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China's Money Demand in a Cointegrating Vector Error Correction Model

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Abstract

This paper estimates open-economy macroeconomic models of the Chinese economy allowing for the structural change caused by the 1992 reforms. Unrestricted vector autoregressions, VARs, and cointegrating vector error correction models, VECMs, are estimated on quarterly data for the early reform period 1980-1992, and the late reform period, 1993-2018. Two long-run cointegrating vectors are identified, which can be interpreted as a long-run, money demand function and a long-run IS type income equation driven by export demand. The 1992 reforms involved a move to a more market oriented system and a transformation of financial institutions and this seems to be responsible for a change in the direction of effect of interest rates in both the IS and LM relationships.

JEL classifications: E51, P34, C32

Keywords: Money demand; Cointegration; China

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1. Introduction

Given the significance of administrative control in much of the Chinese economic system, there has been considerable debate about whether there exist stable long run equilibrium relationships of the sort that are believed to exist in more market oriented systems. For instance, in a centrally planned economy, it can be argued that money demand is not a meaningful concept, because the central bank controls the quantity of money held by households and firms (Delatte et al., 2014). Hence, the existence of stable money demand in China may provide evidence about the extent of its transformation to a market economy and has implications for the central bank's effort to control money supply. There is a short review of the literature on Chinese money demand in section 2.

This paper presents evidence that China exhibits two stable long run equilibrium relationships that can be interpreted as an open economy IS curve and a long run money demand LM curve. In the IS curve output is determined by exports and interest rates, in the LM curve real money demand is determined by output and interest rates. These are the long run equilibrium relationships in the goods and money market for a system in which money, real income, interest rates, inflation and real exports are all treated as endogenous. This system is estimated using an unrestricted vector auto-regression, VAR, and a cointegrating vector error correction model, VECM. While we identify two long run equilibrium relationships, IS and LM curves, previous Chinese cointegration studies have tended to only be able to identify one cointegrating vector. The estimates indicate the importance of export led growth to Chinese development, hence a closed economy model would be inappropriate. The money measure we use is real M2 and real Divisia M2, the broad money aggregate.¹

By a stable long run equilibrium relationship, we mean a stationary linear combination of variables towards which the system is adjusting. We estimate the speed of adjustment, which determines how long it takes to reach the long run. Since the Chinese economy was subject both to major disturbances and to

¹In China money, Renminbi, is issued by the People's Bank of China (PBoC) and banking institutions (including banks, rural credit cooperatives and finance companies). Money is held by non-bank and non-government sectors. M2 includes currency in circulation (banknotes and coins issued by the PBoC less the amount held by banking institutions); demand, time and savings deposits in national currency of resident non-bank, non-government sectors with banking institutions. Deposits account for a large proportion of bank liabilities and bank loans are a major part of domestic credit. Credit expansion in China historically has been accompanied by an expansion of broad money.

institutional frictions that may inhibit adjustment to equilibrium, one may need a long span of data to get good estimates. This paper uses quarterly data over a much longer period than is commonly examined, 1980-2018, covering almost the whole period from the opening of the economy to the present day. Over this period the big break was in 1992, the starting point of Deng Xiaoping's late reforms following his southern tour. We examine whether these reforms changed the relationships and argue that the structural break provides evidence for a change in reform dynamics after 1992. In particular, the 1992 reforms involved a move to a more market oriented economy and a transformation of the financial system that seems to be responsible for a change in the effect of interest rates in both the IS and LM relationships.

In the context of the VECM there are two distinct identification problems, long run and short run. We identify the long run equilibrium relations, which we characterise as the cointegrating IS and LM curves. We do not attempt to identify the short run, within period, interactions. Many studies, for instance [Bakker & Gulde \(2010\)](#), use Choleski decompositions or alternative identifying restrictions on the short run responses to estimate structural vector auto-regressions. This is done either to identify structural shocks such as demand and supply shocks or to identify particular short run relationships like Taylor rules, for changes in interest rates, or Phillips Curves, for changes in inflation. It is not clear that either of those relationships were fundamental to the Chinese economy over this period. Nor is it clear that the recursive models implied by the usual Choleski orderings are appropriate. Since there is no agreement on the restrictions needed to identify Chinese structural vector auto-regressions, or the appropriate Choleski orderings, we leave the short run adjustment processes to be determined by the data and focus on identifying the long run relationships about which economic theory is more informative. To analyse the time profile of the responses of the variables to shocks we use Generalised Impulse Response Functions (GIRFs), which do not require short run identifying assumptions.

With two cointegrating vectors there are three stochastic trends driving the system. The two cointegrating vectors represent equilibrium relationships and all five variables adjust to restore equilibrium and we can examine how disequilibrium in the goods or money markets feeds back onto each of the five variables. Since they are not identified, the short-run adjustment equations towards these long-run equilibrium conditions cannot be given a structural interpretation but may capture mixtures of money-supply adjustments, a Phillips curve and a Taylor rule.

Our contribution to the literature is threefold: We jointly estimate long-run money demand and IS-type relationships for the Chinese economy in a cointegrating framework that identifies two cointegrating vectors. Secondly, we estimate a small open-economy system that emphasises the role of export-led growth for China. Lastly, taking advantage of a longer dataset than commonly employed in the literature, we find significant structural changes in these cointegrating relationships around a time when crucial market reforms have been implemented, providing evidence for the effect of China's transformation to a more market-based financial system.

This paper is organized as follows. Section 2 provides a short literature review followed by an overview of reforms after 1978 in section 3. Most money demand functions have been estimated as single equations. We use a systems approach. Section 4 introduces the theory of money demand and then sets out the systems approach. Section 5 describes data and variables employed and section 6 reports results of cointegration and the impulse response analysis. In the cointegration analysis, section 6.2, we first estimate long-run money and income equilibrium relationships and then analyse their adjustment processes. Section 7 concludes.

2. Literature

A number of studies have evaluated the demand for money across a range of industrial and developing countries (see the survey of [Sriram \(2000\)](#)). For China [El-Shagi & Zheng \(2018\)](#) review 61 studies on money demand over the last 30 years that employ various datasets from the 1950s up to most recent economic development, suggesting the existence of a stable long run demand relationship. They also find a substantial publication bias towards rejecting stability of Chinese money demand. China's economic transition likely implies the existence of structural breaks that affect estimates of money demand functions. This is further complicated by measurement differences arising from the chosen monetary aggregates or opportunity cost measures. There is further debate on the existence of a stable long-run money demand relationship. Cointegration methods are commonly employed to investigate this.

The literature on Chinese money demand is largely separated between early and pre-reform periods, 1950-1990, ([Chow, 1987](#); [Yi, 1993](#); [Hafer & Kutan, 1994](#); [Chen, 1997](#)) and late or post-reform periods after 1980 ([Bahmani-Oskooee & Wang, 2007](#); [Delatte et al., 2014](#); [Huang, 1994](#)). There is a debate on the

existence of structural breaks around important shifts in money demand that reflect the transition of the Chinese economy: the early financial liberalization reforms initiated in 1978 and Deng Xiaoping's southern tour in early 1992 as well as the 14th National People's Congress in October 1992 that included a 16-point financial reform program in 1993. Some studies point towards the incremental nature of these shifts. [Prasad & Rajan \(2006\)](#) argue that early reforms following the late 1970s, particularly in the financial sector, have been rolled out very locally first and that only following the success of such small-scale experiments reforms were more widely implemented. [Zuo & Park \(2011\)](#) therefore argue that in fact the reform process is smooth and gradual without distinct or sharp regime shifts although the reforms themselves are very fundamental. Under the assumption of a smooth roll-out of reforms, [Zuo & Park \(2011\)](#) employ a smooth time-varying cointegrating regression approach. But a prevailing belief among economists who study China is that China's economic reforms have undergone significant structural changes ([Lee et al., 2008](#)). This is underpinned by theoretical arguments of increasing monetary transactions that imply drastic increases to money demand in early reform stages that level off over time ([Delatte et al., 2014](#); [Mukherjee, 1967](#)). We share this belief, highlighting the importance of Deng Xiaoping's southern tour in particular in China's reforms. Whilst the existence of stable long-run money demand for China is a common finding, such results are sensitive to sample selection as well as measurement and specification issues, which casts doubt on comparisons of many results. We employ a longer dataset that spans the entire reform period and allows us to estimate long-run equilibrium relationships for both, money market and goods market and obtain more reliable estimates of structural breaks in the equilibrium relationships.

Chinese money demand has been estimated for different monetary aggregates (M0 ([Hafer & Kutan, 1994](#); [Qin, 1994](#); [Chen, 1997](#)); M1 ([Deng & Liu, 1999](#); [Bahmani-Oskooee & Wang, 2007](#)); and M2 ([Hafer & Kutan, 1994](#); [Baharumshah et al., 2009](#); [Huang & Huang, 2017](#))). Whilst [Chen \(1989\)](#) argues that narrow monetary aggregates, such as M1 are better in capturing long-run policy effects, [Hafer & Kutan \(1994\)](#) find that the share of currency in circulation (M1) in broad money (M2), dropped from 60 percent in 1970 to about 35 percent by the late 1980s. This reflects the impact of financial reforms that have led to money being increasingly held in deposit accounts. In this respect M2 offers a more robust monetary measure that is more suitable for comparisons of monetary aggregates over a longer span of data.

