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Did Monetary Policy Matter? Narrative Evidence from the Classical Gold Standard

Jason Lennard*

Abstract

This paper investigates the causal effect of monetary policy on economic activity in the United Kingdom between 1890 and 1913. Based on the Romer and Romer (2004) narrative identification approach, I find that following a one percentage point monetary tightening, unemployment rose by 0.8 percentage points, while inflation fell by 2.7 percentage points. In addition, monetary policy shocks accounted for more than a quarter of macroeconomic volatility.

JEL: E31, E32, E52, E58, N13.

1 Introduction

The macroeconomic effects of the Bank of England's monetary policy during the classical gold standard was a subject of great interest to contemporaries. A long line of economic historians have revisited the subject since such as Tinbergen (1950), Pesmazoglu (1951), Ford (1962), Andréadès (1966), Goodhart (1972) and Sayers (1976). At one end of the spectrum, Sayers argues that it "did not matter", while at the other, Andréadès notes that it had "very injurious effects".

Quantitative estimates are few and far between in the literature. Jeanne (1995) estimated a structural vector autoregression (SVAR) for the British economy in this period. The results show that a contractionary monetary shock lowered output proxies but raised prices in this period - the so-called "price puzzle". A recent review of estimates of the efficacy of monetary policy in modern economies based on this methodology finds that one-third of studies suffer from the same problem (Rusnak et al., 2013).

In a classic paper, Romer and Romer (2004) address the price puzzle using a new methodology: the narrative approach. In the first stage, the central bank's reaction function is

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estimated using data that was available to policymakers in real time. The residuals from this regression constitute exogenous monetary policy shocks. In the second stage, this new measure is used to estimate the macroeconomic effects of monetary policy. The narrative approach improves on traditional SVARs as the full information set can be controlled for, while in the latter degrees of freedom quickly vanish with the inclusion of additional variables.

Romer and Romer (2004) show that a contractionary monetary shock has a significant, negative impact on output and prices in the modern US economy, which is consistent with New Keynesian models and sticky prices. However, the narrative approach has only been applied in one other context. Cloyne and Hürtgen (2016) find qualitatively similar results for the modern UK economy. This paper therefore contributes to this literature as only the third application of the narrative approach to monetary policy, and the first for a historical period and an alternative monetary regime.

The choice of sample period under investigation (1890-1913) is informed by three considerations. Firstly, the underlying sources are not consistent until 1890. Secondly, previous research on the Bank's reaction function during the classical gold standard covers the same years (Morys, 2013; Davutyan and Parke, 1995; Giovannini, 1986; Dutton, 1984; Pippenger, 1984). Thirdly, the targets and actions of the Bank were relatively stable during this period. It was a period in which the Bank "only watched the gold and took the necessary steps automatically (Giuseppi, 1966)."

The results of the analysis show that monetary policy did matter. In response to a one percentage point monetary tightening, unemployment increased by up to 0.8 percentage points, while inflation fell by up to 2.7 percentage points. In addition, monetary policy shocks accounted for as much as 28% of unemployment volatility and 27% of inflation volatility.

This paper also contributes to another literature. Orphanides (2001) argues that the interpretation of historical monetary policy rules hinges on the use of real-time data. There is a long literature that estimates the Bank of England's reaction function during the classical gold standard that includes data that was not available to policymakers and/or excludes important information that was (Morys, 2013; Davutyan and Parke, 1995; Giovannini, 1986; Dutton, 1984; Pippenger, 1984). The first stage of the narrative approach boils down to the estimation of the central bank's reaction function. In light of the Orphanides criticism, a real-time information set for all 1,257 monetary policy decisions between 1890 and 1913 is reconstructed from archival sources. This will be a useful resource for future research.

The rest of the paper is structured as follows. Section 2 sketches a brief historical and theoretical background. Sections 3 and 4 cover the methodology and data. Section 5 derives the new measure of monetary shocks and explores some of its properties. Section 6 analyzes the causal effect of monetary policy shocks on the macroeconomy. Section 7 investigates the robustness of the baselines results. Section 8 concludes.

2 Background

2.1 History

In order to understand "monetary policy" in Britain during the classical gold standard, it is important to grasp the objectives of its conductor, the Bank of England. As Sayers (1976) put it, the Bank ran three horses at the same time. The first was the protection of the country's gold reserves; the second was the financing of the government; and the third was the commercial duty to the stockholders. However, if there was a clash, then the first objective came above the others.

In pursuit of its objectives, the Bank of England's primary instrument was Bank Rate (Goodhart et al., 1994): the rate at which it lent to the banking system (Capie and Webber, 1985). There is evidence that the Bank also used open market operations and gold devices (Sayers, 1976). However, as Eichengreen et al. (1985) argue, Bank Rate "was the most visible and controversial of the Bank's instruments, and as such is the variable most likely, when subjected to detailed analysis, to yield information on the pressures and considerations influencing the formulation of policy."

2.2 Theory

In theory, monetary policy should not be effective under fixed exchange rates. Consider a monetary expansion in which the central bank purchases government bonds. In this instance, the money supply increases, which drives down the nominal interest rate. In a world free from expected exchange rate depreciation, risk premiums and transaction costs, investors sell domestic currency to the central bank to reap the higher reward overseas. This reduces the money supply and increases the nominal interest rate back to their original levels.

In practice, a number of imperfections undermined this mechanism during the classical gold standard. Firstly, the exchange rate was not rigidly fixed, but fluctuated within the "gold points". The $/£ exchange rate, for example, fluctuated between 4.84 and 4.91 between 1890 and 1913 (Thomas and Dimsdale, 2016). Klein and Shambaugh (2015) show that a degree of flexibility allows for some monetary autonomy. Secondly, risk premiums were not equal across countries. Bordo and Rockoff (2009) find that countries on the gold standard enjoyed lower risk premiums than those that were not, while Obstfeld and Taylor (2003) show that core countries benefited from lower premiums relative to the periphery. Thirdly, and this is related to the first point, transaction costs were not zero. In the case of gold flows between Britain and the US, the cost of arbitrage was between 0.4 and 0.8 per cent of the nominal value (Officer, 1986). In summary, Officer (1986) finds that the interest rate parity condition did not hold between, at least, Britain and the US, despite both being core countries on the gold standard. As such, there would have been scope for exogenous changes in Bank Rate during the classical gold standard.

3 Methodology

3.1 The Identification Problem

A reasonable first step towards the estimation of the effects of monetary policy might be to regress a macroeconomic variable of interest, x_t, on a measure of monetary policy, i_t:

$$x_t = \beta_0 + \beta_1 i_t + \epsilon_t \tag{1}$$

However, then as now, monetary policy systematically reacted to current macroeconomic conditions, which we might simply model as:

$$i_t = \gamma_0 + \gamma_1 x_t + \varepsilon_t \tag{2}$$

It is clear that there is an issue of reverse causality here, which arises from the fact that monetary policy simultaneously affects macroeconomic outcomes in equation 1 while macroeconomic outcomes simultaneously affect monetary policy in equation 2. The simple estimation of equation 1 will therefore lead to biased estimates of β_1. To see why, recall a variant of the formula for the OLS estimate of β_1:

$$\hat{\beta_1} = \beta_1 + \frac{Cov(i_t, \epsilon_t)}{Var(i_t)} \tag{3}$$

The parameter $\hat{\beta_1}$ is equal to the true parameter β_1 plus the covariance between the independent variable and the error term. In order for OLS to yield unbiased estimates of $\hat{\beta_1}$, that is $\hat{\beta_1} = \beta_1$, the covariance between the independent variable and the error term must be zero, i.e., $Cov(i_t, \epsilon_t) = 0$, or the variance of i_t must be explosive. This, of course, is one of the Gauss-Markov assumptions underlying OLS.

