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Testing the global extent of the endogenous-money hypothesis: a panel vector autoregression approach*

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This paper examines the endogenous-money hypothesis using a panel-data set of 144 countries over the period 2001–2017. Its empirical analysis is conducted in a panel vector autoregressive framework, a hybrid econometric methodology that offers the advantage of jointly accounting for endogeneity issues (as in traditional vector autoregressive modeling) and individual/country-level heterogeneity associated with a panel-data structure. A panel version of the Granger non-causality test and an examination of orthogonalized impulse-response functions and forecast error variance decompositions are applied to test the causal ordering among loans, the money base, broad money, output, and prices. The empirical findings support causation running from loans to broad money and from broad money to the monetary base. A causal link running from loans, output, and broad money to total reserves is strongly supported and, in all cases, the causality is unidirectional from these variables to the money base. Beyond that, a complex interaction among prices, production, credit, and money is found, suggesting that the best approach to understanding the endogeneity/exogeneity issue is to rely on the hypothesis of endogenous money as reflected in the 'liquidity preference' interpretation.

Keywords: *endogenous money, bank loans, PVAR, panel Granger causality*

JEL codes: *E51, E52, E58*

1 INTRODUCTION

The question of whether money supply is exogenous or endogenous as well as the related issue on the transmission mechanism of monetary policy have long been debated amongst monetary economists. On the one hand, we find the exogenous-money approach has been widely accepted for years by mainstream macroeconomists and also fully endorsed by Monetarism. According to this view, under the assumption of a stable money multiplier, monetary authorities determine the quantity of money

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through actions affecting the level of reserves, and the commercial banking system can only extend new loans when it obtains new central-bank money. Thus, the supply of money is conceived as a fully controlled variable by the central bank and its variations irremediably as promoting changes in nominal income. Although in the short run money may play a role in determining real variables, this would be the result of some market frictions or imperfections. In the long run, changes in the stock of money will bring about changes in the price level.

On the other hand, we find the Post-Keynesian endogenous-money theory which with notable strength has been confronting the theoretical and empirical problems that arise when one moves beyond the notion of commodity money towards a credit-money system.

At the theoretical level, the Post-Keynesian position implies that credit-money is anticipated by the banking system to finance entrepreneurs and household requests. The equilibrium in the credit market determines, via the loans–deposits line, the supply of new bank deposits. Having created deposit money in response to such demands, the banks then need to get hold of extra reserves to meet reserve requirements set by the monetary authority, or simply to maintain the convertibility of their deposits into fiat currency on demand. To avoid losing control of interest rates or a liquidity and financial disaster, the central bank cannot simply refuse to supply the needed reserves. In terms of policy analysis, it suggests that central-bank interventions to control the growth rate of money and credit are not nearly as potent a tool as they are assumed to be in the mainstream literature.

While these propositions are now widely accepted by most, if not all, Post-Keynesian economists, there are still several details in the theory of endogenous money that are contentious. The debate between what have now been called Horizontalists, Structuralists, and supporters of the so-called liquidity-preference view have centered the discussion on issues related to the degree of accommodation by central banks to the demand for reserves of banks, to the relevance of liquidity preference of banks, and to the mechanisms that reconcile the different liquidity preferences of economic actors (Fontana 2004).

Considerable empirical work has been undertaken concerning the exogenous/endogenous money-supply issue using different econometric methods. We provide here a review of the empirical literature and show that most studies consist of single-country research using time-series methodology. Only a few studies examine the endogenous-money hypothesis in a range of countries, and apart from Nayan et al. (2013), all of them are still comparisons among single-country estimations. Nayan et al. (2013) is the only study that uses a panel-data set to presumably estimate the determinants of the money supply. However, their effort suffers from several shortcomings. First, in their panel estimation the dependent variable is the money-to-GDP ratio, and as important as it may be, it does not represent a clear measure of the money supply. Second, their work is limited to studying whether a set of chosen variables have significant explanatory power on the money supply. Their work does not provide an extension of this single equation approach to models of interdependent variables where a feedback mechanism exists, and no effort is found in testing causality among variables.

In response, this study investigates whether money in its narrow or broad sense is exogenous or endogenous using a panel-data set of 144 countries over the period 2001–2017 at an annual frequency. We also investigate whether any of the three views of the Post-Keynesian monetary theory discussed above applies to the set of countries under scrutiny in the short run. We conduct our empirical analysis in a panel vector autoregressive (PVAR) framework. The most outstanding feature of the PVAR model is that it is a hybrid econometric methodology between the classic panel model and the vector autoregressive (VAR) model. Thus, it offers the advantage to jointly account for endogeneity issues (as in traditional VAR modeling) and individual/country-level heterogeneity associated with panel-data structure. The paper deviates from Nayan et al. (2013) in that it further seeks to test the money-endogeneity/exogeneity hypothesis by conducting panel Granger causality estimation techniques in a PVAR model. The variables involved in the model are a measure of the money stock (*MS*), real GDP as a measure of economic activity (*Y*), the consumer price index (*P*), bank loans (*BL*), and the monetary base (*MB*). Following the estimation of the PVAR model, we compute orthogonalized impulse-response functions (IRFs) and forecast-error variance decompositions (FEVDs) to track the impact of each variable in the system over time.

The paper is organized as follows: Section 2 presents the debate on the issues of money-supply exogeneity and endogeneity along with the testable hypotheses. Section 3 reviews the empirical literature. Section 4 details the econometric methodology. The data and results are discussed in Section 5, followed by concluding remarks in Section 6.

2 ANALYTICAL DEBATE AND TESTABLE HYPOTHESES

To properly understand the main features, implications, and testable hypotheses of these contrasting views in monetary theory, we first describe the conventional exogenous-money view and after that we further summarize the three major strands that lead to the formulation of the endogenous-money approach.

2.1 The conventional view on exogenous money

The conventional view in prevailing monetary textbook theory posits that the money supply is created from the interaction of the money multiplier and the monetary base, with the level of the latter being set by the central bank. Thus, the monetary base and the money supply are determined by the central bank. Keynes's presentation in *The General Theory* of the quantity of money as an exogenous variable under the control of the monetary authority not only became standard in major macroeconomic and monetary textbooks, but also provided a rationale for the rehabilitation of the quantity theory of money as well as an unusual impulse to the exogenous-money thesis. As such, the role of the central bank is seen as that of a quantity-setter and price-taker. If the central bank, for instance, uses its discretionary power to buy government securities from the banking system in exchange for money, then the central bank credits the reserve accounts of the banks involved, and reserves in the banking system rise relative to deposits. If reserves increase above the legal reserve requirements, the banking system as a whole must increase its holding of deposits. This happens since banks respond to the initial injection of additional reserves by creating loans financed with monetary liabilities. Loans create deposits and deposits create new loans so that the money supply would consequently witness a multiplied increase according to the money multiplier (determined by the reserve ratio and the cash ratio). As a result, the supply of money in the form of bank deposits rises.[1]

1. This is the multiplier story and model of the money supply, originally developed by Brunner (1961) and Brunner and Meltzer (1964), that became the standard paradigm in macroeconomics and money and banking textbooks to explain how the policy actions of the central bank influence the money stock. It also has been used in empirical analyses of money stock control and the impact of monetary policy.

In a second stage, the assets market will react to rebalance the money market. In the conventional Keynesian world of two assets (money and bonds), since the demand for money has not initially changed, market interest rates decrease to match the higher supply of money and increasing aggregate demand. In the Monetarist view associated with Friedman (1968) the transmission mechanism will certainly be a bit different since he insisted that a far wider range of assets and interest rates must be considered (assets such as durable and semi-durable consumer goods, structures, and other real property). Hence, excess money holdings can be gotten rid of by purchasing a variety of durable goods and assets rather than bonds. Yet, if the portfolio disequilibrium is disposed of in this manner, a money supply expansion will impact aggregate demand via its indirect interest effect on investment, but also directly through its influence on the purchase of consumer durables as assets.

Following the Monetarist canon, in the third and final stage, lower interest rates and portfolio adjustments will increase spending in the economy. Then business investment increases in the face of lower borrowing costs and new portfolio allocations. Consumer spending on housing and durable goods also increases. Whether this increase in aggregate spending has a final effect on output (and employment) or the price level will depend on how much prices and wages react to the spending impulse. Friedman (1968) and also mainstream economists will resort to the file of imperfect information and expectations to justify short-term effects on output, but long-term effects on prices. From this proposition, the exogenous view asserts that fluctuations in the quantity of money are the dominant cause of fluctuations in money income (Friedman 1956). Further, this view will claim that the objectives of monetary policy are best met by targeting the growth rate of the money supply rather than by engaging in discretionary monetary policy (Friedman 1960).

2.2 The endogenous-money approaches

Some developments within mainstream economics recognize that the money supply is to some degree endogenous. For instance, it is recognized that the money multiplier is in part determined by the portfolio decisions of the private sector; thus, even if the central bank were rigorously to control the monetary base, this would not yield precise control over the total supply of money. Moreover, it is said that the central bank can, if it wishes, choose to control interest rates rather than money stock. Further, the amount of money in the economy can be endogenous when fiscal dominance implies that the central bank loses the power to control high-powered money, and/or when in the presence of a fixed exchange rate system the monetary base changes according to the magnitude and orientation of foreign-exchange transactions.

However, the endogeneity of money envisaged by Post-Keynesian theorists is to some extent different and more deeply rooted. Nicholas Kaldor and Basil Moore, two of the most prominent figures of the endogeneity thesis, would argue that money is endogenous because the central bank simply does not have the option of exercising genuine quantitative control over the stock of money in a credit-driven system. Changes in the money stock are driven in the first instance by private-sector loan demand, which, they claim, the commercial banks are obliged to accommodate. The central bank then determines the level of interest rates, and ultimately fully accommodates whatever amount of banks' demand for reserves and liquidity the system needs (at the going interest rate) to support lending and deposit activities; that is, it would discard direct control over the monetary base since this would conflict with its function as lender of last resort, which is necessary for maintaining the integrity of the whole pyramid of money and credit.[2]

In this Accommodationist or Horizontalist view pioneered by Kaldor (1970; 1982), Moore (1979; 1983; 1988), Kaldor and Trevithick (1981), and Lavoie (1996; 2006), two analytical implications have generated a sharp debate among Post-Keynesian scholars. First, the idea that central banks always accommodate with the required amount of central-bank money (at a given rate of interest). Second, the suggestion that there is no independent demand function for money since it is always identically equal to the quantity of money that is supplied (Moore 1991, p. 132), an idea that raised concerns for those who think that the flow of new deposits created by an expansion of bank lending has to be matched by the public's desire to arrange their wealth in such a way that they are willing to hold the additional money.

The point is that not all Post-Keynesians fully share the 'extreme' endogeneity theory. Contention exists among advocates of the endogenous-money theory as demonstrated by the debate between Accommodationists and the so-called Structuralists. While both sides agreed that the money supply is credit-driven, Structuralists (see for instance Pollin 1991; Dow 1996; 2006; Palley 1996) argue that full accommodation could not be the proper scenario since the central bank may retain some control over the supply of reserves and interest rates can change instead. Rochon (1999) argues that increases in the demand for loans may find in the process shortages of liquidity that lead to congestion in the market for bank loans. But this congestion can be mitigated by bank asset and liability management. Moreover, Palley (2013) finds four critical differences between Structuralists and Horizontalists. He argues that the Horizontalist view discarded important insights such as the role of money demand and liquidity preference, some endogenous components of interest rates, the role that the market for bonds and the bond rate play in the specification of the loan demand and mark-up changes, and finally the possibility of credit rationing. All these aspects involve a more complex interaction between broad and narrow money, the array of assets, interest rates, the market for loans, and nominal income.

