08/RT/14

Páipéar Taighde Teicniúil
Research Technical Paper

Money demand in Ireland, 1933-2012

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Non Technical Summary

Using annual data from several sources, we study the evolution of narrow money (M1), broad money (M2), income, prices and long and short interest rates in Ireland over the period 1933-2012. The purpose of the analysis is to see whether the behavior of these time series in this eighty-year period can be explained by standard money demand theory.

Ireland experienced a number of monetary and economic regimes in this period. Economic growth in Ireland was weak in the 1930s, largely as a consequence of the Great Depression and the Economic War with the UK that started in 1932 and during which a policy of economic self-sufficiency was instituted. This policy ended in the 1950s with a shift towards outward-looking economic policies that heralded a period of relatively strong economic growth in the 1960s and 1970s. In the early 1980s, however, growth fell sharply, partly reflecting disinflation policies in a number of countries. Our sample includes the Celtic Tiger boom that started in the early 1990s which evolved into the construction boom of the early-2000s. Finally, the sample also covers the financial crisis which began in 2008.

This long sample also spans several monetary regimes. At the time of independence in 1922, the monetary and financial system of Ireland was completely integrated with that of the United Kingdom, and monetary arrangements evolved gradually over time. Following the establishment of the Central Bank of Ireland in 1943, the link to the UK monetary system remained extremely close with the Irish pound pegged at unity to Sterling until Ireland joined the European Monetary System (EMS) in 1979. The Central Bank of Ireland then conducted monetary policy with an adjustable exchange rate peg until Ireland joined the Economic and Monetary Union in 1999.

We estimate money demand functions for Ireland for the period 1933-2012. Our estimates for long-run money demand using M2 are stable and close to our prior expectations. Specifically, the estimates indicate a unit price elasticity, a real income elasticity of 1.7 and a negative interest rate elasticity as suggested by standard money demand analysis. However, for M1 we obtain low price elasticities, and a relatively high income elasticity, and detect parameter instability. We therefore drop M1 from the analysis and estimate a short-run money demand function for M2. While it passes a number of diagnostic tests, the standard error of the regression in large, suggesting that the relationship between money growth and its determinants in Ireland was not very close in the 80 years of data we studied.

MONEY DEMAND IN IRELAND, 1933-2012

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Abstract

Using annual data from several sources, we study the evolution of M1, M2, income, prices and long and short interest rates in Ireland over the period 1933-2012. We find cointegration and that prices, income and interest rates are weakly exogenous. While the estimates for M2 are stable and close to our priors, for M1 we obtain very low price elasticities, and a relatively high income elasticity, and detect parameter instability. We estimate a short-run M2 demand function that passes a number of diagnostic tests, although the standard errors of the regressions is large.

Keywords: Ireland, historical statistics, long time series, money, income, prices.

JEL Number: E3, E4, N14.

The views expressed in this paper are solely our own. We are grateful to our discussants, Morgan Kelly and Ella Kavanagh, and participants at the SSISI presentation for helpful comments and suggestions and to Frank Browne, Mark Cassidy, Patrick Honohan, Philip Lane, Reamonn Lydon, Maurice McGuire, Cormac Ó Gráda, Gerard O'Reilly, Kevin O'Rourke and John Turner and participants at a Central Bank of Ireland seminar for comments. Contact information: Stefan Gerlach, Central Bank of Ireland, PO Box No. 559, Dame Street, Dublin 2, Ireland, email: stefan.gerlach@centralbank.ie, tel +353 1 224 6007, fax: +353 1 671 6528; Rebecca Stuart, Central Bank of Ireland, PO Box No. 559, Dame Street, Dublin 2, Ireland, email: rebecca.stuart@centralbank.ie, tel +353 1 224 4159, fax: +353 1 671 5338.

1. Introduction

In this paper we study the long-run dynamics of money (as measured by M1 and M2), real GDP, consumer prices and interest rates in Ireland over the period 1933-2012. The purpose of the analysis is to see whether the behavior of these time series in this eighty-year period can be explained by standard money demand theory. Somewhat surprisingly, there appears to be no literature that studies these variables in Ireland over a similar extended sample period, despite the fact that such studies have been conducted on a number of other countries.[1] The paper thus adds to the literature on developments in the Irish economy from a long-run perspective.

Ireland experienced a number of monetary and economic regimes in this period. Economic growth in Ireland was weak in the 1930s, largely as a consequence of the Great Depression and the "Economic War" with the UK that started in 1932 and during which a policy of economic self-sufficiency based on industrialization through import-substitution was instituted.[2]

While the war ended in 1938, the import-substution policy was continued for many years both during and after the Second World War or "The Emergency" as it is called in Ireland.[3] [4] Economic growth in this period was weak, mainly due to poor economic policies (Ó Gráda 2008). The 1950s ended with a policy-shift towards outward-looking economic policies, including tariff reductions and reliance on foreign direct investment, that began with the Programme for Economic Expansion in 1959, and

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[1] For the period 1840 to 1921, O'Rourke (1998) proxies GDP estimates using monetary data. Long-run money demand in a number of countries has been studied extensively in the literature, including in the US for 1946 to 1996 by Ball (1998), in the UK from 1878 to 1993 by Ericsson et al. (1997), in the euro area from 1981 to 1994 by Fagan and Henry (1998), in Canada from 1953 to 1990 by Haug and Lucas (1996), in Switzerland for 1936 to 1995 by Gerlach-Kristen (2001), in Greece from 1975 to 1994 by Ericsson and Sharma (1996) and in Japan, Germany, Canada, the US and the UK over the period 1974 to 1990 by Hoffman et al. (1995).

[2] Ó Gráda (1995) notes that since the Irish pound was pegged to Sterling, one would have expected the Irish economy to received a boost from the depreciation of Sterling that followed after the British Government's decision to leave the gold standard in 1931.

[3] Ó Gráda (2011) discusses economic performance during the Emergency.

[4] It is an interesting question what the impact of the Emergency on money demand might have been. The inability to purchase many goods and the resuting forced saving suggests that it rose.

heralded a period of relatively strong economic growth in the 1960s and 1970s. In the early 1980s, however, growth fell sharply, partly reflecting disinflation policies in a number of countries.

Our sample includes the "Celtic Tiger" boom that started in the early 1990s when the economy grew at a rapid rate for a sustained period driven largely by exceptional export performance accompanied by moderate wage and price inflation and healthy public finances. In the early-2000s, however, the boom that had been underpinned by fundamentals became one sustained by a credit-fuelled construction bubble, which ultimately culminated in the financial crisis beginning in 2008.