This assumption is not met, however, in the case of equation 1. Let x_t be a measure of output and assume that the central bank leans against the wind, i.e., $\gamma_1 > 0$. In the case of a positive shock to ϵ_t, a demand shock for example, x_t will rise in equation 1 , which in turn raises i_t in both equations 1 and 2. Thus, the $Cov(i_t, \epsilon_t) \neq 0$. In fact, $Cov(i_t, \epsilon_t) > 0$. As a result of this positive covariance and the expectation that $\beta_1 < 0$, equation 3 implies that $\hat{\beta_1}$ will be downwardly biased towards zero. Therefore, the simple estimation of equation 1 will *underestimate* the effects of monetary policy.

3.2 Narrative Identification

An interesting solution to the endogeneity problem is the narrative approach developed by Romer and Romer (2004). The procedure involves two stages. In the first stage, the policy instrument, i_t, is regressed on the information set available to the central bank, Ω_t. Thus, equation 2 becomes:

$$i_t = f(\Omega_t) + \varepsilon_t \tag{4}$$

In doing so, the endogenous component of monetary policy that systematically reacts to information regarding the current and future state of the economy is captured by the function $f(.)$. The residual, ε_t, therefore represents the exogenous component of monetary policy. In the second stage, the new series of exogenous monetary policy shocks is used in place of i_t in equation 1 to yield unbiased estimates of β_1.

4 Data

4.1 The Timing of Monetary Policy Decisions

During the classical gold standard, the level of Bank Rate was decided at the weekly meeting of the Court of Directors (National Monetary Commission, 1910). This meeting was the historical equivalent of the meetings of the Monetary Policy Committee or the Federal Open Market Committee. As a first step, the minutes of the Court of Directors are used to record the dates on which the Court met between 1890 and 1913 (Bank of England Archive, G4/112-136). In general, the Court met each Thursday, although on 13 occasions, typically around Christmas, the Court met earlier in the week. In addition, there were four "Governor's rises", which were emergency increases in Bank Rate made by the Governor outside of the Court of Directors. In total, there were some 1,257 monetary policy decisions during this period.

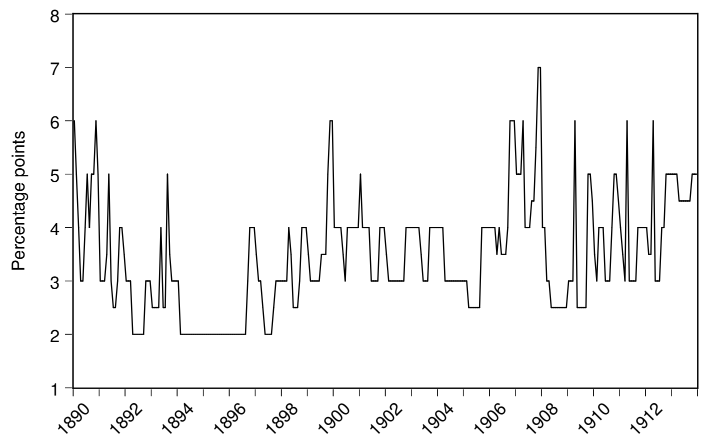
4.2 Bank Rate

The dates of monetary policy decisions are tied with their outcome using archival sources that recorded the prevailing level of Bank Rate at the end of each day (Bank of England Archive, C1/38-61). The final series was checked against Hawtrey (1938) and is plotted in figure 1.

4.3 Information Set

The narrative identification approach requires an accurate, real-time approximation of the policymakers' information set at the time of each monetary policy decision. According to Sayers (1976), the "Daily Accounts", which contained "exact information, kept up to date"

Figure 1: Bank Rate



Note: Month end.

relating to the Bank's internal position and the wider macroeconomy, were "geared" towards this purpose. An inspection of the sources bears this out (Bank of England Archive, C1/38-61). At the front and back of these books, weekly data relating to bullion flows, other central banks' rates of discount, sterling exchanges rates, consol prices, wheat prices and bank clearings, among others, were listed, while the middle of the books held disaggregated balance sheets on a daily basis. In general, stocks were recorded at the close of business on the day before the Court of Directors met and flows appeared in the books as changes since the last meeting. We could think of this source as somewhat comparable to the Federal Reserve's "Greenbooks".

I therefore transcribe these series from the Daily Accounts to produce a new balanced real-time data set for all monetary policy decisions between 1890 and 1913. In doing so, I try to be sure that the data tied to each meeting was actually available to the Court in real time. For example, on 21 September 1911, the Daily Accounts show that the Bank of England altered its policy rate on the same day as the Bank of France. In this instance, I turn to contemporary sources to determine whether the Bank was aware of this information. An article in *The Times* (22 September 1911) stated that, "the Bank of England rate was yesterday raised from 3 to 4%. The advance was quickly *followed* [my italics] by the raising of the bank rates of France and Austria-Hungary". Therefore, for the Court's meeting on 21 September, I use the Bank of France's policy rate *before* the change. As a result, there should be no simultaneity bias in the first stage regression.

5 The New Measure of Monetary Shocks

5.1 Specification

The estimates of the Bank of England's reaction function are based on the new data set and the following model:

$$\Delta i_m = \phi_0 + \phi_1 i_{m-1} + \phi_2 \Delta B_m + \phi_3 P_m + \phi_4 \Delta i_m^F + \phi_5 \Delta i_m^G + \phi_6 \Delta e_m^F + \phi_7 \Delta e_m^G + \phi_8 \Delta e_m^{US} + \phi_9 (G_m^X - G_m^M) + \phi_{10} \Delta Q_m + \phi_{11} \Delta Y_m + \phi_{12} \pi_m + \varepsilon_m \quad (5)$$

where all variables are measured at a decision-by-decision frequency denoted by subscript m. The dependent variable, Δi_m, is the change in Bank Rate (percentage points). In terms of the independent variables, i_{m-1} is the level of Bank Rate at the previous meeting (percentage points), which has been included to capture recent macroeconomic conditions (Cloyne and Hürtgen, 2016) and any tendency toward mean reversion (Romer and Romer, 2004). ΔB_m is the change in the total bullion held by the Bank of England (%), which is measured as the sum of gold and silver coin and bullion in the Banking and Issue departments. P_m is the proportion (%), which is defined as the Banking Department's reserve of notes and coin to the sum of its deposits and post bills. Δi_m^F and Δi_m^G are the change in the minimum rates of discount of the banks of France and Germany respectively (percentage points).[1] Δe_m^F, Δe_m^G and Δe_m^{US} are the changes in the exchange rates in Paris, Berlin and New York (domestic currency per £). $(G_m^X - G_m^M)$ is net exports of gold coin and bullion (£ millions). ΔQ_m is the rate of consol price inflation (%). ΔY_m is the change in bank clearings (%). Finally, π_m is the rate of wheat price inflation (%).

To arrive at this specification, I run Phillips-Perron tests to determine if the variables contain unit roots. $I(1)$ variables are transformed into first differences or growth rates. In some cases, I also transform stationary variables as they yield more information than in levels, which implies that the Court were influenced by changes or rates of change.