Moreover, a (presumably) third strand of the literature, the proponents of the so-called liquidity-preference view, have pointed out that even accepting that the banks passively accommodate the demand for loans, it does not follow that money demand and supply are always necessarily equal as Accommodationists claim. While the Horizontalists predict that all newly created money in the form of deposits backing new loans will be willingly held, supporters of the liquidity-preference view note that it might not be the case as different groups of economic agents have different preferences concerning how much money they wish to hold. Howells (1995) and Arestis and Howells (1996), for instance, have argued that when new money is brought into existence via bank lending, the arguments of the money-demand function have to change over time to reconcile the demand for money with the new level of the money supply. In other words, changes in the relative interest rate are needed in such a way that the new total stock of money is willingly held as such. Howells's (1997, p. 433) reconciliation mechanism assumes that when people have particular preferences in holding wealth (for instance, deposits), this 'causes them to rearrange their portfolios with consequences for prices, output, interest rates, and so on.' Moreover, the reaction to an

2. However, the Horizontalist position is indeed less crude and more clever, since it considers that central banks may not always accommodate rising bank loans and, in contrast, may be more interested in retaining control of the interest rates and preventing financial innovations from occurring.

autonomous increase in the liquidity preference of the public or banks (that is, the demand to hold money or near-money assets) is likely to produce unexpected results if the central bank does not accommodate, affecting interest rates, the supply of loans, and likely output, prices and even the demand for loans.[3]

2.3 Testable hypotheses

Irrespective of the debate over the adjustment process or the transmission mechanism emphasized by each of the strands of the money endogeneity literature and debate, an idea fully shared by most scholars involved in that debate is that changes in banks' credit extension cause the money supply to increase. We follow this simple approach to test the money-endogeneity hypothesis against the conventional money-exogeneity approach for a sample of emerging and developed economies. The alternative money-endogeneity views explained above are also investigated.[4]

Table 1 summarizes the representative hypotheses of the several theoretical views on the exogenous/endogenous nature of the money supply. But before discussing the hypotheses in more detail, it should be made clear that in the panel VAR methodology used in this study, only short-run coefficients are estimated, and only short-run causality is inferred. Therefore, in Table 1 only short-term directions of causality are considered relevant.

The exogenous-money hypothesis depicts causality from money supply (*MS*) to total bank loans (*BL*) and causality from the monetary base (*MB*) to banking loans (*BL*). If the Monetarist view holds true, then an additional test should indicate unidirectional causality from the M2 money supply (*MS*) to nominal income (*NI*) or either from the money supply (*MS*) to output (*Y*) in the short run, and to prices (*P*) but in the long run.

If demand for reserves is accommodated by the central bank, and the loan supply schedule of commercial banks is demand-led, the endogenous-money approach in Table 1 predicts unidirectional causality from total bank loans (*BL*) to the monetary

Table 1 Testable hypotheses for empirical investigation

The exogenous-money approach	The Accommodationist approach	The Structuralist approach	The liquidity-preference approach
$MS \rightarrow BL$	$BL \rightarrow MS$	$BL \leftrightarrow MB$	$BL \leftrightarrow MS$
$MB \rightarrow BL$	$BL \rightarrow MB$	$P \leftrightarrow MS$	$P \leftrightarrow MS$
$MS \rightarrow P$	$P \rightarrow MS$	$Y \leftrightarrow MS$	$Y \leftrightarrow MS$
$MS \rightarrow NI$	$Y \rightarrow MS$ or $Y \leftrightarrow MS$		

Definition of the variables: *MS* = money suppy, *MB* = monetary base, *BL* = bank loan, *NI* = nominal GNP, *P* = index of price level, *Y* = real GNP.

3. From this perspective, commercial banks may not always accommodate all credit demand from non-financial agents, because – as with any agent operating under non-probabilistic uncertainty – they display liquidity preference, which can lead them to ration the supply of credit, while their capacity for innovation allows them, during boom cycles, to expand the supply of credit beyond the official reserve requirements and regulatory parameters.
4. As such, we do look also into the transmission mechanism suggested by the different Post-Keynesian perspectives.

base (*MB*) and to the M2 money supply (*MS*). Moreover, this Accommodationist approach may imply unidirectional causality from prices (*P*) and real income (*Y*) to the money supply (*MS*) and either bidirectional causality between real income (*Y*) and the money supply (*MS*). On the relationship between money and real output or income, Kaldor and Trevithick (1981) indicate that there is a two-way (feedback) link between them. Changes in real income affect the demand for bank credits causing a change in money growth. Simultaneously, bank credits create deposits used to finance additional aggregate demand.

The Structuralist hypothesis in Table 1 can be described as a mixed empirical model (Nell 2000), which incorporates some ideas of the exogenous-money view, and some of the Accommodationist view. The Accommodationist part of the model depicts causality from bank loans (*BL*) to the base (*MB*), and the Monetarist part of the model depicts causality from the base (*MB*) to total bank credit (*BL*) since central banks do not always provide the reserve requirements in a passive way leading to congestion in the market for bank loans.[5] If the Structuralist view holds true, then an additional test should indicate bidirectional causality between money income (*NI*), or its corresponding components (*P* and *Y*), and the money supply (*MS*).

The empirical hypothesis of the liquidity-preference view in Table 1 predicts causality from total bank credit (*BL*) to the money supply (*MS*) when the money supply is endogenously determined. However, if the demand for money and the demand for loans are independent, the supply of deposits created by the net flow of new bank lending need not be willingly held by new deposit owners, who have independent liquidity preferences about the amount of money they wish to hold. If this were the case, the independent demand for money would place a constraint on the ability of loans to create deposits. Hence, as pointed out by Shanmugam et al. (2003) and Baradurin et al. (2013), causality can also be expected from the money supply (*MS*) to bank credit (*BL*). Moreover, if the demand for loans and the demand for money are not similar, then there is a reconciliation problem which, as argued by Nell (2000), may induce new deposit holders to dispose of any excess by either spending it or buying bonds, inducing further changes in interest rates. The actions by deposit holders then could trigger further price and output changes so that the supply of deposits is eventually reconciled with the demand for deposits. As a result, though output and prices may affect the money supply (as in the Accommodationist case) a feedback mechanism between these components of nominal income (*NI*) and money (*MS*) can also be inferred from the liquidity-preference approach.[6]

3 EMPIRICAL LITERATURE

A preliminary review of the empirical research on the endogeneity of money discussing theoretical and practical shortcomings has been made by Howells (2006). Unfortunately, Howells concentrates his effort mainly on some relevant but reduced work carried out within the limits of the UK economy as well as on his contributions

5. It also assumes bidirectional causality between bank loans and the money multiplier. However, the money multiplier is not included in our empirical tests.
6. Though bidirectionality between money income and money supply in both the Structuralist and liquidity-preference approaches may pass through changes in the interest rates, the lack of data on interest rates for the group of countries and the period analysed does not allow us to contrast hypotheses with this variable.

found in Howells and Hussein (1998) and Caporale and Howells (2001). According to him, most empirical works broadly confirmed the link between loans and deposits in the endogeneity hypothesis. In his own words, 'the present state of empirical knowledge appears to confirm the hypothesis that loans cause deposits' (Howells 2006, p. 61). Nayan et al. (2015) present a renewed but also incomplete effort to survey the empirical literature. They found 13 studies where the endogenous-money hypothesis was tested and mostly confirmed, however they missed or ignored the bulk of empirical work. A reason that may explain their incomplete account is that their review concentrated on studies that investigate whether the endogenous-money findings, if they do exist, follow the Accommodationist, Structuralist, or liquidity-preference viewpoints.

In contrast, Table A1 (in Appendix 1) presents the collection of empirical studies we have found up to the present. Of course, any review of empirical work on the endogeneity of money faces a fundamental problem of where to draw the line. For our review of the empirical literature, we report and summarize in Table A1 works where the core of the endogeneity hypothesis preferably comprise jointly or individually the possibility of two causal links: loans or even money depend upon economic activity (broadly defined) and loans create deposits and money. We have left aside an increasing number of studies focused on estimations of the demand for loans.[7] Moreover, this compilation does not include concerns with the much older inquiry into the relation between money and inflation. Thus we found that since the work of Moore and Threadgold (1980) and Kaldor (1982), perhaps the earliest economists who empirically investigated the theory of endogenous money, about 64 further studies have been conducted up to the present.

Moore and Threadgold (1980) and Kaldor (1982) analysed the data for the UK for a rather similar sample period (from 1965 through 1979) and estimated respectively a demand for loans equation and an equation for annual changes for the money stock, utilizing the ordinary least squares (OLS) method. Moore and Threadgold tried to explain the endogeneity of money reporting an estimation of a demand-driven market for loans equation where firms' costs (working capital needs) were significant and with a high impact on credit demand, but in which the elasticity of the same demand for loans to changes in the real cost of borrowing was low.[8] In contrast, Kaldor's findings suggested directly that money supply was determined by the demand for bank lending.

But it was the joint work of Moore and Stuttman (1982) that reported the first investigation conducted along the lines of Granger and Sims causality tests. They used three variables for the US: monetary base, bank loans, and four different monetary aggregates. A causal link from each of four different monetary aggregates to the base, and from commercial bank lending to the monetary aggregates, allowed them to maintain the endogenous-money hypothesis, as suggested by the credit-money theory. Moore (1983) extended this evidence for the US economy using an explicit test of the hypothesis that the demand for loans depends upon firms' production plans.

Later on, in his seminal book, *Horizontalists and Verticalists*, Moore (1988) provided the most conspicuous and influential empirical evidence for the endogenous-money hypothesis using causality tests. He used monthly data (with some variations) from 1974 to 1980 and offered a range of Granger and Sims causality tests on four

7. Most of the first empirical studies on the endogenous-money hypothesis contained testing of the single relationships between borrowing needs (working capital) and bank loans.
8. The work of Moore and Threadgold, though published in *Economica* in 1985, had an antecedent in a Bank of England working paper (Moore and Threadgold 1980).

different measures of (US) money, the monetary base, and bank loans. His evidence strongly suggested that unidirectional causality runs from bank lending to each of the four monetary aggregates and each monetary aggregate was shown in turn to cause the monetary base unidirectionally.

Following these seminal works of Kaldor and Moore and for about 20 years (1982–2002), most of the empirical literature on the endogeneity of money was focused on single-country studies for developed economies. Table A1 shows that out of 25 studies conducted in that period, only four were directed to test the hypothesis of the endogeneity of money in developing countries. The first study for a developing country we found was conducted for Brazil by Dias Carneiro and Fraga Neto (1985) almost concurrently with the studies of Kaldor and Moore. In Dias Carneiro and Fraga Neto (1985), Granger causality tests in a VAR framework were run between the monetary base, bank lending, the price level, and real GDP. The evidence was strongly consistent with the hypothesis that the monetary base was credit-driven and demand-determined.

Several additional things can be highlighted from Table A1. First, since the beginning of 2000 the number of empirical studies carried out increases (see Figure A1 in the Online Appendix, available at https://doi.org/10.4337/roke.2022.03.09). Interestingly, during this second phase, the studies have focused more on developing countries and emerging markets than on developed economies. In fact, of 44 studies found between 2002 and 2018, 31 concentrate efforts on emerging markets and developing countries. Second, over the whole period (1980–2019) single-country studies predominate and most of them test for causality between the variables involved using the standard Granger causality test in a time-series framework and very often applying VAR and VECM methods.[9] Third, the evidence strongly favors the hypothesis of endogeneity. Indeed, in an overwhelming number of studies, Granger causality is found to run from bank lending to the base, and to the money supply, and not from the base to the money supply and to loans, as the mainstream view maintains. Finally, only eight out of the 66 studies reported here examine the nature of broad money in a range of countries, namely the G7 countries (Howells and Hussein 1998; Badarudin et al. 2013), or Gulf Cooperation Council Countries as in Tas and Togay (2012). But all these studies are still comparisons among single-country estimations.

Among the few multi-country studies, only one, Nayan et al. (2013), analyses the Post-Keynesian hypothesis of money endogeneity in a large sample of countries and using a panel-data set. These authors applied four different regression methods, namely: pooled OLS, panel fixed effects, and system and difference generalized method of moments (GMM) to panel data covering 177 countries for the 1970–2011 period. However, and in contrast to most of the studies for single countries, Nayan et al. (2013) do not implement a procedure for detecting Granger causality in their panel-data set.

Panel-data sets consisting of many individuals and many time periods are becoming widely available. A particularly salient case is the growing availability of cross-country data over time. Therefore, the focus of panel-data econometrics has been gradually shifting from the micro panel, with large N and small T, to macro panels, where both N and T are large. In the present work, however, we have an intermediate situation since our

9. Most causality studies since the late 1980s employ unit-root tests to examine the stationarity properties of variables, perform cointegration analysis, mostly following the Johansen procedure, and formulate a vector error-correction model (VECM) to capture both long-run and short-run sources of causality between the variables.

data set has a large N but a 'medium' T due to the limited information we can find in some of our variables.[10]

Despite the latest developments in this branch of econometrics in which specific causality testing can be employed for panel data, the current empirical literature testing the endogeneity hypothesis appears to be lagging and remains nil. To strengthen the argument that endogenous-money theories are, at a minimum, relevant to understanding our world monetary system, we will use a much larger data set than many previous studies and attempt to apply a panel Granger non-causality test.