This long sample spans several monetary regimes. Thus, at the time of independence in 1922, the monetary and financial system of Ireland was completely integrated with that of the United Kingdom. While there were no changes to the monetary arrangements at independence, they evolved gradually over time. In 1927 a Currency Commission was established and Irish coins were issued, followed by bank notes in 1928. The Central Bank of Ireland (CBI) was established in 1943, partially in response to the fact that after the start of the war, it became clear that Ireland could not expect to rely on the Bank of England to serve as its central bank.

The link to the UK monetary system remained extremely close with the Irish pound pegged at unity to Sterling until Ireland joined the European Monetary System (EMS) in 1979. This was a fixed but adjustable exchange rate system. The central rate of the Irish pound against the German Mark was realigned seven times by a total of 35.75% between September 1979 and January 1987.[5] The pound was subsequently devalued by a further 8% in January 1993. With the bands broadened to +/- 15% in the summer of 1993, the CBI then operated monetary policy with some discretion until it became a founding member of the Economic and Monetary Union in 1999.

To conduct the study, we construct a long historical data set, drawing from a number of different secondary sources. The combination of data in this way is problematic.

[5] See Artis and Taylor (1994, Table 1).

First, economic and statistical changes may make data lack comparability over time. For instance, the increase in the relative importance of services in the economy has arguably reduced the volatility of consumer prices. This process is likely to have been accentuated by the increase in the number of components in the CPI, which would have tended to reduce the volatility of the aggregate. Second, with the exception of interest rates and exchange rates, macro economic aggregates are unobserved and must be estimated. These estimates are likely to have become better over time in response to the use of improved statistical techniques and better data. Third, economies evolve, leading to a strong presumption that macro economic relationships may display instability. However, whether that is so is entirely an empirical question.

Overall, while there are good reasons for analysts to be sceptical about the usefulness of data from distant historical episodes, it seems difficult to argue that these data are so poor as to be of no value for economic analysis. Modern data are also subject to measurement errors and contemporary economies also experience structural change. There is therefore no reason to disregard historical data out of hand.

While our hands are tied by the limited availability of data, we discuss how measurement errors may influence our econometric findings and study whether the uncovered relationships are stable over time. Furthermore, it should be noted that our research design is likely to uncover economic relationships, or reveal them more clearly, than many other studies of the Irish economy. First, we use annual data that are likely to be less noisy than quarterly data. Second, we use a very long sample period. Since the relationships between money and the economy are subject to long lags, it is likely to be easier to detect the underlying dynamics in these data than in short samples of quarterly data.

The paper is structured in five Sections. Since the focus is on the demand for money in Ireland, in the second section we briefly review how monetary arrangements have evolved in Ireland since independence. In Section 3 we discuss the data and how the

time series evolve over time. In Section 4 we turn to econometric evidence. We first review the unit root behaviour of the time series that we study -- broad money, prices, real GDP and short-term interest rates -- before testing for cointegration. We find evidence of cointegration. While the estimates for M2 indicate a unit price elasticity, a real income elasticity of 1.7 and a negative interest rate elasticity as suggested by standard money demand analysis, the estimates for M1 indicate very low price elasticities of approximately 0.4, and an income elasticity of money demand of 1.1.

We proceed by exploring the stability of the estimated relationships and find that while the VAR including M1 shows instability, the evidence for the VAR including M2 is much weaker. We therefore drop M1 from the analysis and estimate a short-run money demand function for for M2. While it passes a number of diagnostic tests, the standard error of the regression in large, suggesting that the relationship between money growth and its determinants in Ireland is not close. Section 5 concludes the paper.

2. Monetary regimes in Ireland since 1922

Collecting long time series of data on the money stock in Ireland is rendered difficult by a number of changes in the monetary regime. Following independence, the monetary system was initially unchanged.[6] While it would have been difficult to introduce changes rapidly, the fact that the monetary arrangements appeared to function satisfactorily must have reduced the impetus for action. Three types of bank notes circulated: British Treasury notes; Bank of England notes; and notes issued by six Irish banks that constituted the bulk of the issue. The banks also operated in Northern Ireland and held reserves in London, where their notes were redeemable in Sterling.

[6] This section draws on Brennan (1931), Moynihan (1975), Honohan (1995), Ó Gráda (1995) and Kelly (2003).

In this period it is difficult to determine the money supply since the circulation of sterling notes in Ireland is not known (although it appears to have been limited), and because it is not clear how the Irish bank note issue should be divided between Northern Ireland and the Irish Free State. In any case, data on bank deposits do not appear to be readily available.

Nevertheless, it was clear that the arrangements in force were unsuitable for an independent country. In 1926 the Government therefore established a Banking Commission under the chairmanship of Professor Henry Parker Willis of Columbia University, with the objective of reviewing what implications independence had for the monetary and financial system. The Committee recommended that the State should establish its own currency at par with Sterling and that responsibility for the issuance of bank notes should be held by a new Currency Commission that was to be established. The Commission’s recommendations were included in the Currency Act of 1927 that introduced the Saorstát pound, which was fully backed by Sterling assets and redeemable in Sterling in London.

While these arrangements fell short of those in economies with a central bank, the Irish financial system functioned well and enjoyed access to the deep London market, implying that the absence of a money market in Dublin was unproblematic. With the new currency fully backed and the Currency Commission’s objectives limited to ensuring convertibility against Sterling, the credibility of the exchange rate parity was not in question. Moreover, the Bank of Ireland conducted the Government’s banking business satisfactorily.

Further impetus towards the establishment of a central bank came as a consequence of the Commission of Inquiry into Banking, Currency and Credit which reported in 1938. The Commission concluded that the monetary authority should be given power to make advances to banks on collateral of Government securities and to conduct open market operations.

Following the introduction of a bill in the Dail in 1942, the CBI was established in March 1943. Kelly (2003) notes that the close link to Sterling was not called into

question and that the new central bank lacked some traditional banking functions, in particular the ability to restrict credit conditions, that implied that it was not in a position to set interest rates and to conduct an active monetary policy. As Honohan (1995) emphasises, the functioning of the Currency Commission and the CBI implied that monetary arrangements in Ireland are best described as those of a currency board, at least until the early 1970s. As a consequence, Irish interest rates followed closely those in Britain and were thus determined with little, if any, reference to domestic economic conditions although, of course, these were shaped by those prevailing in Britain.

