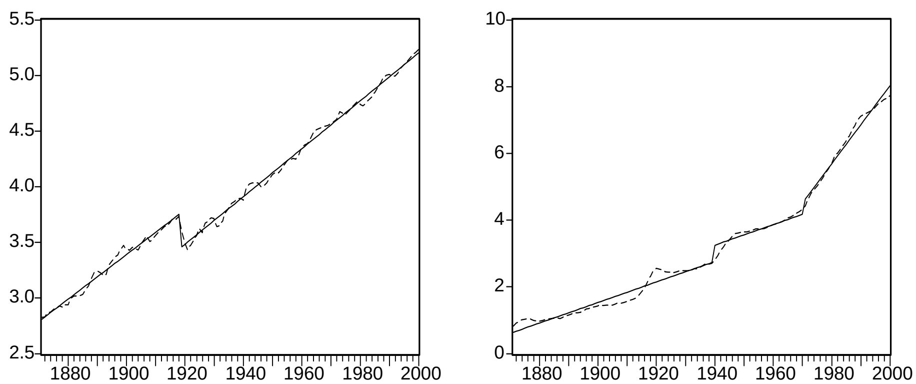
In particular, we empirically verify whether the monetary neutrality propositions remain addressable (and if so, whether they hold or not), when unit root tests are carried out allowing for (possibly) multiple structural breaks in the long-run trend function of the variables. It is found that conclusions on monetary neutrality are sensitive not only to whether there is a break or not, but also to the number and location of breaks.

Our ultimate finding is that neglected deterministic breaks appear to induce over-rejections of the LRN hypothesis. To motivate the issue of broken trends and monetary neutrality, consider the case of the U.K. Results in Serletis and Koustas (1998) and Noriega (2004), both based on the FS methodology, indicate that LRN does not hold for M4. This implies that a permanent *stochastic* shock to the level of money has a long lasting real effect on UK output. Now consider the graphs of real output and money in Figure 1, which indicate the presence of one structural break in output (1918) and two structural breaks in money (1939, 1970)[3].

As can be seen, even though M4 underwent two breaks, one in level and another one in level and slope of trend, real output did not register any major change in its long-run trend function, from 1919 to 2000; it actually fluctuated in a stationary fashion for over 80 years.

Figure 1

UK real output (left) and money (M4, right), 1871-2000



Based on this evidence, in sharp contradiction with recent research in the area, it could be argued that money has been neutral in the UK for most of the twentieth century. This is a case of rejection of the LRN hypothesis due to neglected breaks. Cases like this point to an heuristic notion of deterministic neutrality, to be introduced below.

We use as our starting point the results recently obtained in Noriega (2004) regarding

[3]Details on how to estimate the number and location of breaks will be given below.

the order of integration of money and output for the data set described above[4]. After a brief review of the FS methodology, we analyze in section 2, the behaviour of these orders of integration under different trend specifications, allowing for an increasing number of structural breaks in the long-run trend function under the alternative hypothesis. Note that under broken trend-stationary models, permanent changes are deterministic, as opposed to stochastic.[5] This allows the possibility of investigating any potential relationship between the estimated break dates and historic events. Section 3 offers an alternative heuristic interpretation of 'deterministic neutrality' based on the presence of these permanent deterministic shocks. It reports the empirical results under both the traditional stochastic interpretation based on FS, and the deterministic one. Section 4 concludes.

2 Econometric Methodology

2.1 The FS tests of LRN and LRSN

Economists care about long-run monetary neutrality (LRN) because most theoretical models of money predict that money is neutral in the long-run; that is, the real effects of an unanticipated, permanent change in the level of money, tend to disappear as time elapses. They also care about LRN because LRN is often used as an identification assumption (i.e. the large literature using Blanchard-Quah (1989) decompositions). On the other hand, the case for monetary superneutrality has limited theoretical support[6]. As summarized by Bullard (1999), "if monetary growth causes inflation, and inflation has distortionary effects, then long-run monetary superneutrality should not hold in the data. On the contrary, a permanent shock to the rate of monetary growth should have some long-run effect on the real economy; why else should we worry about it?" (p.59).

Empirical results based on the reduced-form tests of Long Run Neutrality (LRN) and Long Run Superneutrality (LRSN), derived by FS, depend on the order of integration of both real output and the money aggregates. A number of recent papers examine the validity of these key macro propositions using long annual data and the reduced form tests of FS[7].

[4] Noriega (2004) determined the order of integration of money and output by estimating the number of unit roots present in the data, under the asymptotically consistent sequential procedure of Pantula (1989), using the unit root tests developed by Ng and Perron (2001).

[5] Our econometric methodology borrows from Ng and Perron (1995), Bai and Perron (1998a, b), and Noriega and de Alba (2001).

[6] In the literature on monetary growth theory, there are very few available models which embody some form of monetary superneutrality. See for instance, Sidrauski (1967), Hayakawa (1995) and Faria (2001).

[7] Bae and Jensen (1999) examine these propositions by extending FS long-run neutrality requirements to long-memory processes. An alternative econometric perspective of LRN and LRSN is presented in King and Watson (1997).

In this literature, the orders of integration are identified through the application of common used test, as the Augmented Dickey-Fuller, *ADF*, of Said and Dickey (1984), the Z tests of Phillips-Perron (1988), and the stationarity *KPSS* tests of Kwiatkowski, et. al. (1992), to real output and the money aggregates. For instance, LRN finds empirical support in the studies of Boschen and Otrok (1994, US data), Haug and Lucas (1997, Canadian data), Serletis and Krause (1996, international data set), Wallace (1999, Mexican data), and Bae and Ratti (2000 Brazilian and Argentinean data). Utilizing the more powerful tests of Ng and Perron (2001), Noriega (2004, international data set) finds weaker support for LRN.

Even though the paper's objective is not to derive conclusions on monetary neutrality based on the FS methodology, we do apply it and use the results as a benchmark against which we compare results based on the methodology put forward in the next subsection, for which neutrality testing also depends on permanent shocks, but of a deterministic nature. This subsection briefly present*s* the main ingredients of the FS methodology. They show that LRN and LRSN can be tested through the significance of the slope parameters b_k in the following long-horizon (OLS) regression:

$$\left[\sum_{j=0}^{k} \Delta^{\langle y \rangle} y_{t-j}\right] = a_k + b_k \left[\sum_{j=0}^{k} \Delta^{\langle m \rangle} m_{t-j}\right] + \varepsilon_{kt}, \tag{1}$$

where y and m stand for real output and (exogenous) money; Δ represents the difference operator ($\Delta^j y_t = y_t - y_{t-j}$), $\langle y \rangle$ stands for the order of integration of y (i.e. $\langle y \rangle = 1$ means that y is integrated of order one, or $y \sim I(1)$), and ε is a mean zero uncorrelated random variable. Theoretically, $\lim_{k\to\infty} b_k \equiv b$, gives an estimate of the long-run derivative (LRD) of real output with respect to a permanent stochastic exogenous shock in both the level of money (denoted LRD_N), and the growth rate (trend) of money (denoted LRD_{SN}).

FS show that, in order to interpret neutrality results, the order of integration of output and money should obey certain restrictions. For instance, the order of integration of money should be at least equal to one ($\langle m \rangle \geq 1$) for LRN to make sense, otherwise there are no stochastic permanent changes in money that can affect real output. Table 1 summarizes values of the LRD under different possibilities on the order of integration of the variables. According to the table, when $\langle m \rangle \geq \langle y \rangle + 1 \geq 1$ the long-run derivative is zero, providing direct evidence of neutrality. When $\langle m \rangle = \langle y \rangle = 1$, LRN is testable through b. In this case, LRD_N measures whether the permanent movements in output are associated with permanent stochastic movements in the level of money. If for instance b is significantly different from zero, then LRN does not hold.

Table 1

The *LRD* and the Order of Integration of Money and Output

	LRD_N			LRD_{SN}		
$\langle y \rangle$	$\langle m \rangle = 0$	$\langle m \rangle = 1$	$\langle m \rangle = 2$	$\langle m \rangle = 0$	$\langle m \rangle = 1$	$\langle m \rangle = 2$
0	undefined	$\equiv 0$	$\equiv 0$	undefined	undefined	$\equiv 0$
1	undefined	b	$\equiv 0$	undefined	undefined	b

Source: Adapted from Fisher and Seater (1993).

Superneutrality, however, is not addressable when there are no permanent stochastic changes in the *growth rate* of money. In other words, superneutrality requires $\langle m \rangle \geq 2$. When $\langle m \rangle = 2$ and $\langle y \rangle = 0$, $LRD_N = LRD_{SN} = 0$, i.e., both LRN and LRSN hold, since one cannot associate permanent shocks to the growth rate of money to nonexistent permanent changes in output (further discussion of several cases of interest can be found in FS). Therefore, proper determination of the orders of integration of y and m is crucial in assessing LRN and LRSN of money.