4 EMPIRICAL METHODOLOGY

The scant empirical literature evaluating the endogeneity of money hypothesis using panel-data sets brings an opportunity to test how far the hypothesis can go beyond single-country studies. Moreover, panel-data sets allow a more accurate inference of model parameters since they usually contain more degrees of freedom and more sample variability than cross-sectional or time-series data, hence improving the efficiency of econometric estimates. In response, we use a panel vector autoregressive model (PVAR) to evaluate the endogeneity of money hypothesis. PVAR models study the endogeneity of multiple variables, controlling by individual heterogeneity (fixed effects). Also, PVAR models permit us to estimate panel versions of the Granger non-causality test, impulse-response functions (IRFs) and forecast-error variance decompositions (FEVDs).[11]

PVAR models take advantage of both temporal (t: year) and cross-sectional (c: country) dimensions, in contrast with common VAR models which only consider temporal dimensions. That is, we consider for each country c in the panel the vectors of endogenous variables Y_{ct-l} with lagged values $l = 1, \dots, p$ to gain degrees of freedom and achieve more robust estimations. The generic form of a PVAR model is presented in (1) as in Love and Zicchino (2006).

$$Y_{ct} = A_1 Y_{ct-1} + \dots + A_p Y_{ct-p} + BZ_t + \epsilon_{ct}, \quad (1)$$

where $Y'_{ct} = (Y^1_{ct}, \dots, Y^k_{ct})$ is a vector containing k endogenous variables of interest (or transformations of those variables), Z_t is a vector containing time-varying exogenous variables or deterministic terms, dummy variables or a constant, A_i and B are parameter matrices associated with vectors Y_{ct-p} and Z_t respectively, and $\epsilon_{ct}' = (\epsilon^1_{ct}, \dots, \epsilon^k_{ct})$ is an error vector that collects the effects of factors not considered by the model. The lag order (VAR order) is denoted by p.

The use of panel data imposes the same underlying structure for each cross-sectional unit, that is, that the coefficients in the matrices A are the same for all countries $c = 1, \dots, C$ in our sample. This constraint is violated in practice – hence, to allow for country heterogeneity, fixed effects are introduced. However, fixed effects are correlated with the regressors due to lags of the dependent variables (Arellano and Bond 1991; Blundell

10. In contrast to Nayan et al. (2013), our study includes the monetary base as one of the several endogenous variables (see Table A2 in the Online Appendix for details, available at https://doi.org/10.4337/roke.2022.03.09). Due to the limited scope of the information on this variable, we selected in our study the year 2001 as the initial date to thereby include a representative number of countries for the various regions of the world (see Table A1 in Appendix 1).
11. For an overview of PVAR models applied in macroeconomics, see Canova and Ciccarelli (2013).

and Bond 1998). The common practice is to employ forward mean-differencing (Arellano and Bover 1995) to eliminate the fixed effects. This procedure is also called a Helmert transformation (Lee and Yu 2010), and keeps the orthogonality between the 'filtered' variables and their lagged regressors, so we can use lags as instruments for the estimation of the model through the generalized method of moments (GMM) (Love and Zicchino 2006). In addition, if the PVAR model is estimated using first differences of the endogenous variables, then the model allows for the analysis of short-run adjustment effects but not of structural long-run effects (Melguizo Cháfer 2015).

The estimation of model (1) requires stationarity of the endogenous variables to prevent spurious estimations and explosive dynamics. Stationarity can be evaluated through the Fisher-type tests – like the augmented Dickey–Fuller (ADF) test – which do not require a strongly balanced panel (Choi 2001). Concerning the model stability, it can be evaluated by checking whether the eigenvalues of the companion matrix of the dynamical system represented in (1) are located inside the unit circle (Hamilton 1994). After evaluating stationarity, A_i, B, and ϵ_{ct} can be estimated through GMM, with the advantage that the combination of temporal and cross-sectional dimensions ensures consistent, robust, and asymptotically normal results under the assumption of stationarity (Arellano and Bover 1995; Abrigo and Love 2016). To identify the maximum number of lags p to be used in (1), the moment selection criteria for GMM models can be used (Andrews and Lu 2001).

Once the PVAR model is estimated, a panel version of the Granger non-causality test can be applied (Abrigo and Love 2016). The null hypothesis H_0 of the tests claims that all the past values of Y_{ct}^i considered in (1) do not have a statistically significant influence on the current values of Y_{ct}^j. If H_0 is rejected (at least one past value of Y_{ct}^i has a significant influence on Y_{ct}^j), then it is said that Y_{ct}^i 'Granger-cause' Y_{ct}^j. In the case that Y_{ct}^i Granger-cause Y_{ct}^j but not vice versa, then it is possible to assume that there is a causal relation from Y_{ct}^i to Y_{ct}^j (noted as $Y_{ct}^i \rightarrow Y_{ct}^j$). Otherwise, if Y_{ct}^i Granger-cause Y_{ct}^j and vice versa, then there is a simultaneity indicating that both variables are statistically significant in the model (noted as $Y_{ct}^i \leftrightarrow Y_{ct}^j$) although causality between these variables is not completely clear since there may be omitted factors that simultaneously influence both.

Once the unknown parameters are estimated, the reduced-form VAR permits the implementation of dynamic simulations. The results come in the form of IRFs and their coefficients analysis, as well as FEVDs that represent the impact of innovations or shocks to any specific variable on other variables in the system. To obtain IRFs capable of estimating contemporaneously uncorrelated shocks, it is necessary to diagonalize the covariance matrix of the residual term $\Sigma = V[\epsilon_{ct}]$. One usual diagonalization is the Cholesky decomposition of Σ. This process is called VAR identification and involves a particular ordering of variables in the VAR system. The identifying assumption is that the variables that appear earlier in the system are more exogenous or least endogenous, and those which appear later are more endogenous. Also, the variables that appear earlier affect the following variables contemporaneously and with lags, while the variables that appear later only affect the previous variables with lag. Finally, the FEVD is obtained to quantify the importance of each shock when explaining the variation of each variable in the system (Abrigo and Love 2016).[12]

12. Instead of the Cholesky decomposition, a structural PVAR model may be estimated using some assumptions on the contemporaneous interactions among endogenous variables (see Kotarski and Deskar-Škrbić 2016), as in the context of a VAR model. We keep the Cholesky decomposition since we develop a robustness check based on all the permutations of the endogenous variables (see Figure 2).

5 DATA, RESULTS, AND DISCUSSION

We estimate a PVAR model using annual data from 144 countries over the period 2001–2017 (see Table A2 in the Online Appendix for the list of countries, available at https://doi.org/10.4337/roke.2022.03.09). Variables considered are real GDP (*Y*), consumer price index (*P*), bank loans (*BL*), money supply (*MS*), and monetary base (*MB*), all measured in local currency and transformed into US dollars using the DEC alternative conversion factor. These variables have been obtained from the World Bank and the International Monetary Fund (see Table A3 in the Online Appendix for details, available at https://doi.org/10.4337/roke.2022.03.09).

ADF tests suggest stationarity can be assumed for the log differentiation of all variables (Table A4 in the Online Appendix, https://doi.org/10.4337/roke.2022.03.09).[13] Indeed, Table A4 indicates that estimated *p*-values for these tests are close to 0.000, which implies that the null hypothesis of unit roots can be rejected at any conventional significance level.[14] Thus, we use in our PVAR model the first difference of the logarithm of the variables, implying that our results hold from a short-term perspective. Given these endogenous variables, the minimization of the moment selection criteria (MBIC and MQIC) suggests that the preferred model is a first-order PVAR ($p = 1$) using the first four lags of the endogenous variables as instruments (Table A5 in the Online Appendix, https://doi.org/10.4337/roke.2022.03.09). Under these conditions, we fit a first-order PVAR using as exogenous variables a time trend and a dummy variable to control for the global financial crisis (2007–2009) (Table A6 in the Online Appendix, https://doi.org/10.4337/roke.2022.03.09) and, after proving that the eigenvalue stability condition is accomplished (Figure A2 in the Online Appendix, https://doi.org/10.4337/roke.2022.03.09), we perform the Granger non-causality test (Table 2).

The non-causality test suggests that the log differentiation of the monetary base does not Granger-cause any of the other endogenous variables of the model (when comparing other variables with $\Delta\ln(MB)$, all *p*-values are greater than 0.05 in Table 2), but it is Granger-caused by all of them except prices. This may be interpreted as evidence in favor of the endogeneity of money since, after controlling countries' heterogeneity (with the Helmert transformation), the growth of the monetary base does not seem a viable instrument of monetary policy that could be exogenously managed by central banks (at least for this large sample of countries and using data from 2001 to 2017). Hence the conventional view in which the commercial banking system can only extend new loans when it obtains new central-bank money is completely rejected. Instead, the growth of the monetary base seems extremely endogenous when compared with the rest of the variables (particularly with the growth of bank loans).

Another favorable result for the endogeneity of money is that the growth of bank loans Granger-causes all other endogenous variables of the model, including the growth of both the monetary base and the money supply (when comparing other variables with $\Delta\ln(BL)$, all *p*-values are lower than 0.05 in Table 2). Unidirectional causality running from bank lending to each of the monetary aggregates represents evidence in favor of Moore's Accommodationist position. A second link that might support the Accommodationist approach is the fact that inflation and the growth of real GDP Granger-cause all endogenous variables in the model, including the growth of bank loans, except for the case of

13. Log differentiation of $x = \Delta\ln(x)$. Since this is a logarithmic approximation of the growth rate of *x*, the terms 'log differentiation' and 'growth' are used interchangeably.
14. For the log differentiation of the IPC, stationarity is rejected for one statistic but accepted for the other three.

Table 2 Granger non-causality Wald test

Equation	Excluded	chi2	Df	p-value
$\Delta\ln(P)$	$\Delta\ln(Y)$	36.300	1	0.000
	$\Delta\ln(BL)$	5.024	1	0.025
	$\Delta\ln(MS)$	48.983	1	0.000
	$\Delta\ln(MB)$	0.010	1	0.922
	All	51.566	4	0.000
$\Delta\ln(Y)$	$\Delta\ln(P)$	47.240	1	0.000
	$\Delta\ln(BL)$	6.838	1	0.009
	$\Delta\ln(MS)$	36.258	1	0.000
	$\Delta\ln(MB)$	0.009	1	0.926
	All	110.969	4	0.000
$\Delta\ln(BL)$	$\Delta\ln(P)$	41.399	1	0.000
	$\Delta\ln(Y)$	92.679	1	0.000
	$\Delta\ln(MS)$	48.038	1	0.000
	$\Delta\ln(MB)$	2.105	1	0.147
	All	143.662	4	0.000
$\Delta\ln(MS)$	$\Delta\ln(P)$	43.602	1	0.000
	$\Delta\ln(Y)$	39.993	1	0.000
	$\Delta\ln(BL)$	9.881	1	0.002
	$\Delta\ln(MB)$	0.124	1	0.724
	All	110.857	4	0.000
$\Delta\ln(MB)$	$\Delta\ln(P)$	0.286	1	0.593
	$\Delta\ln(Y)$	45.390	1	0.000
	$\Delta\ln(BL)$	67.800	1	0.000
	$\Delta\ln(MS)$	53.231	1	0.000
	All	126.171	4	0.000

Notes: H_0: excluded variable does not Granger-cause equation variable. H_a: excluded variable Granger-causes equation variable.

inflation that does not Granger-cause the monetary base.[15] It may seem strange that price inflation does not cause the growth of the monetary base when it Granger-causes the growth of bank loans, and the growth of bank loans Granger-causes the growth of the monetary base. However, as we see below, when orthogonal IRFs are estimated, an exogenous increase in prices will be followed by a significant increase in $\Delta\ln(MB)$. This result is also confirmed when we estimated the IRFs for all possible variable orderings.

Though the findings confirm the loan to money link, they also suggest a feedback from money to loans. Indeed, in the case of the growth of the money supply, the Granger test presents evidence of simultaneity with all endogenous variables except for the growth of the monetary base (all p-values are lower than 0.05 when $\Delta\ln(MS)$ is excluded in Table 2; in contrast, all p-values are higher than 0.05 when $\Delta\ln(MB)$ is excluded). This result, where the test depicts causality from the growth of the money supply to the growth of bank loans (in Table 2, p-values are lower than 0.05 for 'equation $\Delta\ln(BL)$ – excluded $\Delta\ln(MS)$' and vice-versa, thus each variable Granger-causes the other), may support the empirical hypothesis of the liquidity-preference view (see Table 1). Thus, changes in the

15. All p-values are lower than 0.05 when $\Delta\ln(P)$ and $\Delta\ln(Y)$ are individually excluded in Table 2; that is, $\Delta\ln(P)$ and $\Delta\ln(Y)$ individually Granger-cause all other variables, except for the case when $\Delta\ln(P)$ is excluded from the $\Delta\ln(MB)$ equation causing a p-value higher than 0.05.