Further measurement issues arise from transaction (or scale) and opportunity cost measures entering money demand itself. For the former, different income measures are employed, such as national income (Chow, 1987), real national income per capita (Yi, 1993) or real GDP (He, 2017; Huang & Huang, 2017; Dou, 2018). Opportunity costs measures mostly differ in maturity of interest rates employed. Baharumshah et al. (2009) use the seven-day inter-bank rate, Jiang (2016) uses nominal interest rates paid on 3-month time deposits by commercial banks, Huang (1994) uses real interest rates on one-year savings deposits, while Aliha et al. (2019) use the lending rate.

With the opening of the Chinese economy foreign investment opportunities are also considered as opportunity costs. Mehrotra (2008) argues that Renminbi appreciations increase capital inflows that add to the domestic money supply and therefore increase Renmimbi demand. Wu (2009) does not find significant effects of exchange rates on money demand but instead find evidence of a positive impact of expectations of Renmimbi appreciations since 2005 on money demand. However, Dou (2018) rejects the impact of both expected exchange rates and capital mobility on Chinese money demand, as tightly controlled capital and foreign exchange markets implied little variation and therefore limited information contained in such measures. Alternative attempts to control for the financial deregulation effect after 1994 using dummy variables have been unsuccessful.

A natural starting point in analyses of money demand are short-run adjustment dynamics to long-run money demand functions (Chow, 1987; Qin, 1994). But Hafer & Kutan (1994) argue that it is not clear if such long-run equilibrium relationships exist. More recent approaches therefore employ cointegration techniques to establish long run relationships between money and other variables (Hafer & Kutan, 1994; Chen, 1997). Error correction models can then be used to evaluate the dynamic adjustment process (Huang, 1994; Deng & Liu, 1999; Aliha et al., 2019). However, such models suffer from simultaneity bias, as the ordering of causal effects between variables is often unclear. Structural vector autoregressions, such as in Dou (2018) can overcome the simultaneity bias but often establish causality by imposing recursive identification restrictions that are sensitive to the ordering of variables.

We investigate Chinese money demand in a systems approach, using a reduced-form VAR and generalized impulse response functions, which overcome the shortcomings of structural VARs and capture long run relationships and short run adjustment between money, income and their determinants us-

ing a vector error correction model. Given the sensitivity of results to structural breaks we investigate pre-specified break dates with model selection criteria to then obtain estimates for sub-samples around significant breaks separately. To estimate money demand, we employ real GDP as a scale measure of the economy and the 1-year lending rate as an opportunity cost measure. We further include exports in the system, to capture open economy aspects of Chinese money demand.

3. Overview of Financial Market Reforms in China after 1978

The Chinese economy underwent a series of far-reaching economic and financial reforms after 1978. This was in an attempt to transform gradually from a government-controlled financial system to a market-based financial system, where markets, rather than governments, determine resource allocation. Whilst a large number of different reforms were implemented throughout the last four decades, a very significant reform effort can be linked to the almost 20-years tenure of Deng Xiaoping as China's paramount leader² from 1978 to his death in 1997. This section gives a brief overview of reforms at the time. Initially economic reform efforts were implemented experimentally, e.g. through designation of Special Economic Zones (SEZs), where some reforms were first implemented before being rolled out in a wider context (Prasad & Rajan, 2006). But there is reason to believe that Deng Xiaoping's southern tour of 1992 in particular had a lasting impact on reforms.³ We therefore distinguish two main episodes of Deng's reforms, the early reform period, 1978-1992, and the period following Deng's southern tour, which led to a renewed commitment to his reform agenda in the 14th National Congress of the Communist Party of China.

3.1. Early Reform Period: 1978-1992

China's "Reform and Opening-Up" policy was introduced at the Third Plenary Session of the 11th Central Committee of the Communist Party of China in 1978. The focus of early economic reforms was

²The term paramount leader has been used to describe Deng Xiaoping's function, retaining ultimate power at the core of the Politburo, whilst formally not holding all three executive chairman offices, General Secretary of the Communist Party, Chairman of the Central Military Commission, and President of the Peoples Republic. The term is used to distinguish from the office of the President, which is defined as largely ceremonial in the 1982 constitution. Deng neither held the offices of General Secretary nor President but was arguably the most influential Politburo member between 1978 and 1997.

³Zhao (1993) argues that Deng's southern tour was highly unusual and had a decisive impact on political support for his reforms that has been weakened in preceding years. Such shifts in political support are in line with breaks rather than a gradual implementation of reforms.

rural de-collectivisation and an export-led growth strategy that involved a rise in foreign direct investments, which were allocated through the banking sector. Banking reform has therefore early been at the center of the overall reform effort.

Before 1978, China's financial system was dominated by the People's Bank of China, which acted as sole commercial bank and lender (EI-Shagi & Zheng, 2018). Chinese banking reforms evolved around the need to transform the centralised public allocation mechanism of a state-controlled mono-bank system into a market-based allocation mechanism. Early reforms thus focused on the creation of a commercial banking sector, which was followed by marketisation and the opening of the Chinese banking system. To establish a commercial banking sector, in the late 1970s and early 1980s, China established four specialized banks (Agricultural Bank of China, Bank of China, China Construction Bank, Industrial and Commercial Bank of China). These banks were initially limited to their respective sectors, so that, whilst commercial banking was separated from central banking, the allocation mechanism of the banking sector remained public. Commercial banks were allowed to compete from 1985 on, but lacked incentives to do so, due to their common public ownership structure.

Bank ownership was therefore targeted in a series of reforms that allowed private shareholders and increased competition between banks. Initially, shareholding reform focused on SEZs, which also allowed minority foreign-ownership to attract foreign direct investments. The Shenzhen and Shanghai SEZs were the only cities that allowed private shareholders, which later led to the foundation of main stock exchanges. Following the success of economic liberalisation in SEZs, reforms were scheduled to be extended to other areas, but slowed towards the end of the 1980s.

3.2. Late Reform Period following Deng Xiaoping's 1992 Southern Tour

At the turn of the decade, Deng's reforms were met with increasing opposition from conservative cadres. At the same time there was a built-up of non-performing loans by the mid-90s as a result of excessive lending to state owned enterprises (Berger et al., 2009; Lardy, 1998). To win support for his economic reforms, Deng, who by then resigned from his official post as Chairman of the Central Military Commission, gave a series of public speeches during visits to southern Chinese cities, later referred to as his Southern Tour. Deng's speeches and political involvement had a profound political impact on a renewed reform effort. Following Deng's idea of "socialism with Chinese characteristics", the 14th National

Congress of the Communist Party of China in 1992, in particular, set the reform goal as “building a socialist market economy” and “market economy” was incorporated for the first time into the institutional framework of China. This renewed commitment to economic reform led to further shareholding reform of state-owned enterprises and banks and was followed by a number of further liberalisation reforms including outsourcing of public lending activities into policy banks in 1994, the formal separation of central from commercial banking in 1995, the establishment of City Commercial Banks in 1995, de-regulation of the inter-bank and capital market in 1996, easing of restrictions on foreign bank operations in mainland China and SEZs between 1994 and 1996, and restructuring and recapitalisation of the banking sector in 1997. The shift from a dual- to a multi-tiered banking system also included the establishment of Joint Equity Commercial Banks (JECBs), which were considered in China’s commercial banking system from the early 1980s, but most JECBs were established after 1992. The establishment of JECBs in particular has reduced government influence in lending decisions (Berger et al., 2009). This and increasing openness of the Chinese banking sector to foreign investors and bank branches were important factors in improving competitiveness and efficiency of the Chinese banking system. Further shareholding reforms were implemented in 2003, following China’s accession to the World Trade Organisation (WTO), and there was a further increase in competition between 2003 and 2013 (Tan & Floros, 2018).

Given the number of reforms implemented after 1978, it is difficult to identify individual reforms that have led to a change of the financial allocation mechanism of the Chinese economy, but it is likely that this is due to a combination of the restructuring and marketisation of China’s banking sector between the late 1980s and the mid 1990s. Arguably, events following Deng Xiaoping’s southern tour had a major impact on widespread liberalisation and marketisation efforts throughout the 1990s, leading to structural changes in the capital allocation mechanism.

4. Model

4.1. Money demand theory

We derive money demand using a Neo-Keynesian model of short run adjustment to a long run money demand function and output equation, where in equilibrium money demand equals money supply. Long run money supply is controlled by the PBoC for given income, interest rates, and other variables. In the

short run, variables are endogenous and the PBoC can either adjust interest rates (Taylor rule) or money supply (McCallum rule). The adjustment process may also reflect a short run Phillips curve determining inflation.

We derive the long run money demand function from the quantity theory of money as

$$\frac{M}{P} = K(1 + R)^\alpha y^\beta, \quad (4.1)$$

where M is nominal money, P is prices, K is a constant, R is interest rate ($V(R) = (1 + R)^{-\alpha}$), and y is real income. We assume that in the long-run the central bank satisfies money demand and follows a Taylor rule. Re-writing (4.1) in logarithmic transformations gives:

$$lm \approx lK + \alpha R + \beta ly, \quad (4.2)$$

where lm , ly , and lK are natural logarithm of real money demand, real income, and constant K . We capture real effects on variables by including inflation. This gives us an extended long-run real money demand function that determines equilibrium real money balances, lm_t^* :

$$lm_t^* = \beta_0 + \beta_1 ly_t + \beta_2 p_t + \beta_3 R_t, \quad (4.3)$$

where p_t is inflation.