The close link to Sterling was broken in 1979 when the Government elected to join the EMS as a founding member. While this implied some softening of the role of the exchange rate commitment, monetary policy in Ireland remained focussed the requirement of exchange rate stability, a number of devaluations of the Irish pound notwithstanding. As a consequence, the possibility of gearing monetary policy to domestic macroeconomic conditions was limited. Interest rates in Ireland therefore remained largely determined by external considerations.[7]

In January 1999 Ireland became a founding member of the Eurosystem. The Irish money supply was redenominated in euro at the fixed conversion rate of 1 euro = IR£ 0.78. Since the introduction of the euro there are no data on the use of currency in Ireland. Moreover, a distinction is made between the “Irish contribution to the euro area money stock” and the money stock held by “Irish residents.” Of course, after the introduction of the euro, short-term interest rates in Ireland are again determined largely by external factors, except since the onset of the economic crisis in 2010.

[7] Browne and O’Connell (1978) emphasise the importance of externally determined interest rates for the dynamics of money demand in Ireland.

3. The data

In this section we review the data used in the econometric study below. We emphasise from the outset that precisely what data should be used in the estimation of money demand functions is unclear and that a large part of the literature discuss the importance of alternative data definitions. For instance, money could be measured by M0, M1, M2 or M3, and the scale variable could either be real GDP (or, in the case of Ireland, real GNP), real consumption or some measure of wealth. Similarly, data on the opportunity cost of holding money, which should be measured by the spread between the return on non-monetary assets and the yields on the different types of deposits included in the monetary aggregate in question, are not easily available.

Unfortunately, we only been able to construct long data series on M1 and M2; one potential scale variable, real GDP; and on a long and a short interest rate. We are therefore unable to address a range of interesting questions about alternative data choices.

The data stem from Gerlach and Stuart (2013) who discuss their construction in some detail. Since the sample period spans 80 years, no single source provides all the data. The data set is therefore constructed using a number of different sources, including the Central Statistics Office (CSO), the Economic and Social Research Institute, the OECD, the IMF, the ECB, Moynihan (1975), Mitchell (2007), Homer (1963) and the website from the Maddison project.[8]

Generally, current vintage of data are used as far back as possible under the assumption that it is subject to smaller measurement errors than older vintages. Older time series are then spliced in order to construct a single time series. We do this using the growth rates of the older series rather than their levels, as it often occurs that due to base year effects or definition changes the levels of the series are significantly different. Where more than one series was available, the decision of

[8] See: www.ggdc.net/maddison/maddison-project/home.htm.

what series to use was based on a comparison of growth rates over overlapping periods.

3.1 Money Supply

Data for M1 and M2 are taken from Moynihan (1975) for the period 1933 to 1950, and from Mitchell (2007) from 1950 to the 1970s. Thereafter, data are available from the Central Bank of Ireland. M1 is narrow money supply, and is generally defined as the sum of currency in circulation and non-government current account balances. Broadly speaking, M2 is definied as M1 plus non-government deposit accounts. However, the exact definition of 'deposit account' and the treatment of interest accrued changes through time.

Monetary data are typically subject to frequent breaks and the Irish data are no exception. In 1982 consistent rules using international statistical and accounting standards were adopted. Another break occurs in 1999 when Eurosystem definitions begin, and the collection of data for both "Irish residents" and the "Irish contribution to euro area" began. The "Irish contribution" data include deposits in Irish resident credit institutions by other euro area private-sector residents. The "Irish resident" definition more closely represents money held by Irish citizens, and it is therefore used in our analysis. Furthermore, in line with Eurosystem requirements, in 2003 securities issued to non-euro area residents were excluded from M2.

3.2 Inflation

The Consumer Price Index is available from the CSO from 1933 to 2012.

3.3 Real and nominal GDP

For real GDP, data from 1933 to 1938 are taken from the Maddison website.[9] For nominal GDP, while the Maddison data could be multiplied by the CPI, it is not clear that this would be an appropriate price index, and instead we use data from

[9] These data are available on a per capita basis, and population data from the census are used to calculate an aggregate figure.

Moynihan (1975) on nominal gross domestic expenditure for this period. Data from 1938 to 1947 are taken from official estimates of national income published in 1946 and 1951.[10] Data on both real and nominal GDP are available from the CSO from 1947 to 2012.[11]

3.3 Short and long-term interest rates

In the absence of appropriate Irish interest rate data, and with the Irish financial system before 1980 closely tied to the United Kingdom, we use the open-market rate of discount in London for the period 1933 to 1960 as a proxy for Irish short-term rates, and UK interest long rates as a proxy for Irish yields for the period 1933 to 1952. For the period 1960 to 1983, Irish short-term rates from the IMF's International Financial Statistics (IFS) are used, and from 1984 to 2012, short-term rates are from the OECD. Irish long-term interest rates are taken from the IMF's IFS from 1952 to 2012.

3.4 Review of the constructed series

Figure 1, which contains plots of the growth rates of M1 and M2, shows that money growth was high during World War 2, in the 1970s and in the late 1990s. Both M1 and M2 contracted in 2008 when the collapse of Lehman Brothers triggered a full-blown international financial crisis, and in 2010 and 2011 after Ireland requested financial assistance from the IMF, ECB and the European Commission, the "Troika." Interestingly, Figure 2 shows that while the first and second of these episodes were associated with high inflation, the third was associated with rapid income growth. Since Ireland was operating in a fixed exchange rate system through the entire sample period, althought exchange rate realigments were common in the EMS until

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[10] See, White Paper (1946) and CSO (1951). In both cases, the data are for total national income, and are reported only in nominal terms. However, a retail price trend is also reported in both publications, and this is used to deflate the series for real GDP.

[11] There are three breaks over this time period: in 1995, 1970 and 1959. Data prior to 1995 exclude FISIM (the Financial intermediations sector indirectly measured). From 1970 to 1995 data are chain-linked annually and referenced to 2009; data prior to 1970 are at 1995 prices. Data prior to 1959 are estimates.

1987, this suggests that money growth responded passively to changes in prices and income.

Figure 3 shows that short and long interest rates rose gradually from the end of the 1940s as inflation rose, peaked together with inflation around 1980s, and fell subsequently.

4. Econometric estimates

In this section we discuss our econometric estimates. We first test whether the different time series we study have unit roots, then turn to the question of whether they are cointegrated. Since we have data on both M1 and M2 and data on both short and long interest rates, we estimate four money demand functions.

4.1 Unit root tests

Table 1 presents the results of Augmented Dickey-Fuller tests for the sample period for the logarithms of narrow money (M1), broad money (M2), prices, real income and short-term and long-term interest rates. The tests are conducted including a constant and a time trend, and the lag length is determined by the Schwarz information criterion (SIC) and the Akaike information criterion (AIC). The table shows, not unexpectedly, that we are unable to reject the null hypothesis of a unit root for all variables in levels.