Table 3 Summary of interactions obtained from Granger non-causality test

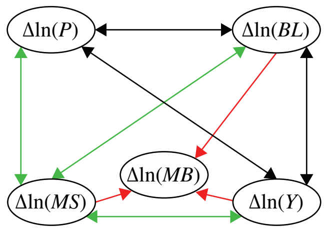
Countries	Data period and frequency	Econometric method	Variables employed	Results
144 (see Table A2)[a]	Yearly: 2001–2017	PVAR	*BL* = bank loans *MS* = money supply *MB* = monetary base *Y* = real GDP *P* = CPI	$\Delta\ln(BL) \leftrightarrow \Delta\ln(BL)$
				$\Delta\ln(BL) \leftrightarrow \Delta\ln(Y)$
				$\Delta\ln(BL) \leftrightarrow \Delta\ln(MS)$
				$\Delta\ln(BL) \rightarrow \Delta\ln(MB)$
				$\Delta\ln(MS) \leftrightarrow \Delta\ln(P)$
				$\Delta\ln(MS) \leftrightarrow \Delta\ln(Y)$
				$\Delta\ln(MS) \rightarrow \Delta\ln(MB)$
				$\Delta\ln(P) \leftrightarrow \Delta\ln(Y)$
				$\Delta\ln(Y) \rightarrow \Delta\ln(MB)$

Note: a. To be found in the Online Appendix, available at https://doi.org/10.4337/roke.2022.03.09.

liquidity preference of the public which are represented in the supply of money may have an impact on the market for loans. This interpretation is also confirmed by the fact that the growth of the money supply in our exercise can influence the dynamic behavior of prices and output, while these monetary and real variables may also Granger-cause the growth of the money supply. All these results, as well as other Granger causalities obtained from the PVAR model, are summarized in Table 3, while the complex *endogeneity structure* formed by the interactions among endogenous variables is represented in Figure 1.

To obtain IRFs through Cholesky decomposition, we select a 'contemporaneous endogeneity' order similar to the structural specification presented by Kotarski and Deskar-Škrbić (2016, p. 427) in their study of money endogeneity for the eurozone. First, we assume prices are the 'most exogenous' variable in the model since they may not be contemporaneously determined by the rest of the variables (price stickiness). Second, we consider real production can be influenced immediately by prices but there are no immediate effects from other monetary variables. Thirdly, we assume that bank loans react contemporaneously to prices and production (for example, demand-driven incentives), but that they do not react immediately to the money supply because the latter may be affected by exogenous liquidity preferences which are not contemporaneously reflected in the demand for loans. Finally, we assume that the money supply is contemporaneously endogenous to all variables except the monetary base since the latter is the 'most endogenous' monetary variable identified in the empirical model through the Granger test. Thus, the order used for the Cholesky decomposition is prices *P* (least endogenous), production *Y*, bank loans *BL*, money supply *MS*, and monetary base *MB* (most endogenous).

Given this order as a 'base case,' the orthogonal IRFs are estimated and presented in Figures A3 through A7 in the Online Appendix (available at https://doi.org/10.4337/roke.2022.03.09). These functions indicate that an exogenous increase in prices (Figure A3) tends to immediately increase all the other variables, but, in the next period, there is a negative 'stabilization' effect that counteracts the positive initial responses, and for the monetary base it seems to be a periodic response with another positive effect. After three periods, the responses are not statistically significant. For the case of an exogenous increase in output (Figure A4), an immediate significant



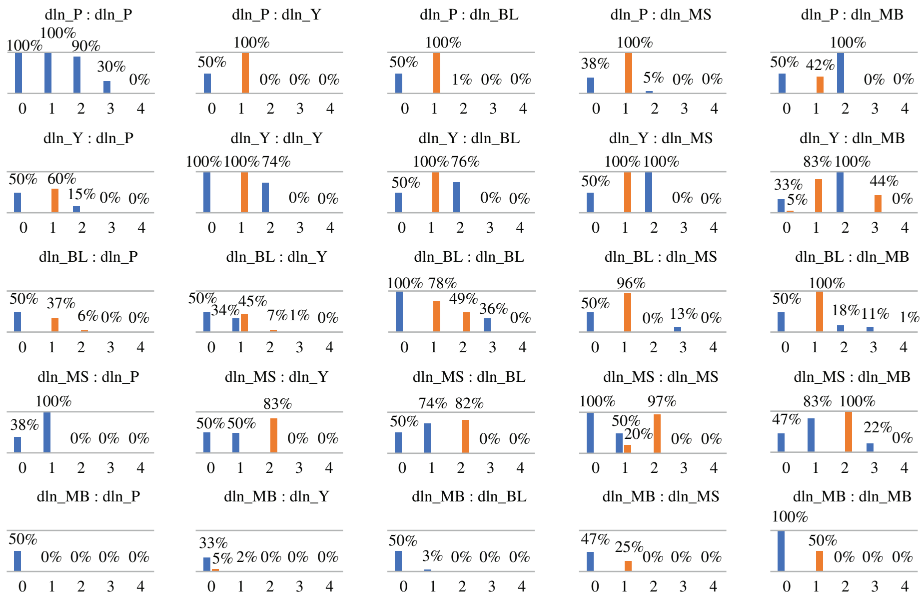
Note: Black arrows: Simultaneity among credit, production, and prices.
Dashed black arrows: Endogeneity of monetary base (potentially 'Accommodationist').
Gray arrows: Money endogeneity with 'liquidity preference.'

Figure 1 Endogeneity structure obtained from Granger non-causality test

positive effect on bank loans and the money supply can be detected (maybe as a response to a demand-side positive shock, for instance) as well as a small positive effect on the monetary base, and no significant effect on prices. Again and except for prices, after these immediate positive and significant responses, there is a negative 'stabilization' effect and a periodic response in the case of the monetary base. When analysing the case of a credit shock (Figure A5), it is remarkable to find positive and immediate significant effects on domestic production and the money supply that are not followed by negative significant responses, that is, in these cases the 'stabilization' is not significant. In contrast, for the case of the monetary base, a credit shock causes both an immediate positive and significant response and a subsequent negative and significant 'stabilization' effect. Such dynamics reinforce the hypothesis of money endogeneity. It is also remarkable that, in response to a money-supply shock (Figure A6), all variables initially increase in a statistically significant fashion and the subsequent negative 'stabilization' is relatively low, implying that an exogenous increase in the money supply may not only have inflationary effects but also positive real effects at least in the short run (though not contradicting the endogenous-money thesis against the idea that money is 'neutral' in the short run). Finally, a shock in the monetary base (Figure A7) does not present significant effects on any of the rest of the endogenous variables of the model, a relevant result since it reinforces the intuition that the monetary base does not seem an effective monetary policy instrument.

To cross-check our results, we develop a robustness check by estimating the orthogonal IRFs and their confidence intervals for all the permutations of the endogenous variables of the PVAR model and identify the percentage of those permutations that bring positive or negative significant responses to an exogenous shock in each variable (Figure 2).[16] This robustness check suggests that the qualitative dynamics of the IRFs for most of the permutations are quite similar to the dynamics obtained from the 'base-case' (Figures A3–A7 in the Online Appendix, available at https://doi.org/10.4337/roke.2022.03.09): a shock in prices has an immediate positive and significant effect and a subsequent 'stabilization' effect on the rest of variables (Figure 2, first row), a shock in production generates a periodic sequence of positive–negative–positive responses (Figure 2, second row), a credit shock has positive immediate effects and

16. An alternative robustness check may compare the orthogonal IRFs with the *generalized impulse-response functions* (GIRFs) that are not sensible to the ordering of the variables (Pesaran and Shin 1998). However, the GIRFs cannot be interpreted as structural impulse-responses since they employ 'extreme identifying assumptions' that may contradict each other 'unless the covariance matrix is singular' (Kim 2013, p. 150).

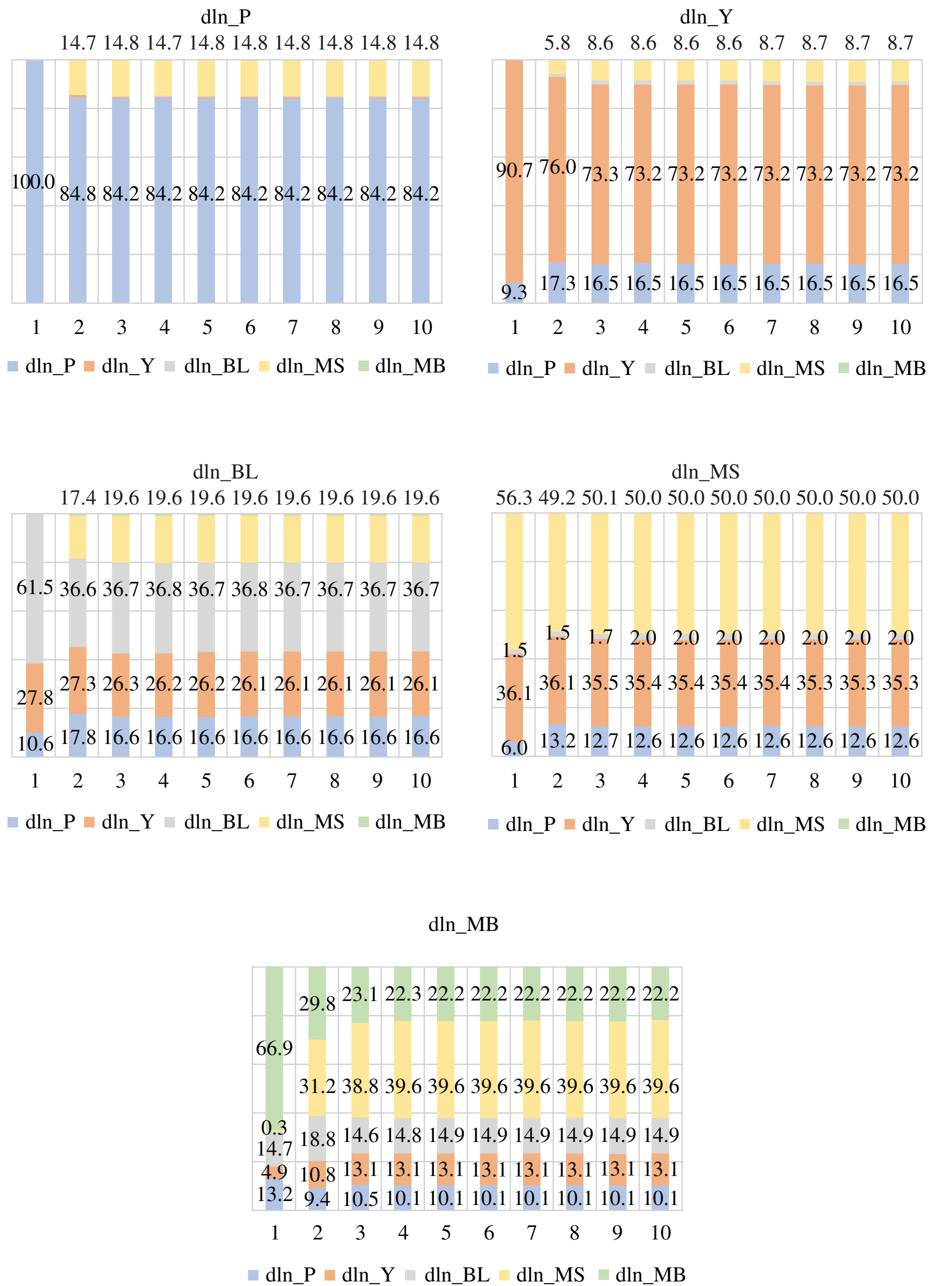


Notes: IRFs = impulse-response functions. Percentages of the 5! = 120 permutations of all the endogenous variables that give a significant positive (black) or negative (gray) impulse-response effect. Significance is based on confidence intervals estimated by bootstrap with 200 Monte Carlo simulations at a 95 percent level of confidence.

Figure 2 Robustness check for orthogonal IRFs

subsequent 'stabilization' effects (Figure 2, third row), a shock in the money supply has two initial periods of positive effects before 'stabilization' emerges (Figure 2, fourth row), and finally for a shock in the monetary base there is only a modest number of permutations reporting an immediate positive effect while most of the permutations suggest that there are no significant responses (Figure 2, fifth row). Another relevant result coming from this robustness check is the tendency of the monetary base to react as the most endogenous variable of the model since it tends to respond to shocks for a longer number of periods than the other variables (Figure 2, fifth column).

Since the orthogonal IRFs bring robust results, we estimate the FEVD (Figure 3) where we observe that the variance of prices is highly influenced or explained by a self-reinforcement effect (84.2 percent), which corroborates the idea that inflation has an important inertial or persistent component. Only a small proportion of the variance of prices is associated with the money supply (14.8 percent). For the case of real GDP, the self-reinforcement effect is also strong (73.2 percent), but prices and the money supply have a relevant influence altogether (16.5 percent and 8.7 percent respectively). The variance of bank loans also yields a self-reinforcement effect (36.7 percent), and is additionally influenced by prices (16.6 percent), production (26.1 percent), and the money supply (19.6 percent). For the money supply, we find a self-reinforcement effect (50.0 percent), but also production (35.3 percent) and prices (12.6 percent) contribute to the forecast error variance of broad money. In a lower proportion, the variance of the money supply is affected by bank loans (2.0 percent). The variance of the monetary base (which does not significantly influence other variables) is influenced by production



Note: Units: percentage points of total variance.