In terms of model dynamics, I appeal to information criteria to inform the selection of lags. The BIC is minimized with no lags while the AIC is minimized with three lags. In this specification of the first stage regression, I side with the BIC in order to estimate fewer parameters. For the implications of alternative variations of the first stage regression on the baseline results, see section 7.1.

[1] On the occasions that a range was given, the minimum was used. This is consistent with the treatment of Bank Rate, which was considered to be the minimum rate of discount. See Bank of England Archive (G15/97) for internal evidence.

5.2 Determinants of Changes in Bank Rate

The results from the estimation of equation 5 are reported in table 1. The coefficient on the initial level of Bank Rate is negative, as in Romer and Romer (2004) and Cloyne and Hürtgen (2016), and is statistically significant. The sign implies a tendency towards mean reversion as opposed to a consideration of recent macroeconomic conditions. As expected, the coefficients on the Bank's holdings of bullion and the proportion are negative and statistically significant as in Goodhart (1972) and Pippenger (1984), which implies that Bank Rate was increased (decreased) in response to declining (increasing) reserves.

Table 1: Determinants of Changes in Bank Rate (Δi_m)

Variable	Coefficient	Standard Error
Constant (ϕ_0)	0.311^{***}	0.061
Initial Bank Rate (i_{m-1})	-0.037^{***}	0.007
Bullion (ΔB_m)	-0.014^{***}	0.003
Proportion (P_m)	-0.004^{***}	0.001
Change in Bank of France's discount rate (Δi_m^F)	0.055	0.085
Change in Bank of Germany's discount rate (Δi_m^G)	0.135^{***}	0.028
Change in French francs/£ (Δe_m^F)	0.661^{*}	0.350
Change in German marks/£ (Δe_m^G)	1.377^{***}	0.434
Change in US dollars/£ (Δe_m^{US})	3.205^{***}	0.999
Net exports of gold coin and bullion ($G_m^X - G_m^M$)	0.035^{***}	0.010
Consol price inflation (ΔQ_m)	-0.044^{***}	0.011
Change in bank clearings (ΔY_m)	-0.000	0.000
Wheat price inflation (π_m)	0.001	0.003

Notes: $*/**/***$ indicate significance at 10/5/1% level. $R^2 = 0.175, F = 21.957, N = 1256$. The sample covers all monetary policy decisions between 1890 and 1913.

With respect to the discount rates of the banks of France and Germany, the positive coefficients are evidence of "defensive" (Bloomfield, 1959) changes in Bank Rate, although the magnitude implies that this was a good deal less than basis point for basis point. A 100 basis point increase in the Bank of Germany's discount rate, for example, was matched by a 13.5 basis point increase in Bank Rate. This result is qualitatively similar, but smaller than that found by Morys (2013). The effect was statistically insignificant for the Bank of France. In addition, Bank Rate positively covaried with the foreign exchanges. These results are also consistent with Morys (2013).

The positive coefficient on the net exports of gold coin and bullion implies that Bank Rate was raised (lowered) in response to an efflux (influx) of gold, as in Jeanne (1995) and Pippenger (1984), which is consistent with the "rules of the game". Bank Rate was also increased (lowered) in response to a decrease (increase) in the price of consols. As the price of bonds is negatively related to the yield, this can be interpreted as a positive association between the long-term market rate of interest and Bank Rate.

The final two rows have a bearing on an enduring debate in economy history: the degree to which the Bank of England ran a countercyclical monetary policy during the classical gold standard (Jeanne, 1995; Dutton, 1984; Bloomfield, 1959). Bank clearings (Klovland, 1998) and the price of wheat (Campbell et al., forthcoming; Rostow, 1948) are sometimes considered as economic fundamentals in the nineteenth century. Wheat, in particular, was an important determinant of workers' real wages (Campbell et al., forthcoming). It was these variables that the Bank of England monitored on a weekly basis, as opposed to ex-post constructed monthly unemployment or inflation series that are staples of previous research on the reaction function. The statistical insignificance of bank clearings and the price of wheat implies that the Bank of England had little concern for the general macroeconomy over and above its core objectives.[2]

5.3 Constructing the New Shock Series

The inclusion of the information set in equation 5 purges the endogenous component of monetary policy changes. As such, the residual is a measure of exogenous monetary policy shocks. However, it is currently measured at a decision-by-decision frequency. In order to transform the residuals into a monthly series, I match the shock with the month in which it occurred. In months with multiple decisions, I sum the shocks, following Romer and Romer (2004) and Cloyne and Hürtgen (2016). The new measure of monetary policy shocks, m_t, is shown in figure 2.

An alternative, and perhaps more illuminating way, to view the shocks is to plot the cumulative sum minus the 36-month moving average of its lagged values, as in Coibion (2012), which yields an indicator of the stance of monetary policy. Figure 3 plots the stance of monetary policy during the classical gold standard based on this procedure. The intuition runs that zero represents normal monetary policy, relative to recent experience (Bernanke and Mihov, 1998), while positive (negative) values indicate tight (loose) monetary policy, also relative to recent experience.

5.4 What are the Shocks?

The new series of monetary policy shocks represents deviations in Bank Rate from the Bank of England's *average* response to current macroeconomic conditions. The deviations might have arisen for a number of reasons. One could be linked to the human nature of the Court of Directors. If the mood of the Court was particularly pessimistic, or a pessimistic Director

[2]See table A.1 for a more nuanced perspective. The Bank reacted asymmetrically to changes in these variables, responding only to increases in bank clearings and wheat prices.

Figure 2: New Measure of Monetary Policy Shocks (m_t)

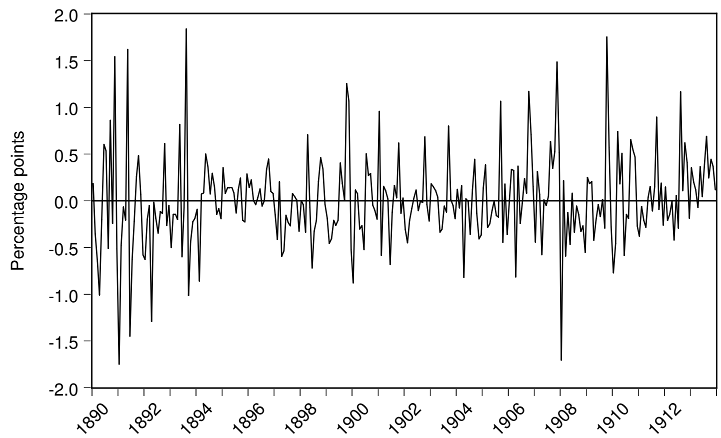
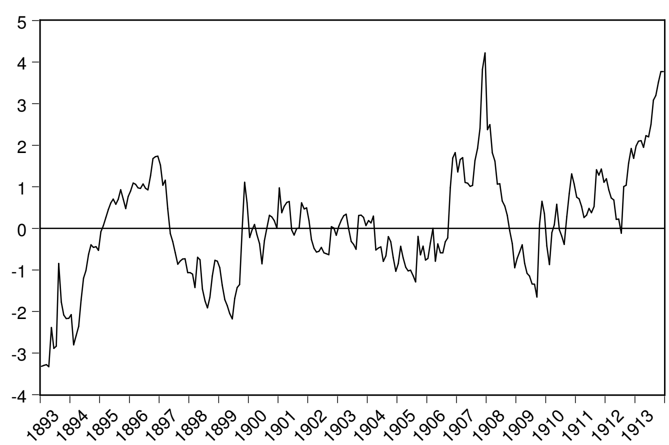