If the long-run demand for money is stable, then, following a McCallum rule using M2 as monetary target, monetary policy can help to stabilize the economy or at least remove monetary policy as a source of macroeconomic instability. Additionally, if demand for money did not change unpredictably then money supply targeting is a reliable way of attaining a stable inflation rate.

4.2. A systems approach

Much of the analysis of Chinese money demand has been done in a single equation context, such as the money demand derived above. But since the IS and LM curves are equilibrium conditions in a general equilibrium model it is natural to consider them in a systems context. The VECM, that we shall adopt, is a restricted form of a VAR, which allows an economic interpretation of the long run relation-

ships.⁴ VARs⁵ are the solution to dynamic stochastic general equilibrium models.

Consider an m vector, in our case 5, of variables, $\mathbf{x}_t = (m_t, y_t, x_t, R_t, p_t)$, logarithms of real money, income and exports, interest rate and inflation rate. Suppose that these are determined by a canonical Dynamic Stochastic General Equilibrium (DSGE) model:

$$\mathbf{B}_0 \mathbf{x}_t = \mathbf{b} + \mathbf{B}_1 \mathbf{x}_{t-1} + \mathbf{B}_2 E_t(\mathbf{x}_{t+1}) + \mathbf{u}_t, \quad (4.4)$$

where $E_t(\mathbf{x}_{t+1})$ is the rational expectation of \mathbf{x}_{t+1} , given information at t . The solution is given by

$$\begin{aligned} \mathbf{x}_t &= \mathbf{C} \mathbf{x}_{t-1} + \mathbf{B}_0^{-1} \mathbf{u}_t, \\ \mathbf{x}_t &= \mathbf{A}_1 \mathbf{x}_{t-1} + \varepsilon_t, \end{aligned} \quad (4.5)$$

where \mathbf{C} solves $\mathbf{B}_2 \mathbf{C}^2 - \mathbf{B}_0 \mathbf{C} + \mathbf{B}_1 = 0$. The solution is unique and stationary if all the eigenvalues of \mathbf{C} and $(\mathbf{I} - \mathbf{B}_2 \mathbf{C})^{-1} \mathbf{B}_2$ lie strictly inside the unit circle. The solution of the canonical DSGE model,⁶ (4.5), is a first order VAR.

Similarly the VAR is the reduced form of a standard simultaneous equation model, with no exogenous variables,

$$\mathbf{B}_0 \mathbf{x}_t = \mathbf{B}_1 \mathbf{x}_{t-1} + \mathbf{u}_t, \quad (4.6)$$

with

$$E(\mathbf{u}_t \mathbf{u}_t') = \Omega. \quad (4.7)$$

The reduced form is the VAR:

$$\begin{aligned} \mathbf{x}_t &= \mathbf{B}_0^{-1} \mathbf{B}_1 \mathbf{x}_{t-1} + \mathbf{B}_0^{-1} \mathbf{u}_t, \\ \mathbf{x}_t &= \mathbf{A}_1 \mathbf{x}_{t-1} + \varepsilon_t, \end{aligned} \quad (4.8)$$

with

$$E(\varepsilon_t \varepsilon_t') = \mathbf{B}_0^{-1} \Omega \mathbf{B}_0^{-1'} = \Sigma. \quad (4.9)$$

⁴We also analyse the response of variables to generalised impulses. Unlike the VECM, this is performed on an unrestricted VAR.

⁵Or Vector Autoregressive Moving Averages in some cases with unobservables.

⁶A detailed theoretical derivation of general equilibrium relationships can be found in [Schinckus et al. \(2018\)](#).

The reduced form has $m + m^2$ regression parameters plus $m(m + 1)/2$ independent covariance matrix parameters. These can be estimated consistently. However the structural form has $m + 2m^2$ regression parameters plus $m(m + 1)/2$ independent covariance matrix parameters. To obtain the structural form parameters from the VAR requires m^2 just identifying restrictions which specify the parameter values on the basis of economic theory.

The identifying restrictions can be either on the coefficients $\mathbf{B}_0, \mathbf{b}, \mathbf{B}_1$ or the covariance matrix Ω . A special case of an identified system is a recursive structure, imposed by specifying the order of the variables in a Choleski decomposition. If the variables can be ordered so that \mathbf{B}_0 is lower triangular, the elements above the diagonal are zero, this provides $m(m - 1)$ restrictions. If Ω is also diagonal, all the off-diagonal elements are zero, this provides another $m(m - 1)$ restrictions. Together with the m normalisation restrictions, the coefficients of the dependent variables are unity, these provide the m^2 restrictions required. However, these just identifying short run restrictions on \mathbf{B}_0 and Ω are untestable and tend to be controversial.⁷

Most DSGE models are cast in terms of stationary variables, deviations from steady state, thus are not informative about long run relationships. However, if \mathbf{x}_t is a vector of $I(1)$ variables that cointegrate (4.6) can be reparameterised

$$\mathbf{B}_0 \Delta \mathbf{x}_t = (\mathbf{B}_1 - I) \mathbf{x}_{t-1} + \mathbf{u}_t, \quad (4.10)$$

with reduced form:

$$\begin{aligned} \Delta \mathbf{x}_t &= \mathbf{B}_0^{-1} (\mathbf{B}_1 - I) \mathbf{x}_{t-1} + \mathbf{B}_0^{-1} \mathbf{u}_t, \\ \Delta \mathbf{x}_t &= \Pi \mathbf{x}_{t-1} + \varepsilon_t. \end{aligned} \quad (4.11)$$

If there are r cointegrating relationships, long run equilibrium conditions, there will be linear combinations of the $I(1)$ \mathbf{x}_t , $\mathbf{z}_t = \beta' \mathbf{x}_t$, which are $I(0)$, so

$$\begin{aligned} \Delta \mathbf{x}_t &= \alpha \mathbf{z}_{t-1} + \varepsilon_t, \\ \Delta \mathbf{x}_t &= \alpha \beta \mathbf{x}_{t-1} + \varepsilon_t. \end{aligned}$$

⁷Although the solution of the rational expectations model, (4.5), is the same as reduced form of the simultaneous equations model, (4.8), to identify the rational expectations model requires $2m^2$ restrictions, rather than m^2 .

The α are adjustment coefficients. If there are r cointegrating vectors to identify the β we need r restrictions on each cointegrating vector. These long run identifying restrictions are often more plausible than the short run identifying restrictions discussed above. Suppose there are two cointegrating vectors, an IS curve and an LM curve. One identifying restriction on each equation will be provided by the normalisation, the choice of the dependent variable, output in the IS curve and money in the LM curve. The second just identifying restriction can be obtained by excluding exports from the LM curve and money from the IS curve. An over-identifying restrictions can be obtained by using real interest rates, which says that the coefficients of interest rates and inflation should be equal and opposite. This gives us the two deviations from long run equilibrium that we can estimate:

$$z_{1t} = y_t - \beta_{11}x_t - \beta_{12}(R_t - p_t), \quad (4.12)$$

$$z_{2t} = m_t - \beta_{21}y_t - \beta_{22}(R_t - p_t). \quad (4.13)$$

We expect the effect of exports on output and output on money to both be positive. While it is usual to expect the effect of interest rates on output and money to be negative, this is less clear cut and will depend on the nature of the financial system and the extent of financial repression. It is possible that reforms to the financial system, of the sort that happened in 1992, will change the way interest rates operate in the economy.

4.3. Empirical Hypotheses

Above we argued that the IS and LM type equations of a typical macroeconomic model can be interpreted as long run equilibrium conditions that can be estimated as cointegrating vectors. This leads to our two main empirical hypotheses for the Chinese economy:

H1: Two cointegrating vectors exist that can be estimated as equations (4.12) and (4.13).

H2: There is a structural break in the cointegrating relationships in 1992.

The existence of cointegrating vectors that resemble macroeconomic equilibrium conditions would provide evidence for an allocation mechanism that is in line with equilibria for market-based allocations. This would suggest that post 1978 the Chinese economy did follow a trajectory that suggests that reforms

aiming at market-based allocations were successful. We test hypothesis H1 by testing for the existence of cointegrating vectors using the Johansen procedure and by evaluating the stability of estimated cointegrating vectors. In the literature the overall pace of reforms is often seen as gradual. Whilst there is merit in that, H2 suggests that Deng Xiaoping's Southern Tour did affect the pace of reforms, and that there is therefore a structural break in the data around that time. We evaluate the hypothesis by comparing the sum of information criteria of models estimated on subsamples of the data before and after 1992 with those obtained for models estimated for the entire data. We evaluate relationships between variables separately for both subsamples in an analysis of generalised impulses of an unrestricted VAR.

5. Data

We employ a sample of quarterly time-series on Chinese monetary and macroeconomic variables, spanning 1980-2018.^{8 9} Real variables are obtained using the Consumer Price Index (CPI) in 2010Q1 prices. Summary statistics are given in Table 1 based on three periods: the whole sample period, 1981Q1-2018Q3; the early reform stage, 1981Q1-1992Q4; and the late reform stage, 1993Q1-2018Q3.

Contemporaneous correlations between variables are given in Table 2. A striking shift in correlations from monetary to real variables indicates the impact of far-reaching market liberalisation reforms in China: general equilibrium is driven by aggregate demand and supply relationships rather than prices.

Figure 1 plots the evolution of variables in terms of growth rates and the evolution of the monetary measure and exports as a share of GDP. Real money growth is quite volatile, particularly in the first half of the sample, but increased by 200% overall. This is even more pronounced for export growth, with a notable trough around the financial crisis for both. There is a relatively stable growth rate of money relative to GDP that appears closely associated with an increase in exports for the first 25 years of the sample. This suggests the existence of a stable link between money demand and trade for most of the sample. Correlations with interest rates further indicate the presence of structural breaks, which would

⁸Datasources are given in Table A.8 of Appendix A.