Figure 3 Forecast-error variance decomposition

(13.1 percent), prices (10.1 percent), bank loans (14.9 percent), the money supply (39.6 percent), though it shows an important self-reinforcement component (22.2 percent). In a broad sense, these results suggest a complex interaction among prices, production, credit, and money. To understand such a complex interaction, it seems to us that the best approach is to rely on the hypothesis of endogenous money (particularly the 'liquidity preference' interpretation). The results also indicate that narrow money as represented by the monetary base could not help forecasting real income, prices, broad money, and loans. Thus, the one-direction simplistic causation claimed by Monetarism and other mainstream interpretations where a higher monetary base increases the money supply and causes inflation or even a higher level of output is rejected all the way.

6 CONCLUSIONS

The age-old debate that persists in the monetary economics literature on the endogenous/exogenous nature of monetary aggregates is empirically analysed in this study using a World Bank and IMF data set for 144 economies over a period spanning 2001–2017. Our study seems to be the only one that adopts the now standard econometric panel vector autoregression (PVAR) approach and tests statistical causality for a large set of countries that contains measures of broad (money supply) and narrow money (monetary base), lending, prices, and output. The methodology employed can be encapsulated as a threefold approach: (a) control for individual fixed effects by forward-mean-differencing ('filtering' fixed effects) through the Helmert transformation, and evaluation of stationarity; (b) a system generalized method of moments estimation; and (c) a panel version of the Granger non-causality test and examination of orthogonalized impulse-response functions, and variance decompositions.

The most important conclusion drawn from our empirical work is that, irrespective of the monetary regimes in place at the time, the growth of the monetary base does not Granger-cause the growth of any other endogenous variable of the model (even $\Delta\ln(P)$, that is, inflation), but is Granger-caused by all of them (except prices). Thus, our study views the traditional characterization of an exogenously controlled reserve aggregate (as 'causing' some money stock aggregate or lending) as fundamentally mistaken. Since we have conducted this study for a period in which many policymakers increasingly view short-term nominal interest rates as the main instrument of monetary policy, it should not be surprising to detect causation running from loans to broad money and from broad money to the monetary base.

Moreover, causality tests support the Post-Keynesian contention that the money supply is endogenously determined, with the growth of loans $\Delta\ln(BL)$ causing a proportionate change in the rate of growth of the money supply $\Delta\ln(MS)$. Also, we find causality from $\Delta\ln(MS)$ to $\Delta\ln(BL)$, something that may support the theoretical content of the liquidity-preference view more than the Accommodationist view.

This interpretation in favor of the liquidity-preference view is also confirmed by the bidirectional causality found between the rate of growth of the money supply and the dynamic behavior of output and prices respectively. Indeed, the growth of the money supply in our exercise can influence the dynamic behavior of prices and output, while the growth of these monetary and real variables may also Granger-cause the growth of the money supply.

The findings also confirmed the $\Delta\ln(P) \rightarrow \Delta\ln(BL)$ link, and the $\Delta\ln(Y) \rightarrow \Delta\ln(BL)$ link (which supports the inference that changes in total spending plans drive changes in bank loans), but they also suggest feedback from loans to prices and output.

Beyond the results reported through the use of Granger non-causality tests, estimation of the impulse-response functions reveals that an exogenous increase in production has an important positive and significant immediate effect on bank loans and the money supply (maybe as a response to a positive demand-side shock, for instance) and that a credit shock has a positive and significant immediate effect on production and the money supply (in both cases, the subsequent negative 'stabilization' effect is relatively low or even non-significant). In contrast, a shock in the monetary base does not present significant effects on any of the endogenous variables of the model. All these results obtained from a base case and by a robustness check reinforce the hypothesis of money endogeneity. It is also remarkable that, in response to a money-supply shock, all variables of the model increase in a statistically significant fashion (again, in support of the liquidity-preference view).

Finally, the decomposition that measures the share of the variances that are attributed to structural disturbances at a given frequency indicates that there is a complex interaction among prices, production, credit, and money, but in one sense the results of the FEVD are straightforward, indicating that narrow money as represented by the monetary base could not help forecasting real income, prices, broad money, and loans.

Despite these results, it is worthwhile being cautious about their interpretation. As stated, we use Granger causality as the main test to discriminate the presence or absence of endogeneity, as is the fashion in the literature, and Granger causality is based on the fundamental statistical axiom that the past and the present may predict (cause) the future, but the future does not predict the past. But as Tobin's criticism of Friedman made clear a long time ago, it is precisely the axiomatic imposition of a temporal ordering, where one event follows another event, that may lead to a *post hoc ergo propter hoc* fallacy that invalidates causal reasoning. Moreover, a critical review of the variables, the methodology, and the sample involved in our empirical work raises other possibilities using different variables (such as interest rates homogenized across countries, an index for demand expectations, etc.), samples, and approaches, which are yet to be followed by researchers. For instance, further work could extend the analysis of causal relationships into a long-term context by constructing a representation of a cointegrated panel vector error correction (PVEC) model.[17] Another exercise may be to divide the sample of countries between those that strictly follow an inflation targeting regime and those that do not. Even recognizing these possible limitations and extensions, our results provide findings comparable to existing studies, with a novel econometric methodology, for a very recent period, and for more countries not yet brought under the investigation on this issue.

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17. A PVEC model requires the identification of one or more cointegration vectors that describe long-term stable relations among endogenous variables within the panel-data set. Kao (1999), Pedroni (2004), and Westerlund (2005) tests may be used in that sense. However, these tests require the 'large-N-large-T' condition to be fulfilled to gain good coverage and power properties; in practice, simulations show that these properties are gained with $T = 100$ or greater. Since our data set has only an average of $T = 10$ observations for each country, we preferred to focus on short-term dynamics through a PVAR model.

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APPENDIX 1

Table A1 Empirical studies on the money-endogeneity hypothesis

Author(s) and publication year	Countries	Data period and frequency	Econometric method(s)	Variables employed	Results
Moore and Threadgold (1980)	UK	Quarterly – 1965Q1–1978Q2	OLS	L = flow of loans to IICs; r = real interest rate; IB = import bill for industrial materials; w = wages and salaries;	$\Delta w \rightarrow L$, $\Delta IB \rightarrow L$
Kaldor (1982)	UK	Annual – 1966-1979	OLS	L = loans; M = money	$L \rightarrow M$
Moore and Stuttman (1982)	US	Quarterly – 1973Q1–1981Q4	Granger causality	L = commercial bank lending; BM = monetary base; M = money stock	$L \rightarrow M$, $M \rightarrow BM$
Moore (1983)	US	Quarterly – 1964Q1–1979Q4	OLS	L = loans; MC = material costs; w = money wage; r = real interest rate; SBC = stock building costs	$\Delta w \rightarrow \Delta L$, $\Delta MC \rightarrow \Delta L$
Dias Carneiro and Fraga Neto (1985)	Brazil	Quarterly – 1971Q1–1981Q4	Granger causality, VAR	L = loans; P = price level; Y = real GDP; BM = base money	$\Delta BM \leftrightarrow \Delta CPI$ and $L \rightarrow Y$
Eichner (1985)	US	Quarterly – 1953Q1–1978Q4	OLS	$FedHGS$ = Federal Reserve Holding of Government Securities; RES = required reserves; CC = currency in circulation; FdA = net change in Fed assets	$\Delta CC \rightarrow \Delta FedHGS$, $\Delta FdA \rightarrow \Delta FedHGS$, and $\Delta RES \rightarrow \Delta FedHGS$
Myatt (1986)	US	Monthly – 1954–1984	Sims causality test	i = nominal interest rate; r = real interest rate; $DLogM1$ = growth of narrow money; p = inflation	$\Delta Log\text{M1} \leftrightarrow i$, $\Delta Log\text{M1} \leftrightarrow r$, $p \rightarrow DLog\text{M1}$ and $p \rightarrow r$
Arestis (1987)	UK	Quarterly – 1964Q1–1985Q1	Structural equation model	L = bank lending to the industrial sector; ICC = expected changes in borrowing needs of industrial firms	$\Delta ICC \rightarrow \Delta L$

(continues overleaf)

Table A1 (continued)

Author(s) and publication year	Countries	Data period and frequency	Econometric method(s)	Variables employed	Results
Moore (1988)	US	Monthly – 1974M1–1981M1	Granger and Sims causality tests	L = commercial loans; M = money; BM = monetary base	$BM \leftrightarrow M$, $L \rightarrow BM$ and $L \rightarrow M$
Chowdhury et al. (1990)	Yugoslav, Greece and Spain	Quarterly – 1962Q1–1986Q4	Granger causality test	IIP = Index of Industrial Production; M1 = narrow money	$IIP \rightarrow$ M1 (Yugoslav), M1 $\rightarrow IPP$ (Greece), M1 $\rightarrow IIP$ (Spain)
Hoover (1991)	U.S	Annual – 1950–1985	Regression stability to causal ordering	P = price level; M = money	$P \rightarrow M$
Pollin (1991)	US	Monthly – 1968M6–1988M5	Granger–Sims causality	rf = federal funds rate; rd = discount rate; rm = market rates	$rf \rightarrow rm$, $rf1 \rightarrow rd$
Marselli (1993)	Italy	Monthly – 1975M1–1990M8	Cointegration, ECM and Granger causality	BR = borrowed reserves; FR = free reserves; L = loans, B = bonds in banks portfolio; BM = base money	$L \rightarrow BR$, $L \rightarrow FR$, $B \rightarrow BR$, and $B \rightarrow FR$
Palley (1994)	US	Monthly – 1973M1–1990M6	Granger causality test	ΔLL = loans and leases of commercial banks; ΔMM = money multiplier; DBM = base money	$\Delta BM \rightarrow \Delta M$ and $\Delta L \rightarrow \Delta MM$
Arestis and Mariscal (1995)	UK	Quarterly – 1963Q1–1990Q3	ADL model	ΔL = loans; $\Delta M3$ = money;	$\Delta L \rightarrow \Delta$M3
Howells and Hussein (1998)	G7	Quarterly – 1957Q1–1992Q4 (Canada, Japan, Italy and the US), 1962Q1–1992Q4 (Germany), 1977Q4–1992Q4 (UK), 1975Q1–1993Q4 (France)	Cointegration and Granger causality	M = broad money; L = loans	$L \rightarrow M$
Joshi and Battacharyya (1999)	India	Monthly 1993M1–1998M12		LC = loans to commercial sector; LG = loans to the government; M3 = broad money; IPI = Industrial Production Index	$LC \rightarrow$ M3

Rath (1999)	India	Monthly – 1980M7–1998M3	Granger causality in a VAR framework	L = loans; MM = money multiplier; M0 = money; BM = base money	$\Delta LogL \leftrightarrow \Delta LogMM$, $\Delta LogL \leftrightarrow \Delta Log\text{M0}$, $\Delta LogMM \leftrightarrow \Delta Log\text{M0}$
Nell (2000)	South Africa	Quarterly – 1966Q1–1979Q4	Granger causality and cointegration	L = loans; MM3 = M3 money multiplier; M3 = money supply; y = money income; BM = base money	$BM \leftrightarrow L$, $L \rightarrow$ MM3, M3 $\leftrightarrow$ y
Caporale and Howells (2001)	UK	Quarterly – 1970Q1–1998Q4	Toda–Yamamoto causality test	L = bank loans; T = transactions; D = deposits	$\Delta L \rightarrow \Delta D$, $T \rightarrow \Delta D$
Greenidge et al. (2001)	Selected Caribbean countries	Quarterly – 1960Q1–1998Q3	Causality tests in VAR and VECM frameworks	M = broad money; M1 = narrow money; BM = reserve money; L = loans	Causal patterns may differ according to whether the monetary arrangements of the countries follow either a fixed or flexible exchange rate regime.
Luintel (2002)	India, Nepal, Pakistan and Sri Lanka	Annual – 1959–1996 India, 1966–1997 Nepal, 1961–1997 Pakistan and 1957–1996 Sri Lanka	Toda and Phillips causality test	M1 = narrow money; M2 = money; CPI = Consumer Price Index; Y = real GDP	M1 $\leftrightarrow$ CPI (India), M2 $\leftrightarrow$ CPI (Nepal), M1 $\rightarrow$ CPI (Nepal), CPI $\rightarrow$ M1 (Pakistan), CPI $\rightarrow$ M2 (Sri Lanka) and M1 $\leftrightarrow$ CPI (Sri Lanka)
Holtermöller (2003)	Germany	Quarterly – 1975Q1–1998Q4	Cointegrated VAR	M3 = broad money; BM = monetary base; y = nominal GDP; s = short term rate; I = long term rate	M3 $\rightarrow BM$, $M \rightarrow y$

