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MONEY, INTEREST RATES AND PRICES IN IRELAND, 1933-2012

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Abstract

In this paper we assemble an annual data set on broad and narrow money, prices, real economic activity and interest rates in Ireland from a variety of sources for the period 1933-2012. We discuss in detail how the data set is constructed and what assumptions we have made to do so. Furthermore, we estimate a simple SVAR model to provide some empirical evidence on the behaviour of these time series. Money supply shocks appear to be the most important drivers of both money and prices. Interest rate shocks, which capture monetary policy, play an important role driving output and, of course, interest rates. The GDP shocks, which raise prices, seem of less importance.

Keywords: Ireland, historical statistics, long time series, business cycles, SVAR.

JEL Number: E3, E4, N14.

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1. Introduction

The Irish monetary system has undergone large changes since Saorstát Éireann, the Irish Free State, was established in 1922. At that time, the Irish and British monetary and financial systems were completely integrated. While there were no changes to the monetary arrangements at independence, they started to evolve immediately afterwards. Thus, in 1927 a Currency Commission was established and Irish coins were issued and in 1928 bank notes followed. The relationship weakened further after the establishment of the Central Bank of Ireland in 1943 in response to the fact that after the start of the Second World War, or "the Emergency," it became clear that Ireland could not expect to rely on the Bank of England to serve as its central bank.[1] Nevertheless, the link with the monetary system in the UK remained close, with Sterling circulating at par with the Irish pound and the exchange rate pegged at unity until Ireland became a founding member of the European Monetary System 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.

Given these changes in the monetary system, it is interesting to explore how the relationships between narrow and broad money (as measured by M1 and M2), real GDP, prices and short and long interest rates have evolved over time in Ireland. In this paper we do so, focusing on the period 1933-2012, a period of great change in the Irish economy that has been extensively covered in previous literature.[2] Briefly, the sample period begins with the Economic War that started in 1932 and during

1 See the discussion in Cormac Ó Gráda, 'Five Crises', Central Bank of Ireland T.K. Whitaker Lecture, 29 June, 2011.

2 See, for example, Frank Barry, (2003), "Irish Economic Development over Three Decades of EU Membership", *Czech Journal of Economics and Finance*, 53 (9-10), 394-412; Frank Barry, (2008), "Ireland – Politics, Institutions and Post-War Economic Growth", CESifo Forum 1/2008; Kennedy, K. A., T. Giblin and D. McHugh (1988), The Economic Development of Ireland in the Twentieth Century, First ed., London, Routledge, and Kevin O'Rourke, (1995), "Emigration and living standards in Ireland since the famine", *Journal of Population Economics*, 8 (4), 407-421, November.

which a policy of economic self-sufficiency based on import-substitution industrialisation was instituted.

With no industrial or engineering base, Ireland was not well equipped for the economic impact of the Second World War. Benefitting from no armament drive, Ireland experienced little reduction in unemployment, with emigration, predominantly of males to Britain, continuing throughout the period.[3] Thereafter, industrial production grew more rapidly. Between 1946 and 1952 jobs in industry increased by over 50,000, although the industrial workforce remained less than half the size of that in agriculture.[4] The end of the 1950s saw a policy shift that began with the adoption of the Programme for Economic Expansion in 1959, leading the economy to be increasingly opened to international market forces, resulting in a period of relatively strong economic growth in the 1960s. One of the main aims of the programme was a reduction in unemployment.[5] While the opening of trade under the economic programs initially led to redundancies, the size of the industrial workforce surpassed that in agriculture in the late 1960s.

Inflation began to rise towards the end of this period, significantly deviating from UK inflation for the first time in the post-war period. Attributed to higher wage growth, this differential created some unease, as it was felt Ireland was pricing itself out of its main export market.[6] Subsequently, the oil crisis in the 1973, and the deficit-spending that took place to promote economic activity in its immediate aftermath, prompted a period of inflation in Ireland that was very high even by the standards of western European countries. Thus, in 1975 the CPI rose by 19% and the GDP deflator rose by 22%. In this year, the National Economic and Social Council of Ireland noted that Ireland appeared to have lost its competitive advantage over the UK entirely,

3 Joseph J. Lee, (1989), Ireland 1912-1985: Politics and society, First ed., Cambridge University Press.
4 Lyons, F. S. L. (1985), Ireland Since the Famine, First ed., Fontana Press, London.
5 Cormac Ó Gráda, (1997), A Rocky Road: The Irish Economy since the 1920s, First ed., Manchester University Press
6 R. C. Geary, E. W. Henry and J. L. Pratschke (1970), "Recent price trend in Ireland", *Economic and Social Review*, 1, 345-357.

attributing this to three factors: wage agreements that resulted in wages rising strongly in response to soaring inflation; fiscal efforts to prioritise employment and maintain living standards which were funded by taxes that contributed directly to CPI increases[7], and the world recession in the wake of the first oil crisis which reduced demand for exports at the same time domestic costs were rising rapidly.[8] The government spending measures were largely unsuccessful in boosting the economy, and tough fiscal measures were implemented to address a rapidly rising debt-to-GDP ratio in the mid- to late-1980s. Inflation rates subsequently declined gradually, reaching lows of 2% and 4%, respectively, in 1988.

A notable feature of this period was that Ireland now actively and successfully pursued a policy of attracting foreign direct investment (FDI). The prohibition on foreign ownership of industry was lifted with the abolition of the Manufacturers Act. The result was that by 1983 Ireland attracted more than ten times the US FDI per manufacturing worker than rest of the EU combined.[9] Nonetheless, unemployment remained high in the 1980s: of all males aged 15-19 in 1986, 20% had emigrated five years later.[10]

It was not until the mid-1990s and the start of the Celtic Tiger that unemployment dropped precipitately. This period saw rapid economic growth over 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 changed character, becoming one sustained by a credit-fuelled construction bubble. This culminated in the financial crisis that began in 2008 and that led to sharp contractions in a number

7 For instance, increases in indirect taxes and excise duties on petrol alone added 3% to CPI.
8 National Economic and Social Council, (1975), "Economy in1975 and Prospects for 1976", Dublin.
9 Frank Barry, John Bradley and Eoin O'Malley, (1999), "Indigenous and foreign industry: Characteristics and performance" in F. Barry (ed) Understanding Ireland's Economic Growth, First ed., Macmillan Press, London.
10 Brendan Walsh, (1999), "The Persistence of High unemployment in a Small Open Labour Market: The Irish Case", in F. Barry (ed) Understanding Ireland's Economic Growth, First ed., Macmillan Press, London.

of important macroeconomic variables, including money growth, inflation, real and nominal GDP that we study here.

A central part of this paper consists of the compilation of a long historical macroeconomic data set for Ireland, using data from a number of different published sources.[11] The combination of data in this way is not without problems.

First, in many cases little is known about the data. For instance, it is rarely clear whether the annual data should be interpreted as averages over the year or as capturing economic conditions at the end of the year. Moreover, breaks in the data may not be reported in the sources we have used.

Second, 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 changed the composition of the basket for the consumer price index and has most likely reduced the volatility of consumer prices over time. This process is likely to have been accentuated by the increase in the number of components in the CPI, which also would have tended to reduce the volatility of the aggregate. Moreover, with the exception of interest rates and exchange rates, macroeconomic aggregates are unobserved and must be estimated. These estimates are likely to have improved in the 80 year period we study in response to the use of better statistical techniques and data. Furthermore, economies evolve over time, leading to a strong presumption that macro-economic relationships may display instability. However, such instability may be difficult to detect in estimated regressions if the equations fit poorly. It is therefore an empirical question whether structural changes are so large as to cause instability in empirical relationships.

Overall, while there are good reasons for analysts to be skeptical about data from distant historical episodes, in particular in cases in which they are constructed

11 These are the same data as those used to study money demand in Stefan Gerlach and Rebecca Stuart (2014), "Money Demand in Ireland, 1933-2012", *Journal of the Statistical and Social Inquiry Society of Ireland*, 43, 1-17.

from a range of sources, it seems difficult to argue that these data are so poor as to be of no value for economic analysis. Furthermore, modern data are similarly subject to measurement errors and contemporary economies also experience structural change.

In the paper we study the relationship between money, economic activity, short-term interest rates and prices since 1933. The objectives are to review the availability of data; consider the evolution of some important macroeconomic aggregates in Ireland; and present tentative empirical evidence on macroeconomic fluctuations. It is structured in six Sections. In Section 2 we briefly discuss the monetary regimes in place in Ireland during the period of our study. In Section 3 we review how we compile the long time series of macroeconomic data, and in Section 4 we review the data. In Section 5 we estimate a Structural VAR (SVAR) model in order to provide some empirical evidence on economic fluctuations in Ireland over the period 1936-2012. Section 6 concludes the paper.

2. Monetary regimes in Ireland since 1922

In contrast to the changing fiscal and economic policy outlined above, due to the monetary regimes in place, short-term interest rates, which large capture the stance of monetary policy, were determined by factors outside of Ireland for most of the sample period. Nonetheless, three distinct monetary regimes can be identified. Following independence, the monetary system was initially unchanged.[12] While it would have been difficult to introduce changes rapidly, the fact that the monetary arrangements appeared to function well must have reduced any sense that it was urgent to do so. Three types of bank notes circulated: British Treasury notes; Bank of

12 This section draws on Joseph Brennan, (1931), "The Currency System of the Irish Free State," Paper read to the *Statistical and Social Inquiry Society of Ireland*, 5 March; Maurice Moynihan, (1975), Currency and Central Banking in Ireland 1922-1960, Dublin, McGill and McMillan; Patrick Honohan, (1995), "Currency board or Central Bank? Lessons from the Irish Pound's link with Sterling, 1928-1979"; Cormac Ó Gráda, (1995), "Money and Banking in the Irish Free State 1921-1939," in Banking, Currency, and Finance in Europe Between the Wars, ed. by. Charles H. Feinstein, Peter Temin and Gianni Toniolo, Oxford University Press and John Kelly, (2003) "The Irish Pound: From Origins to EMU," Central Bank of Ireland Quarterly Bulletin, Spring, 89-115.

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.

In this period it is difficult to determine the size of the money stock 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 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 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 money and capital markets 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, 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 felt 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 Dáil in 1942, the Central Bank of Ireland was established in March 1943. However, the close link to Sterling was not called into question and the new central bank lacked some traditional banking functions, in particular the ability to influence credit conditions, that implied that it was not in a position to set interest rates and to conduct an active monetary policy.[13] As Honohan (1995) observes, the functioning of the Currency Commission and the Central Bank of Ireland implied that monetary arrangements in Ireland, at least until the early 1970s, are best described as those of a currency board.[14] As a consequence, Irish interest rates followed closely those in Britain and were thus determined with little, if any, direct reference to economic conditions in Ireland.