⁹Whilst the PBoC targets deposit rates, our estimates assume lending rates, which gives similar results. Our results are further robust to employing Divisia M2 money instead of M2 money (Due to data availability, Divisia M2 is used from 1999 on (see: <http://cfds.henucon.education/index.php/data/chinese-divisa-data>); we used M2 for data from 1992-1999). Estimates using deposit rates are given in Tables A.9 and A.10 and impulse responses obtained from using Divisia M2 in Figure A.4 of Appendix A.

Table 1: Summary Statistics.

1981Q1-2018Q3:						
	$D^y(lm)$	$D^y(ly)$	$D^y(lx)$	p	R	r
Mean	14.26	9.13	12.43	4.92	7.11	2.34
Median	13.86	8.89	12.24	2.44	6.56	3.00
Max.	33.58	14.24	55.87	27.97	12.06	8.63
Min.	-8.51	3.83	-33.34	-1.97	4.35	-14.45
Std. Dev.	6.87	2.56	15.54	6.30	2.07	4.44
Obs.	151	151	151	151	151	151
1981Q1-1992Q4:						
	$D^y(lm)$	$D^y(ly)$	$D^y(lx)$	p	R	r
Mean	16.67	9.24	15.33	6.69	8.10	1.62
Median	18.57	9.57	17.03	4.81	7.92	2.89
Max.	33.58	14.15	40.44	27.97	11.34	7.73
Min.	-8.51	3.83	-33.34	1.50	5.04	-14.45
Std. Dev.	9.13	3.36	16.90	6.54	1.51	5.06
Obs.	48	48	48	48	48	48
1993Q1-2018Q3:						
	$D^y(lm)$	$D^y(ly)$	$D^y(lx)$	p	R	r
Mean	13.13	9.07	11.07	4.09	6.65	2.68
Median	12.74	8.71	8.58	2.13	5.85	3.19
Max.	31.65	14.24	55.87	26.70	12.06	8.63
Min.	3.05	5.94	-27.94	-1.97	4.35	-12.41
Std. Dev.	5.21	2.11	14.76	6.03	2.13	4.10
Obs.	103	103	103	103	103	103

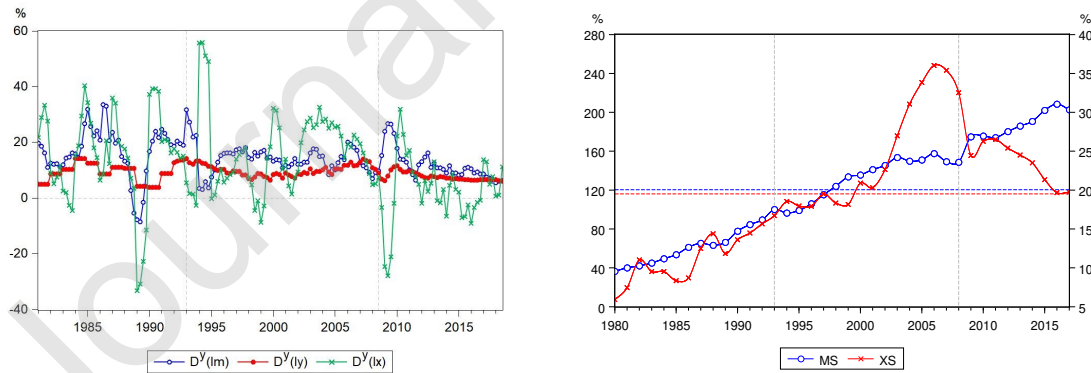
Notes: The unit for each variable is percent annual rates (% pa). $D^y(lm)$ gives year-on-year growth rate of real money, $D^y(ly)$ of real income, and $D^y(lx)$ of real exports. p gives seasonally adjusted quarterly CPI inflation, R the one-year nominal lending rate, and r the one-year real lending rate.

be in line with wide-reaching liberalisation of Chinese fixed income markets that started in 1996 and ended with a commitment to full liberalization of interest rates in 2013.

Table 2: Correlation Matrices.

1981Q1-2018Q3:						
	$D^Y(lm)$	$D^Y(Iy)$	$D^Y(Ix)$	p	R	r
$D^Y(lm)$	1	0.29***	0.21***	-0.38***	0.03	0.48***
$D^Y(Iy)$	0.29***	1	0.31***	0.22***	0.21***	-0.20**
$D^Y(Ix)$	0.21***	0.31***	1	0.02	0.06	0.00
p	-0.38***	0.22***	0.02	1	0.70***	-0.95***
R	0.03	0.21***	0.06	0.70***	1	-0.46***
r	0.48***	-0.20**	0.00	-0.95***	-0.46***	1
1981Q1-1992Q4:						
	$D^Y(lm)$	$D^Y(Iy)$	$D^Y(Ix)$	p	R	r
$D^Y(lm)$	1	0.30**	0.71***	-0.76***	-0.36**	0.74***
$D^Y(Iy)$	0.30**	1	0.17	-0.19	-0.27***	0.14
$D^Y(Ix)$	0.71***	0.17	1	-0.59***	-0.42***	0.54***
p	-0.76***	-0.19	-0.59***	1	0.50***	-0.97***
R	-0.36**	-0.27***	-0.42***	0.50***	1	-0.28*
r	0.74***	0.14	0.54***	-0.97***	-0.28*	1
1993Q1-2018Q3:						
	$D^Y(lm)$	$D^Y(Iy)$	$D^Y(Ix)$	p	R	r
$D^Y(lm)$	1	0.27***	-0.29***	-0.20**	0.12	0.32***
$D^Y(Iy)$	0.27***	1	0.44***	0.56***	0.49***	-0.51***
$D^Y(Ix)$	-0.29***	0.44***	1	0.33***	0.18*	-0.33***
p	-0.20**	0.56***	0.33***	1	0.77***	-0.95***
R	0.12	0.49***	0.18*	0.77***	1	-0.54***
r	0.32***	-0.51***	-0.33***	-0.95***	-0.54***	1

Notes: Null hypothesis: the correlation coefficient between variables is zero. * denotes to reject the null hypothesis at 10% significance level, ** at 5% significance level and *** at 1% significance level. $D^Y(lm)$ gives year-on-year growth rate of real money, $D^Y(Iy)$ of real income, and $D^Y(Ix)$ of real exports. p gives seasonally adjusted quarterly CPI inflation, R the one-year nominal lending rate, and r the one-year real lending rate.

Figure 1: Real Money, Income and Export Growth; Money and Exports as Share of GDP.

Note: In the left-hand subgraph, the blue line represents year-on-year growth rate of real money ($D^Y(lm)$), the red line represents year-on-year growth rate of real income ($D^Y(Iy)$), and green line represent year-on-year growth rate of real money real exports ($D^Y(Ix)$). In the right-hand subgraph, the blue line represents money share in the GDP (MS), and the red line represents exports share in the GDP (XS); the blue dashed line represents the average money share in the GDP, and the red dashed line represents the average exports share in the GDP.

6. Results

The VECM imposes economic restrictions on the VAR and these restrictions allow estimation and interpretation of the long-run equilibrium relationships. Thus both the unrestricted VAR and the restricted VECM are informative in different ways. We begin with the specification of an unrestricted VAR in section 6.1, we then impose the normalisation restrictions outlined in section 4.2 to investigate the cointegrating relationships in the VECM. Cointegration tests do not reject the hypothesised cointegrating vectors so we proceed with the analysis of the cointegration relationships and the adjustment processes that ensure the stability of long-run equilibrium relationships. Following the cointegration analysis, we return to the unrestricted VAR to analyse the interaction between the variables using generalised impulse responses. This is in the spirit of Sims (1980) in that it avoids imposing identifying restrictions.

6.1. VAR Specification

We chose the specification of the VAR based on economic theory, which in the light of section 4 informs the selection of variables, and statistical adequacy, as measured by information criteria. These are used to determine lag-lengths and structural breaks. We also check other diagnostic statistics. Lag length 5 was chosen. The Johansen maximum likelihood procedure employed in section 6.2 is based on normally distributed errors, the residuals can be leptokurtic.¹⁰ We hence tolerate some degree of non-normality. We estimate the model separately for three different samples: the whole period, 1980Q1-2018Q3; the early reform period, 1980Q1-1992Q4; and the late reform stage, 1993Q1-2018Q3. A trend is included for the early reform period. Table 3 gives a summary of information criteria for models estimated.

The sums of both information criteria across the two sub-samples are much lower than those obtained for the whole sample. This indicates that estimating models separately for early and late reform periods yields an improved fit. It further suggests the existence of a structural break in 1992, in line with hypothesis H2. Equipped with this, we proceed with estimates of the sub-samples rather than the whole period.

¹⁰Juselius (2006) argued that it is not necessary for the residuals in the VARs to have normal distribution, if this is caused by excess kurtosis.

Table 3: Information Criteria for Different Sub-samples.