Finally, it is important to mention that since the neutrality tests of FS are based on how *changes* in the level of money are ultimately related to *changes* in output, cointegration is neither necessary nor sufficient for long-run neutrality.[8]

2.2 Unit roots and structural breaks in money and output

Fisher and Seater‘s tests of monetary neutrality rely on the presence of stochastic permanent changes in money and output. If there are no such changes in either variable, then LRN is unaddressable (the LRD_N is undefined). On the other hand if there is a stochastic permanent change in the level of money, while output follows a stationary process, then LRN holds by definition (since $LRD_N = 0$).

The presence of permanent stochastic changes in money and output, as indeed in many other macro variables depends, however, on the way the trend function is treated, i.e., the modelling of the long-run. The most common approaches in the literature include linear trends (Nelson and Plosser (1982)), broken trends (Perron (1989, 1997)), polynomial trends (Schmidt and Phillips (1992)), the Hodrick-Prescott filter (Hodrick and Prescott (1997), Cogley and Nason (1995)), and smooth transition trend models (Leybourne, et. al. (1998), Sollis, et. al. (1999)).[9] Among these, models allowing for structural breaks (broken trend models) have become very popular in the literature, both theoretical and applied (Lanne,

[8] See Fisher and Seater (1993) p. 414-15 for details.

[9] See also Pollock (2001) for the analysis of three different approaches to the estimation of econometric trends.

et. al. (2003), Sen (2003), Perron and Zhu (2002), Maddala and Kim (1998), Ben-David and Papell (1995, 1998), Stock (1994)). As Perron (2003) has pointed out, "changes in the trend function bias unit root tests towards a non-rejection and they need to be explicitly accounted for prior to performing unit root tests" (p.5). We utilize a resampling procedure based precisely on this idea: unit root testing is carried out allowing for (an increasing number of) structural breaks in the trend function of the variables.

In particular, following Rudebusch (1992) and Diebold and Senhadji (1996), we simulate the distribution (and obtain the empirical density) of the t-statistic for the null of a unit root, under the hypotheses that the true models are both a Broken Trend Stationary (BTS) model with up to four structural breaks, and a Difference-Stationary (DS) model, both estimated from the data. We then compare the position where the sample estimate of the t-statistic for testing a unit root lies relative to the empirical densities under the estimated BTS and DS DGPs. Following Perron (1989), we consider three different types of BTS models, one allowing a break in level, one a break in slope of trend, and one combining both types of breaks: in level and trend.

We now present the procedure for testing the presence of a unit root while allowing an unknown number of structural breaks in the deterministic trend function. Denote by Y_t the logarithm of the observed series (output or money). Consider the following BTS model with $0 \leq m \leq 4$ structural breaks in level and slope of trend, and DS model, respectively:

$$\Delta Y_t = \mu + \beta t + \sum_{i=0}^{m} \theta_i DU_{it} + \sum_{i=0}^{m} \gamma_i DT_{it} + \alpha Y_{t-1} + \sum_{i=1}^{k} a_i \Delta Y_{t-i} + \varepsilon_t, \tag{2}$$

$$\Delta Y_t = \sum_{i=1}^{k} a_i \Delta Y_{t-i} + \varepsilon_t, \tag{3}$$

for $t = 1, 2, \ldots, T$, where T is the sample size, ε_t is an iid process, and DU_{it} and DT_{it} are dummy variables allowing changes in the trend's level and slope respectively, that is, $DU_{it} = \mathbf{1}(t > T_{b_i})$ and $DT_{it} = (t - T_{b_i})\mathbf{1}(t > T_{b_i})$, where $\mathbf{1}(\cdot)$ is the indicator function and T_{b_i} is the unknown date of the i^{th} break $i = 1, 2, ..., m$ (we use the convention that $\theta_0 = \gamma_0 = 0$).

Under the BTS model of Equation (2), we assume $\alpha < 0$, so that Y_t fluctuates stationarily around a deterministic linear trend, perturbed by m structural breaks. This is a generalization to m breaks of the Innovational Outlier Model, used by Perron (1989) and others.[10] Under the DS model (3), on the other hand, Y_t follows a unit root process ($\alpha = 0$), where no deterministic components are considered. The reason is that interest centers on the

[10]The only difference is that (2) does not include a pulse variable, called $D(TB)_t$ by Perron (1989). This is also the approach in Zivot and Andrews (1992).

AR parameter and its associated t-statistic estimated from (2), both of which are invariant with respect to the parameters $\mu, \beta, \theta_i, \gamma_i$, for any sample size[11].

Note that the location (T_{b_i}), type (level, trend, or level and trend), and number (m) of breaks, as well as the AR order (k) in the above equations are unknown. We proceed as follows:

1. For the no breaks case ($m = 0$) one simply runs an ADF test for the presence of a unit root by estimating (2) with an arbitrary maximum value for k, labeled $k\max$ (see for instance Ng and Perron (1995)), and reducing the AR order by one as in step 3 below (but ignoring the use of the AIC).

2. For each value of $1 \leq m \leq 4$, start with a $k\max$ and estimate (2) by OLS the 3^m BTS models, and chose the location of break(s) from the minimum of the sequence of residual sum of squares, computed over the m-dimensional grid of combinations of m breaks (as in Bai and Perron (1998b)):

$$(\widehat{T}_{b_1}, ..., \widehat{T}_{b_m}) = \underset{T_{b_1},...,T_{b_m}}{\arg\min} RSS(T_{b_1}, ..., T_{b_m}),$$

where the minimization is taken over all partitions $T_{b_1}, ..., T_{b_m}$ such that $T_{b_i} - T_{b_{i-1}} \geq h$. This criterion is called $\min RSS$, and it implies simultaneous determination of location for m breaks via a global search. The partitions of T in $m+1$ segments obey:

$$\begin{gathered} k + 1 + h \leq T_{b_1} \leq T - mh \\ T_{b_1} + h \leq T_{b_2} \leq T - (m-1)h \\ \vdots \\ T_{b_{m-1}} + h \leq T_{b_m} \leq T - h, \end{gathered}$$

where h represents the smallest possible size for a segment.[12]

3. The Akaike Information Criterion (AIC) is then calculated for each of these 3^m regressions. If the coefficient on the $k\max^{th}$ lag is not significant for the model which yields the smallest AIC, then estimate (2) as in step 2, but with $k\max - 1$ lags of the differenced dependent variable. Again, compute the AIC for the 3^m regressions corresponding to the newly estimated break dates. Continuing in this fashion, we select the combination '*model type/lag length*' which corresponds to the model which yields the smallest value of the AIC (amongst

[11] See for example Perron (1989, p.1393).

[12] This representation for h is based on the dynamic programming algorithm introduced by Bai and Perron (1998b) to obtain global minimizers of the RSS. In empirical applications below, we set $h = 6$. Results are robust to various other choices of h.

the 3^m models) *and* a corresponding significant lag (called $\hat{k}$), using a two-sided 10% test based on the asymptotic normal distribution.[13]

To discriminate between DS and BTS for the cases $1 \leq m \leq 4$, we simulate the distribution of the t-statistic for the null hypothesis of a unit root ($\alpha = 0$ in (2)), called $\widehat{\tau}$, under the hypotheses that the true models are the BTS models (2) (following steps 1-3) and the DS model (3), both estimated from the data.[14]. That is, under the BTS (DS) model we use the estimated parameters from (2)((3)), and the first $k+1$ observations as initial conditions ($\Delta Y_2, ..., \Delta Y_{k+1}$) to generate 10,000 samples of ΔY_t, $t = 2, ..., T$, with randomly selected residuals (with replacement) from the estimated BTS (DS) model. For each generated sample, regression equation (2) is run and the corresponding 10,000 values of $\widehat{\tau}$ are used to construct the empirical density function of this statistic under the BTS (DS) model, labeled $f_{BTS_m}(\widehat{\tau})$, $m = 0, ..., 4$ ($f_{DS}(\widehat{\tau})$).[15]

We then obtain the position where the sample estimate of the t-statistic for testing a unit root ($\overset{\wedge}{\tau}_T$) from the estimation of equation (2), lies relative to the empirical (simulated) densities, for each value of m. These positions are calculated as the probability mass to the left of $\overset{\wedge}{\tau}_T$, denoted $p_{BTS_m} \equiv \Pr[\widehat{\tau} \leq \widehat{\tau}_T \mid f_{BTS_m}(\widehat{\tau})]$ and $p_{DS} \equiv \Pr[\widehat{\tau} \leq \widehat{\tau}_T \mid f_{DS}(\widehat{\tau})]$. A value of $p_{DS} > 0.10$ would indicate that there is not enough evidence in the data against the DS specification. We conclude in favour of a BTS specification with m structural breaks when $p_{DS} \leq 0.10$ and $0.10 < p_{BTS_m} < 0.90$.