The close link to Sterling was broken in 1979 when the Government elected to join the European Monetary System (EMS) as a founding member. While this implied some softening of the role of the exchange rate commitment, monetary policy in Ireland continued to be geared to the requirement of exchange rate stability, occasional devaluations of the Irish pound notwithstanding. As a consequence, there was little possibility of gearing monetary policy to domestic macroeconomic conditions and Irish short-term interest rates were therefore largely determined from abroad.

In January 1999 Ireland became a founding member of the Eurosystem. As a consequence of this change, the Irish money supply was redenominated in euro at the fixed conversion rate of 1 euro = IR£ 0.78. Interestingly, although this was the third monetary regime in Ireland during our sample period, in all cases interest rates have been determined largely abroad. Thus, between 1933-1979 interest rates were

13 John Kelly, (2003) "The Irish Pound: From Origins to EMU," Central Bank of Ireland Quarterly Bulletin, Spring, 89-115.
14 Patrick Honohan, (1995), "Currency board or Central Bank? Lessons from the Irish Pound's link with Sterling, 1928-1979".

largely determined in London, given the rigorously fixed exchange rate regime. Similarly, during the EMU era 1999-2012, short-term interest rates were determined by the ECB's Governing Council in Frankfurt.[15] Between these periods the Irish pound floated within a band which did not allow for any monetary policy independence but at the time required increases in short-term Irish interest rates to offset speculative outflows. Since the introduction of the euro there is no data on the use of currency in Ireland. Moreover, a distinction is made the "Irish contribution to the euro area money stock" and the money stock held by "Irish residents." Of course, interest rates in Ireland have also since the introduction of the euro been determined largely by external factors.

3. Compiling long macroeconomic time series for Ireland

In this section we discuss the construction of the macroeconomic time series, beginning with some general information, and then focusing on the specifics of each individual series.

We use data over a sample period of 80 years. Unfortunately, no single source provides all the data and it is therefore necessary to rely on a number of different sources, including the Central Statistics Office (CSO), the Economic and Social Research Institute (ESRI), the OECD, the IMF, the ECB, Moynihan (1975), Mitchell (2007), Homer (1963) and the website for the Maddison project.[16]

In the absence of objective criteria for constructing long time series by combining data from several sources, unless otherwise noted the current vintage of data is used as far back as possible under the assumption that it is subject to smaller measurement

15 Of course, long-term interest rates embody credit and liquidity risk premiums and therefore at times diverged from those outside of Ireland.

16 See: Maurice Moynihan, (1975), Currency and Central Banking in Ireland 1922-1960, Dublin, McGill and McMillan, B. R. Mitchell, (2007), International Historical Statistics: Europe 1750-2005, Sixth ed., Palgrave McMillan, Sidney Homer, (1963), A History of Interest Rates, Rutgers University Press, New Brunswick, NJ and www.ggdc.net/maddison/maddison-project/home.htm.

errors than older vintages. Older time series are then spliced in order to construct a single time series.

In many cases there are differences in the levels of the series. Such differences can arise for a number of reasons, including changes in the number of reporting banks in the case of monetary aggregates and base-year differences in the case of real GDP. Where more than one series was available, the decision was based on a comparison of growth rates in these series during any overlapping period with the more recent vintage of data, with the series which most closely matched the recent vintage chosen. The sources and construction of the individual series are set out below, and the final series are available in Appendix 1.

3.1 Money Supply

Collecting data on the supply of money is difficult in the case of Ireland. First, at the time of independence, the monetary system was fully integrated with that of the United Kingdom and Sterling bank notes circulated freely. Second, monetary data are typically subject to frequent breaks and the Irish data are no exceptions. Data from Moynihan (1975) for both M1 and M2 are used from 1933 to 1950. Moynihan defines M1 as cash plus deposits at the Associated banks, and M2 as cash plus current and deposit accounts at the Associated banks. Data from Mitchell (2007) are used for M1 for over period 1950 to 1980, and for M2 over the period 1950 to 1971. Mitchell defines M1 as currency in circulation plus demand deposits (other than those of the central government). M2 also includes time and savings deposits and foreign currency deposits of residents.[17] Data from 1980 for M1 and from 1971 for M2 are available from the Central Bank of Ireland (Figures 1 and 2). Prior to 1999, the data that we use for M2 were classified as M3, however, since M3 was then defined as currency outstanding and Licensed Banks' current and deposit accounts[18]

[17] Unfortunately, it is not clear from Mitchell what sample of banks is used for the money supply data.
18 Precisely, this definition applies from 1972-1981. Accrued interest of resident private-sector entities is included. This is likely due to the introduction in 1982 of consistent rules (including on the

it is consistent with the earlier definitions of M2. The current definition of M2 is M1 (currency in circulation and overnight deposits) plus deposits with agreed maturity up to 2 years, deposits redeemable at notice up to 3 months and post office savings accounts.

There is a break in both series in 1999 when data collection under Eurosystem definitions began. As the new definitions did not run concurrently with the old ones, no growth rate is available for 1999. However, monthly data for 1999 is available. We therefore annualise the 11-month growth rate (January to December) to proxy an annual rate for 1999.[19] Joining a currency union also affected how Irish money supply was defined. From 2000 onwards M1 and M2 data were collected on the basis of both "Irish contribution to the euro area" and for "Irish residents". 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.

A further break in the series occurred in 2003 when, in line with Eurosystem requirements, securities issued to non-euro area residents were excluded from M2, while holdings by credit institutions of debt securities up to two years maturity issued by euro-area MFIs are netted off debt securities issued in this category.

3.2 Inflation

The Consumer Price Index is available from the CSO from 1933 to 2012. The base year for this series is 1914.

3.3 Real and nominal GDP

For real GDP, data from the Maddison website are used from 1933 to 1938. These data are reported on a per capita basis. To calculate the aggregate level of

residency of the customer, the treatment of accrued interest and bad debts) which were compiled using international statistical and accounting standards were adopted.

19 We also seasonally adjust the series before calculating the changes using the Census X11.2 method used by the U.S. Bureau of Census. The annualised growth rate is 31.5% for M1 and 17.3% for M2.

GDP, we use population data from the census provided by the CSO.[20] Data between 1938 and 1944 are sourced in a White Paper on National Income and Expenditure presented to the Oireachtas in March 1946, and data between 1944 and 1947 are taken from the Tables of National Income and Expenditure compiled by the CSO and presented to the Oireachtas in February 1951.[21] However, it is clear from the White Paper and the CSO's 1951 release that no data were collected in this period, and that these were estimates made in retrospect.[22] In both cases, the data are for total national income, and are reported only in nominal terms. However, a price trend is also reported in both publications, and this is used to deflate the series. Real GDP data are available from the CSO from 1947 to the 2012 (Figure 3).[23] [24]

The Maddison data are also available during the period 1938 to 1947. However, the growth rates differ dramatically between the White Paper and CSO (1951) publication and the Maddison data. In contrast to the other two sources, the Maddison data indicate that the growth rate of GDP was (almost exactly) zero throughout the Second World War (Figure 3), which suggests that no data were in fact recorded for this period. As a consequence, we prefer the data originally published by 'official' sources for the time period that they are available.

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20 The Census was conducted every ten years between 1926 and 1946 and on a five-yearly basis thereafter. We interpolate the missing years using a cubic spline. The 1976 Census was cancelled as an "economy measure," with the result that one took place in 1979, and the 2001 Census was postponed until 2002 due to an outbreak of foot and mouth disease in Britain and Ireland.

21 See White Paper (1946), "National Income and Expenditure, 1938-1940" and Central Statistics Office (CSO) (1951), "Tables of National Income Expenditure, 1938 and 1944-50."

22 The White Paper on National Income and Expenditure published in 1946, and containing data for the period 1938 - 1944, states that it *'inaugurates a series of official estimate of national income and expenditure… Heretofore the official statistical service has been unwilling to assume responsibility for statistics relating to national income through rough approximations have been made from time to time for departmental use'*.

23 There are three breaks over this time period: in 1995 (data prior to 1995 exclude FISIM, the Financial intermediations sector indirectly measured), 1970 and 1959. Data from 1970 to 1995 are chain-linked annually and referenced to 2009; data prior to 1970 are at 1995 prices. Furthermore, there is no overlap in the two data vintages immediately before and after 1970. We therefore use growth rates of the real GDP series from the ESRI Databank for this year to splice the series. Data from 1959 to 1970 are at 1995 prices. Data prior to 1959 are estimates.

24 Both real and nominal GDP data are also available from the OECD from 1970 onwards. The growth rates in the OECD data vary marginally from those of the CSO series (Figures 3 and 4). We do not use the OECD data as the CSO is the official statistics provider in Ireland.

Nominal GDP is constructed in a similar manner (Figure 4). The Maddison data which are used for real GDP from 1933 to 1938 are not available in nominal terms. While these data could be deflated by CPI, it is not clear that this would be an appropriate deflator, and we instead use the Moynihan (1975), Appendix 10, pp. 528-529 series on nominal gross domestic expenditure. Data from the 1951 CSO release and the 1946 White Paper are used for the period 1938 to 1947. CSO data are used from 1947 to 2012.

3.3 Short and long-term interest rates

With the Irish financial system closely tied to the British between independence and the abandonment of the fixed peg to Sterling in 1979, we can obtain information on Irish interest rates in two ways. Most obviously, there are data on Irish interest rates that can be used. However, these appear not to be available as far back in time as data on interest rates in the UK. This may reflect the fact that Irish markets were much less important than UK markets and that there was less demand for information about Irish interest rates. Alternatively, it may be that there were no active markets for Irish debt.[25] Of course, the deep and liquid markets in London that were open for Irish residents together with the fixed exchange rate to Sterling must have hindered the development of local financial markets.

We use the annual average of the open-market rate of discount in London, quoted in Homer (1963, pp. 417-420) for the period 1933 to 1962 as a proxy for Irish short-term rates. This is the rate paid in London on three months' bankers' bills or three months' bankers' acceptances. We use this rate because short-term interest rate data for Ireland are either not available, or are not appropriate to this study. Data on Irish rates available during this period appear to be official rates that may have deviated from actual market rates: there is little or no movement in any available rate over the period to 1951, while it is likely that the fact that an increase in the UK Bank

25 For instance, it may be that debt issued by the Irish government was held to maturity by Irish financial institutions.

Rate in the 1950s was not matched in Ireland led to a deviation of official rates and markets rates for Irish banks (Figure 5).[26] Furthermore, it is arguable whether a money market existed in Ireland throughout much of this period to provide an 'Irish' market rate.[27] The London open-market rate which we use is both lower and more volatile in the period 1933 to 1951 than the official rates reported by a number of sources. However, it moves closely with data from the IMF's IFS database on the discount rate in the period after 1951.[28] The London overnight rate is therefore used for the period to 1962. The discount rate from the IMF is used for the period until 1984, and data on the short-term rate from the OECD are used for the most recent period.