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Table A1 (continued)

Author(s) and publication year	Countries	Data period and frequency	Econometric method(s)	Variables employed	Results
Rodriguez et al. (2004)	Spain	Monthly – 1978M11–1998M10	Granger test, EC model	C = cash; M3 = money; M = broad money	$C \rightarrow$ M3, $C \rightarrow M$, (1978:11-1986:12) and M3 $\rightarrow C$, $M \rightarrow C$ (1897:1-1998:10)
Ahmad and Ahmed (2006)	Pakistan	Monthly – 1980M1–2003M12	Granger causality test	L = bank advances; BM = monetary base; M = broad money; MM = broad money multiplier; QI = Quantum Index of Manufacturing Activity	$L \rightarrow M$, $L \rightarrow BM$, $M \leftrightarrow QI$
Panagopoulos and Spiliotis (2006)	Greece	Monthly – 1971M1–1999M2	Lutkepohl and Reimers causality within a VAR	IIP = Index of Industrial Production; M1 = narrow money; M3 = broad money; BM = base money	$IIP \rightarrow$ M1, M3 $\rightarrow BM$, $BM \rightarrow$ M1
Vymyatnina (2006)	Russia	Monthly – 1995M07–2004M09	Granger causality test	P = Consumer Price Index; M2 = broad money; L = loans to the non-financial private sector; LSE = loans to state enterprises	$P \rightarrow$ M2, $L \rightarrow$ M2, $LSE \rightarrow$ M2
Cifter and Ozun (2007)	Turkey	Monthly – 1997M1–2006M6	VEC model-based causality test	BM = monetary base; L = credit capacity; r = real interest rate; IPI = Industrial Production Index; p = inflation; RER = real exchange rate; M1 = narrow money; M2 = money	$LogL \rightarrow LogM$, $LogL \rightarrow LogBM$

Özgür and Ertürk (2008)	US	Quarterly – 1959–1979, 1980–1994, 1995–2005	OLS	L = bank credit; D = deposits; M3 = broad money	For 1959–1979 $L \rightarrow$ M3; for 1980–1994 $L \rightarrow$ M3; no relationship after 1995
Badarudin et al. (2009)	10 Emerging Economies	Monthly – 1999M6–2007M7	Granger causality in a VECM	L = bank credit; M = money	$L \rightarrow M$ (China, India, Turkey, Malaysia and Czech Republic)
Jayaraman and Choong (2009)	Pacific Island	Quarterly – 1980Q1–2007Q4	Granger causality within a VECM	M1 = narrow money; M2 = money; RM = reserve money	M2 $\leftrightarrow$ RM (Fiji and Vanuatu) and $RM \rightarrow$ M2 (Samoa, Solomon, Tonga)
Jablecki (2010)	Poland	Monthly – 1998M1–2008M11	Granger causality test	CG = credit growth; LG = liquidity growth	No causality found
Rachma (2010)	Indonesia	Monthly – 1997M5–2010M6	VAR and IRFs from VAR	M0 = base money; M2 = broad money; CPI = Consumer Price Index	M2 $\rightarrow$ M0 and M2 $\rightarrow$ CPI
Badarudin et al. (2011)	G7	Quarterly – Sample period varies for different countries' data availablity	Granger causality test and causality from VECM	M = money supply; BSP = bank stock price; L = loans	$LogL \leftrightarrow LogM$ (Canada, France, Japan, UK and US), $LogL \rightarrow LogM$ (Canada, Italy, Germany, UK and US), $LogM \rightarrow LogBSP$ (France, Canada and US), $LogM \leftrightarrow LogBSP$ (Canada, Japan, Germany, Italy and UK)
Haghighat (2011)	Iran	Annual – 1968–2009	Causality from VECM	M = money supply; Y = income; BM = money base; L = loans	$L \rightarrow MM$, $M \rightarrow Y$, $L \rightarrow BM$ and $L \rightarrow M$

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Table A1 (continued)

Author(s) and publication year	Countries	Data period and frequency	Econometric method(s)	Variables employed	Results
Işik and Kahyaoğlu (2011)	Turkey	Quarterly – 1987Q01–2007Q03	Cointegration, log likelihood test of exogeneity and VECM	BM = base money; Y = real GNP; L = stock of loans of the banking systems	$LogL \rightarrow LogBM$, $LogY \rightarrow LogBM$
Yong (2011)	China	Monthly – 1999M12–2010M12	OLS	BM = base money; FER = foreign exchange reserves; M = bills and notes	$FER \rightarrow BM$, $M \rightarrow BM$
Carpenter and Demiralp (2012)	US	Monthly – 1990M1–2007M12	Granger causality and VAR	RB = reserve balances; reservable deposits = RD; M = money, D = deposits; TD = time deposits; L = loans	$D \rightarrow RB$, $L \rightarrow RD$
Haghighat (2012)	Iran	Annual – 1968-2007	Causality from VECM	M = money supply; Y = income; BM = money base; L = loans; MM = money multiplier	$L \rightarrow MM$, $M \rightarrow Y$, $L \rightarrow BM$ and $L \rightarrow M$
Tas and Togay (2012)	Gulf Cooperation Council Countries	Monthly, Quarterly and Annual	C statistics and Granger causality test	y = nominal GDP; Bm = monetary base; M1 = narrow money; M2 = money; L = total bank credit; MM1 and MM2 = money multipliers	$LogL \leftrightarrow Log$M2 (Oman and Qatar), $LogL \rightarrow Log$M2 (Saudi Arabia and UAE), LogM2 $\rightarrow LogL$ (Bahrain and Kuwait)
Badarudin et al. (2013)	G7	Quarterly – sample period varies for different countries' data availability	Cointegration, VECM and Granger causality	M = money supply; Y = income; BM = money base; L = loans; MM = money multiplier; D = deposits	$L \rightarrow M$
Bozoklu (2013)	Turkey	Quarterly 1987Q1–2011Q4	Toda–Yamamoto causality test and leveraged bootstrap simulation approach	Y = real GDP; M2 = broad money; CPI = consumer price index; i = short term interest rate	$Y \leftrightarrow$ M2

Chigbu and Okorontah (2013)	Nigeria	Annual – 1970–2008	Pairwise Granger causality test	M = money supply; Y = real income; $1/p$ = value of money; LR = liquidity ratio; i = real bank rate	$Y \rightarrow M$, $i \rightarrow M$
Luo (2013)	BRICS	Quarterly – 1982Q1–2012Q4	VAR, VECM and Granger causality	M = money supply; Y = income; BM = money base; L = loans; D = deposits	$L \rightarrow M$ and $M \rightarrow L$ (in India and Russia)
Rahman (2013)	Saudi Arabia	Annual – 1968–2011	Granger causality/block exogeneity test	M = money supply; NOY = non-oil real income; CPI = Consumer Price Index	$NOY \leftrightarrow M$, $NOY \rightarrow CPI$, $M \rightarrow CPI$
Shrestha (2013)	Nepal	Monthly – 1994–2010	OLS and Granger causality	M1 = narrow money; M2 = money; h = reserve money; MM2 = money multiplier; L = domestic credit	$h \leftrightarrow L$, MM2 $\leftrightarrow L$
Vymyatnina (2013)	Russia	Monthly – 1995M7–2011M12	Granger causality in a VECM	$L1$ = credit to state-owned firms; $L2$ = credit to the private sector; M1 = narrow money; M2 = broad money; M0 = monetary base; p = inflation; y = money income	$L1 \rightarrow$ M0, M0 $\rightarrow L2$, M1 $\rightarrow L2$, M2 $\rightarrow y$,
Lopreite (2014)	Euro Area (as a whole)	Annual – 1999–2010	VAR and VECM with Granger causality	L = bank loans; M1 = narrow money; M3 = broad money; MM1, MM2; MM3 = money multipliers; BM = base money; IPI = Industrial Production Index	$BM \rightarrow L$, MM1 $\rightarrow L$, MM2 $\rightarrow L$, MM3 $\rightarrow L$, $IPI \rightarrow$ M1, $L \rightarrow$ M3
Nishiyama (2014)	US	Quarterly – 1984Q1–2003Q4	Granger causality test	NBR = non borrowed reserves; $NYBD$ = sum of New York Bank's deposits	$NYBD \rightarrow NBR$
Aktakas et al. (2015)	Turkey	Quarterly – 1987Q1–2011Q1	VECM	L = credit to the private sector; M = money stock; I = private investment	$LogL \rightarrow LogM$, $LogI \rightarrow LogM$

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Table A1 (continued)

Author(s) and publication year	Countries	Data period and frequency	Econometric method(s)	Variables employed	Results
Almutair (2015)	Saudi Arabia	Monthly – 1997M1–2015M2	VAR, VECM and Granger causality	M1 = money supply; L = loans; D = demand deposits; TD = time deposits	$L \rightarrow$ M1, $D \rightarrow$ M1 (in the long-run), M1 $\rightarrow D$ (in the short-run)
Lopreite (2015)	US	Monthly – 1999M1–2011M5	VAR and Granger causality	L = loans; M1 = narrow money supply; M2 = broad money supply; BM= monetary base; $LSEC$ = loans adjusted for securitization; IPI = Industrial Production Index	$LogL \rightarrow Log$M1, $LogL \rightarrow Log$M2, $LogL \rightarrow LogBM$, $LogL \leftrightarrow LogIPP$
Elhendawy (2016)	Egypt	Annual – 1990–2014	Granger causality	L = domestic credit; M = money supply; D = deposits; p = consumer price inflation; BM = monetary base	$L \leftrightarrow M$, $L \leftrightarrow$ p
Güney and Cepni (2016)	Turkey	Monthly – 2006M1–2015M5	Granger causality in a VAR and VECM framework	M = money supply; L = loans; D = deposits; BM = base money	$L \leftrightarrow D$, $L \rightarrow M$, and $D \rightarrow M$
Kotarski and Deskar-Škrbić (2016)	Eurozone	Quarterly – 1999Q1–2015Q4	Granger causality, IRFs from SVAR	L = loans; D = deposits; M = money; P = price level; g = real GDP growth	$L \rightarrow D$, $g \rightarrow M$, $g \rightarrow L$, $P \rightarrow L$
Mueller and Wojnilower (2016)	US	Quarterly – 1959–2008	Toda and Yamamoto causality test in a VAR framework	L = loan; M1 = narrow money; M = money; y = nominal income; BM = monetary base	$L \rightarrow BM$, M2 $\rightarrow BM$, M1 $\rightarrow BM$ and $y \rightarrow L$
Bachurewicz (2017)	Poland	Monthly – 2001M12–2016M12	Granger causality test on an unrestricted VAR	M3 = broad money; BM = monetary base; L = loans; MM3 = money multiplier; D = deposits	$L \leftrightarrow BM$, $BM \rightarrow D$, $L \rightarrow D$

Dedeoglu and Ogut (2018)	Turkey	Monthly – 2009M10–2016M11	Symetric and asymetric causality in a VAR model	L = bank loans; M2 = money	$L \rightarrow M$
Regret (2018)	Zimbabwe	Monthly – 2009M1–2017M5	VECM causality test	$LogL$ = loans; LogM3 = broad money; LogMM3 = money multiplier; $LogCPI$ = Consumer Price Index; $LogD$ = deposits; $LogBM$ = monetary base	$LogL \leftrightarrow LogD$, $LogL \leftrightarrow Log$M3, LogMM3 $\rightarrow LogL$
Levrero and Deleidi (2019)	US	Monthly – 1959M1–2016M9	VECM and Toda-Yamamoto non-causality Test	L = Credit granted by commercial banks; D = deposits; BM = monetary base	$LogL \rightarrow LogD$, $LogL \rightarrow LogBM$, $BM \leftrightarrow D$
Rahimi (2019)	Iran	Monthly – 2006M04–2018M12	Diks and Panchenko's non-parametric Granger causality test	L = bank loans; BM = monetary base; M = narrow money; M2 = liquidity	$LogL \leftrightarrow LogM$, $LogL \leftrightarrow Log$M2, $LogL \rightarrow LogBM$
Li et al. (2021)	China	Monthly – 2000M1–2016M11	Bootstrap rolling window causality test	IR = accumulation of international reserves; M2 = money	$IR \rightarrow$ M2

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Testing the global extent of the endogenous-money hypothesis: a panel vector autoregression approach