We use in this section the above discussed convention that if a variable is stationary around a broken trend then it is integrated of order zero. We discuss below the implication of such convention. Results are given in Table A1 of the appendix. The first column indicates the number of breaks allowed in the trend function, m. The second column refers to the estimated lag length, $\hat{k}$. In the empirical applications $k\max$ is set at 5. The next columns report the estimated break dates. The type of break allowed in the trend function is reported in parenthesis. Column labeled AC reports the $p-$values for the Lagrange Multiplier test of the null hypothesis that the disturbances are serially uncorrelated against the alternative that they are autocorrelated of order one. The next column reports the value of the $t-$statistic for testing the null hypothesis of a unit root, estimated from equation (2). The probability mass to the left of this estimate, under each of the simulated DS and BTS specifications, is presented in the last two columns of the table.

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[13] Note that if there are no significant lags, then $\hat{k} = 0$, which implies an AR(1) model for equation (2). If this is the case, the selection of the model follows simply from the lowest value of the AIC. The same approach is applied in Noriega and de Alba (2001).

[14] A similar apprach is used by Kuo and Mikkola (1999) for the US/UK real exchange rate series.

[15] The 10,000 fitted regressions utilize the estimated value of k, under the BTS (DS) model. All calculations were carried out in GAUSS.

In order to illustrate results of our testing procedure, let us analyze some particular countries. In the case of the U.K, Table A1 shows that for real output, the unit root can not be rejected for $m = 0$ ($p_{DS} > 0.10$), while the TS model is not supported by the data ($p_{BTS_0} > 0.90$). When we allow for a drop in level and an increase in slope of trend in 1918, the unit root is strongly rejected[16], while the alternative is not: one would not be able to reject the estimated BTS model at even the 20% significance level. Note that, in fact, for all broken trend cases considered ($1 \leq m \leq 4$), the DS model is strongly rejected, while the various alternatives are not. We decide in favour of the BTS model with one break, however, since $p_{DS} < 0.10$ and p_{BTS_1} is closest to the middle of the empirical distribution, under a parsimonious specification.[17] For the money aggregate, the DS model is rejected under the presence of multiple breaks ($m = 2, 3, 4$). However, since the probability associated with the two breaks model (one in level (1939), and another in level and trend (1970)) is the one closest to the middle of the distribution, we choose a BTS model with $m = 2$.

Figure 2 depicts, for U.K. output, the position of $\widehat{\tau}_T$ relative to the simulated densities of $\widehat{\tau}$ for different values of m. As can be seen, when $m = 0$ it is not possible to discriminate between the two competing hypotheses. On the other hand, when $m \geq 1$ it becomes evident that the sample value of $\overset{\wedge}{\tau}_T$ could not have been generated from the DS model.

[16]These results are in line with those obtained by Duck (1992).

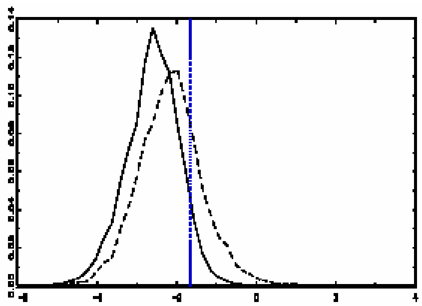
[17]Note that the inclusion of a single break is sufficient to eliminate the unit root behaviour of output. In the impirical analysis that follows, neutrality results for the UK are not sensitive to whether we allow for one break or two breaks in real output.

Figure 2

Empirical Densities of Tao for DS and TS models for United Kingdom Real Output

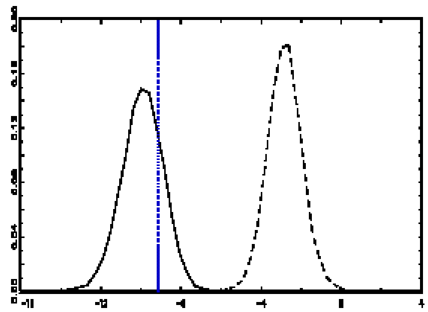
No breaks case, m=0

p_{BTS_0}=.933; p_{DS}=.742



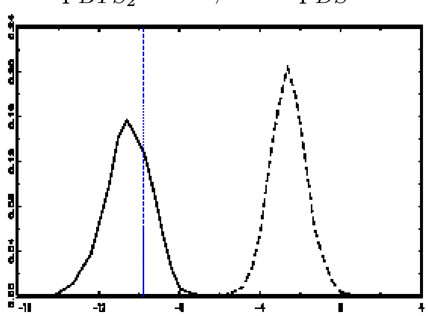
One break case, m=1

p_{BTS_1}=.764; p_{DS}=.000



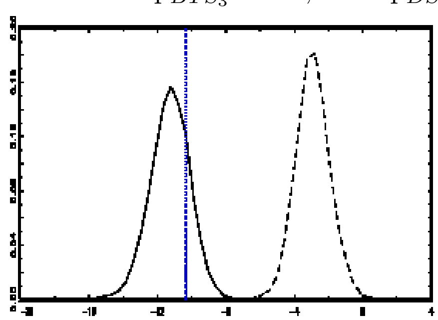
Two breaks case, m=2

p_{BTS_2}=.763; p_{DS}=.000



Three break case, m=3

p_{BTS_3}=.791; p_{DS}=.000



Four breaks case, m=4

p_{BTS_4}=.839; p_{DS}=.000

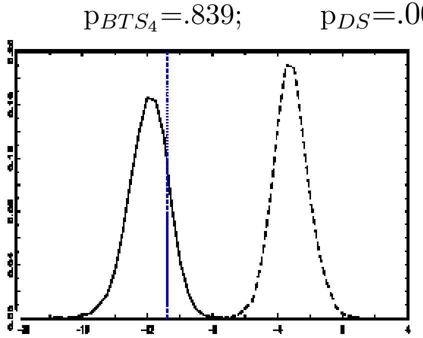
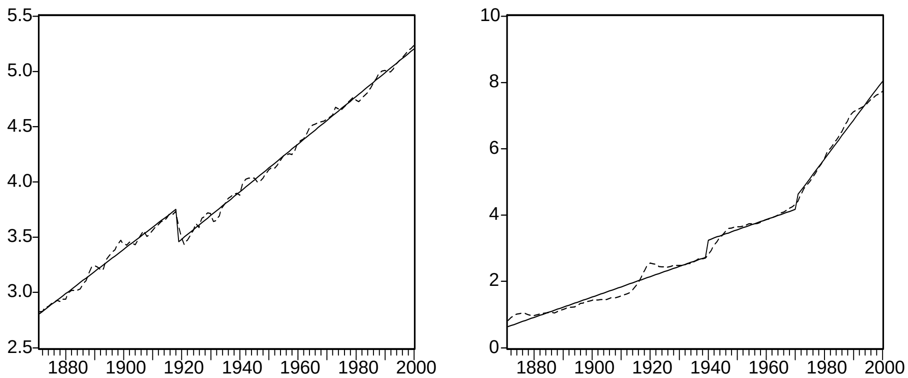


Figure 3 shows graphs of UK output and money, together with their corresponding fitted broken trends.

Figure 3

United Kingdom

Y, I(0) + 1 break : 1918 (LT) | M4, I(0) + 2 breaks: 1939(L), 1970 (LT)



Note: L stand for Level break, and LT stand for Level and Trend break.

A different picture arises for the case of Argentina. For real output, the DS model is rejected at the five percent level for all broken trend specifications, while under the BTS model, the probability closest to the middle of the distribution corresponds to the case of 3 structural breaks. For $M2$, the probabilities indicate that a stochastic permanent change cannot be rejected. In fact, for the cases $m = 1, 2$, the rejection of the DS model is towards an explosive root, i.e., on the right tail of the empirical distribution. The values of the AR parameter for these cases are $\widehat{\alpha} = 1.07, 1.08$, respectively. For the other two Latin American economies, Brazil and Mexico, the picture is similar: after allowing for breaks, money remains stochastically nonstationary, while output becomes a broken trend stationary process.[18]

For Australia output, the DS model can be rejected for $2 \leq m \leq 4$. However, it is only for $m = 3$ that the alternative is not rejected (and is closer to the middle of the empirical distribution). Similar conclusions are reached for the money aggregate. Canadian money clearly rejects a unit root against a BTS model with one break in level in 1920. For Sweden, real output and money can be represented by a BTS model with $m = 3$.