Long-term interest rates prior to 1952 are proxied using UK interest rates. Homer (1963) reports a high and low bond yield for each year in the period from 1922. We take the midpoint of these yields in these years. From 1948 to 1952, IFS data are available for the UK. Data are taken from the IMF's International Financial Statistics (IFS) from 1952 to the present. Data from other sources are available over this period, including from Homer (1963), the CSO and the OECD. However, as the IMF series is available for the full period and, as it evolves over time in similar ways to the data from other sources, we use it (Figure 6).

4. Review of individual time series

As our primary interest at the current stage is to explain broad developments in the Irish economy over the sample period, we start by plotting the final series in Figures 7-10. In the interest of brevity, we only consider M2 in the analysis below.

26 Indeed, data indicate that the official rate was unchanged at 3 per cent from 1932 to 1941. In 1942, the rate was reduced to 2.5 per cent, and remained at this level until 1951.

27 Indeed, as late as 1969, Thomas F. Hoare, 'Nature and Functions of an Irish Money Market' *Journal of the Statistical and Social Inquiry Society of Ireland*,XXII, II: 1-27, 1969/1970 debates the existence of an Irish money market, but concludes that one does, indeed, exist.

28 Data prior are also available from the OECD from 1922 to 1949. These also move very closely with the London rate that we use over the period 1922 to 1933. A further alternative would be to use the Bank of England "Bank Rate", but that is a posted penalty rate that provided a ceiling to market rates.

The reason for doing so is that Gerlach and Stuart (2014) found that M2 appears to be much more stably related to interest rates, prices and real income than M1.[29]

In Figure 7 we plot the growth rate of M2 and the inflation rate. The graph shows that money growth peaked in the early 1940s during the Emergency, following the first oil shock in the 1973 and around the establishment of the euro in 1999. Interestingly, these episodes of high money growth appear to match quite well with episodes of inflation. Thus, although inflation was high during the Emergency and in the 1970s, despite increasing somewhat, it was not particularly high in the late 1990s.

Figure 8 plots nominal and real GDP growth. Most of the variation in nominal GDP arises from changes in the price component rather than in real economic activity, however, the period of rapid growth in real GDP around 2000 drove strong nominal GDP growth at that time. Real GDP contracted sharply after the property bubble burst in 2008. Real GDP growth was low in other periods, in particular in the 1950s when it averaged 2.2% and in 1960-1980 when it averaged 4.2%.

Figure 9 shows M2 and nominal GDP. As one would expect, money growth and nominal income growth are closely, but not perfectly, correlated, suggesting that movements in velocity must be of some importance.

Figure 10 plots short and long nominal interest rates. These remained at low levels until 1950, subsequently rose to a peak around 1980, and then declined towards the end of the sample. There are two interesting episodes of marked divergences between short and long rates. The first took place in 1992 when pressure across a range of exchange rate pegs within the European Monetary System and forced many central banks, including the Central Bank of Ireland, to tighten

29 Stefan Gerlach and Rebecca Stuart (2014), "Money Demand in Ireland, 1933-2012", *Journal of the Statistical and Social Inquiry Society of Ireland*, 43, 1-17.

monetary policy sharply.[30] The second episode occurred in 2009-2012, when concerns about the state of public finances in Ireland led to a large increase in the credit risk premium on long bond yields.

5. A Structural VAR model

In this section we provide a preliminary analysis of the data. The results in Gerlach and Stuart (2014) indicate that there are close relationships between real GDP, consumer prices, M2 and short-term interest rates. We therefore focus on these variables here.

Before proceeding, we emphasise three points. First, the work below is a first step towards the modelling of macroeconomic fluctuations in Ireland during the sample period. It is easy to think of extensions that we leave for future work. Most obviously, while we propose one particular identification scheme, there could exist other identifying restrictions that might provide more interesting interpretations of the data. Furthermore, we do not look at sub-periods such as before and after the abandonment of the peg to Sterling in 1979.

Second, we only consider a small number of macroeconomic time series and disregard other important variables, such as wage and unemployment rates and external variables. While it would be interesting to include a broader set of variables, it seems useful to start the modelling of macroeconomic fluctuations in Ireland by consider a smaller set of time series.

Third, the Irish economy is small and highly open, operated with exceptionally close links to the UK economy until the abandonment of the peg to Sterling in 1979 and has since been member of the exchange rate mechanism and euro. As a consequence, one would expect Irish macroeconomic time series to be determined largely by external developments. Since external variables are not incorporated explicitly in the analysis, they are captured by the shocks.

30 In the event, this attempted defense of the exchange rate was unsuccessful as the Irish punt was devalued by 10% on 30 January 1993. For a discussion see John Kelly, (2003) "The Irish Pound: From Origins to EMU," Central Bank of Ireland Quarterly Bulletin, Spring, 89-115.

5.1 Preliminaries

We start by testing for cointegration among the logarithms of CPI, M2, real GDP and the level of the short-term interest rate by estimating a VAR for these variables. The Schwartz information criterion indicates that a lag length of 2 is appropriate. While a LM test does not reject the hypothesis of no autocorrelation (p = 0.33), a test of the hypothesis that the parameters on the third lag are jointly zero rejects (p = 0.05). We therefore conclude that use a VAR(3) model is appropriate to capture the dynamics in the data and estimate it over the sample 1937-2012. Finally, we compute trace and maximum eigenvalue tests of the hypothesis that the variables are not cointegrated. While the tests reject (p = 0.03; p = 0.03), they do not reject the hypothesis of at most one cointegrating vector. We therefore conclude that there is one cointegrating relationship between the variables.

5.2 The model and identification

The finding of cointegration among the variables implies that they can be described by a Vector Error Correction (VECM) model, that is, by a restricted VAR model for the levels of the variables.[31] For that system to be interpretable, it must be identified. That can be done in a number of ways.[32]

It is useful to be clear about how we do so. We start with the structural model of the economy (where, without loss of generality, we consider a first-order system and omit intercepts for brevity):

$$(1) \qquad BX_t = \Gamma X_{t-1} + \varepsilon_t$$

where the diagonal elements of B are all unity, where the covariance matrix of $\varepsilon_t, \Sigma_\varepsilon$, is diagonal, and where X_t denotes the vector of variables in the model, which in our case consists of the log-levels of the price level, the money stock, real GDP and the level of the short interest rate. The B matrix captures the contemporaneous relationships between the variables.

31 Imposing the restrictions of the VEC model in estimation improves efficiency but is not necessary. For computation convenience we do not do so here.

32 See the discussion in Walter Enders, (2010), Applied Econometric Time Series, 3rd edition, Wiley, Hoboken, NJ, specifically, Chapter 5.

Pre-multiplying with B^{-1}, we obtain the VAR model:

(2) $\quad X_t = \mathrm{A}X_{t-1} + e_t$

where $A = B^{-1}\Gamma$ and $e_t = B^{-1}\varepsilon_t$ with covariance matrix Σ_e. While the model in equation (1) is unknown, we can estimate the reduced-form VAR in equation (2).

The problem we face is how to retrieve the structural model of the economy in equation (1) from the estimates of equation (2). In particular, we wish to obtain estimates of B and ε_t from the estimated values of e_t. To think about this problem, note that a covariance matrix of a n-dimensional vector has $(n^2 + n)/2$ independent elements. Furthermore, since the diagonal elements of B are unity, it has $(n^2 - n)$ unknown off-diagonal elements. Finally, recall that the n diagonal elements of the covariance matrix of the structural ε_t shocks are also unknown. In sum, by estimating the VAR model in equation (2) we can compute the 10 independent elements of Σ_e, but need to compute 12 unknown elements of B and the 4 unknown elements of Σ_ε. Thus, we need at least 6 more restrictions.

Sims (1980), in a seminal paper, imposed these restrictions by assuming that B is lower triangular, that is, that the 6 elements above the diagonal all zero.[33] This can be achieved by simply ordering the variables in the desired way and computing the Cholesky factorization of the covariance matrix of the VAR residuals.

While the VAR model proposed Sims (1980) was just identified and best thought of as a reduced form, Bernanke (1986) showed how to introduce over-identifying restrictions and obtain a Structural VAR (SVAR).[34] Here we follow Bernanke and achieve identification by imposing further restrictions. We posit a model which captures the idea that in the sample period that we study, Ireland was a small open economy (SOE) operating under fixed or heavily managed exchange rates, which implies that domestic economic conditions were very heavily influenced by international conditions.

33 See, Christopher Sims, (1992), "Interpreting the macroeconomic time series facts: the effects of monetary policy," European Economic Review, 36, 975-1000.

34 See Ben S. Bernanke, (1986), "Alternative Explanations for the Money-Income correlation", Carnegie-Rochester Conference Series on Public Policy, 25, 49-100.

We identify four structural shocks:

1. An price level shock ($e_{p,t} = \varepsilon_{p,t}$). For a SOE, such shocks are predominantly external. Given lags, we expect such shocks principally to lead to an gradual increase the demand for money and the money stock.

2. A money supply shock ($e_{m,t} = \varepsilon_{m,t}$). Under fixed (or heavily managed) exchange rates, such shocks can be thought of as global inflationary shocks that over time cause a rise in the price level.

3. A real GDP shock ($e_{y,t} + b_{y,m}e_{m,t} = \varepsilon_{y,t}$). Because the demand for money reacts quickly to changes in real income, we expect this shock to impact immediately on both real GDP and the money stock.

4. An interest rate, or monetary policy, shock ($e_{i,t} + e_{i,p}\varepsilon_{p,t} = \varepsilon_{i,t}$). Operating under fixed exchange rates, short-term interest rates in Ireland largely reflect interest rate decision made abroad.[35] Since central banks typically raise interest rates in responses to increases in actual and expected future inflation, one would expect such shocks to impact on inflation immediately.

5.3 Estimation

Next we go on to estimate the model. We first estimate a third-order VAR for the levels of the short-term interest rate, and the logarithm of prices, M2 and real GDP, using data for the period 1936-2012.[36] We go on to impose the four restrictions used to identify the structural shocks. These are not rejected by a likelihood ratio test (p = 0.19). Furthermore, both $b_{y,m}$ and $b_{i,p}$ are significant at the 1% level. While simple, this model thus appears to capture the contemporaneous interactions in the data.

35 Such decisions were made by the Bank of England until 1979, the Bundesbank between 1979-1999, and the ECB's Governing Council subsequently.

36 To determine the lag length, we used the Schwartz Information Criterion, which suggested a lag length of two. However, a LM test indicated that a third lag was needed to purge the residuals of autocorrelation.