Figure 3: The Stance of Monetary Policy



was particularly persuasive at a given meeting, then Bank Rate might be changed by more than average, given current macroeconomic conditions. Ogden (1991) argues "that many of the Bank of England's actions at this time depended on the personalities that were around." A second could stem from alterations in the Bank of England's targets. In some periods, the Bank may have placed greater emphasis on the French, as opposed to the German, exchange rate, for example. Another could lie in the Bank's preference for discrete changes in Bank Rate of no less than 50 basis points. Of the 129 changes in Bank Rate, 35 per cent resulted in alterations of ±100 basis points, while the remaining 65 per cent led to changes of ±50 basis points. As a result, current macroeconomic conditions might have called for an increase in Bank Rate of 30 basis points, but instead the Bank increased by either 50 basis points or none at all. Finally, by construction, the shocks also represent random variation in Bank Rate that are inexplicable.

5.5 Predictability of the Shocks

In order to remove any suspicion that the new series of monetary policy innovations might be endogenous, I test to see if the series is predictable from current and lagged macroeconomic variables, as in Cloyne and Hürtgen (2016) and Coibion (2012). The inclusion of contemporaneous values is in line with the identifying assumptions used in the next section. Specifically, I regress the monetary shocks, m_t, on a macroeconomic variable of interest, x_t:

$$m_t = c + \sum_{i=0}^{I} \varphi_i x_{t-i} + \epsilon_t \tag{6}$$

The results from estimating equation 6 are shown in table 2. Alternative specifications are reported, the first with 3 lags (Cloyne and Hürtgen, 2016); the second with 6 lags (Cloyne and Hürtgen, 2016; Coibion, 2012). The macroeconomic variables of interest are the seasonally adjusted unemployment rate, the 12 month wholesale price inflation rate and the 12 month share price inflation rate. Unemployment and inflation are included as these will be the dependent variables in the second stage analysis. A thorough discussion of these variables is delayed until then. Share price inflation has been included to gauge whether financial markets predicted the shock. New research shows that changes in monetary policy influenced share prices in nineteenth-century Britain (Campbell et al., forthcoming). Therefore, if financial markets could have predicted the monetary shock, one would expect that share prices would move in anticipation of the shock itself.

In all cases, the large P-values indicate that we cannot reject the null hypothesis of exogeneity. As a result, the new series is appropriate to identify the macroeconomic effects of monetary policy.

Table 2: Predictability of Shocks

	$I = 3$		$I = 6$	
Independent variable	F-statistic	P-value	F-statistic	P-value
Unemployment rate	0.36	0.84	0.72	0.65
Inflation	1.13	0.34	0.89	0.51
Share price inflation	0.68	0.60	0.65	0.72

Note: The sample runs from January 1890 to February 1912. Share price inflation calculated from Smith and Horne (1934) in Thomas and Dimsdale (2016).

6 The Macroeconomic Effects of Monetary Policy

6.1 Specification

The next step is to estimate the macroeconomic effects of the new measure of monetary policy innovations. In line with Romer and Romer (2004), the baseline model is a three variable structural VAR with a measure of the real economy, prices and the monetary shocks included.

As in a number of studies on this subject, for example Cloyne and Hürtgen (2016), Coibion (2012), Bernanke et al. (2005) and Romer and Romer (1989), unemployment is included in the model to gauge the real effects of monetary policy. It is preferred over other candidates in this instance, such as GDP or industrial production, simply because the alternatives are not available at a monthly or quarterly frequency. The unemployment series, based on the work of Denman and McDonald (1996) in Thomas and Dimsdale (2016), measures the percentage of trade union members unemployed. It has been seasonally adjusted using a Census X-13 filter. However, there are two breaks in the series in 1912: the first in March due to a labour dispute (Klovland, 1998) and the second in September as a result of the watershed Unemployment Insurance Act of 1911. The sample period for the analysis in section 5.5 onward therefore ends in February 1912.

The measure of prices, based on the work of Sauerbeck in Thomas and Dimsdale (2016), is the 12 month percentage change of the wholesale price index for all commodities. A limitation of the series is that it is an *unweighted* average of 45 commodities. However, Sauerbeck weighted the series "implicitly by entering two or more items for particularly important articles (Klovland, 1993)." Klovland evaluated the weighting schemes of alternative indices for the nineteenth century such as that of Gayer et al. (1975), *The Economist* and the Board of Trade with the conclusion that the Sauerbeck index "seems to be the most representative general price index for the period before the First World War."

In spite of the evidence supporting the exogeneity of the monetary shocks, a structural VAR is used for three reasons. Firstly, the estimation of a VAR is a belt and braces approach to the endogeneity problem. Secondly, Cloyne and Hürtgen (2016) argue that the inclusion of "lagged dependent variables and controlling for other shocks may yield more precise estimates in short samples." Thirdly, it is in line with, and therefore comparable to, the rest of the narrative literature concerned with the effects of monetary policy (Cloyne and Hürtgen, 2016; Romer and Romer, 2004). In section 7.4, I consider an alternative econometric approach.

The details of the model are:

$$\boldsymbol{X_t} = \boldsymbol{B(L)X_{t-1}} + \boldsymbol{\epsilon_t} \tag{7}$$

where $\boldsymbol{B(L)}$ is a polynomial lag operator with P lags and $\boldsymbol{X_t}$ is the vector of variables. Specifically, $\boldsymbol{X_t} = [u_t, \pi_t, shock_t]'$. The measure of monetary policy is the cumulative sum of shocks, $shock_t = \sum_{i=0}^{t} m_i$, which is conventional (Cloyne and Hürtgen, 2016; Coibion, 2012; Romer and Romer, 2004) as the wider VAR literature is based on the level of the policy rate. The remaining aspects of the specification are identical to Cloyne and Hürtgen (2016). In terms of lag selection, I include 24 lags. As to identification, I order the cumulated shock measure last. This assumption implies that the shock does not contemporaneously affect, but is rather affected by, unemployment and inflation. In section 7.3, I demonstrate that the baseline results are robust to alternative lag lengths and timing assumptions.

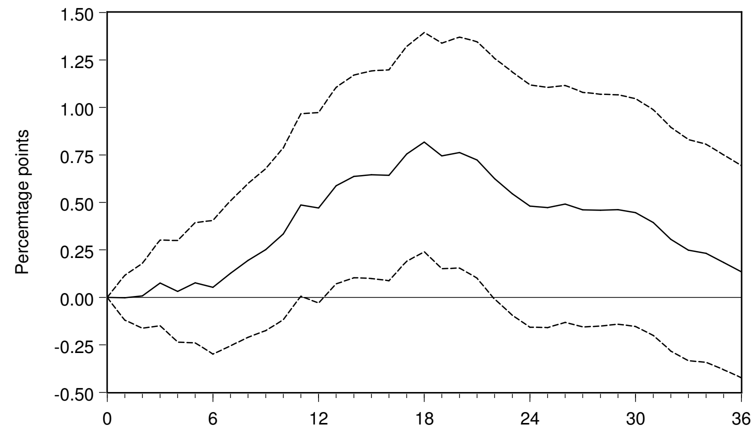
6.2 Impulse Responses

The main results of the paper are shown in figures 4 and 5. Impulse responses from the baseline VAR are plotted along with 95 per cent (2 standard deviation) confidence intervals.