The left-side portion of Table 2 summarizes the empirical results. The countries in the sample have been grouped according to the effect of breaks on the order of integration of the variables. The first group includes Australia, Canada, Sweden, and the U.K. For this group,

[18] In the case of Brazilian output, the DS model is rejected for $m > 0$, and the various BTS alternatives are not. The combination of probability values corresponding to $m = 4$ allows clear cut discrimination among models. Similar arguments apply to Mexico output with $m = 3$. For Brazilian money, when $2 \leq m \leq 4$, $p_{DS} < 0.10$, implying rejection of DS. However, the corresponding BTS models are not supported either, since $p_{BTS_m} > 0.90$. Similar arguments apply to Mexican $M1$ for $m = 4$. In these cases, we do not conclude in favour of a BTS model, since the data also rejects the various alternative hypotheses.

the inclusion of breaks has reduced the order of integration of both money and output (with the exception of Canadian output, which was already known to be $I(0)$ without breaks). A second group comprises Latin American countries, Argentina, Brazil, and Mexico, for which real output seems to follow a broken trend stationary model, while money remains stochastically nonstationary. Finally, for Italy the inclusion of breaks in the trend function does not alter the order of integration for money and output, already established by Noriega (2004) as I(1). Hence, the inclusion of breaks has affected the order of integration of 10 series, and, as we show below, will also affect LRN conclusions.

Table 2
Summary of Results

Country	Series	Order of Integration		LRN			LRSN		
		$m = 0^*$	$m > 0$	m=0*	m > 0		m=0*	m > 0	
					S	D		S	D
Australia	Y	I(1)	I(0)+3b						
	M2	I(1)	I(0)+2b	F	NA	H	NA	NA	H
Canada	Y	I(0)	I(0)						
	M2	I(1)	I(0)+1b	HD	NA	H	NA	NA	NA
Sweden	Y	I(1)	I(0)+3b						
	M2	I(1)	I(0)+3b	H	NA	-	NA	NA	-
UK	Y	I(1)	I(0)+1b						
	M4	I(1)	I(0)+2b	F	NA	H	NA	NA	H
Argentina	Y	I(1)	I(0)+3b						
	M2	I(1)	I(1)	F	HD	NA	NA	NA	NA
Brazil	Y	I(1)	I(0)+4						
	M2	I(2)	I(2)	HD	HD	NA	F	HD	NA
Mexico	Y	I(1)	I(0)+3b						
	M1	I(1)	I(1)	F	HD	NA	NA	NA	NA
Italy	Y	I(1)	I(1)						
	M2	I(1)	I(1)	F	-	NA	NA	NA	NA

S, D stands for Stochastic and Deterministic respectively.

F, H, HD and NA stands for Fails, Holds, Holds by Definition and Not Addressable, respectively.

*These results are taken from Noriega (2004).

3 Stochastic and Deterministic Neutrality

The effect of structural breaks on the order of integration of money and output poses an interesting question about the testing for monetary neutrality: ¿Should we derive conclusions on LRN based only on the stochastic version of the FS test? In order to interpret the evidence for structural breaks presented above, we utilize here an heuristic notion of *deterministic* monetary neutrality, which naturally arises in the absence of permanent stochastic shocks to the variables.

Based on results in the previous section, we present in the right-side portion of Table 2 conclusions on LRN and LRSN. The columns under the headings LRN and LRSN show whether the neutrality propositions hold (H), fail (F), or are not addressable (NA). Results are reported for the cases of no breaks ($m = 0$), and up to 4 breaks ($m > 0$). When allowing for breaks, we offer two distinct interpretations: one based on the stochastic (S) version of neutrality tests (FS)[19], and one based on a deterministic (D) version.

Take for instance the U.K. If breaks are not allowed, the FS test indicates that (stochastic) neutrality fails (see Noriega (2004) for details). Allowing for breaks, both variables are found to follow a stationary process around a broken trend, which means that (stochastic) LRN is not addressable, since there are no stochastic permanent changes in the variables. However, under a deterministic interpretation, some form on LRN seems to hold. According to our results, the long-run behaviour of U.K. output is well characterized as a linear trend, perturbed by a single break in 1918. On the other hand, U.K. money underwent two structural breaks, one in level (1938), and the other in level and trend (1970). Note that these two breaks had no effect on the long-run behaviour of output, which was found to follow a linear trend from 1918 onwards (see Figure 3). We say that money is deterministically neutral (DN) for the U.K. since output fluctuates in a stationary fashion around a linear trend with no breaks from 1918 to 2000. Furthermore, since the 1970 money-break was in level *and trend*, we say that U.K. money is also deterministically superneutral (DSN), at least over a horizon of 30 years.

Similarly, for Australia we conclude that money is DSN (for over 50 years), since the trend of output remained unaltered, after the occurrence of two monetary breaks in level and slope of trend (see Figure 4).

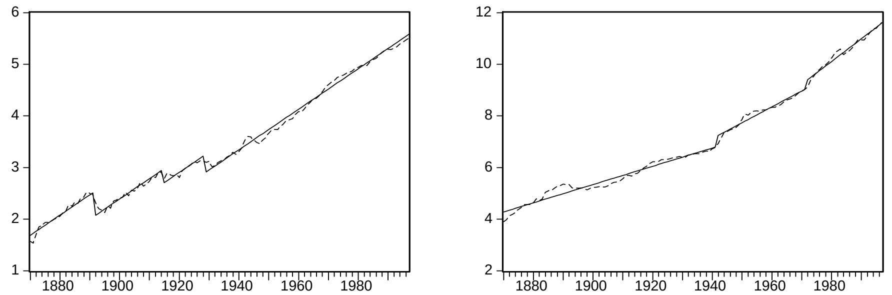
[19] Serletis and Krause (1996) and Serletis and Koustas (1998) utilize this interpretation when analyzing their empirical findings. Note that under the stochastic interpretation, we assume, as in previous studies, the exogeneity of money. For a multivariate approach that allows to examine the effects of long-run monetary endogeneity on reduced-form tests of neutrality see Boschen and Mills (1995).

Figure 4

Australia

Y, I(0) + 3 breaks
1891 (L), 1914 (L), 1928 (L)

M2, I(0) + 2 breaks
1941 (LT), 1971 (LT)



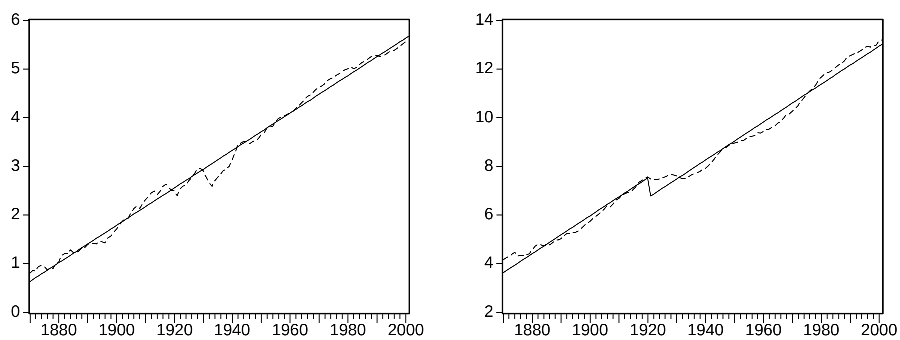
For Canada, a deterministic interpretation of LRN can also be applied, since the drop in level of money in 1920 had no effect on the long-run trend of output, which fluctuated stationarily around a linear trend for over 80 years after the (permanent) monetary break (see Figure 5).

Figure 5

Canada

Y, I(0)

M2, I(0) + 1break:
1918 (L)



Therefore, for three countries in this first group, the presence of deterministic changes in the trend function of the variables would lead to the (preliminary) conclusion that (stochastic) LRN is not addressable. Under the deterministic interpretation, on the other hand, LRN seems to hold for Australia, Canada, and the U.K.

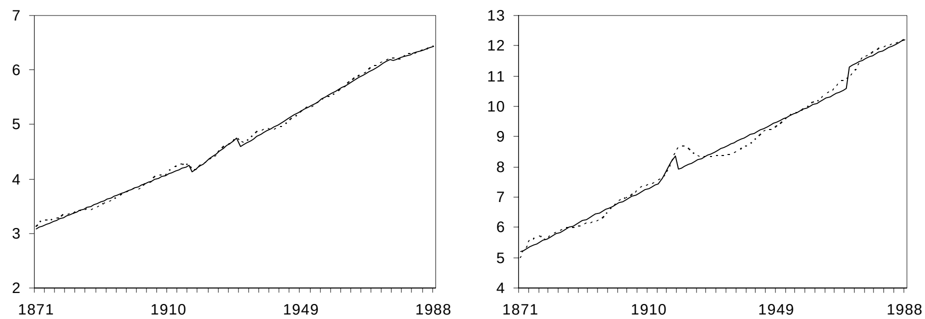
In the case of Sweden, on the other hand, the heuristic notion of deterministic neutrality cannot be applied, since output experienced structural breaks in its

Figure 6

Sweden

Y, I(0) + 3 breaks — 1916 (LT), 1930 (LT), 1975 (LT)

M2, I(0) + 3 breaks — 1912 (LT), 1918 (LT), 1970 (L)



trend function, which may be correlated with the breaks found in the money series. See Figure 6.