To explore the model, we next compute impulse responses, which we show in Figure 11 together with 95% confidence bands. In the figure the first row shows the responses of prices to the four shocks; the second row the responses of M2; the third the responses of real GDP; and the forth the responses of interest rates.

Consider the first column that shows the responses to the first shock, which instantaneously raises the price level by about 3% and which we therefore think of as a *price level shock.* Over time, the higher level prices and therefore of money demand leads to an increase in the money stock. The interest rate remains unaffected since it is larger determined outside of Ireland.

Turning to the responses to the second shock, the second column suggest that that it can be thought of as a *money supply shock* that stimulates real GDP and, over time, the price level. Again the interest rate remains unaffected.

Similarly, we think of the third shock in the third column as a *real GDP shock* that immediate raises the demand for money and therefore money stock. Since prices rise in response to the shock, the increase in real GDP stems is best thought of as reflecting an aggregate demand shock.

Finally, we consider the fourth shock, which raises the interest rate and depresses real GDP. It also *raises* the price level and thus suggests a "price puzzle", we think of as a *monetary policy shock*.[37]

5.4 Historical decomposition

Having identified the VAR and proposed labels for the shocks, in figures 12-15 we decompose the movements in prices, money, real GDP and interest rates into the parts due to the four shocks (relative to the deterministic trend). We first look at the decomposition of the price level in Figure 12. The lightest grey is part due to price level shocks; these appear to play a relative small role. Shock 2, the money

37 The common finding in the SVAR literature that a monetary policy shock is associated with rising inflation (as a consequence of the central bank reacting to rising inflation expectations) was first noted by Christopher Sims, (1992), "Interpreting the macroeconomic time series facts: the effects of monetary policy," European Economic Review, 36, 975-1000, and Martin Eichenbaum, (1992), "Comment on: Interpreting the macroeconomic time series facts," European Economic Review, 36, 1001-1011.

growth shock, appears most important and explains why prices were low relative to trend in the 1960s and rose sharply between the early 1970s and the early 1980s. Economic growth shocks, Shock 3, explain the relatively low inflation before 1970 and also from about 2002. Finally the monetary policy shock accounts for the relatively high price level compared to trend in the 1980s and 1990s.

Figure 13 performs the same exercise for the stock of M2. Not surprisingly, the results are broadly similar to those of the price level shock. The one difference concerns Shock 4, the monetary policy shock, which tended to depress the money stock relative to trend in the 1980s and 1990s, and raise it more recently.

In Figure 14 we turn to real GDP. While real GDP shocks played an important role between 2000-2009, between 2010-12 they served to depress output. Interestingly, the role of GDP shocks is amplified by the monetary policy shocks, which depressed real GDP between 1980-1995 but supported it from 2000-12.

Finally, in Figure 15, we turn to the interest rate. Given that the money supply shocks have played an important role in influencing the price level and thus the rate of inflation, it is not surprising that they have also had a large effect on the level of the interest rate. Short-term fluctuations in the interest rate, however, are largely explained by monetary policy shocks. Thus, between the early 1970s and the middle of the 1990s, monetary policy shocks pushed up interest rates. Strikingly, however, during the boom years between 1999 and 2006, monetary policy shocks pushed down interest rates. This is an indication how ECB's monetary policy did not fit economic conditions in Ireland very well.

It is interesting to consider some specific historical episodes. First, the period of the Second World War is characterized by prices above trend, driven largely by the price level shock (Shock 1). At the same time, output was being dragged below trend by Shock 3, the real GDP shock. This is consistent with the notion that Ireland did not benefit from economically during the war since it was poorly placed to engage in the armament drive.[38]

38 Joseph J. Lee, (1989), Ireland 1912-1985: Politics and society, First ed., Cambridge University Press.

The role of the monetary policy shock (Shock 4) on the interest rate following the oil crises in 1973 and 1979 is evident in the spikes in the interest rate relative to trend during this period. The robust, expansionary fiscal response to the crises is evident in the reversal of the money supply shock (Shock 2) on prices, which begin to grow rapidly from 1973 onwards (Figure 13).

The role of monetary policy in the period following the oil crisis is interesting. During the disinflationary period of the 1980s, a large negative monetary policy shock (Shock 4) to real GDP is evident (Figure 14). This remains negative even as the Celtic Tiger is beginning in the mid-1990s and real GDP begins to grow rapidly. However, with the advent of the euro, the monetary policy shock to real GDP becomes abruptly positive and remains so for the entire period thereafter, supporting GDP growth both in the boom, but also during the crisis.

6. Conclusion

In this paper we have two objectives. First, we compile and discuss an annual macroeconomic data base for Ireland, spanning the period 1933-2012, using published sources. The combination of data in this way is not without problems. In particular, little is known about the data and economic and statistical changes may make data lack comparability over time. But while there are good reasons to be skeptical about data, it seems difficult to argue that these data are so poor as to be of no value for economic analysis. Furthermore, modern data are similarly subject to measurement errors and contemporary economies also experience structural change.

Second, we explore the data by estimating a simple SVAR model for the full sample period. While the model gives a plausible interpretation of the last 80 years of macroeconomic developments, it is easy to think of extensions that we leave for future work. Most obviously, it is possible that other identifying schemes could provide more interesting interpretations of the data. Furthermore, we do not look at sub-periods such as before and after the abandonment of the peg to Sterling in 1979. Finally, we consider a small number of macroeconomic time series and disregard

other important variables, such as wage and unemployment rates, or external variables. These and other extensions we hope to provide in future research.

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Figure 1: Money Supply (M1)

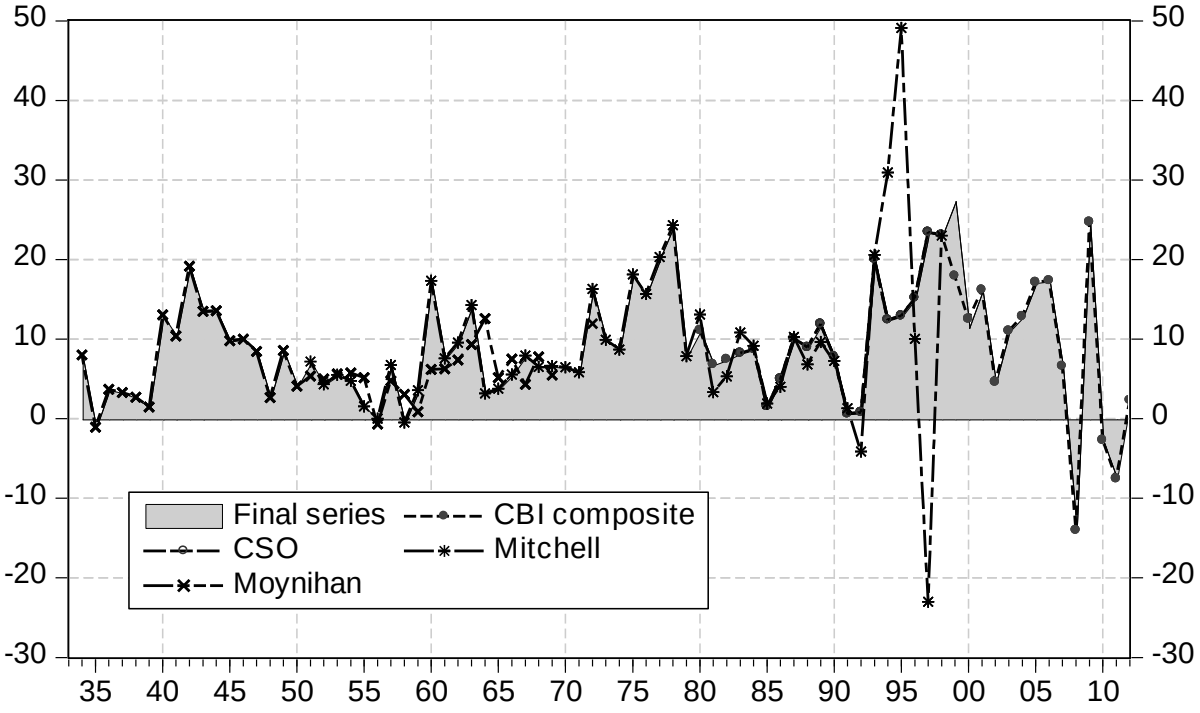


Figure 2: Money Supply (M2)