VAR: 1980Q1-2018Q3				VAR: 1980Q1-1992Q4				VAR: 1993Q1-2018Q3			
Trend	Con-stant	AIC	BIC	Trend	Con-stant	AIC	BIC	Trend	Con-stant	AIC	BIC
Yes	Yes	-8.36	-5.65	Yes	Yes	-8.10	-2.79	Yes	Yes	-10.52	-7.06
No	Yes	-8.34	-5.73	No	Yes	-7.64	-2.52	No	Yes	-10.55	-7.22

6.2. Cointegration Analysis

The cointegration properties of the data are investigated in two steps. We first test the existence of cointegrating relationships using the Johansen procedure, that we then specify in terms of the two cointegrating vectors below. We estimate the cointegrating vectors separately for data before and after 1992 and discuss adjustment processes and stability of the relationships.

6.2.1. Cointegration Tests

The Johansen test results are ambiguous (see Table 4). The trace and maximum eigenvalue cointegration tests indicate the existence of either 2 or 3 cointegrating vectors for the early reform period, and either 1 or 2 cointegrating vectors for the late reform period, depending on assumptions about deterministic terms. We proceed with the assumption of two cointegrating vectors, given the more natural interpretation in line with theoretical predictions and later investigate feedback to these cointegrating vectors to draw conclusions on the stability of long run money demand and IS relationships.

Table 4: Johansen Test for Cointegration: Selected (5% significance level*) Number of Cointegrating Relations by Model.

Data Trend:	None	None	Linear	Linear	Quadratic
Test Type	No Intercept No Trend	Intercept No Trend	Intercept No Trend	Intercept Trend	Intercept Trend
1980Q1-1992Q4:					
Trace	3	2	2	3	3
Max-Eig	2	2	2	2	2
1993Q1-2018Q3:					
Trace	2	2	2	1	1
Max-Eig	1	2	2	2	2

Notes: The Johansen test are based on a VECM(4) of 5-variables (lm, ly, lx, p, R) which does not include seasonals.

6.2.2. Restrictions

As discussed in greater detail in section 4.2, we need to impose two further restrictions on each cointegrating vector in addition to normalising restrictions to achieve unique identification of parameters. Accordingly, for the first cointegrating vector, we assume no impact of exports on money demand and set the respective coefficient equal to zero. In line with theory, exports will instead affect money demand via income. In the second cointegrating vector, we set the coefficient of money equal to zero, assuming neutrality of money in the long run. We further considered restrictions on real interest rates, which assume that the sum of the coefficients on inflation, p , and interest rates, R , is zero. This allows specifying the long run relationships in terms of real ex-post interest rates. A likelihood-ratio test for binding restrictions rejects this on a 5% level for the early sample and does not reject it for the late sample.¹¹ Cointegrating vectors and adjustment coefficients are given in Table 5 for the early and Table 6 for the late sample.

6.2.3. Money Demand

Following the above, money demand relationships can be estimated as

$$lm_t^* = \underset{(0.078)}{1.51} ly_t - \underset{(0.011)}{0.04} (R_t - p_t) - 2.86, \quad (6.1)$$

for the early reform period and

$$lm_t^* = \underset{(0.011)}{1.46} ly_t + \underset{(0.002)}{0.01} (R_t - p_t) - 2.42, \quad (6.2)$$

for the late reform period, where lm^* is the equilibrium level of real money; the difference between interest rates and inflation, $R_t - p_t$, is real interest rates, r_t . Standard errors are provided in parentheses.

In both cointegrating equations (6.1) and (6.2), the income elasticity of demand for money is positive as one would expect since increases in income implies an increase in transaction volumes and hence money demand. It is significantly greater than one, and similar in the two periods: 1.51 in the early period and 1.46 in the late period. The role of opportunity costs, real interest rates, in money demand is significant in both periods, negative in the early period, but small and positive in the late period. One

¹¹These results are robust to employing deposit rates instead. See Tables A.9 and A.10 in Appendix A for further details.

would expect people to hold less money as interest rates rise, which is what happens in the first period. However, the money measure, M2, is a broad money and includes interest bearing time deposits and this may account for the positive association, following the reforms which removed restrictions on the financial system.

6.2.4. IS Relationship

A cointegrating equation that is normalised on income can be interpreted as a long run IS relationship. Here we have for the early sample

$$ly_t^* = \underset{(0.027)}{0.7} lx_t + \underset{(0.006)}{0.01} (R_t - p_t) + 3.8, \quad (6.3)$$

and for the late sample

$$ly_t^* = \underset{(0.023)}{0.68} lx_t - \underset{(0.006)}{0.03} (R_t - p_t) + 3.94, \quad (6.4)$$

where ly_t^* is the equilibrium level of real money. Both equations unsurprisingly highlight the role of exports for the Chinese economy. Real interest rates also enter significantly, albeit with different signs. The negative impact in the late period is what one might expect in a market economy. There are possible supply side and demand side explanations for the positive effect of interest rates on output in situations of financial repression characteristic of the early reform period. On the supply side higher interest rates, increase financial intermediation and improve allocation. [Balassa \(1989\)](#) describes how improvements in financial intermediation increases the productivity of savings, as resources that were outside the financial sector such as inventory accumulation are shifted towards the financial sector. This more efficient accumulation of financial wealth associated with higher interest rates has positive effects on productivity and income. There is also a demand side effect as higher interest rates increase wealth and boost consumption raising output. [Carroll et al. \(2010\)](#) find evidence for consumption-wealth-effects for US housing data. For China, capital-account restrictions may exacerbate this effect.

These results show that a general equilibrium based on a simple IS-LM framework can be reliably estimated for China and that the 1992 reforms changed the role of interest rates in the system. Tables [A.9](#) and [A.10](#) in the appendix again give estimates using deposit interest rates, which give similar results.

Table 5: VECM Estimates for Early Reform Period.

Cointegrating Equation:						
	$lm(-1)$	$ly(-1)$	$lx(-1)$	$p(-1)$	$R(-1)$	C
CointEq1	-1	1.507 (0.079)	0	0.036 (0.011)	-0.036 (0.011)	-2.856
CointEq2	0	-1	0.701 (0.027)	-0.007 (0.006)	0.007 (0.006)	3.800
Error Correction:						
	$D(lm)$	$D(ly)$	$D(lx)$	$D(p)$	$D(R)$	
CointEq1	-0.419 (0.158)	-0.172 (0.067)	-0.648 (0.231)	26.967 (5.514)	4.832 (1.627)	
CointEq2	-0.805 (0.281)	-0.206 (0.119)	-1.209 (0.412)	51.325 (9.814)	6.672 (2.897)	
R-squared	0.798	0.996	0.921	0.873	0.731	
S.E. equation	0.039	0.016	0.057	1.351	0.399	
Akaike AIC	-3.364	-5.074	-2.595	3.746	1.305	
Schwarz SC	-2.458	-4.168	-1.690	4.651	2.211	
S.D. dependent	0.062	0.199	0.146	2.734	0.555	

Notes: Standard errors are in the parenthesis. 47 observations are included. AIC is -7.146 and BIC is -2.225. Restrictions identify all cointegrating vectors at 1% significance level. The LR test for binding restrictions (rank = 2): Chi-square(2) is 7.707, and Probability is 0.021. lm gives the logarithm of real money, ly the logarithm of real income, lx the logarithm of real exports, p the CPI inflation, and R the one-year nominal lending rate. D is the difference operator.

6.2.5. Short Run Adjustment

In the following, we investigate adjustment to long-run money demand and IS functions, that were estimated above. There is evidence for adjustment to the estimated long-run relationships, if adjustment coefficients have opposite signs to coefficients estimated in the cointegrating equation. In that case the adjustment would be stabilising over time.

For money demand, in the early reform stage, income and nominal interest rates' adjustment to the previous disequilibrium of money is significantly stabilising, whilst inflation and the adjustment coefficient of money to the previous equilibria both suggest destabilising dynamics. For the latter this suggests that the cointegrating relationship is unstable. In the late reform stage income and nominal interest rates' significantly adjust, whilst inflation remains destabilising. Error-correction of the system to previous disequilibria, given by the adjustment coefficient of money with its own lag, is estimated at 5.7% within one quarter, albeit insignificantly.

For the IS relationship, we find a significantly stabilising impact of exports and inflation for the early

Table 6: VECM Estimates for Late Reform Period.

Cointegrating Equation						
Cointegrating Eq:						
	$lm(-1)$	$ly(-1)$	$lx(-1)$	$p(-1)$	$R(-1)$	C
CointEq1	-1	1.460 (0.011)	0	-0.007 (0.002)	0.007 (0.002)	-2.420
CointEq2	0	-1	0.683 (0.023)	0.033 (0.006)	-0.033 (0.006)	3.941
Error Correction:						
	$D(lm)$	$D(ly)$	$D(lx)$	$D(p)$	$D(R)$	
CointEq1	0.057 (0.081)	-0.071 (0.028)	-0.433 (0.246)	-13.400 (3.522)	-4.527 (1.246)	
CointEq2	-0.014 (0.023)	0.022 (0.008)	-0.021 (0.068)	-3.917 (0.978)	-0.167 (0.346)	
R-squared	0.394	0.998	0.795	0.690	0.471	
S.E. equation	0.021	0.007	0.065	0.927	0.328	
Akaike AIC	-4.656	-6.816	-2.441	2.881	0.802	
Schwarz SC	-4.068	-6.228	-1.852	3.469	1.391	
S.D. dependent	0.024	0.157	0.127	1.475	0.399	

Notes: Standard errors are in the parenthesis. 103 observations are included. AIC is -10.390 and BIC is -7.192. Restrictions identify all cointegrating vectors. The LR test for binding restrictions (rank = 2): Chi-square(2) is 1.092, and Probability is 0.579. lm gives the logarithm of real money, ly the logarithm of real income, lx the logarithm of real exports, p the CPI inflation, and R the one-year nominal lending rate. D is the difference operator.

reform period. In the late sample, inflation and exports are stabilising, albeit insignificantly for the latter. Nominal interest rates are destabilising. The cointegration relationship is overall significantly stabilising in both periods.