In response to a one percentage point contractionary monetary policy shock, unemployment increased by up to 0.82 percentage points ($t = 2.83$). This was a relatively slow-burning process, with no discernible impact for around 6 months, after which a peak was reached in month 18 and a decay toward zero followed. The effect is statistically significant between months 13 and 21. In terms of the narrative literature, the peak unemployment effect lies somewhere between Cloyne and Hürtgen's (2016) analysis of the modern UK economy, where the maximum response was a little more than 0.1 percentage points, and Romer and Romer's (1989) analysis of the post-war US economy, where it was 2.1 percentage points. The relatively long lag in the transmission of the real effects of monetary policy is also consistent with the the previous narrative literature.

Similarly, in response to a one percentage point contractionary monetary policy shock, the inflation rate fell by up to 2.69 percentage points ($t = -3.15$). The response of inflation was also somewhat protracted, beginning to decline after 6 months, peaking at 15 months and then fizzling out. The effect is statistically significant between months 10 and 19. In terms of the narrative literature, the peak inflation effect also sits centrally in the range of previous estimates. Cloyne and Hürtgen (2016), for example, find that inflation falls by

Figure 4: Response of Unemployment to a Monetary Policy Shock



Notes: The solid line is the impulse response of unemployment to a one percentage point contractionary monetary policy shock with 95% confidence intervals. The sample runs from January 1890 to February 1912.

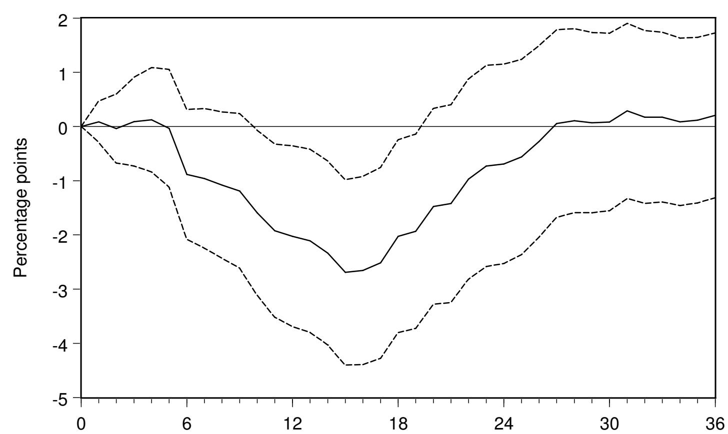
roughly 1 percentage point, while Romer and Romer (2004) estimate that the price level declines by up to 5.9 per cent. While an outside lag of 6 months is far from instantaneous, it is a good deal less sluggish than the response for contemporary economies. In both Cloyne and Hürtgen's (2016) and Romer and Romer's (2004) analyses, inflation is sticky around zero for roughly 2 years before contracting.

Figure 6 plots the impulse response of the cumulated shock series to a one percentage point innovation to itself. The new measure falls by more than half its initial level after six months and fades to zero after roughly a year and a half. This persistence is evidence of a degree of monetary autonomy during the classical gold standard as exogenous changes were not immediately offset. However, in Romer and Romer's (2004) analysis for the modern US economy, the shock takes roughly a year to fall by half and persists above zero for 4 years. This greater degree of persistence may account for the larger effects that they find.

Were monetary policy innovations an important source of economic fluctuations? The forecast error variance decomposition shows that monetary shocks explain a large fraction of the variance in both unemployment and inflation. At the 36 month horizon, monetary shocks accounted for 28 per cent of unemployment volatility and 27 per cent of inflation volatility. These numbers are startling given the range of other macroeconomic shocks that affect the economy, such as shocks to credit, energy, fiscal policy, labour supply, technology and uncertainty.[3] Therefore, in combination with the results from the impulse responses, it seems that monetary policy did matter.

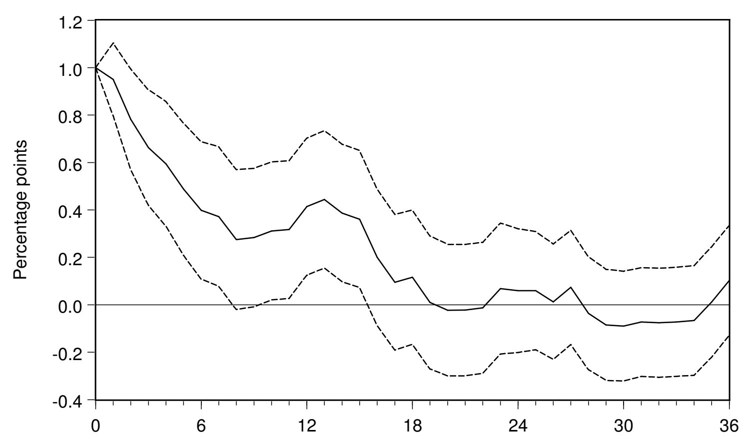
[3]See Ramey (2016) for a discussion of a broad range of macroeconomic shocks.

Figure 5: Response of Inflation to a Monetary Policy Shock



Notes: The solid line is the impulse response of inflation to a one percentage point contractionary monetary policy shock with 95% confidence intervals. The sample runs from January 1890 to February 1912.

Figure 6: Response of Monetary Policy Shock



Notes: The solid line is the impulse response of the cumulated shock to a one percentage point innovation to itself with 95% confidence intervals. The sample runs from January 1890 to February 1912.

6.3 Monetary Policy Transmission Mechanism

Are the effects plausible for Britain during the classical gold standard? To answer this question, I turn to survey data collected by the *The Economist* (23 November 1907; 30 November 1907) in 1907. The survey asked businesses about "the effects of dear money on home trade" - the effect of monetary tightening on economic activity in today's language. In total, 69 responses were received. Table 3 reports a summary of the responses, based on earlier work by Moggridge (1972).

Table 3: Replies to *The Economist's* Survey on the "Effects of Dear Money on Home Trade"

	Effects	Frequency	%
(1)	Adverse expectations as to future consumption demand	11	15.9
(2)	Adverse expectations as to future investment demand	5	7.2
(3)	Generalized uncertainty	1	1.4
(4)	Significantly higher working capital costs	7	10.1
(5)	Significantly higher fixed capital costs	2	2.9
(6)	Availability of credit reduced	3	4.3
(7)	Reductions in raw material prices as stocks realized owing to higher working capital costs	15	21.7
(8)	Buyers expectations of lower prices reducing raw material demand and prices	3	4.3
(9)	No significant effects	4	5.8
(10)	Not applicable	18	26.1
	Total	69	100

Note: Reproduced from Moggridge (1972). The category "adverse expectations resulting from American crisis", included by Moggridge, has been merged with "not applicable" here as this was another, although not unrelated, issue at the time.

The results show that more than two-thirds of replies cited a negative impact of some description following a monetary tightening, while just 5.8 per cent responded that there were would be no significant effects. Therefore, the VAR results are in line with the views of businesses at the time.

Monetary policy affects the macroeconomy through some or all of the following channels: the interest rate channel, the exchange rate channel, the credit channel or through other asset price effects (Mishkin, 1995). If these mechanisms were underdeveloped or lacking entirely in the British economy during the classical gold standard, then this would be difficult to reconcile with the VAR results. However, the replies to the survey point to a number of classic mechanisms that alleviate such a concern.