We therefore go on to perform the test on the first differences of the series. When the lag length is determined by the SIC we find that we can reject the hypothesis of a unit root in all cases, except for the price level (p = 0.10). When the lag length is determined using the AIC, we fail to reject the null hypothesis for M2, prices and real GDP. However, unit root tests are known to have low power and in what follows we therefore treat all variables as integrated of order one.[12]

[12] Indeed, we also obtained different results using different unit root tests. For instance, the Elliott-Rothenberg and Stock test indicates that we can reject the null of a unit root for all series in differences

4.2 Cointegration

Next we explore whether the variables are cointegrated, using a Johansen test. Since this is based on VARs for the four variables (that include either M1 or M2; and either the short or the long interest rate), we first explore the appropriate lag length, allowing for a time trend in the cointegrating vector. We compute the AIC and the SIC which indicate that lag lengths between two and six are appropriate. Using Wald tests to determine whether higher-order lags can be omitted and tests for serial correlation of the residuals, we find mixed evidence regarding the appropriate lag length, although a VAR(3) specification appears broadly appropriate in all cases.

However, performing trace and maximum-eigenvalue tests we find that while the tests generally detect one cointegrating vector, the results are highly sensitive to the lag length selected, irrespective of the choice of monetary aggregate and interest rate included in the analysis. Thus, sometimes the tests indicate no cointegration at the 5% level, frequently one and sometimes two cointegrating vectors. The Granger representation theorem holds that if a group of time series are cointegrated, then at least one of them must adjust in response to deviations from the cointegrating vector. We therefore estimate the cointegrating vector directly using single-equation methods and explore whether the residuals, which capture deviations from the cointegrating vector, are significant in a VAR model for the first differences of the variables included in the cointegrating vector.

4.3 Measurement errors

Before doing so, however, we briefly review how measurement error might impact on the estimates of the cointegrating vector. Of course, that depends on the nature of the measurement error. One possibility is that the average growth rate of a variable is measured poorly. For instance, it is well established that price indices overestimate the rate of inflation because they tend to disregard the fact that price increases induce

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except prices and M2. By contrast, an Ng-Perron test indicates that prices may be stationary at the 10% level.

consumers to purchase goods from sellers that charge relatively low prices and to shift their spending towards cheaper alternatives.[13]

To consider the impact of such an overestimate of the inflation rate, suppose that the (logarithm of the) observed price level, p^*, equals the true, unobserved price level, p, times factor of proportionality: $p^* = \kappa p$, which implies that observed inflation is equal to true inflation time a factor of proportionality, $\Delta p^* = \kappa \Delta p$. Here $\kappa > 1$ captures the extent to which inflation is overestimated.

Next, we disregard income and interest rates to simplify the notation, and note that while the true cointegrating vector is $m - \beta p$, the econometrician estimates $m - \beta^* p^*$. This implies that the estimated long-run price elasticity is given by $\beta^* = \beta/\kappa$. Thus, $\kappa > 1$ will merely lead to $\beta^* < \beta$, that is, to an underestimate of the price elasticity. Given that a large body of monetary theory holds that $\beta = 1$, the inverse of the estimated price elasticity, $1/\beta^*$, could be interpreted as an estimate of κ. How large might this effect be? Given that the average inflation rate in the sample is about 5% and that a plausible estimate of the measurement error is 1%, we have that $\kappa = 1.25$, suggesting that the inflation elasticity may be estimated to be about 0.8 even if, in truth, it was unity.

A second possible measurement error is that the short-run fluctuations of a time series are captured incorrectly in the data, but that the trend estimate is correct. For instance, there are conflicting estimates of real GDP during WW2. Will the exact choice of data impact on the estimated cointegrating vector?

Suppose that the observed (logarithm of the) level of real GDP, y^*, is equal to the true, unobserved level, y, plus a stationary measurement error, z: $y^* = y + \varphi$. Consider next the simplified cointegrating vector $m - \delta y$ and the observed version thereof $m - \delta^* y^*$. Intuitively, δ^* will be estimated in such a way as to match the increases of m and y over the sample. Since the increase in y^* in long samples is

[13] Price indices also tend not to incorporate quality improvements adequately.

entirely dominated by the non-stationarity of y, the presence of φ will have no impact on estimates of δ in long samples.[14]

However, while the transitory measurement error will have no impact on the estimated cointegrating vector, it will of course be important when estimating the short run dynamics of money and real GDP, which involve the stationary growth rates of real GDP that are affected by the measurement error.

The fact that measurement errors, which are likely to be present in studies involving long samples of historical time series, are likely not to matter much for estimates of cointegrating vectors but be important for estimates for short-run dynamics suggests that it is desirable to study the long-run and short-run behaviour of the time series separately.

4.4 Single-equation estimates of cointegrating vector

We first compute single-equation estimates of the cointegrating vector using Fully-Modified OLS (FM-OLS) and Dynamic OLS (DOLS). As noted in Fagan and Henry (1998), financial innovation can impact on estimated elasticities. We therefore include a linear trend to capture gradual changes in velocity, due to changes in payments technology and other factors that otherwise would be ascribed to real GDP or the price level.[15]

Before turning to the results, it is helpful to review briefly our prior expectations of the parameters. Theory holds that the demand for money is a demand for real money balances, implying that the price elasticity should be exactly unity. The income elasticity of money demand is subject to greater uncertainty. While many theoretical models suggest an elasticity of one and this is commonly found in empirical work, in particular for narrow measures of money such as M1, studies of broader aggregates such as M2 and M3 frequently find elasticities in the range of 1.3 to 1.8.

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[14] Fischer (1990) investigates the effects of I(0) measurement errors in a bivariate cointegrated system and concludes that they make it more difficult to reject the hypothesis of no cointegration when it is false.

[15]

Theory suggests that the interest elasticity of money demand is negative since increases in the rate of return on non-monetary assets (such as long government bonds) will reduce the demand for money. However, if the interest rate considered applies to the deposit component of money, then increases in interest rates could seemingly perversely raise the demand for money. The interest rate data we have are crude and we do not know exactly what yields they refer to. Nevertheless, we expect the estimated elasticities to be negative.

Table 2 shows the resulting estimates. Several findings are of interest.

First, the results are broadly similar irrespectively of what estimation strategy is used and indicate that prices, real GDP, the interest rate and the time trend are all significant except when money is measured by M2 and the long interest rate is used to capture the opportunity cost of holding money.