6.3. Impulse Response Analysis

Table 7 reports residual correlation matrices of the system that enter GIRFs. We find that monetary aggregates are more closely associated with interest rates in the late sample and income is gaining in importance. Whilst the impact of income on money increases in the late sample, this remains insignificant in both samples.

Plots of the responses to one-standard deviation generalised impulses are in [Appendix A](#), [Figure A.2](#) for the early reform period and [Figure A.3](#) for the late reform period.¹² The GIRFs for the late sample

¹²We consider estimates that control for potential effects of the financial crisis, which gives similar results. See [Figure A.5](#) of [Appendix A](#) for respective GIRFs.

Table 7: VAR Residual Correlations.

1980Q1-1992Q4:						
	<i>lm</i>	<i>ly</i>	<i>lx</i>	<i>p</i>	<i>R</i>	
<i>lm</i>	1	-0.001	0.419***	-0.527***	-0.355	
<i>ly</i>	-0.001	1	0.155	0.215	0.149	
<i>lx</i>	0.419***	0.155	1	0.321	-0.401***	
<i>p</i>	-0.527***	0.215	0.321	1	0.136	
<i>R</i>	-0.355	0.149	-0.401***	0.136	1	
1993Q1-2018Q3:						
	<i>lm</i>	<i>ly</i>	<i>lx</i>	<i>p</i>	<i>R</i>	
<i>lm</i>	1	0.039	-0.240**	-0.162	-0.167**	
<i>ly</i>	0.039	1	0.234**	0.308***	0.122	
<i>lx</i>	-0.240**	0.234**	1	0.005	-0.065	
<i>p</i>	-0.162	0.308***	0.005	1	-0.028	
<i>R</i>	-0.167**	0.122	-0.065	-0.028	1	

Notes: Null hypothesis: the correlation coefficients between variables are zero. * denotes 10% significance level, ** denotes 5% significance level, *** denotes 1% significance level. *lm* gives the logarithm of real money, *ly* the logarithm of real income, *lx* the logarithm of real exports, *p* the CPI inflation, and *R* the one-year nominal lending rate.

have much lower volatility, which is in line with a general reduction in variances that could be observed between the samples. The early sample shows hardly any significant responses apart from inflationary shocks. The significance of the responses increased in the late sample. Now lagged exports significantly affect money and income. Also income, money and prices significantly affect interest rates and interest rates significantly affect money. It is also interesting to note that seasonality, particularly of income, has decreased substantially in the late sample, where overall responses appear more stable.

7. Conclusion

This paper uses multivariate vector autoregressions, VARs, and cointegrating vector error correction models, VECMs, to investigate the relationships between money, income, exports, inflation and interest rates in China. We focus on the period since 1978, and find a structural break associated with the 1992 reforms, so present separate estimates for an early period 1980Q1-1992Q4, and a late period, 1993Q1-2018Q3. Using the unrestricted VAR, generalised impulse response functions show that whereas the earlier period is dominated by the effects of inflationary shocks, there are much stronger economic linkages in the late period and far more significant interactions between variables.

Using the VECM, there is evidence for two cointegrating vectors representing long-run equilibrium relationships which can be interpreted as an LM function, in which income and interest rates determine

money demand and an open economy IS function in which exports and interest rates determine output. The 1992 reforms which transformed the financial system changed the role that interest rates played in both these relationships. The estimated adjustment coefficients showed the stabilising relationships which returned the system to equilibrium. Adjustment to equilibrium was faster in the late period and interest rate adjustment played a different role in the two periods. It is possible that there was another structural break after the 2007-9 financial crisis, but the estimates were not precise enough to be sure of this.

Although the strength of estimated relationships is not the same as in developed market economies, stable money and income functions that resemble an IS-LM framework, can be reliably estimated for China. These results provide important evidence on China's economic transition to a market-based system, based on stable money and goods market equilibria. There are two main policy implications that these results might have: First, evidence that the Chinese economy is driven by market equilibrium conditions supports the view of that China should receive market economy status in the WTO, which is subject to ongoing disputes. Secondly, China's shift towards a market-based allocation appears to be related to a series of reforms that aimed at corporate and bank marketisation in particular. There are suggestions that a renewed marketisation effort might increase China's potential growth path. Our evidence supports that view.

A number of suggestions for future research emerge from this study. Further research could explore monetary policy shocks in a structural vector autoregressive framework. We abstain from this and follow a largely atheoretical approach that is less restrictive. Lastly, our conclusions are limited by the data employed. Whilst we use longer series than most similar studies, China's continuing transition likely implies further changes to estimated relationships in the future. Observed export dynamics throughout the last decade are indicative of further structural breaks that are promising to be investigated in future research.

Acknowledgements

We are grateful for very useful comments from three anonymous reviewers and from Yunus Aksoy, Hong Bo, Sandeep Kapur, Stephen Millard, Paul Mizen, Joseph Pearlman, Stephen Wright, Zhichao Zhang

and from attendees of the 2018 Birkbeck Jamboree and PhD's seminars, as well as from attendees at the MMF2019 PhD Conference, the EcoMod2019, and BCAM workshop in 2019.

Declaration of Interest Statement

Declaration of interest: none.

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Appendix A. Appendix

Appendix A.1. Figures and Tables for Section 5

Table A.8: Description of Main Variables.

Abbr.	Indicator	Source
M	Banking Survey: Money Plus Quasi Money (Current billion Chinese yuan)	CEIC:1978Q1-2018Q1; NBSC: M2,2018Q2-18Q4
Y	GDP (Current billion Chinese yuan)	DS (CHXGDP.A)
y	Real GDP (2010 price)	DS (CHXGDPR.C): 1980Q1-2018Q3; DS (CHXGDPR.C): 2018Q4-19Q1
X	Exports: fob: RMB (Current billion Chinese yuan)	CEIC: 1981Q1-2018Q1; DS: 1980Q1-2018Q3
CPI	Consumer Price Index (2010Q1=100, seasonally adjusted)	Mohaddes and Raissi (2018): 1979Q2-2016Q4; CEIC: 2017Q1-18Q1; DS: 2018Q1-18Q3
p	Quarterly Inflation in Percent Annual Rates (% pa, seasonally adjusted)	Mohaddes and Raissi (2018): 1979Q2-2016Q4; CEIC: 2017Q1-18Q1; DS: 2018Q1-18Q3
R	Lending Rate (1 year) (% pa)	CEIC: 1980Q1-2018Q1; DS (CHLD11Y): 2018Q2-2019Q1
r	Real Lending Rate (1 year) (% pa)	CEIC: 1980Q1-2018Q1; DS (CHLD11Y): 2018Q2-2018Q3
lm	natural logarithm of real M , m	
ly	natural logarithm of y	
lx	natural logarithm of real exports	

Notes: This paper uses data from 1980Q1-2018Q3. M approximately equals broad money, M2: Based on CEIC data, broad money (M2) approximately equals narrow money (M1) plus quasi money. Data was available for “money (narrow money) plus quasi money” from 1978Q1-2018Q1 in the CEIC database, which we use as a measure for broad money. % pa means percent annual rates. We convert R into real interest rate, r : $r (\%) = [R (\%) / 100 - p (\%) / 100] / [1 + p (\%) / 100] * 100$.

Appendix A.2. Figures and Tables for Section 6

Table A.9: VECM Estimates for Early Reform Period using Deposit Interest Rates.

Cointegrating Equation:						
	$lm(-1)$	$ly(-1)$	$lx(-1)$	$p(-1)$	$DR(-1)$	C
CointEq1	-1	1.671 (0.011)	0	0.021 (0.002)	-0.021 (0.002)	-4.030
CointEq2	0	-1	0.653 (0.022)	0.004 (0.006)	-0.004 (0.006)	4.031
Error Correction:						
	$D(lm)$	$D(ly)$	$D(lx)$	$D(p)$	$D(DR)$	
CointEq1	-0.160 (0.177)	-0.222 (0.063)	-0.503 (0.269)	16.640 (6.929)	6.997 (1.633)	
CointEq2	-0.570 (0.227)	-0.212 (0.081)	-1.063 (0.344)	35.298 (8.852)	5.775 (2.086)	
R-squared	0.800	0.998	0.916	0.843	0.806	
S.E. equation	0.038	0.014	0.058	1.501	0.354	
Akaike AIC	-3.373	-5.430	-2.540	3.956	1.066	
Schwarz SC	-2.467	-4.525	-1.634	4.862	1.972	
S.D. dependent	0.062	0.199	0.146	2.734	0.581	