The interest rate channel, for example, features strongly. It is through this channel that monetary policy affects investment and consumption via its affect on the real interest rate.

In the survey responses, reason (2) explicitly describes a decline in investment, while reasons (4) and (5) implicitly describe a decline in investment. Similarly, adverse expectations of consumption were cited in 15.9 per cent of replies. The implication of reduced investment and consumption is lower aggregate demand, which raises unemployment and lowers prices.

The interest rate channel was particularly well-greased during the classical gold standard. Eichengreen (1992) explains:

> By the end of the nineteenth century, the Bank of England's ability to influence market rates was widely acknowledged and increasingly institutionalized. Banks first in London and then throughout the country began to index their loan and overdraft rates to Bank Rate. London banks fixed their deposit rates 1.5 percentage points below Bank Rate. Rates on new loans were indexed to Bank Rate at a higher level, while those on fixtures (long-term loans to the discount market) were similarly indexed at 0.5 percent above the deposit rate.

The indexation of market interest rates to Bank Rate also extended to the rates of other institutions, such as building societies and finance houses (Capie and Webber, 1985), and out to longer maturities (Eichengreen, 1987). In line with the survey responses, the Bank of England was able to influence the interest rates upon which a broad spectrum of consumption and investment decisions were made

In addition, reasons (7) and (8) indicate that the Bank was also able to influence inflation expectations. As consumption and investment decisions are ultimately based on the real interest rate (nominal rate minus inflation expectations), this would have further amplified the interest rate channel.

Reason (6) points to a functional credit channel in the transmission of monetary policy. As Bank Rate was the rate at which the Bank lent to the banking system, a change would affect the quantity of reserves available to commercial banks. Bernanke and Blinder (1992) explain that when the central bank "reduces the volume of reserves, and therefore of loans, spending by customers who depend on bank credit must fall, and therefore so must aggregate demand."

While not explicitly mentioned in the survey results, the movement in exchange rates afforded by the gold points allowed for a limited exchange rate channel. A contractionary monetary shock would have attracted capital from the rest of the world. As a result, the demand for pounds would have increased, leading to an appreciation of the exchange rate. As such, net exports would have fallen, resulting in a reduction of aggregate demand.

Finally, recent research points to a transmission mechanism through other asset price effects. Campbell et al. (forthcoming) find that Bank Rate was an important determinant of share prices in the nineteenth century. The study shows that a one percentage point increase (decrease) in Bank Rate was contemporaneously associated with a 0.61 per cent fall (rise) in stock returns. The link between Bank Rate and the stock market was also appreciated by contemporaries. On 19 October 1906 Bank Rate was raised from 5 to 6 per cent. *The Economist* (20 October 1906) wrote the following day, "the rise in Bank Rate yesterday has electrified all the markets. Not one escaped from the withering effect of the totally unexpected event [...] the consequence of a high Bank Rate is the imposition of a further check upon general Stock Exchange trade. The man who can get 4.5 per cent from his bankers upon money left with them on deposit sees little object in buying consols or other similar securities which pay 1.25 to 1.5% less."

The link between Bank Rate and asset prices would have amplified the real effects of monetary policy in two ways. Firstly, this would have changed the market value of firms relative to the replacement cost of capital (Tobin's q), which would have altered investment spending. A high q would have stimulated investment as companies could have bought more investment goods for a given issue of equity (Mishkin, 1995). Secondly, in the late nineteenth century, Britain was a "nation of shareholders" (Rutterford et al., 2011). Between 1890 and 1902, 45.1 per cent of individuals owned shares and/or government securities. In addition, these assets made up roughly half of all assets at death. Therefore, Bank Rate would have affected the wealth, and thus consumption, of this large body of individuals.

The Cunliffe Committee (1918), composed of Cunliffe himself (then Governor of the Bank), John Bradbury (Secretary of the Treasury), Arthur Pigou and 11 others, eloquently summarized these very mechanisms in its description of the gold standard before the war:

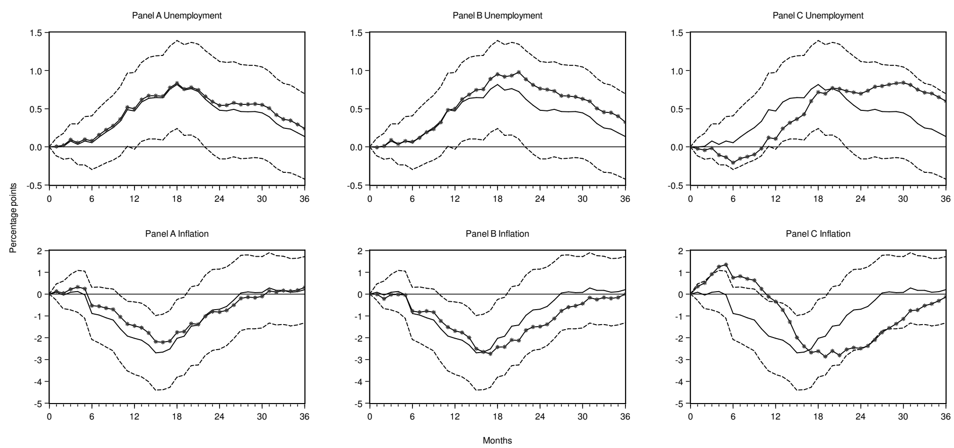
> the raising of the Bank's discount rate [...] led to a general rise of interest rates and a restriction of credit. New enterprises were therefore postponed and the demand for constructional materials and other capital goods was lessened. The consequent slackening of employment also diminished the demand for consumable goods, while holders of stocks of commodities carried largely with borrowed money, being confronted with an increase of interest charges, if not with actual difficulty in renewing loans, and with the prospect of falling prices, tended to press their goods on a weak market. The result was a decline in general prices in the home market which, by checking imports and stimulating exports, corrected the adverse trade balance.

7 Robustness

7.1 Extending the First Stage Regression

In this section, the baseline model is put through a battery of alternative specifications to gauge the robustness of the results. A number of other variables were consistently reported in the Daily Accounts but were not included in the first stage regression. Bankers' balances, for example, are reported to have been monitored by the Bank (Sayers, 1976), but were excluded previously as they were a major component of the proportion. Other variables, such as gold coined by the Royal Mint, net exports of silver bullion, the price of French government bonds, the price of US government bonds, the price of silver and the price of London and North Western Railway consolidated stock - the largest company at the time (Hickson et al., 2011), were also included in the Daily Accounts but excluded in the first stage regression because they had not been cited in the literature as determinants of Bank Rate. Panel A of figure 7 plots the results from the baseline VAR (solid line) alongside the results using the residuals from a first stage regression that includes the extra variables (starred line). In the first stage regression, these variables were not statistically significant. As such, it is unsurprising that their inclusion has no discernible effect on the results.

Figure 7: Robustness to Alternative First Stage Specifications



Notes: The solid (starred) line is the baseline (alternative) impulse response to a one percentage point contractionary monetary policy shock with 95% confidence intervals. The sample runs from January 1890 to February 1912.

A possible concern is that the first stage regression included too few lags. After all, it is plausible that the Court of Directors acted on a run of data, rather than the current week's figures alone. Panel B reports the results using the residuals from a first stage regression with the number of lags determined information criteria. This specification is based on the minimization of the AIC (three lags). The results are somewhat larger than the baseline with a peak response for unemployment of 0.98 per cent ($t = 3.27$) and inflation of -2.74 ($t = -3.09$).