Second, the estimated price elasticities of money demand are very low when money is measured by M1 (around 0.4) but close to unity when it is measured by M2. As noted earlier, finding a low price elasticity could be a sign that the price index underestimates inflation. However, the importance of such measurement errors should of course be the same irrespective of whether M1 or M2 is used. It therefore seems unlikely that measurement errors are important.

Third, the estimated income elasticities are about 1.2 when M1 is used and about 1.7 when M2 is used. While the estimated income elasticity for M2 does not seem unusual, that for M1 is perhaps larger than expected. This may be related to the finding of low price elasticity of the demand for M1.[16] However, if the income elasticity for M1 is restricted to equal 1, the price elasticity remains at 0.43.[17]

[16] For instance, Hoffman et al. (1995) estimate income elasticities of money demand for the US of 0.2 to 0.5, for Japan of 1.20, for Canada of 0.6 to 0.7, for the UK of 0.1 to 0.2 and for West Germany of 1 to 1.2.

[17] This result is sensitive to the inclusion of the linear trend. When this is excluded, and the income elasticity of money demand is restricted to equal 1, the price elasticity is 0.99 and significant at the 1% level. Since the time trend is highly significant, however, we maintain it in the cointegrating relationship.

Fourth, we find that the parameter on the interest rate is estimated to be negative as suggested by theory. The results for M1 do appear not appear sensitive to whether the short or the long interest rate is used to capture the opportunity cost of holding money. However, the long interest rate is less significant than the short interest rate when M2 is modeled. In what follows we therefore use the short interest rate as the measure of the opportunity cost. Interestingly, the trend variable is positive in the M1 regressions and negative in the M2 regressions.

4.5 Weak exogeneity

From Granger's representation theorem, we know that if economic disturbances that move actual money holdings away from the cointegrating relationship occur, one or several of the variables in it will move to restore equilibrium. Since economic conditions in Ireland, in particular the rate of inflation and the rate of interest, are largely determined by developments externally, it is also of interest to explore whether whether prices, interest rates and real GDP are weakly exogenous.

To explore the issues of cointegration and weak exogeneity, we next include the lagged residuals, as measures of the deviation for the long-run disequilibrium, from the FM-OLS regressions in VARs for the first differences of the variables.[18] If there is cointegration, then we would expect the deviation from equilibrium to be significant in at least one equation, most likely the equation for money growth.[19] Furthermore, if prices, real GDP and interest rates are weakly exogenous, then we would not be able to reject the hypothesis that the deviation from long-run equilibrium is insignificant in all these equations.

Table 3 shows tests of the hypothesis that the deviation from disequilibrium is insignificant in the four equations of the VAR, and for the joint test that it is

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[18] The results are virtually identical if the residuals from the DOLS estimate of the cointegrating vector are used.

[19] Of course, one can test for cointegration by testing whether the residuals from the cointegrating regression is stationary. Applying an Augmented Dickey-Fuller test, with lag length determined by the SIC, we obtain p = 0.02 for the residuals from then M1 regression and p = 0.02 for the residuals from the M2 regression, suggesting they are stationary.

insignificant the equations for inflation, real GDP growth and changes in interest rates. We find that the coefficients on the lagged residuals are negative and significant in the M1 and M2 equations and insignificant in the remaining equations. Furthermore, a Wald test on the coefficient of the lagged residuals in the price, real GDP and short-run interest rate equations indicates that they are jointly insignificant ($p = 0.59$ and $p = 0.50$ depending on the measure of money used). This suggests that these three variables are weakly exogenous.

4.6 Stability

Next we turn to the question of the stability of the VAR estimates underlying the Johansen tests. Given that the sample period spans 80 years and covers numerous changes in the economic environment, one would expect the estimates to display instability. But this need not necessarily be the case: if structural changes occur broadly evenly over the entire sample period, the parameters will be estimated with large confidence intervals, making it difficult to detect structural instability. We proceed by computing Bai-Perron tests for multiple breakpoints.[20] We perform the test equation-by-equation rather than for the system as a whole, and therefore chose to test at the 1% level rather than at the 5% level.

Table 4 shows the results for the two VARs using two lags. Testing the equations for the VAR system including M1 at the 1% level, we find breaks in the money growth, inflation and income growth equations. For comparison, testing at the 2.5% level we detect a second break in 1977 for the equation of income growth, and breaks in 1977 and 1994 in the equation for changes in the interest rate.

Next we perform the same tests for the equations for the VAR including M2. Surprisingly, in this case we detect only one break and that in the equation for inflation in 1953. Investigating the inflation equation more closely, we note that the standard errors of the residuals is 4.45 in the 1936-52 sample and 2.15 in the 1953-

[20] Since the sample has 77 observations and there are 10 parameters in each each equation, we trim the sample by 20% (that is, we use the first and last 20% of the observations to obtain preliminary estimates of the parameters for the two periods). An unfortunate consequence of this trimming is that the Celtic Tiger period is disregarded.

2012 sample.[21] Given that the test is performed assuming that the standard errors is the same in the two period, it seems sensible to compute it allowing them to differ. In this case, however, the test detects no break in the inflation equation. The break detected in 1953 appears to be due to change in the variance of the residuals. Since heteroscedasticity does not bias the estimated parameters, the impulse responses should be unaffected by this problem.

Overall, we conclude that the VAR including M1 is subject to a number of breaks, rendering the results unreliable. We therefore do not consider it further. The VAR including M2, in contrast, appears broadly stable. In what follows we therefore focus solely on this system.

We plot the long-run cointegrating relationship and actual M2 in log levels in Figure 5. The estimated level of M2 is somewhat lower than the actual at the start and end of the sample, and there is some deviation during the Celtic Tiger boom of the early-2000s. However, overall the estimated level of M2 fits closely with the actual level of M2.

Before proceeding, we reestimate the cointegrating regression for M2 for the period 1953-2012. An informal comparison of the parameter estimates, having in mind the standard errors of the parameters, suggests the time trend becomes insignificant ($p = 0.30$). Furthermore, the residuals of the cointegration equation, which we think of as the error-correction term in what follows, are very similar (Figure 4). Indeed, the correlation of the error correction terms estimated over the full sample period and the 1953-2012 sample period is 0.91.