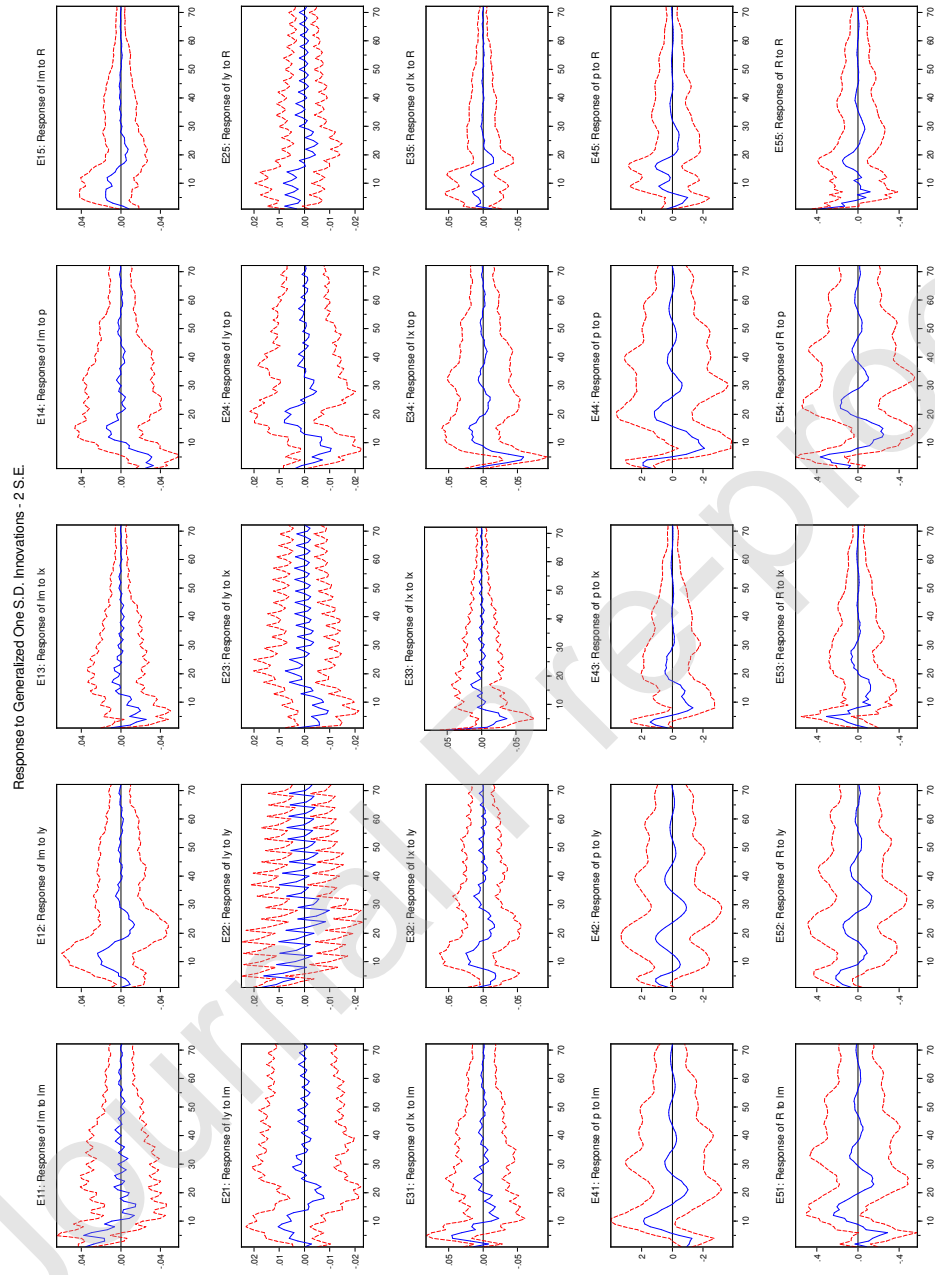
Notes: We assume that there are 2 cointegrating vectors. Standard errors are in parentheses. 47 observations are included. AIC is -7.191 and BIC is -2.27. Restrictions identify all cointegrating vectors. LR test for binding restrictions (rank = 2): Chi-square(2) is 13.729, and Probability is 0.001. lm gives the logarithm of real money, ly the logarithm of real income, lx the logarithm of real exports, p the CPI inflation, and DR the nominal deposit interest rates. D is the difference operator.

Table A.10: VECM Estimates for Late Reform Period using Deposit Interest Rates.

Cointegrating Equation:						
	$lm(-1)$	$ly(-1)$	$lx(-1)$	$p(-1)$	$DR(-1)$	C
CointEq1	-1	1.464 (0.010)	0	-0.010 (0.002)	0.010 (0.002)	-2.435
CointEq2	0	-1	0.664 (0.025)	0.046 (0.008)	-0.046 (0.008)	3.980
Error Correction:						
	$D(lm)$	$D(ly)$	$D(lx)$	$D(p)$	$D(DR)$	
CointEq1	0.080 (0.084)	-0.074 (0.029)	-0.658 (0.253)	-11.563 (3.496)	-5.750 (1.490)	
CointEq2	-0.006 (0.021)	0.016 (0.007)	-0.055 (0.062)	-3.851 (0.861)	-0.410 (0.367)	
R-squared	0.358	0.998	0.785	0.696	0.498	
S.E. equation	0.022	0.007	0.066	0.917	0.391	
Akaike AIC	-4.599	-6.755	-2.390	2.859	1.154	
Schwarz SC	-4.011	-6.166	-1.802	3.448	1.742	
S.D. dependent	0.024	0.157	0.127	1.475	0.489	

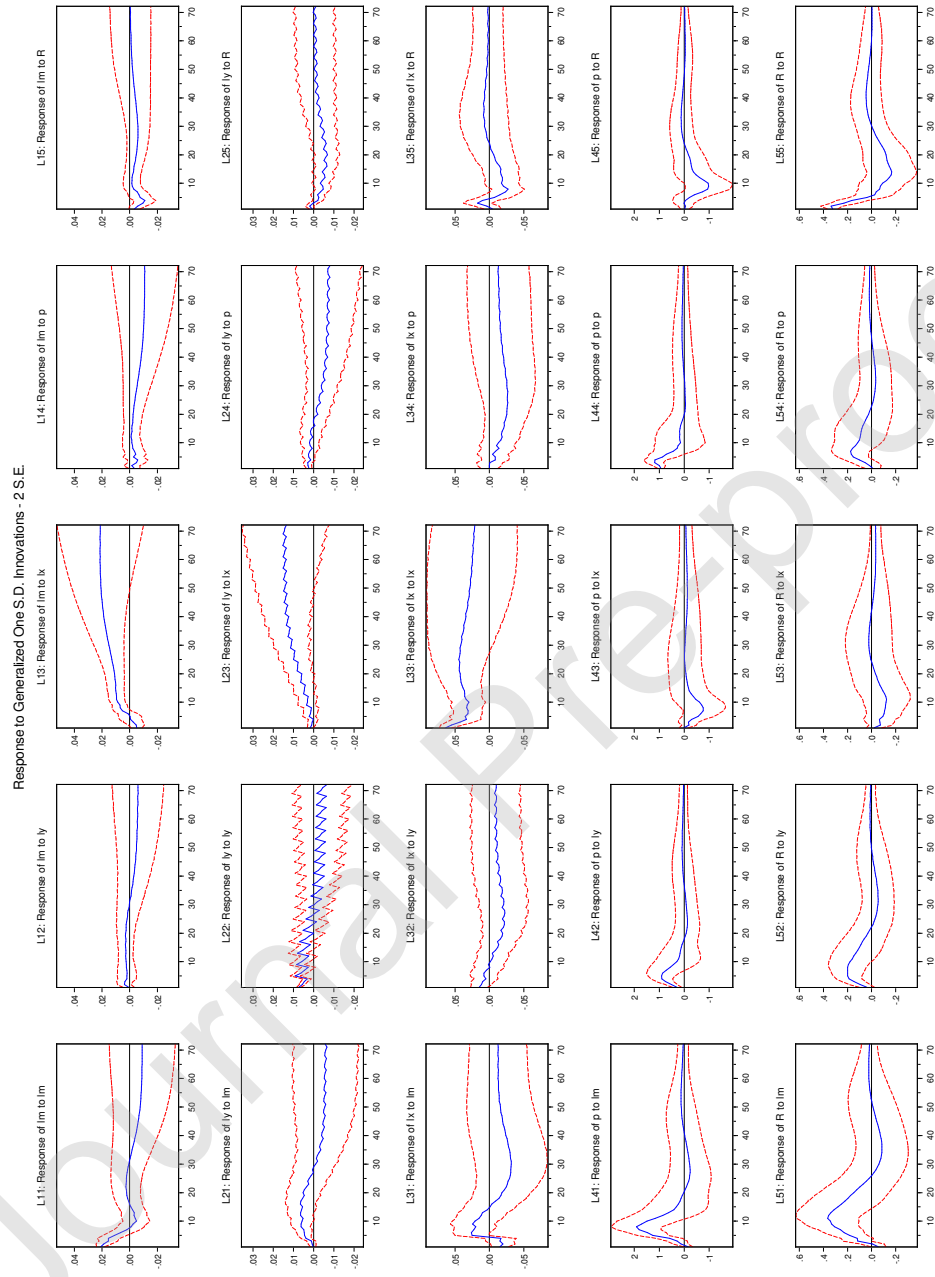
Notes: We assume that there are 2 cointegrating vectors. Standard errors are in parentheses. 47 observations are included. AIC is -9.938 and BIC is -6.74. Restrictions identify all cointegrating vectors. LR test for binding restrictions (rank = 2): Chi-square(2) is 1.07, and Probability is 0.586. lm gives the logarithm of real money, ly the logarithm of real income, lx the logarithm of real exports, p the CPI inflation, and DR the nominal deposit interest rates. D is the difference operator.

Figure A.2: Generalised Impulse Responses for Early Reform Period.