For the group of Latin American economies, output fluctuates in a stationary fashion around a trend with breaks, but deterministic neutrality is not addressable, due to the prevalence of stochastic (unit root) nonstationarity in the money series. Conclusions on monetary neutrality for these cases, then, have to derive from the stochastic interpretation in Table 2 (as in Serletis and Krause (1996) and Serletis and Koustas (1998)), under which a variable that is stationary around a broken trend is integrated of order zero. Hence, for this group of countries output is I(0) while money is I(1) or I(2). In this circumstances, LRN holds by definition, as indicated in Table 2. For Italy deterministic neutrality is also not addressable, since both money and output are I(1) without breaks. However, given that both variables are I(1), results in Noriega indicate that LRN fails. A similar analysis applies for testing superneutrality: the deterministic approach indicates that superneutrality holds for Australia and the UK, while for Canada is not addressable since the break in money was in level, not in level and trend. For Brazil it holds, given that output is I(0) while money is I(2). For the rest of countries superneutrality is not addressable.

Therefore, taking into account the presence of breaks, LRN seems to hold for 6 of the 8 cases analyzed: Australia, Canada, the UK, Argentina, Brazil, and Mexico (under the deterministic approach for the first three, and under the stochastic one for the last three). This contrasts with traditional tests without account for breaks, where it would seem to hold only in three cases. For Sweden, the deterministic approach does not allow to make inference, due to potential correlation among breaks[20]; however, under the traditional FS

[20] Below, we briefly discuss this issue and indicate methods to deal with it.

approach, LRN holds for Sweden. Italy seems to be the only country for which LRN fails.

Results for Australia, Canada, the UK, Argentina, and Brazil coincide with results in Serletis and Krause (1996), Olekalns (1996), Haug and Lucas (1997) and Bae and Ratti (2000). In this respect it can be argued that neutrality holds under both stochastic and deterministic permanent shocks. Our results support those of Noriega (2004) only for the cases where LRN holds: Canada and Brazil. Regarding superneutrality, results for Canada, Argentina, Mexico and Italy support those of Noriega (2004): LRSN is not addressable. In contrast to Noriega (2004), our results indicate that superneutrality does hold for Australia and the UK, once allowance is made for breaks in the trend function.

As noted in section 2.1, under the FS methodology, the order of integration of money should be equal or greater than one, so that the LRD is defined. On the other hand, the order of integration of output is not restricted. The only requirement is that $\langle y \rangle \leq \langle m \rangle$ (the order of integration of output can not be greater than that of money). Under the deterministic interpretation the restrictions are different. Under our approach, one **can** associate permanent shocks to the growth rate of money to nonexistent permanent changes in output. In addition, the identifying restriction of exogenous changes in money is not required under our approach. We summarize the restrictions needed for a deterministic interpretation of our empirical results in Table 3.

Table 3

Restrictions on $\langle m \rangle$ and $\langle y \rangle$		DN	Cases
1)	$\langle m \rangle$: $1 \searrow 0$ + breaks $\langle y \rangle$: $1 \searrow 0$ + breaks	Testable	Australia, Sweden, UK
2)	$\langle m \rangle$: $1 \searrow 0$ + breaks $\langle y \rangle$: $0 \rightarrow 0$	HD	Canada
3)	$\langle m \rangle$: $1 \rightarrow 1$ $\langle y \rangle$: $1 \searrow 0$ + breaks	NA	Argentina, Brazil, Mexico
4)	$\langle m \rangle$: $1 \rightarrow 1$ $\langle y \rangle$: $1 \rightarrow 1$	NA	Italy

The symbols $\searrow$ and $\rightarrow$ indicate that the order of integration of the variable has reduced, and maintained, respectively, after allowing for structural breaks in the trend function.

In case 1), money and output should be stationary around a broken trend for long run deterministic neutrality (DN) to be testable. We propose two ways for testing DN. One is based on the heuristic analysis of precedence used above: if after a break in m there are no breaks in y, then we conclude that money is deterministically neutral, if the break is in level of money, or superneutral if the break is in slope of trend, as in the cases of Australia and the U.K. The second one suites the case of Sweden, which can be analyzed using the recently developed theory of co-breaking, introduced in Hendry and Mizon (1998), Clements and Hendry (1999, chapter 9), and recently advanced and summarized by Hendry and Massmann (2007), or the techniques for testing for common features (Engle and Kozicki (1993), Vogelsang and Franses (2001)). The reduced rank technique developed by Krolzig and Toro (2000) yields information on how breaks are related through economic variables and across time. The application of these techniques is out of the scope of this paper, and will be addressed in future research.

For deterministic neutrality to hold by definition, (case 2), both variables should be stationary, but money around a trend with breaks, as in the case of Canada. Finally, DN and DSN are not addressable (cases 3 and 4), when at least one of the variables contains a unit root, as in the cases of Argentina, Brazil, Mexico, and Italy.

4 Concluding Remarks

This paper empirically documents the impact of (endogenously determined) changes in the long-run trend of money and real output, on the Fisher and Seater (1993) tests of LRN and LRSN, using a long annual international data set. We present evidence on the inability to reject plausible broken-trend stationary models that exhibit transitory dynamics around a long-run deterministic trend subject to infrequent structural breaks. This is particularly true for the output series, whose orders of integration tend to diminish after allowing breaks (with the exception of Italy).

It was found that conclusions on monetary neutrality are sensitive to the number and location of breaks allowed in the long-run trend of the relevant variables. We documented that ignoring breaks can induce (possibly spurious) rejection of neutrality.

Noriega (2004), using linear trends with no breaks, found mixed evidence in favour of LRN, holding for only half of the countries in the sample. Our findings complement those of Noriega (2004), and indicate that monetary neutrality holds, either in its stochastic or deterministic interpretation, in all analyzed countries but Italy. Allowing for breaks and under the stochastic interpretation, LRN is not addressable for half of the countries, while under the deterministic interpretation it holds for Australia, Canada, and the U.K. Furthermore, deterministic LRSN holds for Australia and the U.K.

Our results suggest that a distinction should be made between reactions to deterministic and stochastic shocks. The FS test measures the correlation between permanent stochastic shocks in money and output data. It could be useful to broaden the notion of monetary neutrality by allowing for deterministic and stochastic shocks. There is work in progress by the authors on the asymptotic behaviour of the long-horizon regression estimates under structural breaks in the deterministic component.

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6 Appendix

Table A1

Probability Values for Real Output and Money

m	$\widehat{k}$	T_{b_1}	T_{b_2}	T_{b_3}	T_{b_4}	AC	$\widehat{\tau}_T$	p_{BTS_m}	p_{DS}
Australia, Y									
1870-1997									
0	4					.95	-1.28	.92	.88
1	4	1889(L)				.77	-3.11	.88	.16
2	2	1891(LT)	1930(LT)			.96	-6.69	.90	.00
3	4	1891(L)	1914(L)	1928(L)		.75	-7.43	**.87**	**.00**
4	4	1891(L)	1914(LT)	1928(L)	1962(L)	.76	-8.65	.99	.00
Australia, M2									
1870-1997									
0	1					.98	-0.25	.92	.96
1	1	1933(T)				.94	-3.54	.88	.21
2	1	1941(LT)	1971(LT)			.99	-4.55	**.81**	**.06**
3	1	1892(LT)	1941(LT)	1972(LT)		.63	-6.09	.86	.01
4	2	1892(LT)	1941(LT)	1972(LT)	1983(LT)	.24	-5.43	.89	.03
Canada, M2									
1870-2001									
0	1					.60	-1.54	.882	.779
1	1	1920(L)				.95	-3.80	**.650**	**.052**
2	1	1875(LT)	1920(L)			.97	-3.57	.716	.087
3	5	1920(LT)	1940(L)	1969(L)		.53	-3.73	.672	.158
4	5	1920(L)	1940(LT)	1959(T)	1980(LT)	.95	-1.44	.749	.806
Mexico, Y									
1932-2000									
0	1					.97	-0.46	.95	.92
1	0	1981(L)				.95	-2.96	.75	.27
2	3	1953(T)	1981(LT)			.63	-4.09	.97	.15
3	5	1953(T)	1981(T)	1994(LT)		.76	-8.16	**.60**	**.00**
4	3	1953(T)	1981(T)	1985(L)	1994(LT)	.46	-9.25	.78	.000