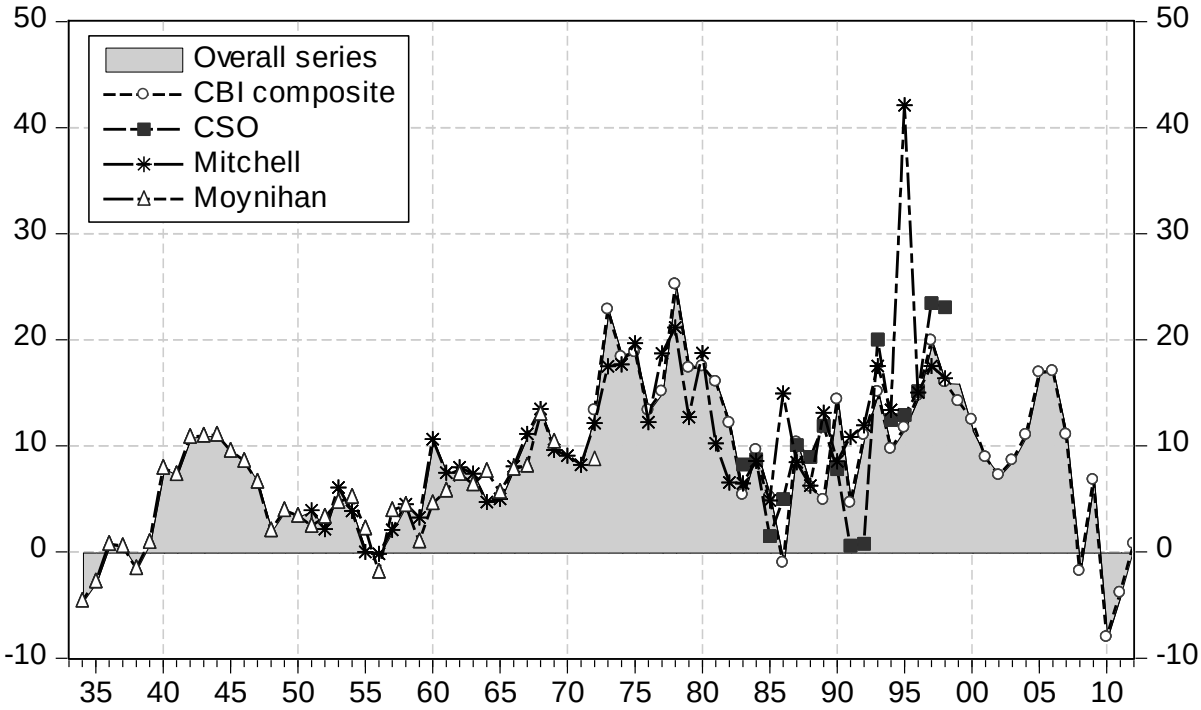


Figure 3: Real GDP

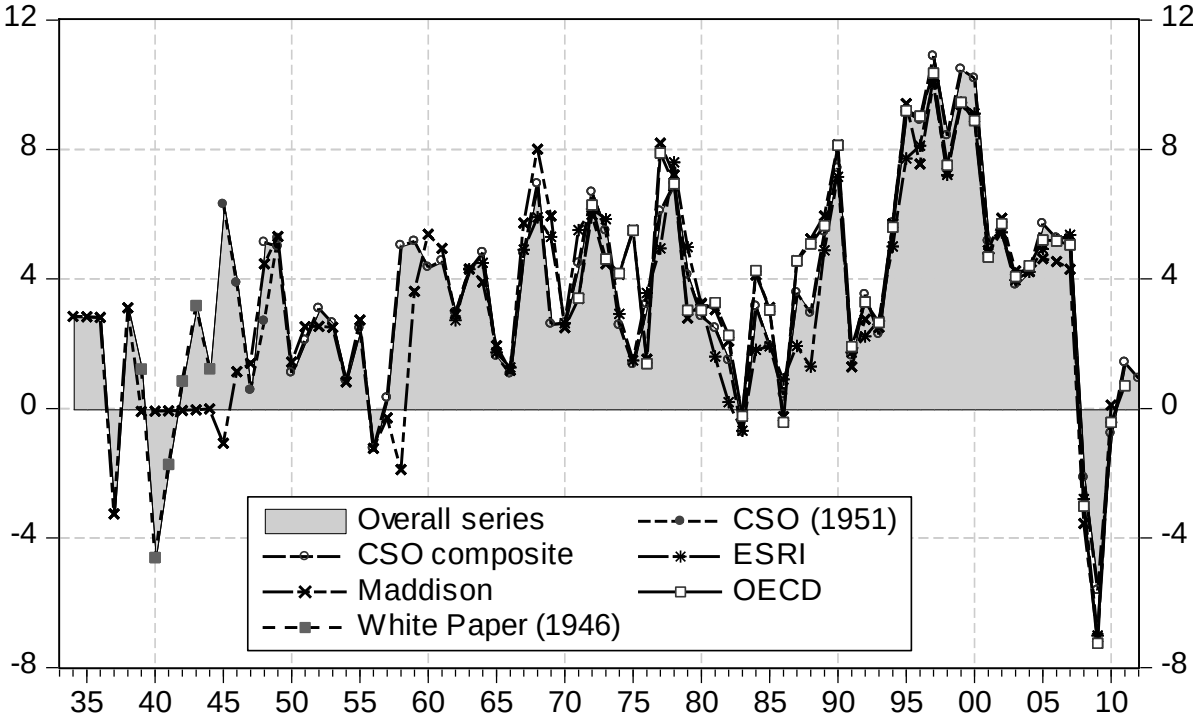


Figure 4: Nominal GDP

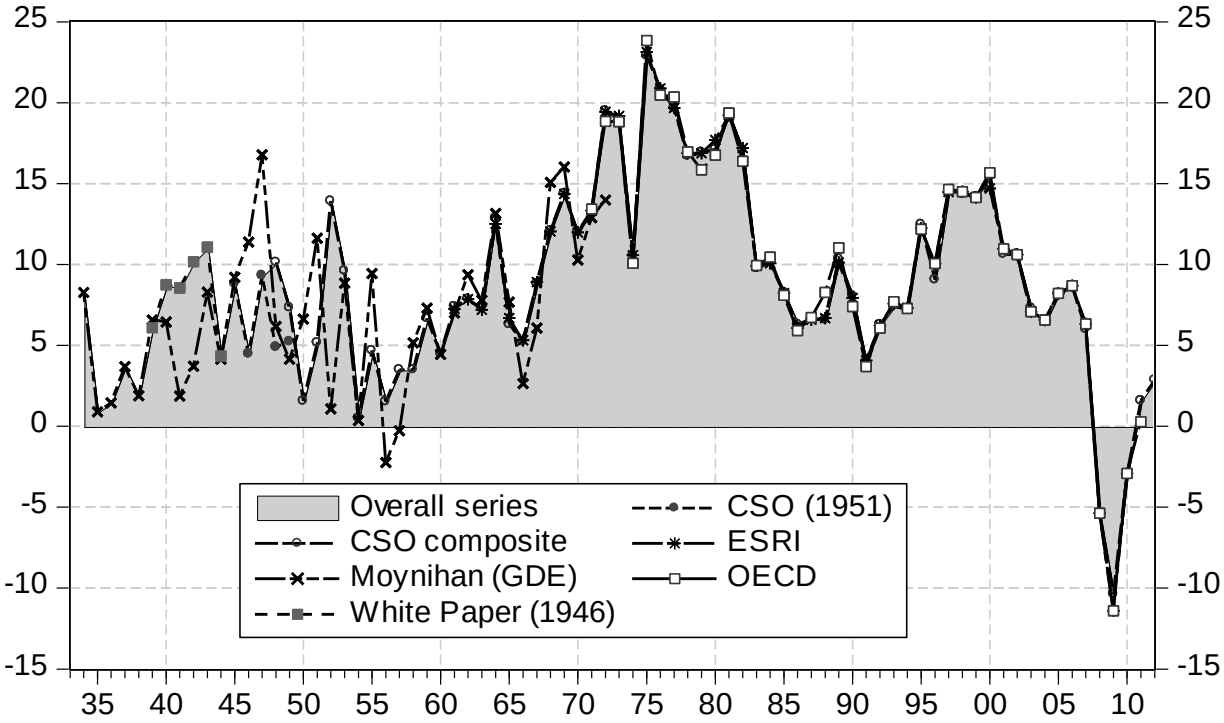


Figure 5: Short-term interest rates

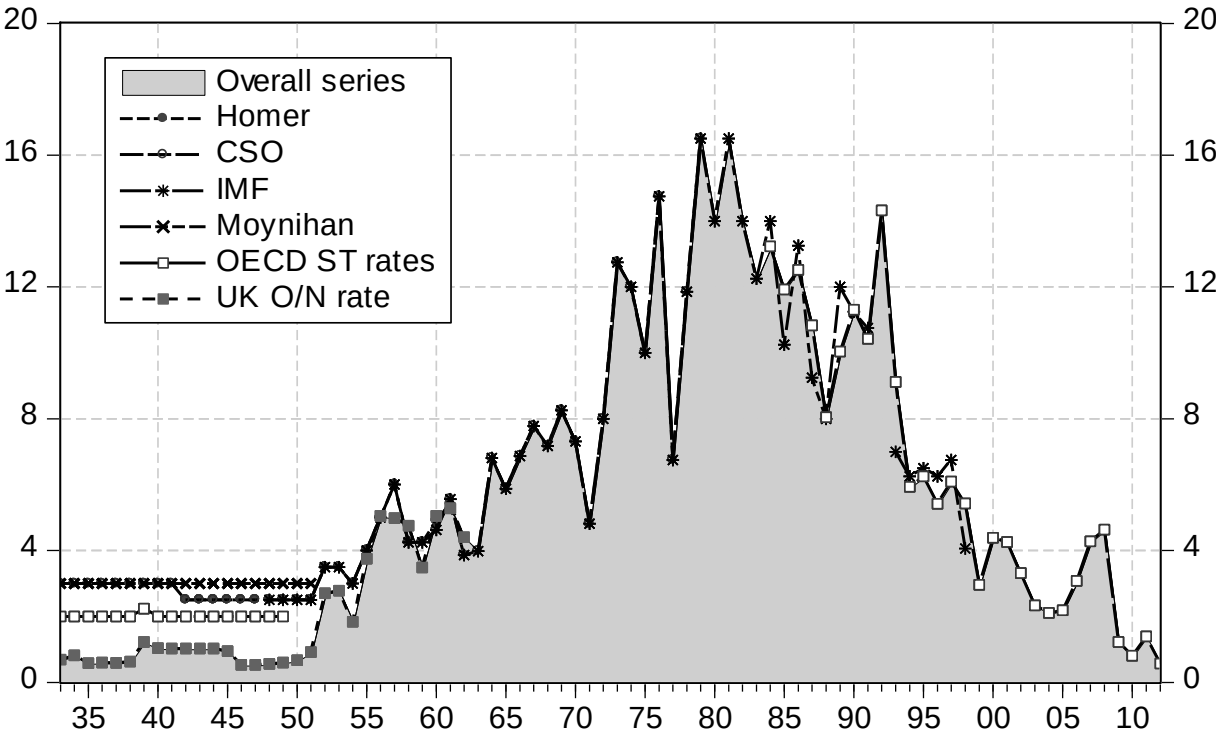


Figure 6: Long-term interest rates

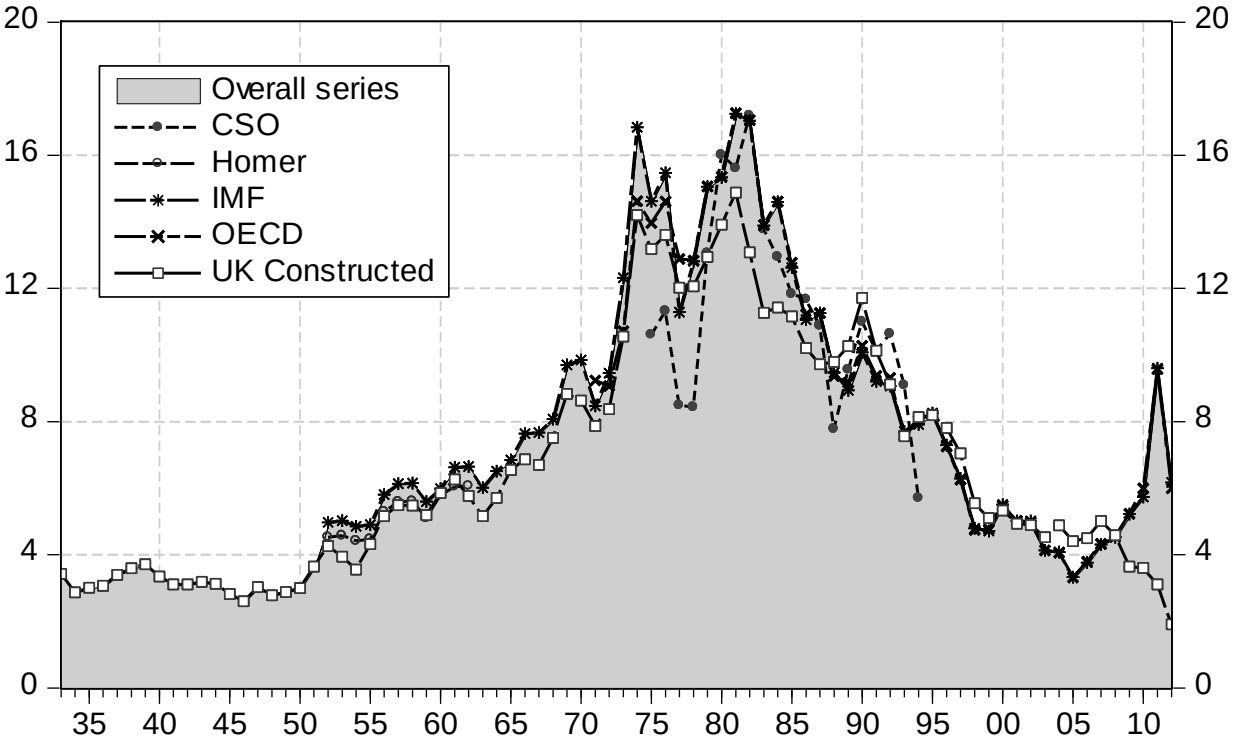


Figure 7: M2 growth and inflation

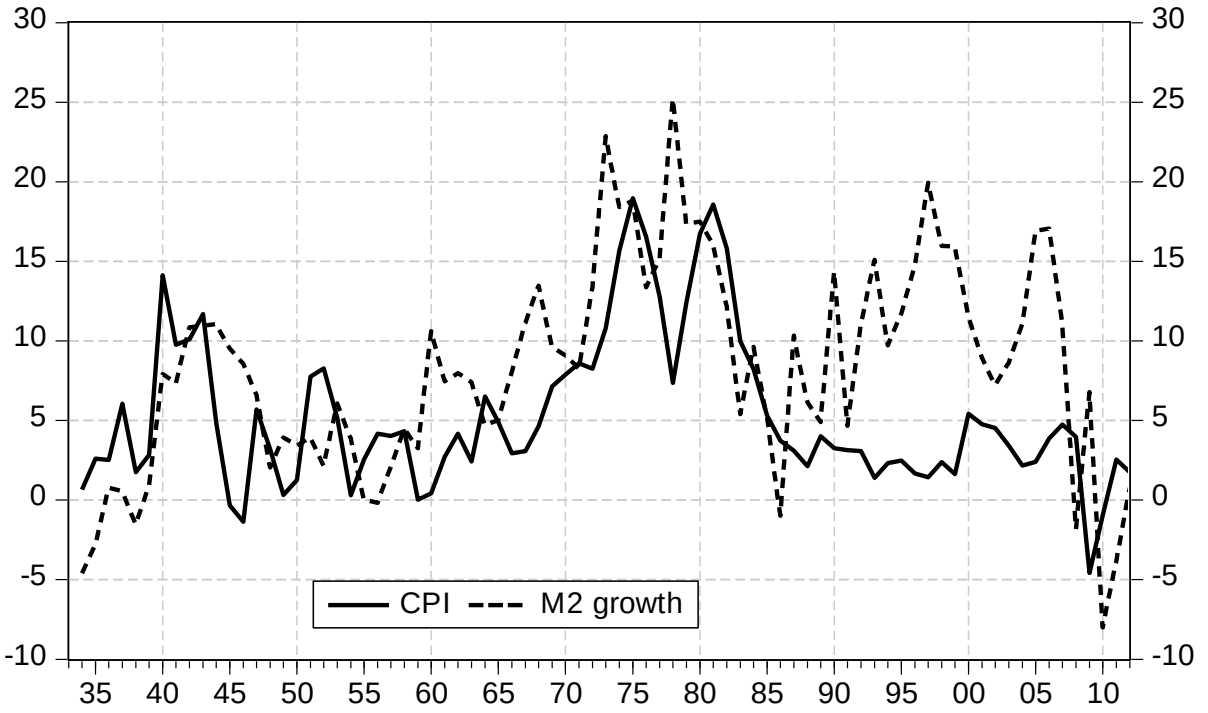


Figure 8: Real and nominal GDP growth

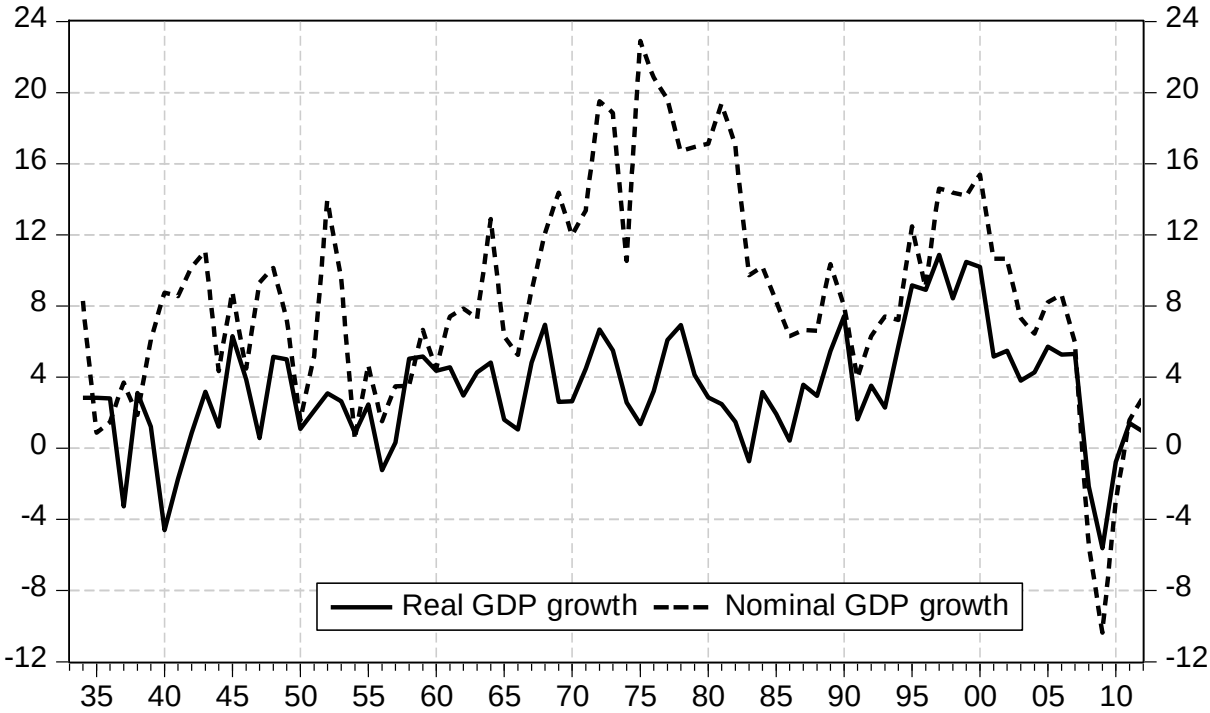


Figure 9: Nominal GDP and M2 growth

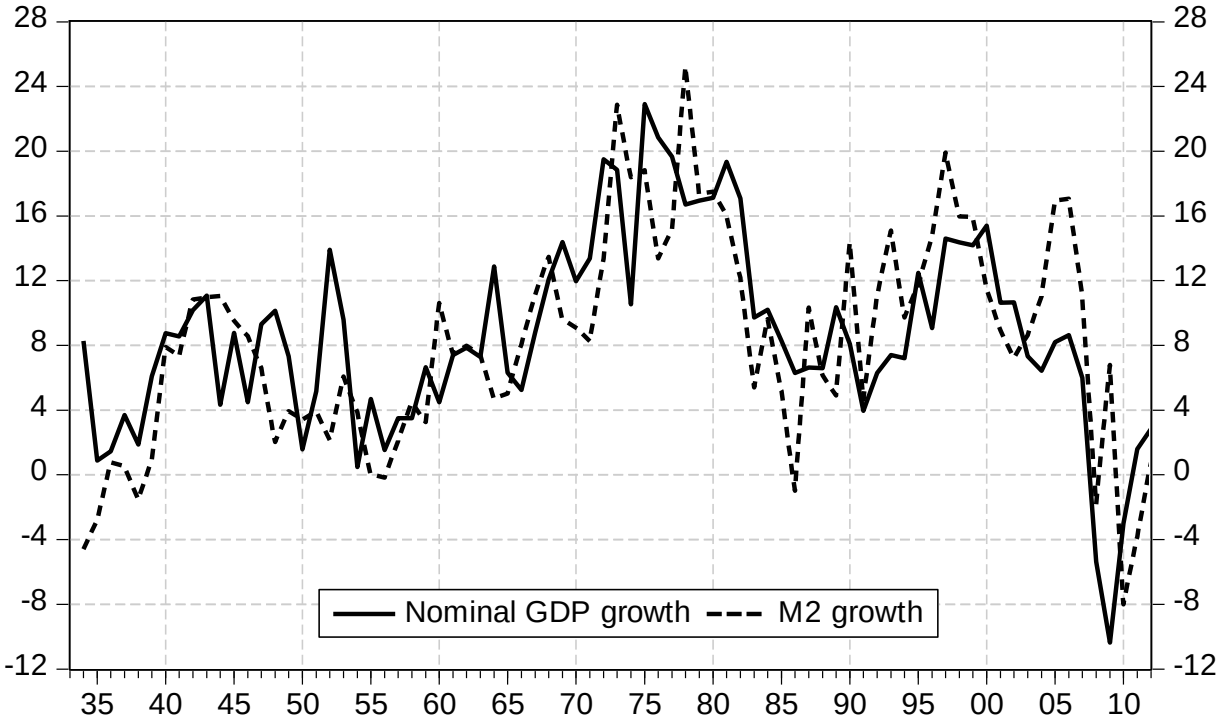


Figure 10: Short- and long-term interest rates

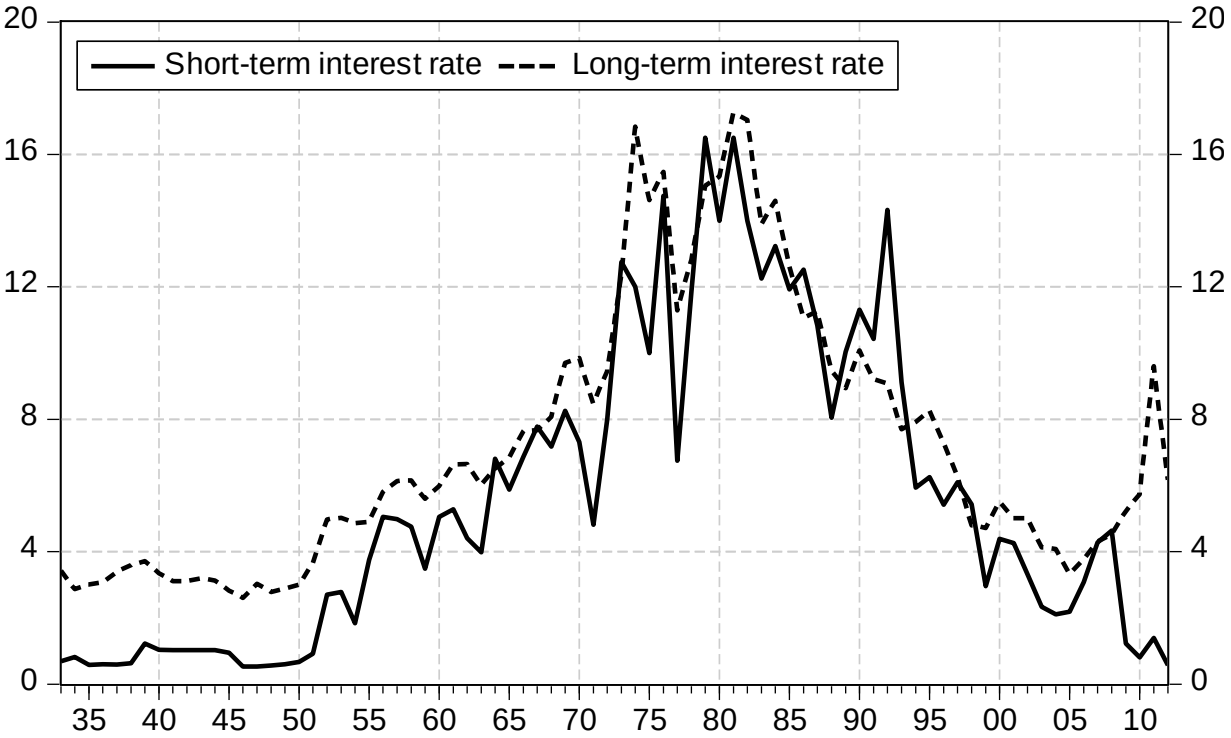


Figure 11: Impulse responses with 95% confidence interval

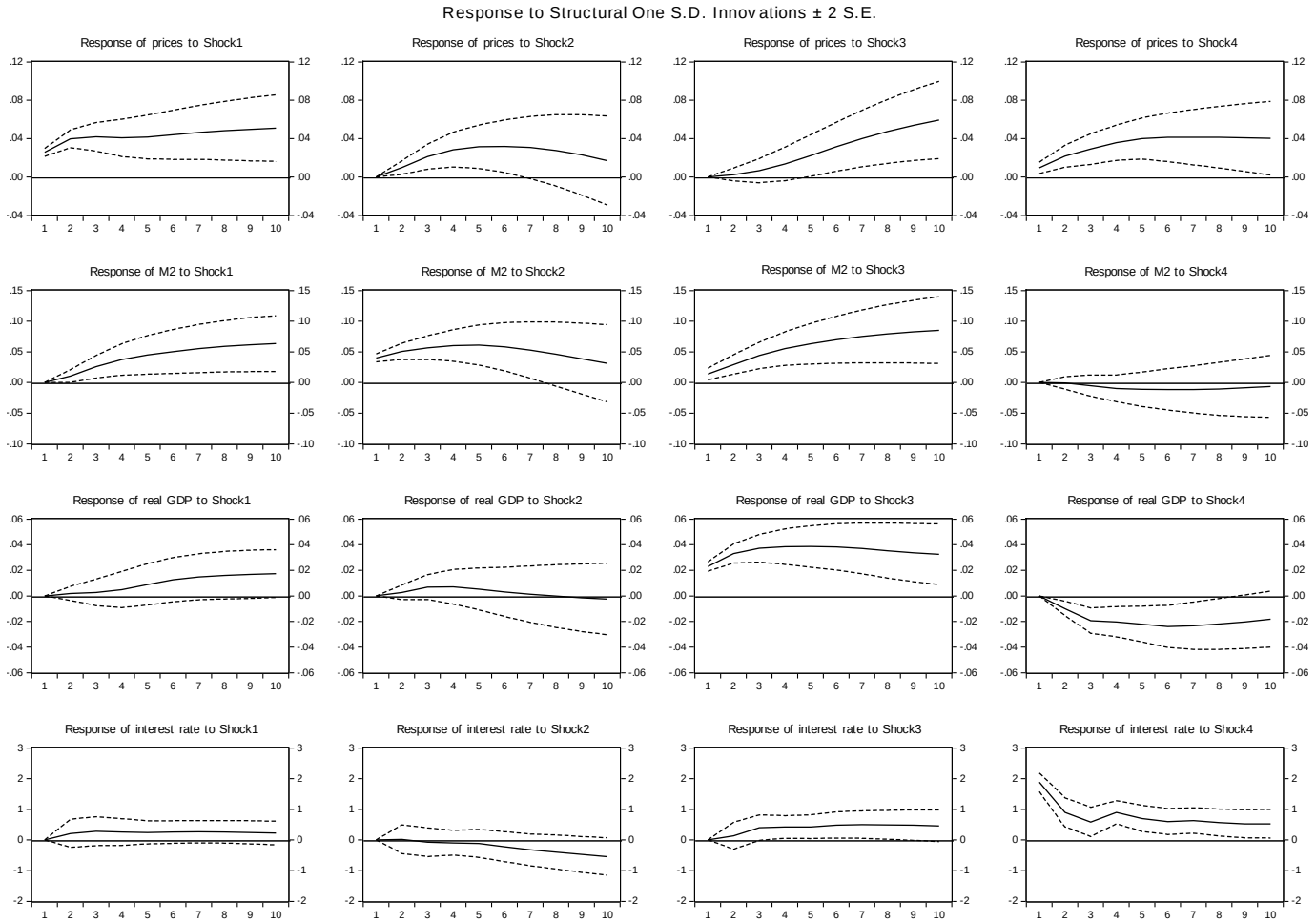


Figure 12: Historical decomposition of prices

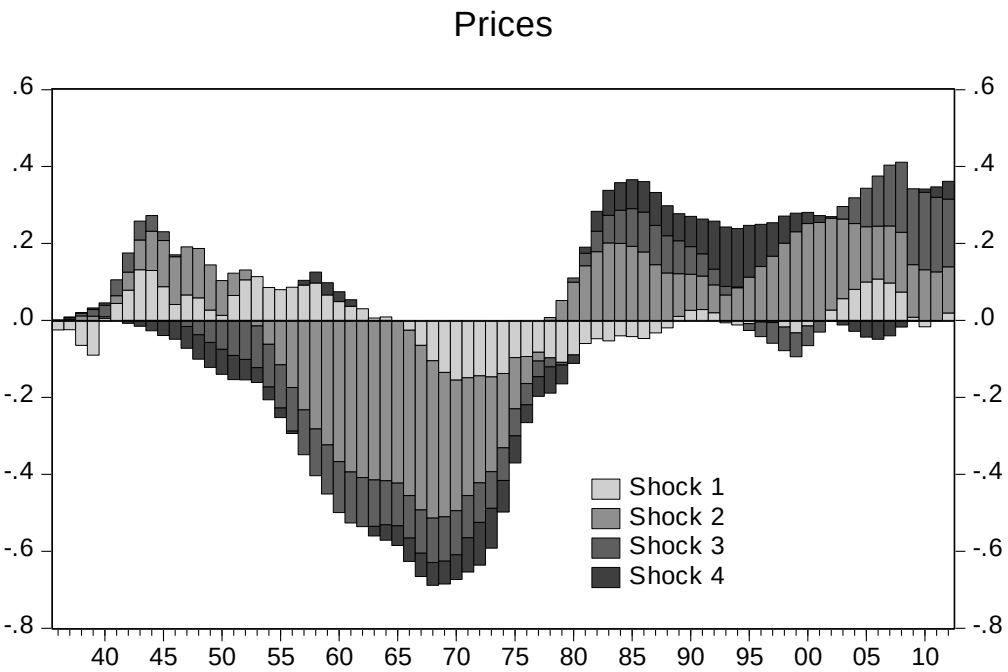


Figure 13: Historical decomposition of M2

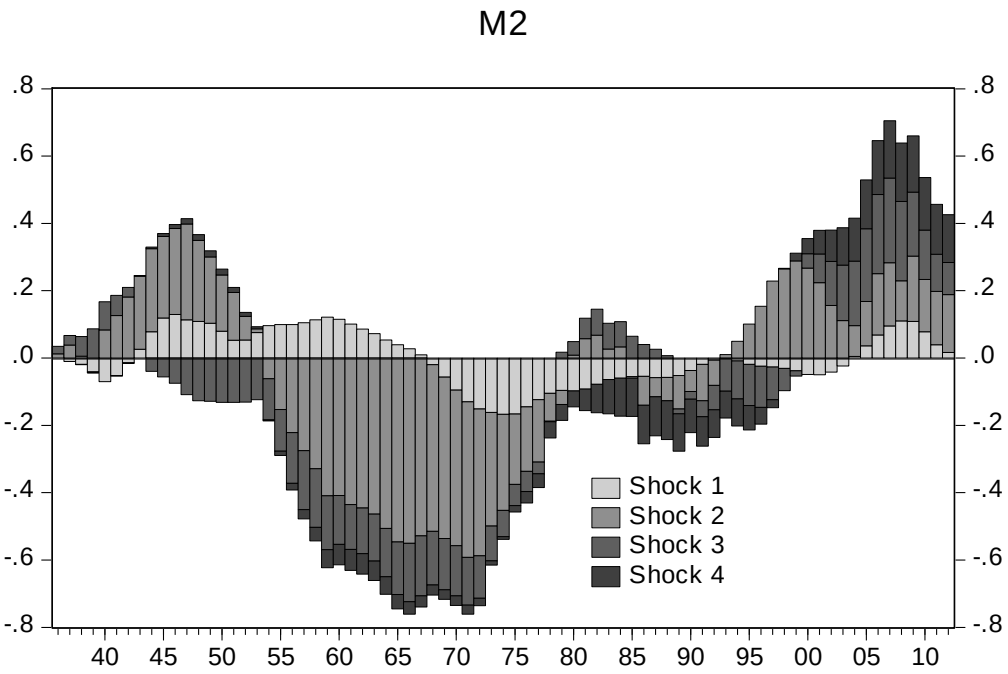


Figure 14: Historical decomposition of real GDP

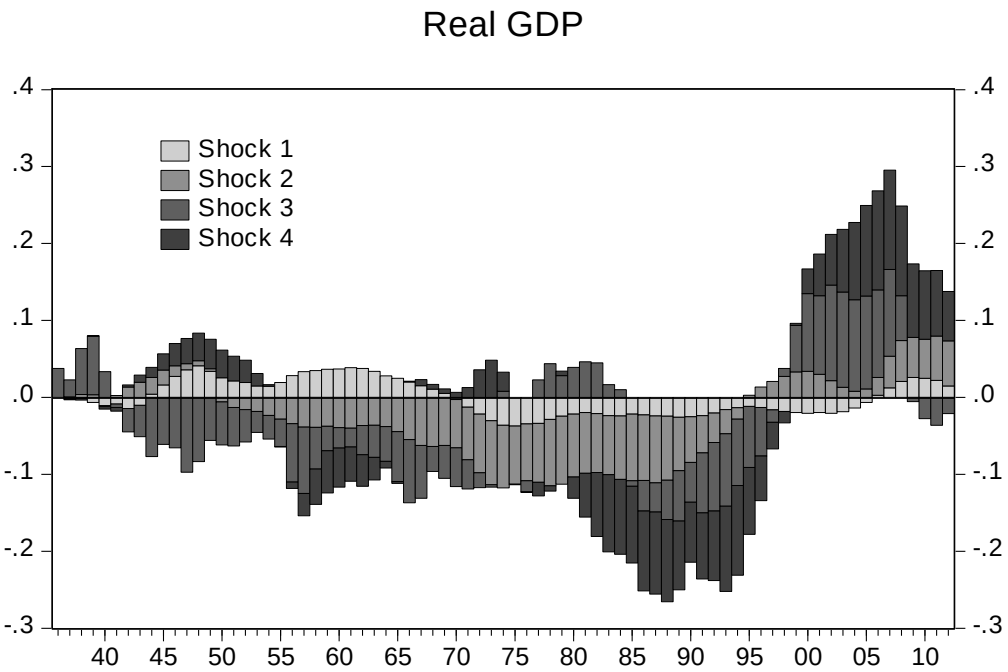
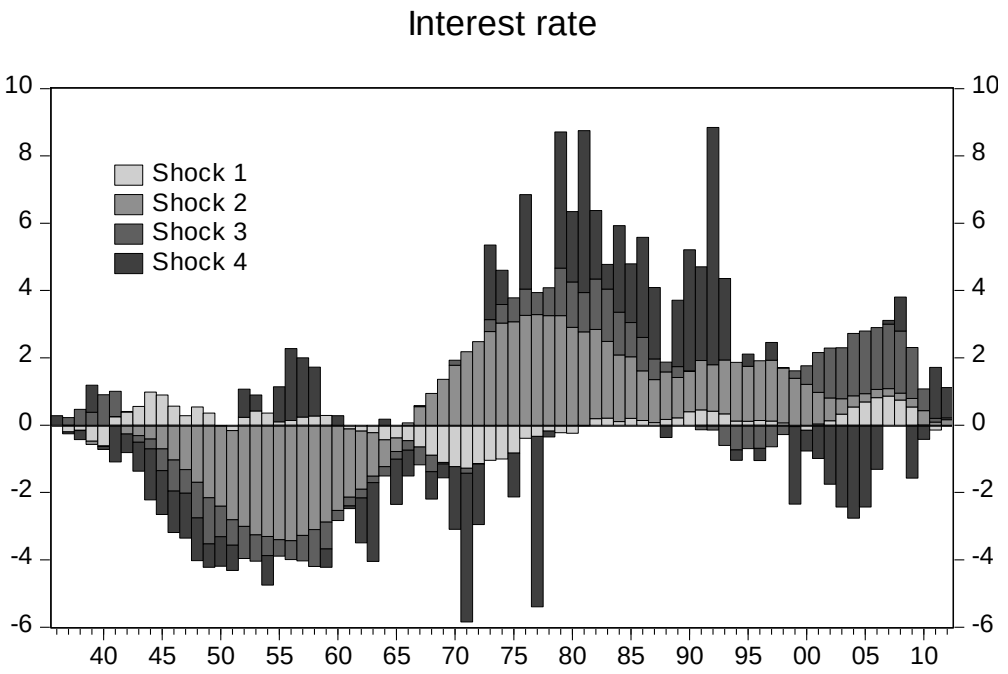


Figure 15: Historical decomposition of interest rate



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APPENDIX 1: Final compiled data series used in estimation

	CPI	Nominal GDP	Real GDP	M1	M2	Short-term interest rate	Long-term interest rate