Previous narrative studies have not accounted for potential asymmetries in the central bank's reaction function. It is plausible, for instance, that holding inflation constant, the central bank might alter the policy rate more strongly to negative output growth than to positive. The same could also be true in a historical context. Davutyan and Parke (1995) find evidence that the Bank of England reacted asymmetrically to a number of variables during this period. For example, there was a significant relationship between changes in Bank Rate and decreases in the Bank's holding of bullion but not between Bank Rate and increases in bullion. With this in mind, I re-estimate equation 5 to allow for positive and negative changes of each variable to have a differential impact on Bank Rate. The results of this exercise are reported in table A.1. Panel C shows that the inclusion of these shocks in the VAR increases the size and persistence of the effects on the macroeconomy. For example, the peak unemployment effect rises to 0.84 per cent ($t = 3.36$) after two and a half years, while the inflation effect peaks at -2.87 ($t = -3.38$) after 19 months.

7.2 Outliers

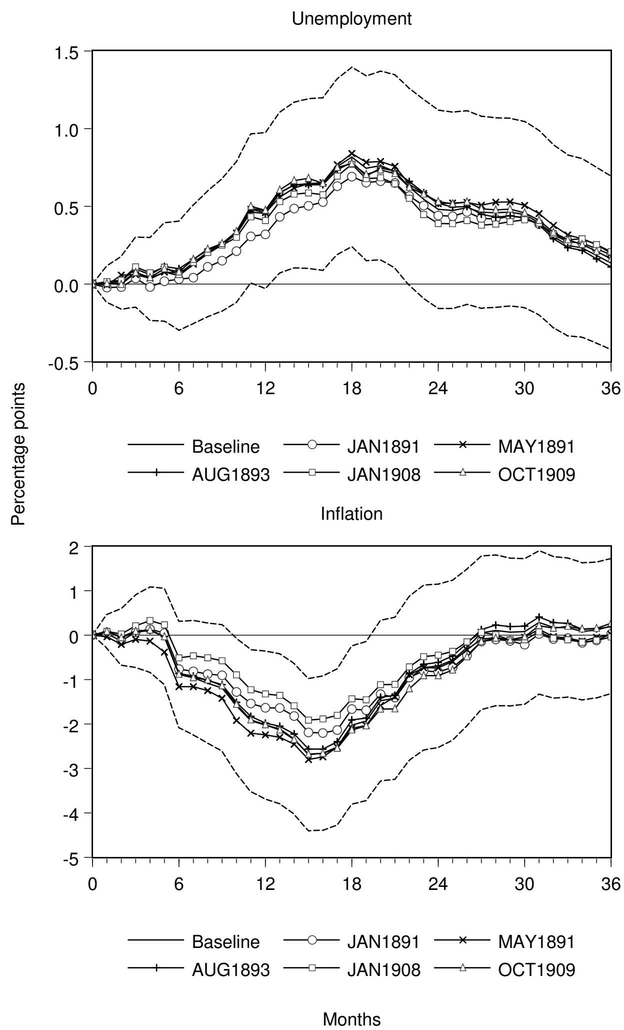
A normal concern in time series analysis is the influence of outliers. I therefore set one of the five largest monthly shocks to zero, re-cumulate the shocks and re-estimate the model. The largest shocks, in order of absolute magnitude, came in August 1893 (1.84%), October 1909 (1.75), January 1891 (-1.75), January 1908 (-1.70) and May 1891 (1.62). As can be seen in figure 8, the impulse response functions are of a similar magnitude and follow a common path.

7.3 Alternative VAR Specifications

In line with Cloyne and Hürtgen (2016), 24 lags were included in the baseline VAR. However, it could be that the results are sensitive to the number of lags included in the model. An agnostic approach as to the correct specification is to refer to information criteria. In a study of the Romer and Romer shocks, Coibion (2012) uses Monte Carlo simulations to assess the performance of the AIC and BIC. The results show that "the AIC does much better, on average, with only minor underestimates of the correct lag specification." Based on the results from the AIC, panel A of figure 9 plots the responses from a model with 18 lags included. The peak responses of unemployment (0.54, $t = 2.22$) and inflation (-2.31, $t = -3.35$) are smaller than the baseline results, but lie well within the two standard error bands.

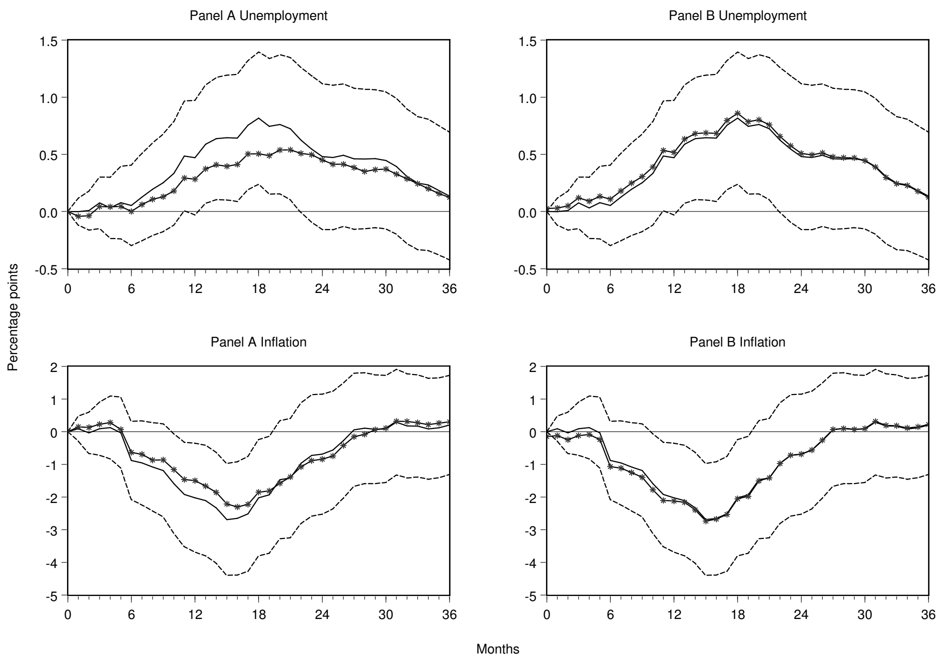
In line with the convention in narrative VARs (Cloyne and Hürtgen, 2016; Coibion, 2012; Romer and Romer, 2004), the measure of monetary shocks was ordered last. However, if the shocks are exogenous, as the evidence in section 5.5 suggests, then the shocks should actually be ordered first. This assumption implies that that the shocks are not affected by, but rather affect, unemployment and inflation contemporaneously. Panel B of figure 9 presents the results from a VAR with the measure of monetary policy shocks ordered first. It is clear that the results are not materially sensitive to this assumption.

Figure 8: Robustness to Outliers



Notes: The solid line is the baseline impulse response to a one percentage point contractionary monetary policy shock with 95% confidence intervals. The sample runs from January 1890 to February 1912.

Figure 9: Robustness to Alternative VAR Specifications



Notes: The solid (starred) line is the baseline (alternative) impulse response to a one percentage point contractionary monetary policy shock with 95% confidence intervals. The sample runs from January 1890 to February 1912.