L, LT and T stand for Level, Trend, and Level and Trend respectively

Table A1

Probability Values for Real Output and Money

m	$\widehat{k}$	T_{b_1}	T_{b_2}	T_{b_3}	T_{b_4}	AC	$\widehat{\tau}_T$	p_{BTS_m}	p_{DS}
Mexico, M2									
1932-2000									
0	3					.73	-2.09	.82	.51
1	1	1987(LT)				.69	4.19	1.0	1.0
2	1	1976(T)	1985(LT)			.78	-4.74	.88	.01
3	2	1945(LT)	1977(T)	1986(LT)		.40	-5.15	.95	.02
4	5	1945(LT)	1959(LT)	1977(LT)	1986(LT)	.99	-5.15	**.83**	**.06**
Sweden, Y									
1871-1988									
0	1					.92	-2.63	.78	.28
1	3	1958(L)				.90	-3.91	.90	.04
2	1	1916(LT)	1930(LT)			.17	-4.49	.80	.06
3	5	1916(LT)	1930(LT)	1975(LT)		.09	-5.15	**.69**	**.02**
4	4	1892(T)	1916(LT)	1939(LT)	1968(LT)	.24	-9.55	.92	.00
Sweden, M2									
1871-1988									
0	2					.81	-1.59	.92	.79
1	4	1918(L)				.99	-2.40	.85	.45
2	4	1912(LT)	1918(LT)			.43	-3.29	.74	.27
3	1	1912(LT)	1918(LT)	1970(L)		.41	-5.45	**.78**	**.01**
4	3	1894(T)	1916(LT)	1935(T)	1970(LT)	.14	-9.20	.96	.00
United Kingdom, Y									
1871-2000									
0	3					.93	-1.67	.93	.74
1	1	1918(LT)				.91	-9.14	**.76**	**.00**
2	1	1902(L)	1918(L)			.78	-9.77	.76	.00
3	1	1902(L)	1918(L)	1979(LT)		.65	-10.32	.79	.00
4	1	1902(L)	1918(L)	1945(LT)	1973(L)	.61	-10.79	.84	.00

L, LT and T stand for Level, Trend, and Level and Trend respectively

Table A1

Probability Values for Real Output and Money

m	$\widehat{k}$	T_{b_1}	T_{b_2}	T_{b_3}	T_{b_4}	AC	$\widehat{\tau}_T$	p_{BTS_m}	p_{DS}
United Kingdom, M4									
1871-2000									
0	2					.93	-0.94	.84	.90
1	2	1970(LT)				.91	-3.12	.85	.23
2	1	1939(L)	1970(LT)			.14	-5.53	**.83**	**.00**
3	1	1913(L)	1939(LT)	1970(LT)		.48	-7.57	.92	.00
4	1	1913(L)	1939(LT)	1967(T)	1989(LT)	.92	-9.66	.87	.00
Argentina, Y									
1884-1996									
0	0					.73	-2.23	.88	.47
1	0	1902 (L)				.93	-3.98	.79	.03
2	0	1902(L)	1980(L)			.72	-5.97	.77	.00
3	5	1912(T)	1917(LT)	1980(L)		.88	-5.73	**.52**	**.00**
4	5	1896(L)	1913(LT)	1929(LT)	1980(LT)	.53	-6.39	.91	.00
Argentina, M2									
1884-1996									
0	3					.69	-0.107	.83	.96
1	2	1989(LT)				.69	8.32	.04	1.00
2	5	1974(L)	1988(LT)			.38	6.01	.56	1.00
3	5	1930(LT)	1974(LT)	1988(LT)		.90	-1.55	.85	.81
4	5	1930(LT)	1970(LT)	1979(LT)	1988(LT)	.95	-3.19	.77	.40
Brazil, Y									
1912-1995									
0	1					.85	-2.73	.79	.23
1	1	1928 (LT)				.65	-4.14	.83	.03
2	3	1928(L)	1970(LT)			.87	-4.44	**.82**	**.05**
3	5	1928(L)	1940(L)	1980(LT)		.23	-6.07	.86	.00
4	4	1928(LT)	1947(T)	1970(L)	1980(T)	.36	-7.96	.81	.00

L, LT and T stand for Level, Trend, and Level and Trend respectively

Table A1

Probability Values for Real Output and Money

m	$\widehat{k}$	T_{b_1}	T_{b_2}	T_{b_3}	T_{b_4}	AC	$\widehat{\tau}_T$	p_{BTS_m}	p_{DS}
Brazil, M2									
1912-1995									
0	5					.02	-0.94	1.00	.90
1	4	1987(LT)				.14	0.24	.14	.10
2	4	1968(T)	1987(LT)			.99	-3.56	1.00	.05
3	5	1944(LT)	1965(LT)	1987(L)		.64	-9.68	1.00	.00
4	5	1940(T)	1958(T)	1981(LT)	1987(LT)	.83	-7.95	.99	.00
Mexico, M1									
1932-2000									
0	3					.95	-1.40	.87	.74
1	1	1991(L)				.38	3.44	1.00	1.00
2	4	1971(T)	1991(LT)			.87	-2.52	.70	.19
3	4	1944(LT)	1971(T)	1991(LT)		.17	0.64	.60	.97
4	1	1942(LT)	1974(T)	1982(LT)	1991(T)	.73	-10.1	.93	.00
Italy, Y									
1870-1997									
0	1					.79	-1.83	.86	.68
1	2	1945(L)				.48	-2.86	.92	.27
2	5	1938(LT)	1945(LT)			.37	-1.42	.77	.93
3	5	1897(L)	1938(LT)	1945(LT)		.84	-0.85	.77	.96
4	5	1917(LT)	1929(L)	1939(LT)	1945(LT)	.51	-0.62	.73	.98
Italy, M2									
1870-1997									
0	1					.44	-2.63	.72	.22
1	1	1937(LT)				.43	-3.65	.90	.19
2	1	1914(LT)	1937(LT)			.43	-3.79	.95	.22
3	3	1914(L)	1939(LT)	1989(T)		.33	-7.24	.93	.00
4	2	1914(L)	1936(LT)	1946(LT)	1987(T)	.15	-7.39	.92	.00

L, LT and T stand for Level, Trend, and Level and Trend respectively

Table A2
Data Series Used in Estimation (All Date in Logs)

	Argentina		Australia		Brazil		Canada		Italy		Mexico			Sweden		UK	
Date	**Y**	**M2**	**Y**	**M2**	**Y**	**M2**	**Y**	**M2**	**Y**	**M2**	**Y**	**M1**	**M2**	**Y**	**M2**	**Y**	**M4**
1870			1.57	3.90			7.60	-0.36	10.11	7.79							
1871			1.53	3.98			7.64	-0.29	10.11	7.95				3.11	5.00	2.82	0.82
1872			1.70	4.12			7.63	-0.22	10.11	8.11				3.17	5.27	2.83	0.92
1873			1.85	4.18			7.72	-0.13	10.15	8.12				3.23	5.32	2.86	0.97
1874			1.86	4.26			7.74	-0.05	10.15	8.15				3.24	5.62	2.87	1.01
1875			1.94	4.37			7.72	-0.21	10.17	8.19				3.22	5.62	2.90	1.03
1876			1.93	4.46			7.65	-0.17	10.16	8.21				3.28	5.68	2.91	1.03
1877			1.95	4.56			7.72	-0.19	10.17	8.25				3.28	5.70	2.93	1.03
1878			2.00	4.56			7.68	-0.16	10.17	8.27				3.28	5.62	2.91	0.99
1879			2.02	4.58			7.78	-0.12	10.18	8.30				3.34	5.59	2.94	0.96
1880			2.06	4.64			7.82	0.05	10.22	8.33				3.34	5.73	2.94	0.97
1881			2.12	4.79			7.95	0.19	10.16	8.33				3.36	5.77	3.00	0.99
1882			2.16	4.72			7.99	0.28	10.21	8.30				3.36	5.81	3.02	1.01
1883			2.27	4.77			7.99	0.25	10.20	8.33				3.41	5.89	3.02	1.03
1884	21.76	-10.99	2.25	5.04			8.07	0.21	10.22	8.38				3.41	5.94	3.02	1.05
1885	21.81	-10.76	2.32	5.09			8.01	0.27	10.24	8.44				3.43	5.98	3.03	1.06
1886	21.81	-10.57	2.30	5.11			8.01	0.25	10.27	8.52				3.44	5.98	3.07	1.06
1887	21.93	-10.52	2.40	5.19			8.05	0.33	10.28	8.55				3.43	5.99	3.11	1.06
1888	22.02	-10.22	2.43	5.27			8.11	0.43	10.25	8.56				3.46	6.02	3.17	1.08
1889	22.18	-9.94	2.52	5.31			8.12	0.46	10.21	8.58				3.48	6.05	3.23	1.12
1890	22.14	-9.83	2.49	5.35			8.17	0.51	10.28	8.56				3.51	6.06	3.24	1.15
1891	22.02	-10.08	2.48	5.34			8.21	0.62	10.29	8.55				3.55	6.12	3.23	1.19
1892	22.10	-10.16	2.32	5.34			8.20	0.71	10.24	8.58				3.56	6.12	3.20	1.22
1893	22.15	-10.09	2.20	5.21			8.19	0.71	10.27	8.58				3.59	6.17	3.21	1.22
1894	22.23	-10.08	2.17	5.18			8.24	0.75	10.27	8.55				3.61	6.19	3.30	1.23
1895	22.23	-10.04	2.12	5.20			8.23	0.77	10.28	8.56				3.67	6.23	3.33	1.28
1896	22.31	-10.04	2.25	5.20			8.21	0.82	10.30	8.54				3.70	6.28	3.36	1.34
1897	22.25	-10.03	2.21	5.16			8.31	0.94	10.26	8.57				3.74	6.37	3.39	1.35
1898	22.33	-10.03	2.35	5.13			8.35	1.05	10.34	8.60				3.77	6.50	3.43	1.37
1899	22.41	-9.98	2.37	5.19			8.44	1.15	10.35	8.67				3.79	6.65	3.47	1.40
1900	22.39	-9.94	2.41	5.22			8.50	1.22	10.40	8.70				3.82	6.78	3.44	1.43
1901	22.47	-9.96	2.42	5.23			8.58	1.34	10.46	8.74				3.80	6.88	3.43	1.44
1902	22.45	-9.91	2.52	5.25			8.66	1.43	10.44	8.77				3.84	6.91	3.46	1.44
1903	22.58	-9.66	2.45	5.24			8.70	1.50	10.49	8.83				3.89	6.96	3.44	1.45
1904	22.68	-9.48	2.56	5.24			8.72	1.62	10.48	8.90				3.92	7.00	3.43	1.43
1905	22.81	-9.27	2.54	5.29			8.81	1.73	10.53	8.99				3.94	7.07	3.47	1.45
1906	22.85	-9.24	2.59	5.37			8.92	1.86	10.54	9.01				4.03	7.17	3.52	1.48
1907	22.88	-9.23	2.72	5.42			8.97	1.82	10.64	9.11				4.07	7.28	3.56	1.51
1908	22.97	-9.10	2.64	5.44			8.92	1.93	10.62	9.16				4.07	7.34	3.51	1.51
1909	23.02	-8.88	2.68	5.48			9.01	2.09	10.68	9.22				4.07	7.38	3.53	1.53
1910	23.09	-8.75	2.73	5.56			9.10	2.17	10.61	9.28				4.13	7.41	3.56	1.56
1911	23.11	-8.72	2.82	5.67			9.16	2.29	10.69	9.33				4.18	7.44	3.59	1.59
1912	23.18	-8.64	2.80	5.70	12.40	-14.43	9.24	2.36	10.71	9.35				4.21	7.49	3.62	1.63