1933	20.35	7.84	40.03	7.93	14.13	0.69	3.43
1934	20.49	8.52	41.19	8.59	13.50	0.82	2.87
1935	21.02	8.59	42.37	8.50	13.12	0.58	3.01
1936	21.56	8.72	43.58	8.82	13.22	0.60	3.07
1937	22.91	9.05	42.18	9.12	13.29	0.59	3.40
1938	23.32	9.22	43.52	9.37	13.09	0.63	3.59
1939	23.99	9.80	44.05	9.50	13.21	1.22	3.71
1940	27.63	10.70	42.07	10.83	14.30	1.04	3.35
1941	30.46	11.65	41.34	12.02	15.39	1.03	3.11
1942	33.69	12.90	41.70	14.55	17.15	1.03	3.11
1943	37.87	14.41	43.04	16.66	19.14	1.03	3.19
1944	39.76	15.05	43.57	19.08	21.37	1.03	3.13
1945	39.62	16.43	46.41	21.04	23.51	0.95	2.83
1946	39.08	17.19	48.24	23.26	25.61	0.53	2.60
1947	41.37	18.86	48.51	25.31	27.36	0.53	3.03
1948	42.72	20.88	51.07	26.00	27.93	0.56	2.78
1949	42.86	22.47	53.69	28.33	29.05	0.60	2.88
1950	43.40	22.82	54.28	29.52	30.05	0.67	3.00
1951	46.90	24.03	55.43	31.71	31.26	0.92	3.64
1952	50.94	27.62	57.17	33.11	31.94	2.70	4.97
1953	53.64	30.40	58.71	34.99	33.93	2.78	5.03
1954	53.80	30.55	59.21	36.70	35.27	1.84	4.85
1955	55.20	32.01	60.69	37.28	35.27	3.76	4.90
1956	57.55	32.51	59.95	37.28	35.21	5.05	5.80
1957	59.92	33.66	60.14	39.88	35.95	4.98	6.13
1958	62.57	34.86	63.25	39.69	37.60	4.75	6.16
1959	62.59	37.26	66.60	41.13	38.85	3.49	5.60
1960	62.86	38.97	69.57	48.92	43.20	5.05	5.98
1961	64.60	41.97	72.82	52.77	46.55	5.28	6.63
1962	67.35	45.40	75.01	58.07	50.42	4.41	6.65