7.4 Results from Single Equations

A possible worry might be that the results are driven by the econometric approach. If the monetary shocks are exogenous, then it is appropriate to include them as regressors in single equations. In line with Cloyne and Hürtgen (2016), I employ Jordà's (2005) local projections method to explore this possibility. The model takes the form:

$$x_{t+h} = c_h + \Psi_h(L)z_{t-1} + \beta_h m_t + \epsilon_{t+h} \tag{8}$$

for $h = 0, 1, 2 \ldots$, where x_t is unemployment or inflation, z_{t-1} is a vector of control variables, $\Psi_h(L)$ is a polynomial lag operator and m_t is the new series of monetary policy innovations. The vector of control variables includes 24 lags of the shock measure, unemployment and inflation. As Ramey and Zubairy (forthcoming) explain, "the coefficient β_h gives the response of x at time $t+h$ to the shock at time t. Thus, one constructs the impulse responses as a sequence of the β_h's estimated in a series of single regressions for each horizon." The standard errors are Newey-West corrected, with the maximum autocorrelation lag $L = h+1$, as in Tenreyro and Thwaites (2016).

Figure 10 plots the impulse responses of unemployment and inflation. The peak response of unemployment (0.81, $t = 2.59$) and inflation (-2.59, $t = -3.93$) is only faintly smaller than the baseline VAR.

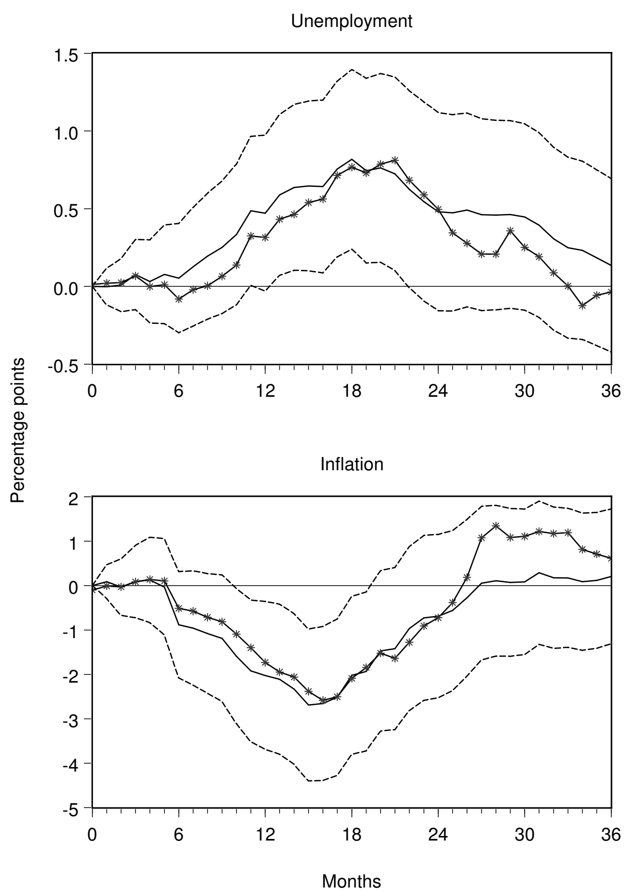
In this section, 10 additional variants of the model have been estimated. The results show that the main results are robust to a number of alternative specifications. In terms of unemployment, the smallest peak effect was 0.54 per cent, while the largest was 0.98. The median peak was 0.81, which is very close to the baseline figure of 0.82. In terms of inflation, the smallest peak effect was -1.91 per cent, while the largest was -2.87. The median peak was -2.59, which is in the region of the baseline figure of -2.69. Additionally, the peak effect for each variable and variant of the model was significant at the 5 per cent level.

8 Conclusions

This paper makes three main contributions. The first relates to the macroeconomic history of the United Kingdom. The results suggest that changes in Bank Rate had large and persistent effects on the macroeconomy. In response to a one percentage point monetary tightening, unemployment rose by up to 0.8 percentage points, while inflation fell by up to 2.7 percentage points. The variance decomposition shows that monetary policy shocks accounted for more than a quarter of macroeconomic volatility. The baseline model was subjected to a thorough sensitivity analysis. In every case, the results indicate that monetary policy did matter.

The second contribution relates to the history of the Bank of England's function reaction,

Figure 10: Robustness to an Alternative Econometric Method



Notes: The solid (starred) line is the baseline (alternative) impulse response to a one percentage point contractionary monetary policy shock with 95% confidence intervals. The sample runs from January 1890 to February 1912.

which was modeled using a new real-time data set. Previous research has shown that this is fundamental to the interpretation of historical monetary policy rules. Although the results are generally consistent with earlier studies, an important finding is that the Bank did not react linearly to observable proxies for economic activity.

The final contribution is economic. The central result from the narrative literature, that monetary policy has large effects on the real economy and the price level, is derived from two modern economies with floating exchange rates. This paper contributes to the external validity of this finding by studying a historical economy with fixed exchange rates.

The new series of monetary policy shocks might be useful for a number of future research questions. An exogenous measure of monetary policy facilitates a move away from a VAR framework into more flexible econometric approaches. An interesting extension in this direction would be test if the effect of monetary policy varied over the business cycle. Other interesting extensions of contemporary relevance include the effects of monetary policy on asset prices and inequality.

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Table A.1: Determinants of Changes in Bank Rate (Δi_m)

Variable	Coefficient	Standard Error
Constant (ϕ_0)	$0.083***$	0.27
Initial Bank Rate (i_{m-1})	$-0.030***$	0.006
Bullion (ΔB_m^+)	-0.003	0.005
Bullion (ΔB_m^-)	$-0.023***$	0.005
Proportion (ΔP_m^+)	-0.004	0.004
Proportion (ΔP_m^-)	-0.005	00004
Change in Bank of France's discount rate (Δi_m^{F+})	0.010	0.114
Change in Bank of France's discount rate (Δi_m^{F-})	0.149	0.128
Change in Bank of Germany's discount rate (Δi_m^{G+})	$0.188***$	0.040
Change in Bank of Germany's discount rate (Δi_m^{G-})	0.049	0.042
Change in French francs/£ (Δe_m^{F+})	$1.362**$	0.568
Change in French francs/£ (Δe_m^{F-})	-0.308	0.615
Change in German marks/£ (Δe_m^{G+})	-0.318	0.725
Change in German marks/£ (Δe_m^{G-})	$3.655***$	0.780
Change in US dollars/£ (Δe_m^{US+})	2.641	1.612
Change in US dollars/£ (Δe_m^{US-})	2.552	1.728
Net exports of gold coin and bullion ($G_m^X - G_m^{M+}$)	$0.070***$	0.016
Net exports of gold coin and bullion ($G_m^X - G_m^{M-}$)	0.006	0.017
Consol price inflation (ΔQ_m^+)	$-0.035*$	0.019
Consol price inflation (ΔQ_m^-)	$-0.060***$	0.019
Change in bank clearings (ΔY_m^+)	$-0.001*$	0.000
Change in bank clearings (ΔY_m^-)	0.001	0.001
Wheat price inflation (π_m^+)	$0.010**$	0.005
Wheat price inflation (π_m^-)	-0.008	0.005

Notes: $*/**/***$ indicate significance at 10/5/1% level. $R^2 = 0.197, F = 13.173, N = 1256$. The sample covers all monetary policy decisions between 1890 and 1913.