Online appendix

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APPENDIX 2

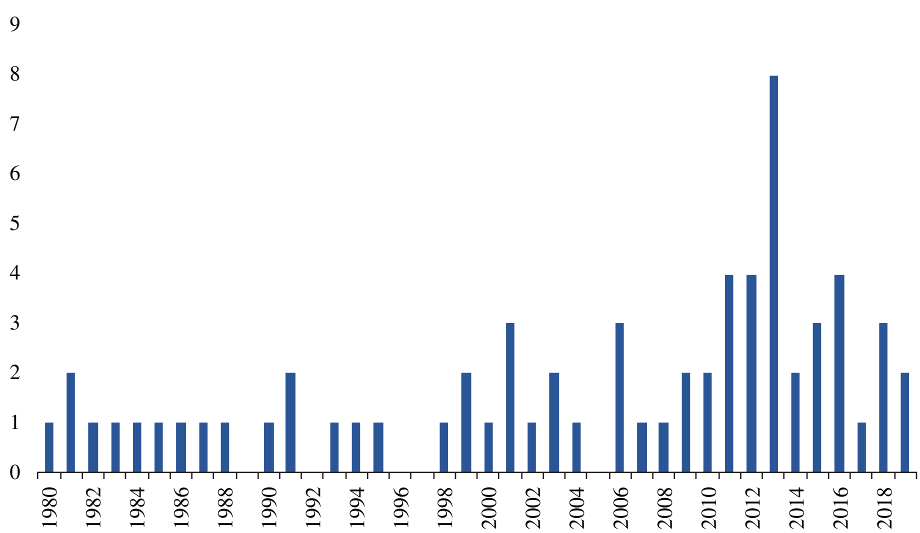

Figure A1 Studies contrasting the endogenous-money hypothesis (1980–2019)

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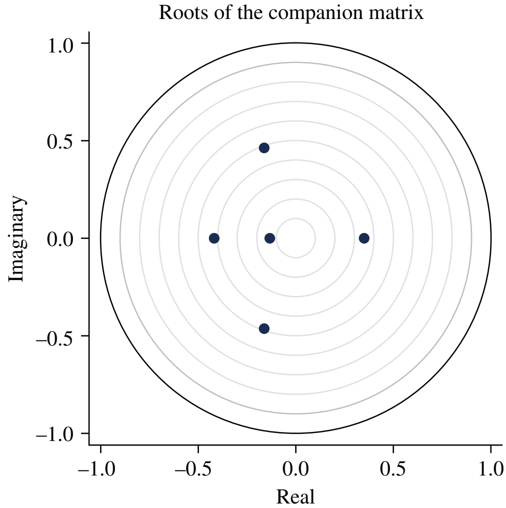
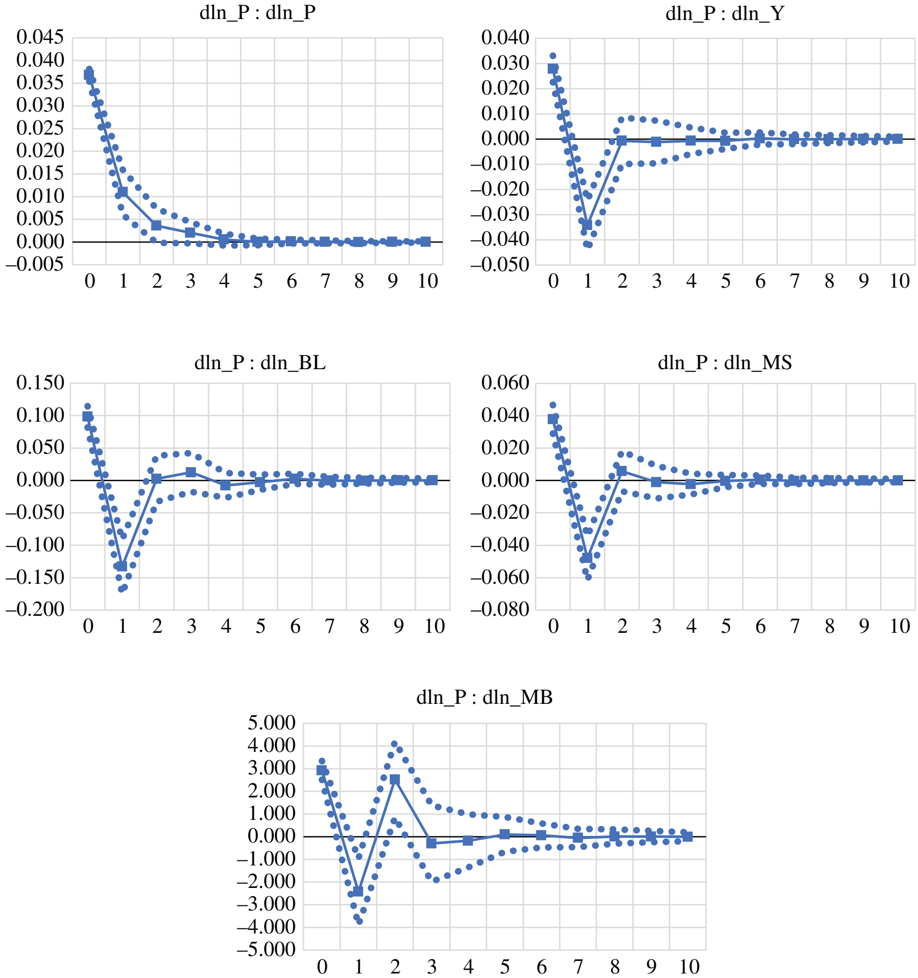
The Lypiatts, 15 Lansdown Road, Cheltenham, Glos GL50 2JA, UK
and The William Pratt House, 9 Dewey Court, Northampton MA 01060-3815, USA



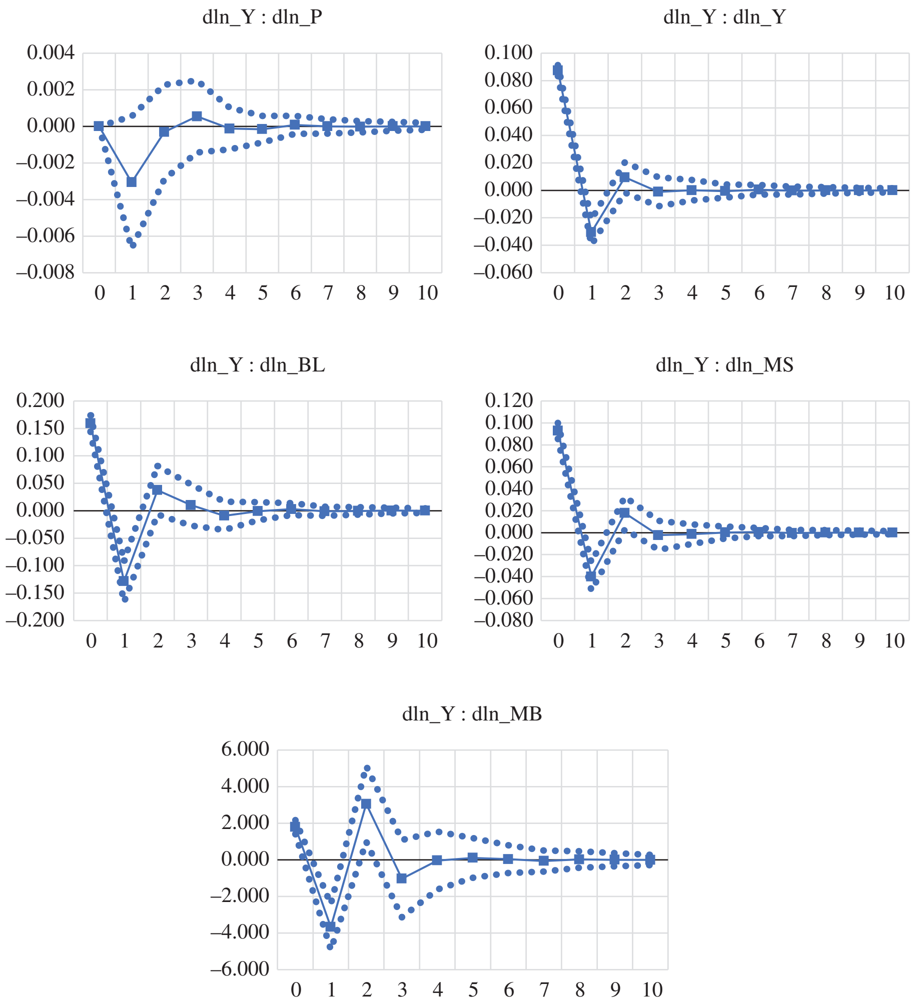
Notes: All the eigenvalues lie inside the unit circle. PVAR satisfies stability condition.

Figure A2 Graph of eigenvalue stability condition



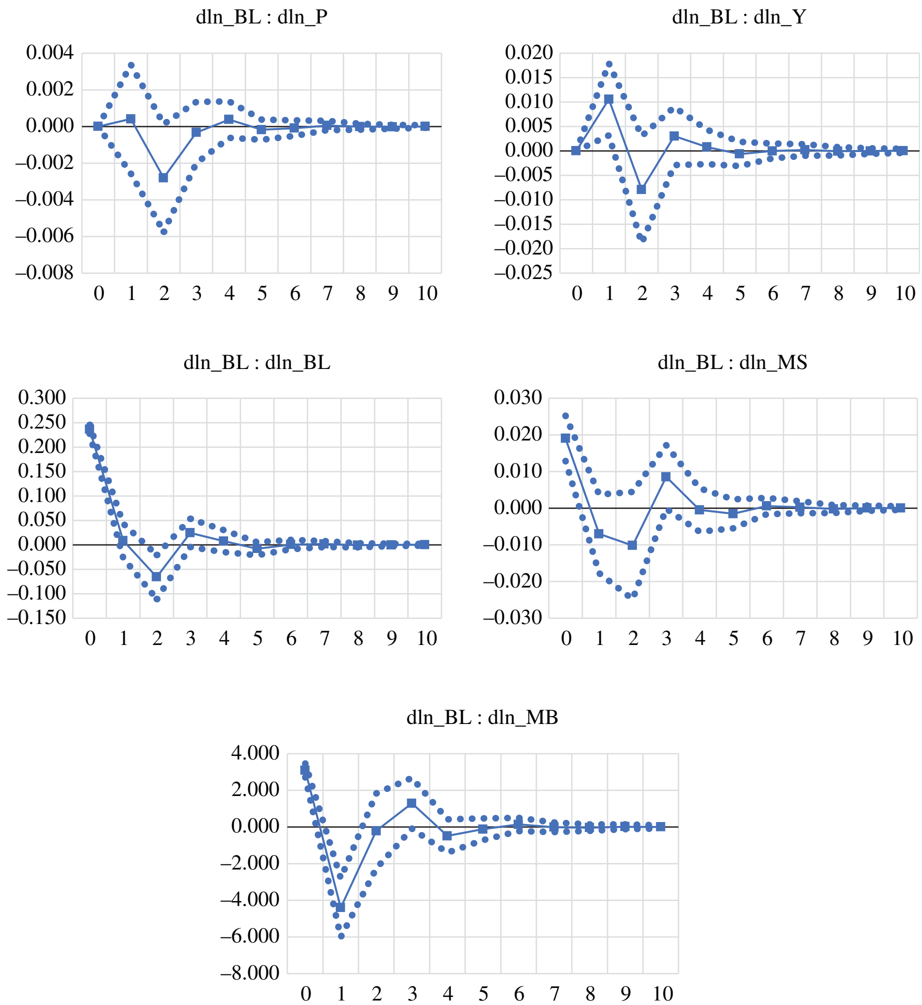
Notes: IRFs = impulse-response functions. Confidence intervals estimated by bootstrap with 200 Monte Carlo simulations at a 95 percent level of confidence.