1963	69.00	48.82	78.28	66.99	54.29	3.98	6.01
1964	73.64	55.54	82.14	69.16	56.90	6.81	6.51
1965	77.35	59.16	83.47	71.81	59.83	5.88	6.85
1966	79.65	62.35	84.37	75.90	64.85	6.87	7.64
1967	82.14	68.09	88.53	82.17	72.49	7.78	7.67
1968	86.05	76.84	94.89	87.71	82.95	7.17	8.08
1969	92.43	88.72	97.40	93.73	91.32	8.25	9.70
1970	100.00	100.00	100.00	100.00	100.00	7.31	9.85

1971	108.96	114.31	104.59	106.02	108.58	4.81	8.47
1972	118.34	138.93	111.82	124.82	124.10	8.00	9.45
1973	131.86	167.75	118.13	137.83	155.98	12.75	12.32
1974	154.23	186.40	121.21	150.36	187.49	12.00	16.84
1975	186.43	234.38	122.87	180.24	226.35	10.00	14.62
1976	219.96	288.71	126.89	210.84	258.74	14.75	15.47
1977	249.95	351.44	134.86	258.31	301.00	6.75	11.29
1978	269.03	415.33	144.55	329.40	387.37	11.85	12.82
1979	304.65	492.01	150.63	356.39	460.74	16.50	15.05
1980	360.16	583.90	154.99	398.33	548.80	14.00	15.33
1981	433.67	708.49	158.89	426.42	644.35	16.50	17.24
1982	507.92	840.48	161.26	459.52	727.79	14.00	17.04
1983	561.19	926.38	160.08	499.01	768.21	12.25	13.88
1984	609.35	1025.93	165.21	544.54	845.76	13.23	14.60
1985	642.52	1114.45	168.43	552.79	890.78	11.93	12.63
1986	666.99	1186.96	169.15	581.06	881.99	12.52	11.06
1987	687.92	1268.38	175.30	642.60	978.06	10.83	11.26
1988	702.65	1354.80	180.56	702.77	1040.09	8.05	9.48