Table A2 (Cont.)
Data Series Used in Estimation (All Date in Logs)

	Argentina		Australia		Brazil		Canada		Italy		Mexico			Sweden		UK	
Date	**Y**	**M2**	**Y**	**M2**	**Y**	**M2**	**Y**	**M2**	**Y**	**M2**	**Y**	**M1**	**M2**	**Y**	**M2**	**Y**	**M4**
1913	23.19	-8.61	2.90	5.67	12.37	-14.49	9.28	2.41	10.73	9.40				4.25	7.55	3.64	1.66
1914	23.08	-8.72	2.91	5.74	12.24	-14.55	9.20	2.42	10.70	9.47				4.26	7.61	3.65	1.75
1915	23.09	-8.60	2.78	5.78	12.15	-14.47	9.27	2.54	10.77	9.61				4.24	7.72	3.68	1.85
1916	23.06	-8.50	2.89	5.89	12.16	-14.28	9.37	2.66	10.84	9.83				4.29	7.90	3.71	1.96
1917	22.98	-8.35	2.86	5.99	12.20	-14.08	9.41	2.84	10.85	10.13				4.17	8.14	3.71	2.14
1918	23.14	-8.06	2.84	6.05	12.32	-13.84	9.35	2.91	10.80	10.45				4.17	8.46	3.73	2.31
1919	23.18	-7.98	2.86	6.15	12.46	-13.70	9.28	2.99	10.76	10.79				4.22	8.64	3.61	2.47
1920	23.25	-7.87	2.81	6.22	12.53	-13.61	9.28	3.04	10.81	10.99				4.28	8.68	3.50	2.55
1921	23.28	-7.92	2.93	6.22	12.55	-13.43	9.18	2.96	10.78	10.97				4.31	8.68	3.44	2.53
1922	23.35	-7.87	2.99	6.23	12.63	-13.27	9.32	2.92	10.83	10.98				4.36	8.59	3.47	2.50
1923	23.46	-7.84	3.02	6.30	12.78	-13.18	9.38	2.93	10.88	11.11				4.41	8.47	3.51	2.45
1924	23.53	-7.82	3.06	6.29	12.89	-13.07	9.39	2.96	10.88	11.23				4.43	8.40	3.56	2.44
1925	23.53	-7.82	3.12	6.31	12.89	-13.10	9.49	3.01	10.94	11.30				4.52	8.35	3.62	2.43
1926	23.58	-7.79	3.09	6.35	12.92	-13.11	9.55	3.04	10.95	11.40				4.58	8.33	3.59	2.43
1927	23.64	-7.73	3.13	6.37	12.97	-12.94	9.64	3.11	10.94	11.43				4.62	8.33	3.67	2.45
1928	23.70	-7.64	3.12	6.39	13.11	-12.80	9.73	3.14	11.03	11.46				4.63	8.32	3.69	2.47
1929	23.75	-7.65	3.10	6.43	13.07	-12.82	9.73	3.12	11.04	11.48				4.70	8.33	3.72	2.48
1930	23.71	-7.65	3.12	6.38	12.98	-12.85	9.69	3.07	10.97	11.48				4.76	8.37	3.72	2.48
1931	23.64	-7.76	3.02	6.40	12.79	-12.82	9.56	3.02	10.95	11.46				4.68	8.37	3.64	2.47
1932	23.60	-7.77	3.04	6.49	12.79	-12.75	9.45	2.98	10.99	11.43	2.32	-0.53	-1.62	4.66	8.36	3.65	2.49
1933	23.65	-7.78	3.09	6.47	12.86	-12.71	9.38	2.99	11.00	11.46	2.43	-0.24	-1.33	4.68	8.37	3.69	2.55
1934	23.72	-7.78	3.13	6.54	13.05	-12.64	9.49	3.05	10.99	11.45	2.49	-0.02	-1.11	4.74	8.39	3.77	2.55
1935	23.77	-7.78	3.15	6.53	13.17	-12.55	9.57	3.12	11.09	11.45	2.56	-0.02	-1.11	4.80	8.40	3.80	2.58
1936	23.77	-7.69	3.20	6.53	13.25	-12.45	9.61	3.17	11.07	11.54	2.64	0.16	-0.77	4.86	8.45	3.85	2.65
1937	23.84	-7.63	3.23	6.61	13.31	-12.35	9.71	3.21	11.15	11.47	2.67	0.32	-0.64	4.88	8.53	3.87	2.69
1938	23.85	-7.65	3.30	6.64	13.34	-12.23	9.71	3.26	11.14	11.57	2.69	0.32	-0.64	4.91	8.57	3.89	2.69
1939	23.88	-7.62	3.25	6.62	13.32	-12.17	9.79	3.37	11.20	11.70	2.74	0.57	-0.41	4.94	8.66	3.90	2.70
1940	23.90	-7.59	3.31	6.72	13.33	-12.08	9.92	3.40	11.16	11.89	2.76	0.77	-0.23	4.90	8.66	3.88	2.80
1941	23.95	-7.47	3.38	6.77	13.29	-11.87	10.05	3.50	11.12	12.20	2.85	0.94	-0.08	4.90	8.72	3.98	2.94
1942	23.96	-7.34	3.52	6.92	13.30	-11.63	10.22	3.63	11.08	12.49	2.90	1.20	0.23	4.93	8.84	4.02	3.08
1943	23.96	-7.20	3.60	7.13	13.31	-11.29	10.26	3.78	10.97	12.90	2.94	1.67	0.69	4.95	8.95	4.03	3.20
1944	24.06	-7.02	3.59	7.34	13.34	-11.02	10.30	3.95	10.71	13.43	3.02	1.90	0.95	4.98	9.05	4.03	3.32
1945	24.03	-6.86	3.53	7.39	13.43	-10.88	10.28	4.07	10.53	13.76	3.05	1.98	1.09	5.04	9.15	4.04	3.42
1946	24.12	-6.62	3.49	7.46	13.55	-10.80	10.25	4.21	10.94	14.19	3.11	1.95	1.07	5.09	9.20	4.00	3.51
1947	24.22	-6.47	3.46	7.49	13.58	-10.81	10.29	4.25	11.13	14.58	3.15	1.95	1.07	5.13	9.24	4.01	3.60
1948	24.27	-6.22	3.53	7.56	13.67	-10.72	10.32	4.34	11.13	14.91	3.19	2.08	1.22	5.18	9.26	4.03	3.61
1949	24.26	-6.01	3.58	7.66	13.75	-10.55	10.35	4.39	11.20	15.13	3.24	2.22	1.33	5.23	9.32	4.07	3.63
1950	24.27	-5.82	3.66	7.86	13.81	-10.34	10.43	4.44	11.26	15.27	3.34	2.50	1.62	5.28	9.40	4.11	3.64
1951	24.30	-5.66	3.72	8.07	13.86	-10.19	10.48	4.46	11.34	15.43	3.41	2.63	1.80	5.31	9.52	4.13	3.65
1952	24.17	-5.52	3.74	8.02	13.93	-10.07	10.56	4.53	11.38	15.60	3.45	2.69	1.84	5.32	9.59	4.12	3.66
1953	24.30	-5.30	3.74	8.13	13.98	-9.90	10.61	4.53	11.45	15.74	3.45	2.77	2.02	5.36	9.66	4.15	3.69
1954	24.30	-5.15	3.80	8.19	14.05	-9.71	10.60	4.62	11.49	15.83	3.55	2.95	2.11	5.41	9.76	4.20	3.73
1955	24.42	-4.98	3.85	8.20	14.14	-9.56	10.69	4.69	11.55	15.95	3.63	3.07	2.23	5.44	9.78	4.23	3.74