4.7 A short-run money demand function

We next estimate short-run regressions for M2 growth as a function of the growth rates of prices and real GDP, changes in the interest rate, and the error correction term. We first do so by regressing M2 growth on its two lagged values, and on the current and two lagged values of inflation, real GDP growth and the current and

[21] This suggests that the residuals are drawn from two distributions with different second moments. If so, one would expect them to be fat tailed. Indeed, a Jarque-Bera test for normality of the errors rejects ($p = 0.00$).

lagged two changes of the short term rate, and the error correction term. These equations are overparametrised and we next go on to “reduce” them, by sequentially deleting insignificant variables, to the equation in column 1 of Table 5.[22] This reduced equation can be interpreted as the short-run money demand function. Interestingly, current income growth and inflation are significant indicating that they have immediate effects on money demand. Furthermore, the lagged growth rate of M2 (in addition to the error-correction term) enters the equation, impling that the adjustment of money demand is subject to lags. We perform a Bai-Perron test and find a break in this equation in 1986. We therefore re-estimate the equation separately for the periods 1936 to 1985 and 1986 to 2012 (columns 2 and 3).

The parameters on inflation and lagged money growth are smaller in the period 1986 to 2012 than in the earlier period (implying slower adjustment through these variables) while the parameter on lagged income growth is larger in the later period. However, the parameter on the error-correction terms in the two time periods is similar, and suggestsing that approximately 30% of a deviation from the cointegrating relationship is offset within a year. The standard error of the regression is 3.2%, which implies that a 95% confidence for the in-sample prediction is ±6.4%. This suggests that the relationship between money, interest rates, income and prices in Ireland is not very close.

5. Conclusions

In this paper we studied the demand for M1 and M2 in Ireland over the last 80 years. Our main findings is that money, price, income and interest rates are cointegrated, implying that it is possible to estimate standard long-run and money demand functions. While we find low price elasticities, but high income elasticities, for M1, for M2 the estimated price elasticities are close to unity, and the income elasticties are

[22] A p-value of 1% is chosen to reduce the likelihood that spurious variables are retained, as per Campos et al., (2005).

about 1.7. We detect instability in the VAR incorporating M1 but little in the VAR incorporating M2.

Next we study how the economy adjusts over time if a deviation from long-run money demand occurs. Perhaps not surprisingly given that the monetary framework in Ireland since independence, we find that only the money stock evolves over time to restore equilibrium.

We go on to estimate a short-run money demand function for M2 and find that the entire adjustment to disequilibria was undertaken solely by the money stock. We find a break in the equation in 1986, and go on to estimate the equation separately for the time period before and after this break. We find that the standard error of the regression is large. Moreover, the convergence to equilibrium is about 30% per year, which is relatively slow. All-in-all, the results suggest that while the demand function for M2 satisfies a number of statistical criteria, from an economic and historical perspective the relationship between money, interest rates, income and prices in Ireland iwas not very close in the 80 years of data we study.

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	Table 1 Augmened Dickey-Fuller tests for unit roots 1933-2012					
Variable	Level; no trend		Level; trend		First difference; trend	
Choice of lag length	SIC	AIC	SIC	AIC	SIC	AIC
M1	0.75 [0.99]	0.75 [0.99]	-1.96 [0.62]	-2.33 [0.41]	-6.33*** [0.00]	-6.33*** [0.00]
M2	-0.01 [0.96]	-0.44 [0.90]	-2.08 [0.55]	-2.07 [0.55]	-3.62** [0.03]	-2.67 [0.25]
Prices	-1.19 [0.68]	-1.39 [0.58]	-2.09 [0.54]	-2.09 [0.54]	-3.16* [0.10]	-2.10 [0.54]
Income	0.61 [0.99]	1.19 [0.99]	-2.56 [0.30]	-1.39 [0.86]	-4.54*** [0.00]	-3.22* [0.09]
Short interest rate	-1.05 [0.73]	-1.05 [0.73]	-0.10 [0.99]	-0.10 [0.99]	-6.74*** [0.00]	-6.74*** [0.00]
Long interest rate	-1.59 [0.48]	-1.59 [0.48]	-1.42 [0.85]	-1.42 [0.85]	-9.14*** [0.00]	-9.13*** [0.00]
	Notes: */**/*** denotes significance at the 10%/5%/1% level. p-values are in brackets. The exact sample period depends on the number of lags used. SIC and AIC denote the Schartz and Akaike information criteria.					

Table 2

Estimated long-run money demand functions for M1 and M2

Dependent var.	M1	M1	M2	M2
	Using FM-OLS; Sample 1934-2012			
Prices	0.41*** (4.84)	0.33*** (3.78)	0.93*** (17.05)	0.92*** (15.97)
Income	1.13*** (5.97)	1.30*** (6.55)	1.69*** (13.65)	1.84*** (14.15)
Short interest rate	-0.03*** (4.52)		-0.02*** (3.56)	
Long interest rate		-0.03*** (3.40)		-0.01* (-1.85)
Trend	0.03*** (3.73)	0.03*** (3.14)	-0.02*** (4.11)	-0.03*** (4.49)
	Using DOLS; Sample 1935 - 2012			
Prices	0.47*** (4.94)	0.40*** (3.67)	0.96*** (14.74)	0.98*** (14.55)
Income	0.91*** (3.27)	1.21*** (4.28)	1.60*** (8.40)	1.82*** (10.60)
Short interest rate	-0.05*** (3.56)		-0.02** (2.25)	
Long interest rate		-0.04** (2.36)		-0.01 (1.10)
Trend	0.04*** (3.46)	0.03** (2.25)	-0.02*** (2.70)	-0.03*** (3.91)

Notes: */**/*** denotes significance at the 10%/5%/1% level. Absolute value of t-statistics in parenthesis. No leads or lags are included when using FMOLS. One lead and lag are included when estimating the equations using DOLS.

Table 3

Significance test of lagged residuals from cointegrating equation in VAR model

Equation	**System including M1**		**System including M2**
M1	-0.30 (3.96)***	M2	-0.21 (2.66)***
Inflation	-0.01 (0.24)	Inflation	0.05 (0.82)
Income	-0.03 (1.03)	Income	-0.03 (0.59)
Short interest rate	2.20 (0.88)	Short interest rate	-4.32 (1.15)
Wald test: inflation, income and short interest rates	1.91 [0.59]	Wald test: inflation, income and short interest rates	2.36 [0.50]

Notes: */**/*** denotes significance at the 10%/5%/1% level. Absolute value of t-statistics are in parenthesis; p-values are in brackets.

Table 4
Bai-Perron tests for multiple breaks
1933-2012

	System with M1		System with M2	
	Confidence level		Confidence level	
Equation	2.5%	1%	2.5%	1%
Money growth	1993	1993		
Inflation	1952	1952	1953	1953
Income growth	1960, 1977	1960		
Changes in interest rate	1977, 1994			

Notes: 20% trimming.