Figure A3 Orthogonal IRFs for a price shock (base case)



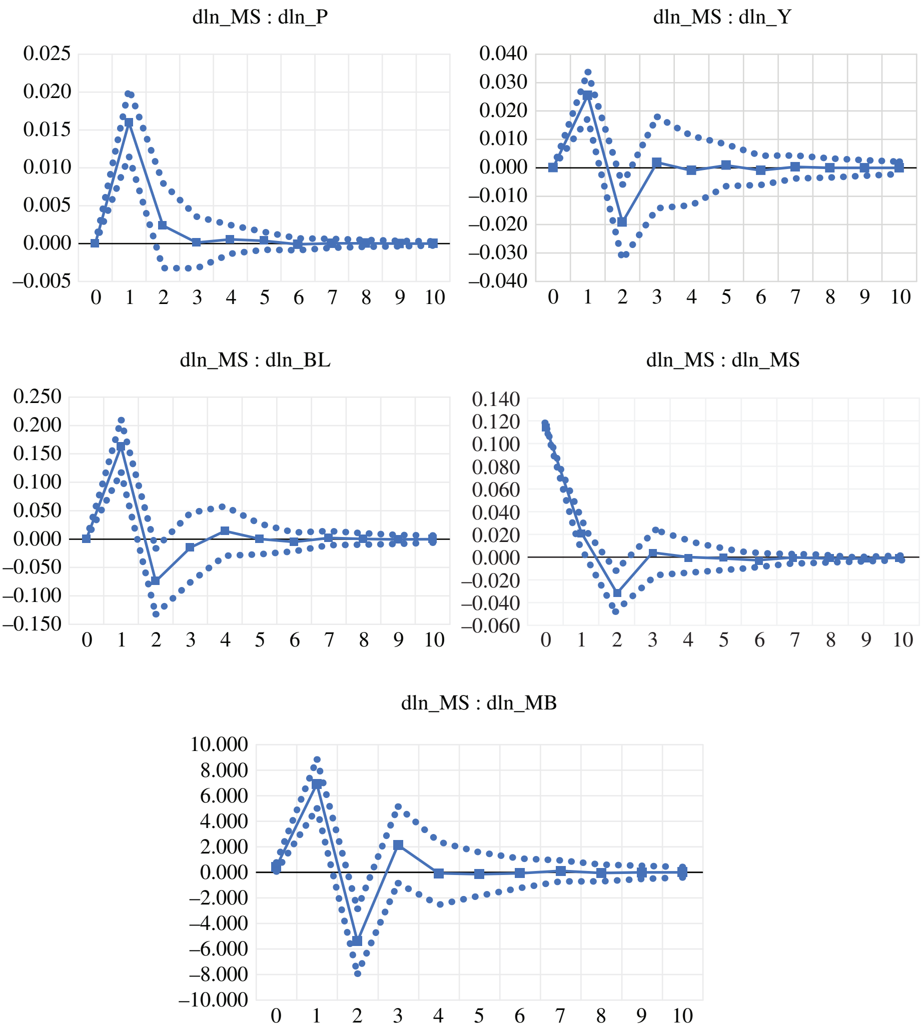
Notes: IRFs = impulse-response functions. Confidence intervals estimated by bootstrap with 200 Monte Carlo simulations at a 95 percent level of confidence.

Figure A4 Orthogonal IRFs for a production shock (base case)



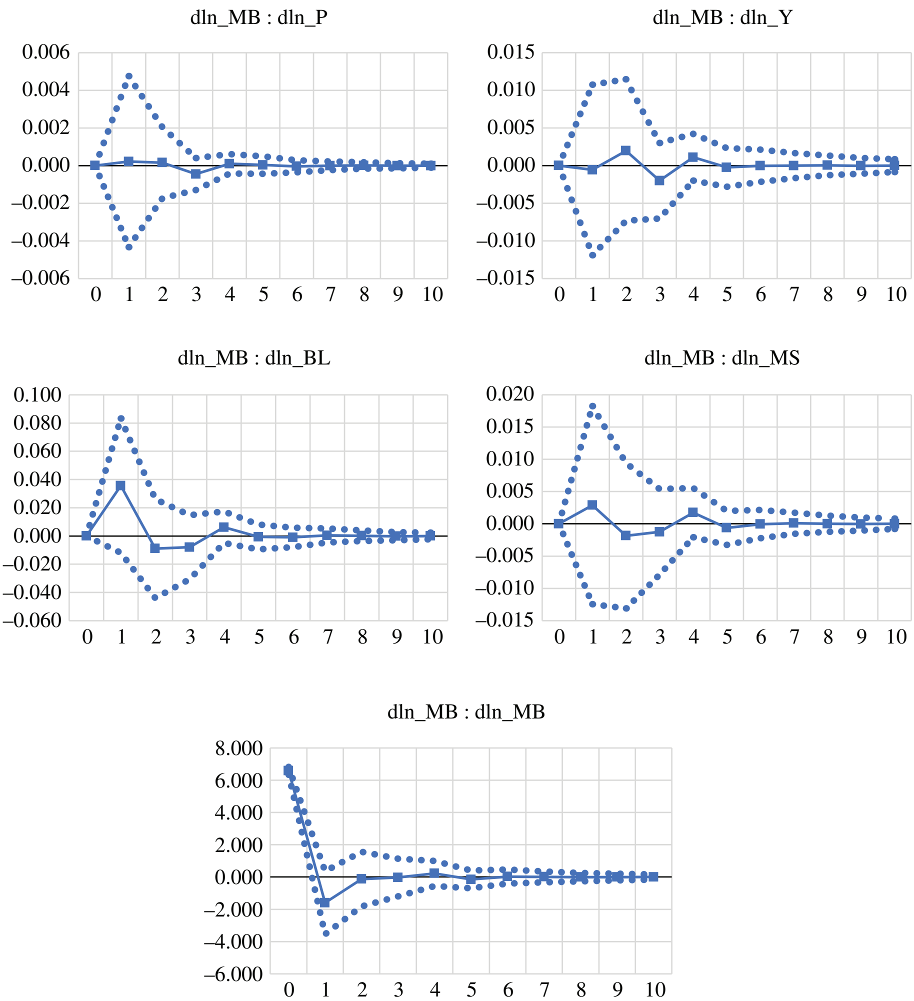
Notes: IRFs = impulse-response functions. Confidence intervals estimated by bootstrap with 200 Monte Carlo simulations at a 95 percent level of confidence.

Figure A5 Orthogonal IRFs for a credit shock (base case)



Notes: IRFs = impulse-response functions. Confidence intervals estimated by bootstrap with 200 Monte Carlo simulations at a 95 percent level of confidence.

Figure A6 Orthogonal IRFs for a money-supply shock (base case)



Notes: IRFs = impulse-response functions. Confidence intervals estimated by bootstrap with 200 Monte Carlo simulations at a 95 percent level of confidence.

Figure A7 Orthogonal IRFs for a monetary-base shock (base case)

Table A2 List of countries used for PVAR estimation

Africa	North America	Central America	South America	Asia	Oceania	European Union	Rest of Europe
Algeria	Mexico	Antigua and Barbuda	Argentina	Azerbaijan	Australia	Austria	Albania
Angola	United States	Bahamas	Bolivia	Bangladesh	Fiji	Belgium	Armenia
Benin		Belize	Brazil	Bhutan	New Zealand	Bulgaria	Belarus
Botswana		Costa Rica	Chile	Brunei/Darussalam	Papua New Guinea	Czech Republic	Bosnia and Herzegovina
Burkina Faso		Dominica	Colombia	Cambodia	Samoa	Denmark	Croatia
Burundi		Dominican Republic	Ecuador	Indonesia	Solomon Islands	Finland	Georgia
Cabo Verde		El Salvador	Guyana	Iran, Islamic Rep.	Tonga	France	Iceland
Cameroon		Grenada	Paraguay	Israel	Vanuatu	Germany	Moldova
Central African Republic		Guatemala	Peru	Japan		Greece	Norway
Chad		Haiti	Suriname	Kazakhstan		Hungary	Russian Federation
Comoros		Honduras	Uruguay	Korea, Rep.		Ireland	Serbia
Congo, Rep.		Jamaica		Kuwait		Italy	Switzerland
Cote d'Ivoire		Nicaragua		Kyrgyz Republic		Luxembourg	Turkey
Djibouti		Panama		Malaysia		Netherlands	Ukraine
Egypt, Arab Rep.		St. Kitts and Nevis		Maldives		Poland	
Eritrea		St. Lucia		Mongolia		Portugal	
Eswatini		St. Vincent and the Grenadines		Myanmar		Romania	
Gabon		Trinidad and Tobago		Nepal		Spain	
Gambia, The				Oman		Sweden	
Ghana				Pakistan		United Kingdom	
Equatorial Guinea				Philippines			
Guinea-Bissau				Qatar			
Kenya				Singapore			
Lesotho				Sri Lanka			
Madagascar				Tajikistan			
Mali				Thailand			
Mauritius				United Arab Emirates			

Morocco
Mozambique
Namibia
Niger
Nigeria
Rwanda
Sao Tome and Principe
Senegal
Seychelles
Sierra Leone
South Africa
Sudan
Tanzania
Togo
Tunisia
Uganda
Zambia

Table A3 Data description

Variable	Description
P: Consumer price index (2010 = 100)	For the World Bank, the consumer price index reflects changes in the cost to the average consumer of acquiring a basket of goods and services that may be fixed or changed at specified intervals, such as yearly. The Laspeyres formula is generally used. Data are period averages.
Y: Real gross domestic product	For the World Bank, GDP is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. Data are in constant local currency.
BL: Bank loans	For the World Bank, the bank loan is the domestic credit provided by the financial sector and includes all credit to various sectors on a gross basis, with the exception of credit to the central government, which is net. The financial sector includes monetary authorities and deposit money banks, as well as other financial corporations where data are available (including corporations that do not accept transferable deposits but do incur such liabilities as time and savings deposits). Examples of other financial corporations are finance and leasing companies, money lenders, insurance corporations, pension funds, and foreign-exchange companies.
MS: Money supply	For the World Bank, money supply is the sum of currency outside banks; demand deposits other than those of the central government; the time, savings, and foreign-currency deposits of resident sectors other than the central government; bank and travelers' checks; and other securities such as certificates of deposit and commercial paper.
MB: Monetary base	For the IMF, the monetary base comprises central-bank liabilities that support the expansion of credit and broad money. The monetary base is also called high-powered money, because changes in the monetary base support larger increases in credit and broad money.
DEC alternative conversion factor	The DEC alternative conversion factor is the underlying annual exchange rate used for the World Bank Atlas method. As a rule, it is the official exchange rate reported in the IMF's International Financial Statistics (line rf). Exceptions arise where further refinements are made by World Bank staff. It is expressed in local currency units per US dollar.

Source: WB and IMF databases.

Table A4 ADF stationarity tests

Variables	Statistics (p-value)			
	Inverse chi-squared P	Inverse normal Z	Inverse logit L^*	Modified inv. chi-squared Pm
Δln(P)	349.3498	–0.6729	–1.8530	3.1220
	(0.0018)	(0.2505)	(0.0322)	(0.0009)
Δln(Y)	461.6394	–5.4745	–6.6090	7.3439
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Δln(BL)	546.2327	–8.1805	–9.2849	10.8809
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Δln(MS)	639.3965	–9.5226	–11.2655	14.6415
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Δln(MB)	736.1694	–9.3775	–12.8223	19.2767
	(0.0000)	(0.0000)	(0.0000)	(0.0000)

Notes: AR parameter: panel-specific. Asymptotics: T -> infinity. Panel means: included. ADF regressions: two lags. Drift term: not included.

Table A5 PVAR lag order selection

Lag	CD	**J**	**J** p-value	MBIC	MAIC	MQIC
1	0.73535	190.04060	5.98e-12	–349.2036	40.04060	–105.86140
2	0.75033	131.51830	2.96e-09	–227.9778	31.51826	–65.74978
3	0.80607	46.34835	0.0058	–133.3997	–3.65164	–52.28566

Selection order criteria:
Sample: 2006–2016 No. of panels = 132
No of obs. = 1326 Ave. no of T = 10.045

Table A6 Results of the fitted PVAR model

Variables	Δln(P)	Δln(Y)	Δln(BL)	Δln(MS)	Δln(MB)
L.Δln(P)	0.30541***	–0.74489***	–2.96484***	–0.96023***	–5.84838
	(0.05966)	(0.10837)	(0.46079)	(0.14541)	(10.94474)
L.Δln(Y)	–0.16421***	–0.63228***	–2.79063***	–0.57631***	–64.38389***
	(0.02725)	(0.05840)	(0.28987)	(0.09113)	(9.55650)
L.Δln(BL)	–0.00977**	0.02805***	–0.14644**	–0.05062***	–20.33747***
	(0.00436)	(0.01072)	(0.04857)	(0.01610)	(2.46991)
L.Δln(MS)	0.13783***	0.22052***	1.39013***	0.18993***	60.63933***
	(0.01969)	(0.03662)	(0.20056)	(0.06655)	(8.31137)
L.Δln(MB)	0.00003	–0.00008	0.00541	0.00043	–0.24236*
	(0.00033)	(0.00092)	(0.00373)	(0.00124)	(0.14670)
Time	0.00045	0.00789***	0.00829**	0.00415**	0.25022**
	(0.00033)	(0.00102)	(0.00369)	(0.00147)	(0.09905)
Crisis	0.00681	–0.01068	0.02384	0.01285	–2.23025**
	(0.00366)	(0.00840)	(0.03055)	(0.01229)	(0.84717)
Observations	1328				

Notes: Variables ‘filtered’ through the Helmert transformation. Instruments: L(0/4), ln(Y), ln(BL), ln(MS), ln(MB), time. Standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.