Table A2 (Cont.)
Data Series Used in Estimation (All Date in Logs)

	Argentina		Australia		Brazil		Canada		Italy		Mexico			Sweden		UK	
Date	**Y**	**M2**	**Y**	**M2**	**Y**	**M2**	**Y**	**M2**	**Y**	**M2**	**Y**	**M1**	**M2**	**Y**	**M2**	**Y**	**M4**
1956	24.42	-4.83	3.90	8.18	14.17	-9.38	10.77	4.72	11.60	16.05	3.69	3.24	2.36	5.48	9.81	4.24	3.73
1957	24.42	-4.71	3.93	8.24	14.24	-9.12	10.79	4.74	11.65	16.14	3.77	3.31	2.42	5.50	9.87	4.25	3.75
1958	24.53	-4.37	3.95	8.24	14.34	-8.93	10.82	4.86	11.70	16.27	3.82	3.45	2.53	5.53	9.95	4.25	3.79
1959	24.42	-4.02	4.03	8.27	14.44	-8.59	10.85	4.85	11.76	16.40	3.85	3.51	2.63	5.58	10.07	4.29	3.83
1960	24.53	-3.58	4.08	8.34	14.53	-8.28	10.88	4.90	11.87	16.52	3.93	3.56	2.96	5.61	10.13	4.35	3.86
1961	24.62	-3.59	4.08	8.33	14.61	-7.90	10.91	4.98	11.95	16.67	3.97	3.62	3.08	5.66	10.13	4.37	3.89
1962	24.62	-3.49	4.14	8.39	14.67	-7.41	10.98	5.02	12.01	16.82	4.02	3.72	3.23	5.70	10.22	4.39	3.91
1963	24.53	-3.20	4.20	8.44	14.68	-6.92	11.03	5.08	12.06	16.97	4.10	3.85	3.39	5.76	10.33	4.43	3.95
1964	24.50	-2.86	4.26	8.54	14.71	-6.34	11.09	5.16	12.09	17.05	4.21	4.07	3.61	5.82	10.41	4.48	4.00
1965	24.61	-2.62	4.32	8.61	14.91	-5.78	11.16	5.27	12.12	17.19	4.27	4.14	3.76	5.86	10.47	4.51	4.06
1966	24.71	-2.34	4.34	8.65	14.95	-5.59	11.22	5.33	12.18	17.33	4.34	4.23	3.94	5.88	10.54	4.52	4.10
1967	24.72	-1.91	4.40	8.72	15.00	-5.18	11.26	5.47	12.25	17.45	4.40	4.31	4.12	5.91	10.66	4.53	4.14
1968	24.75	-1.67	4.47	8.80	15.10	-4.82	11.31	5.61	12.31	17.56	4.48	4.41	4.26	5.95	10.79	4.54	4.21
1969	24.80	-1.48	4.55	8.89	15.20	-4.54	11.36	5.63	12.37	17.67	4.54	4.50	4.44	6.01	10.85	4.55	4.26
1970	24.82	-1.29	4.61	8.96	15.22	-4.29	11.39	5.74	12.43	17.80	4.61	4.61	4.61	6.07	10.87	4.57	4.32
1971	24.86	-1.20	4.65	9.02	15.33	-3.97	11.46	5.84	12.44	17.96	4.64	4.68	4.74	6.08	10.95	4.59	4.43
1972	24.88	-0.46	4.68	9.12	15.44	-3.74	11.52	5.79	12.47	18.15	4.71	4.88	4.90	6.10	11.07	4.61	4.61
1973	24.91	0.10	4.74	9.38	15.57	-3.39	11.59	5.96	12.54	18.33	4.79	5.10	5.03	6.14	11.21	4.68	4.80
1974	24.97	0.53	4.76	9.52	15.65	-3.08	11.62	6.10	12.58	18.47	4.85	5.30	5.20	6.17	11.44	4.66	4.91
1975	24.96	1.46	4.79	9.67	15.70	-2.73	11.64	6.25	12.54	18.68	4.91	5.48	5.43	6.20	11.63	4.65	5.02
1976	24.96	2.97	4.82	9.80	15.80	-2.40	11.74	6.29	12.60	18.98	4.95	5.79	5.57	6.21	11.65	4.68	5.12
1977	25.02	4.16	4.84	9.91	15.85	-2.03	11.80	6.33	12.63	19.30	4.98	6.02	5.79	6.19	11.69	4.70	5.26
1978	24.99	5.16	4.87	9.97	15.90	-1.65	11.88	6.36	12.66	19.64	5.07	6.30	6.05	6.19	11.76	4.74	5.40
1979	25.06	6.21	4.92	10.09	15.96	-1.10	11.96	6.40	12.72	19.93	5.16	6.58	6.35	6.22	11.83	4.76	5.54
1980	25.07	6.87	4.94	10.24	16.05	-0.62	11.98	6.43	12.75	20.12	5.25	6.87	6.72	6.29	11.88	4.74	5.69
1981	25.01	7.56	4.98	10.38	16.01	0.01	12.04	6.50	12.76	20.28	5.33	7.16	7.14	6.29	11.94	4.73	5.88
1982	24.98	8.43	4.98	10.51	16.01	0.62	11.98	6.51	12.76	20.54	5.33	7.59	7.68	6.30	11.97	4.75	5.99
1983	25.02	10.04	4.98	10.59	15.98	1.47	12.04	6.52	12.77	20.75	5.29	7.94	8.16	6.32	12	4.78	6.12
1984	25.04	12.07	5.04	10.37	16.05	2.78	12.14	6.54	12.79	20.92	5.32	8.42	8.69	6.35	12.05	4.81	6.24
1985	24.97	13.73	5.09	10.46	16.12	4.22	12.24	6.55	12.82	21.08	5.35	8.85	9.07	6.37	12.06	4.84	6.37
1986	25.04	14.49	5.11	10.52	16.19	5.58	12.29	6.57	12.84	21.22	5.31	9.40	9.74	6.39	12.13	4.89	6.50
1987	25.06	15.45	5.16	10.64	16.22	6.73	12.37	6.59	12.87	21.33	5.33	10.23	10.61	6.42	12.15	4.93	6.67
1988	25.04	17.15	5.23	10.82	16.22	9.51	12.46	6.62	12.91	21.42	5.34	10.69	10.97	6.44	12.24	4.98	6.83
1989	24.97	20.30	5.27	10.96	16.26	12.25	12.51	6.65	12.93	21.55	5.38	11.03	11.32			5.00	7.01
1990	24.96	22.79	5.29	10.95	16.21	14.89	12.51	6.67	12.95	21.66	5.43	11.51	11.70			5.01	7.12
1991	25.06	23.67	5.29	10.94	16.26	16.88	12.47	6.68	12.96	21.76	5.47	12.30	12.09			4.99	7.17
1992	25.15	24.16	5.31	11.07	16.25	19.72	12.49	6.70	12.97	21.77	5.51	12.46	12.28			5.00	7.20
1993	25.21	24.54	5.34	11.25	16.29	23.13	12.54	6.70	12.96	21.82	5.53	12.58	12.40			5.02	7.25
1994	25.30	24.70	5.39	11.38	16.35	25.65	12.62	6.71	12.98	21.83	5.57	12.62	12.59			5.07	7.29
1995	25.25	24.67	5.42	11.39	16.39	25.98	12.68	6.72	13.01	21.81	5.51	12.69	12.92			5.10	7.39
1996	25.29	24.85	5.47	11.50		26.05	12.70	6.73	13.02	21.86	5.56	13.03	13.18			5.12	7.48
1997			5.50	11.62			12.79	6.74	13.03	21.98	5.62	13.28	13.36			5.16	7.53
1998							12.85	6.75			5.67	13.45	13.55			5.18	7.61
1999							12.93	6.76			5.71	13.70	13.71			5.21	7.65
2000							13.02	6.78			5.78	13.82	13.68			5.23	7.73
2001							13.06	6.98									