1989	731.35	1502.65	190.70	791.56	1092.39	10.04	8.94
1990	755.61	1629.06	205.40	855.48	1261.16	11.31	10.08
1991	779.76	1694.91	208.77	861.14	1321.26	10.43	9.21
1992	804.08	1805.07	216.24	867.93	1475.74	14.32	9.07
1993	815.40	1943.96	221.25	1060.40	1716.21	9.12	7.70
1994	834.53	2089.26	234.29	1200.81	1891.60	5.93	7.92
1995	855.53	2366.77	256.76	1366.67	2126.80	6.25	8.26
1996	870.00	2591.48	280.70	1590.14	2464.35	5.42	7.29
1997	882.63	2998.97	312.97	2010.38	3007.81	6.09	6.29
1998	903.96	3462.35	340.48	2532.25	3528.72	5.43	4.80
1999	918.79	3990.29	378.11	3330.58	4137.84	2.96	4.71
2000	969.92	4654.37	418.72	3737.33	4643.17	4.39	5.51
2001	1017.17	5176.61	440.89	4393.80	5076.71	4.26	5.01
2002	1064.34	5758.97	465.75	4601.37	5457.54	3.32	5.01
2003	1101.39	6196.80	483.84	5137.36	5950.05	2.33	4.13
2004	1125.55	6608.97	504.95	5843.25	6644.59	2.11	4.08
2005	1152.92	7174.08	534.62	6934.37	7870.19	2.18	3.33
2006	1198.34	7820.58	563.52	8247.97	9334.39	3.08	3.77
2007	1256.63	8304.61	594.20	8809.86	10426.68	4.28	4.31
2008	1307.57	7871.28	581.67	7655.47	10238.91	4.63	4.53
2009	1248.99	7096.55	549.93	9800.23	10958.89	1.23	5.23
2010	1237.18	6885.85	545.72	9538.41	10115.47	0.81	5.74
2011	1269.16	6996.12	553.53	8846.84	9734.70	1.39	9.60
2012	1291.60	7198.63	558.72	9052.25	9809.86	0.57	6.17

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