Table 5

Estimates of short-run money demand function for M2, 1936-2012

	ΔM2		
Sample	**1936-2012**	**1936-1985**	**1986-2012**
Lagged m2 growth	0.45*** (4.89)	0.60*** (5.14)	0.21*** (1.89)
Income growth	0.66*** (3.90)	0.66*** (2.97)	1.14*** (5.64)
Inflation	0.38*** (3.37)	0.42*** (3.14)	-1.54*** (4.05)
Lagged error-correction term	-0.20** (3.28)	-0.29*** (3.67)	-0.33*** (4.40)
		R-sq/SE	0.78/0.03

Notes: */**/*** denotes significance at the 10%/5%/1% level. Absolute value of t-statistics in parenthesis; p-values in brackets.

Figure 1: Money supply

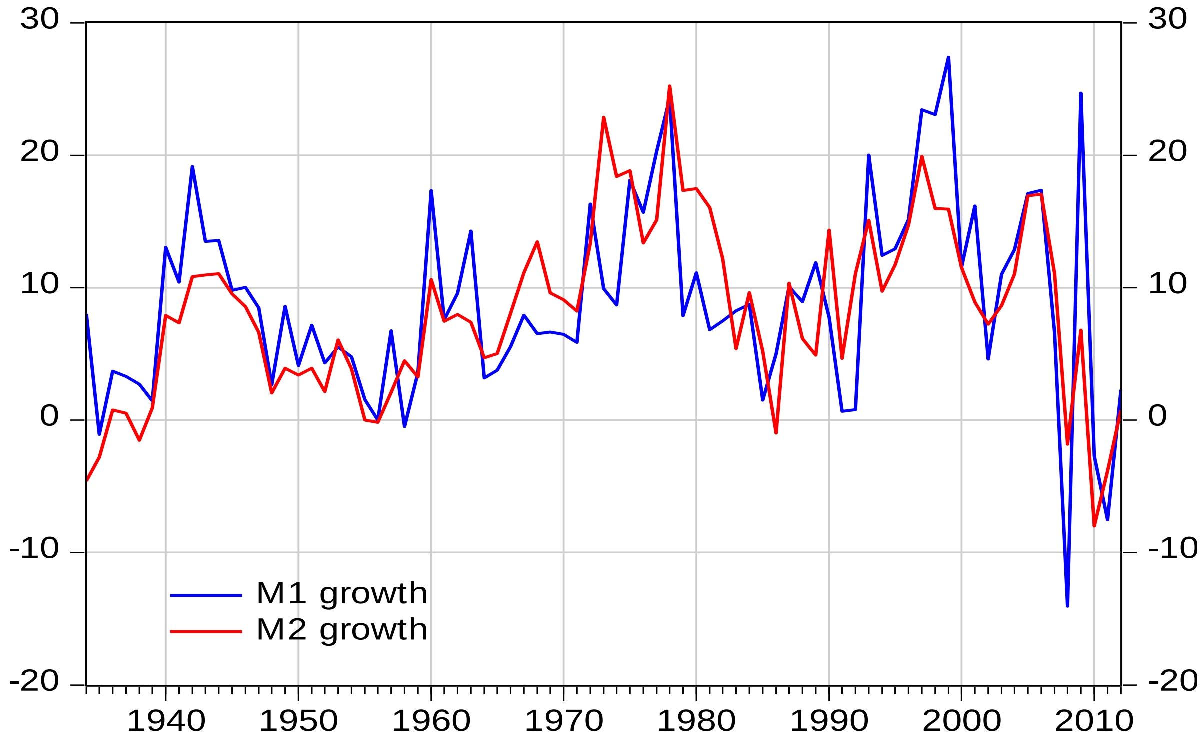

Figure 2: CPI and real GDP

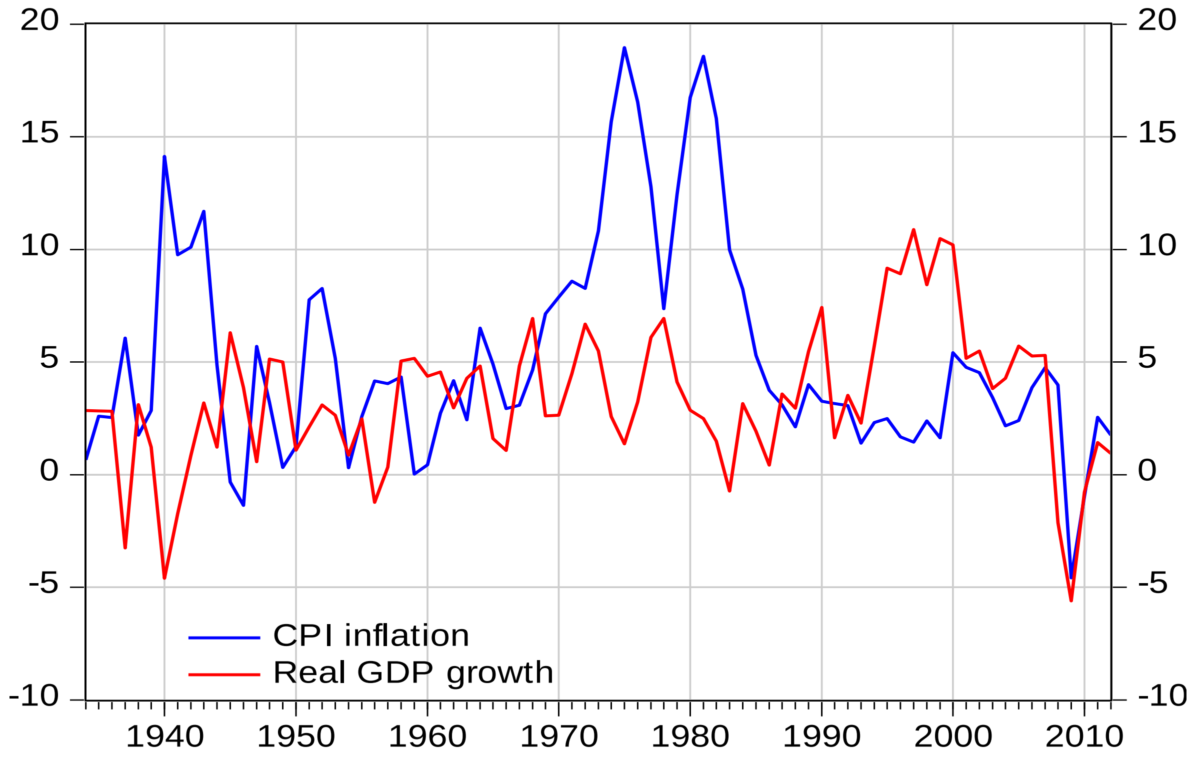

Figure 3: Interest rates

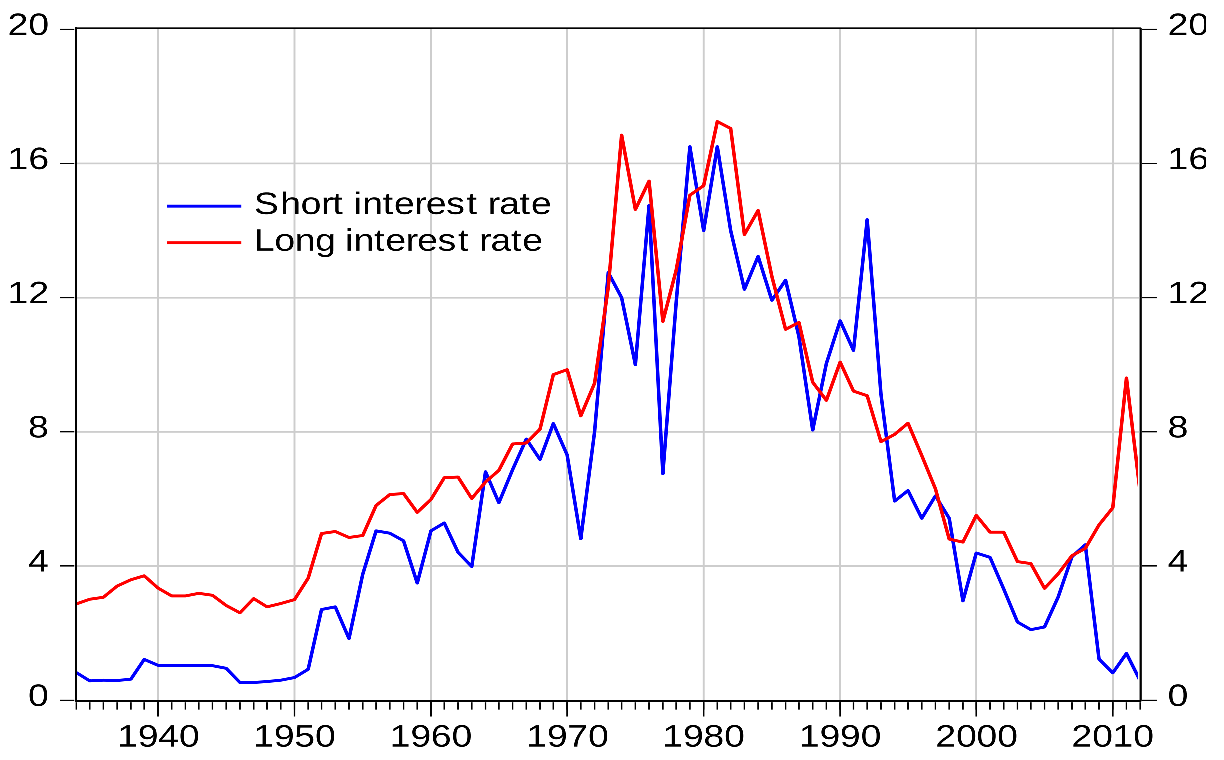

Figure 4: Error correction terms for M2 cointegrating vector

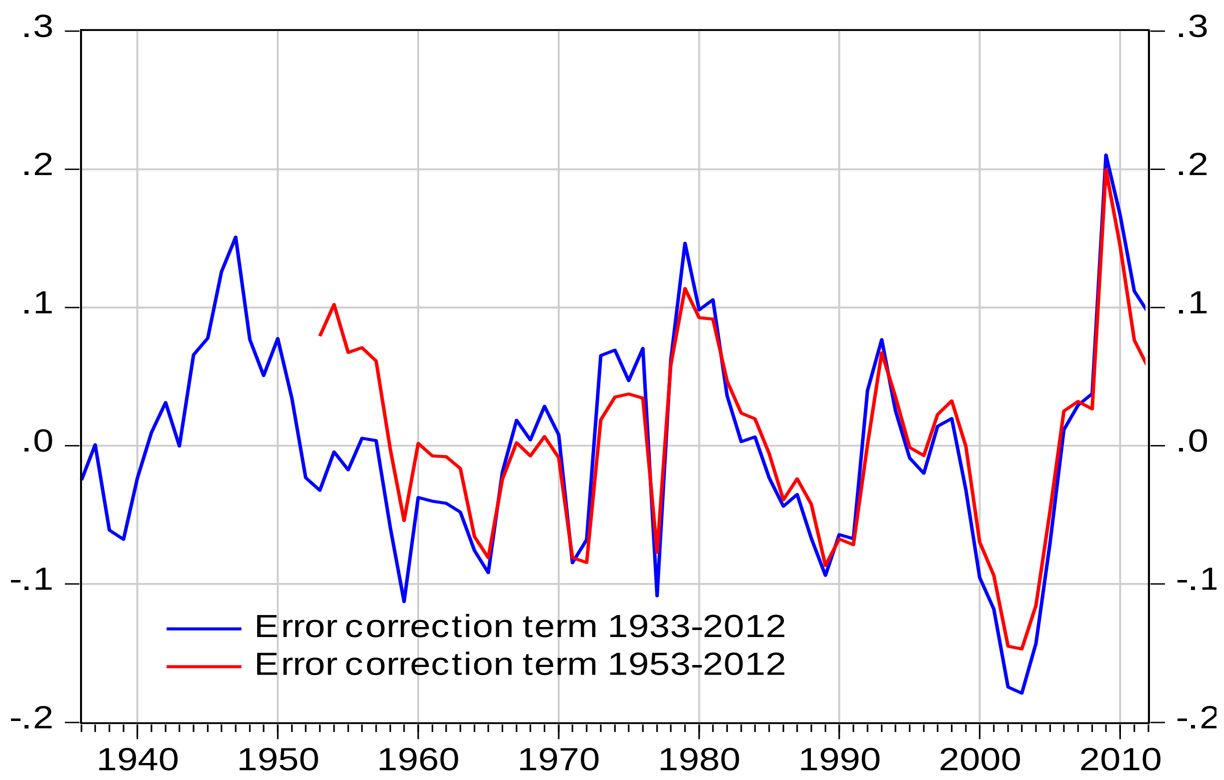

Figure 5: Estimated long-run cointegrating relationship and actual M2