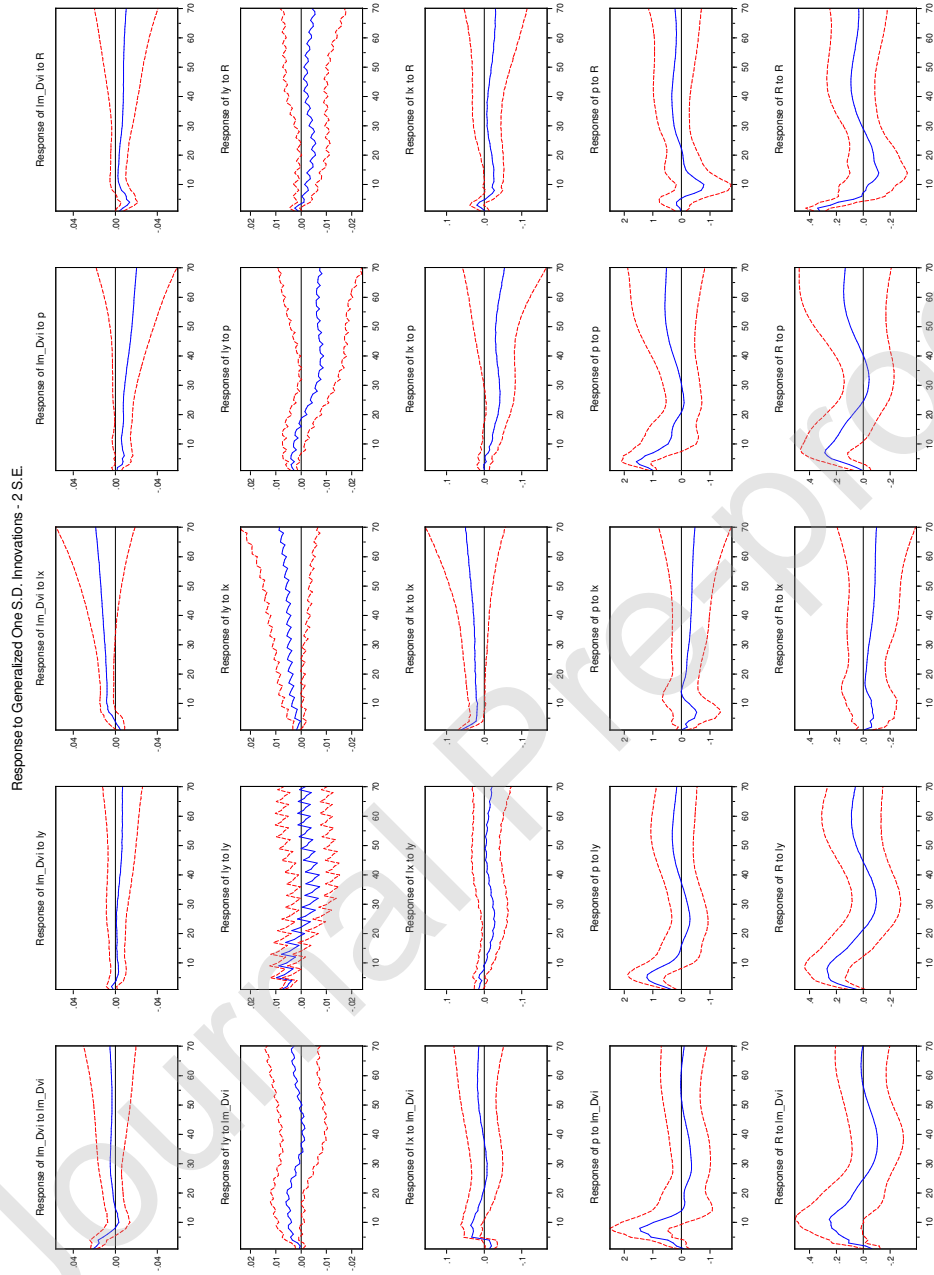
Notes: The blue solid lines gives generalized impulse responses to a one-standard deviation of the variables mentioned on each respective panel. The red dashed lines respective 95% confidence bands. The response standard errors are analytic. lm gives the logarithm of real money, lx the logarithm of real income, ix the logarithm of real exports, p the CPI inflation, and R the one-year nominal lending rate.

Figure A.3: Generalised Impulse Responses for the Late Reform Period.



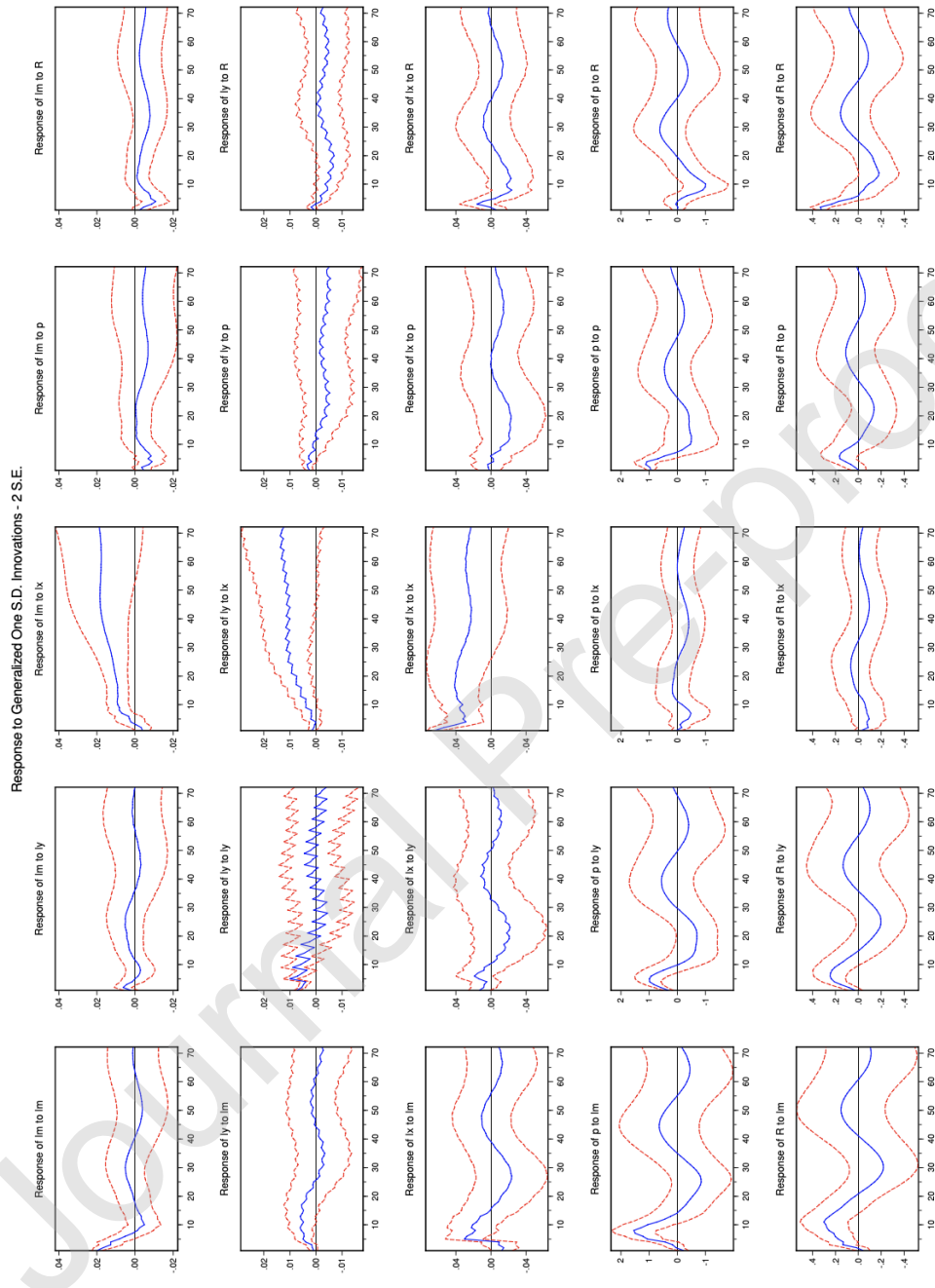
Notes: The blue solid lines gives generalized impulse responses to a one-standard deviation of the variables mentioned on each respective panel. The red dashed lines respective 95% confidence bands. The response standard errors are analytic. lm gives the logarithm of real money, y the logarithm of real income, k the logarithm of real exports, p the CPI inflation, and R the one-year nominal lending rate.

Figure A.4: Generalised Impulse Responses for the Late Reform Period using Divisia M2.



Notes: The blue solid lines gives generalized impulse responses to a one-standard deviation of the variables mentioned on each respective panel. The red dashed lines respective 95% confidence bands. The response standard errors are analytic. Estimates are obtained with Divisia M2 rather than the M2 monetary aggregate. *Im_Dvi* gives the logarithm of real Divisia broad money, *y* the logarithm of real income, *ix* the logarithm of real exports, *p* the CPI inflation, and *R* the one-year nominal lending rate.

Figure A.5: Generalised Impulse Responses for the Late Reform Period including Financial Crisis Indicator.



Notes: The blue solid lines gives generalized impulse responses to a one-standard deviation of the variables mentioned on each respective panel. The red dashed lines respective 95% confidence bands. The response standard errors are analytic. Estimates are controlling for potential effects of the financial crisis by considering an indicator variable for observations after 2007. ln gives the logarithm of real money, ly the logarithm of real income, lx the logarithm of real exports, p the CPI inflation, and R the one-year nominal lending rate.