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MODELLING MONEY SHOCKS IN A SMALL OPEN ECONOMY: THE CASE OF TAIWAN*

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This paper explores the relevance of the Divisia monetary aggregate in Taiwan over the period January, 1985 through to June, 2016. We apply a block recursive structural VAR approach that is adapted to a small open economy by adding the New Taiwan Dollar/US Dollar exchange AQ3 rate to the block of economic activity indicators. We test the hypothesis that measures of money constructed using the Divisia index number formulation are superior indicators of monetary conditions when compared to the central bank's main policy rate, the Taiwanese discount rate. We find that using properly measured monetary data solves short-run price, output and exchange rate puzzles and leads to sensible long-run impulse responses to monetary shocks. Future work on the optimization of the construction of the Divisia index number formulation is recommended.

1 Introduction

Since the first discussions of the Equation of Exchange, economists knew that finding a measure for 'M' was of central importance to empirical work. Schumpeter's (1954) History of Economic Analysis, for example, cites numerous views on the definition of money from both European and American perspectives over the period 1870–1911. By the end of the 1970s, the demand for money appeared to be a stable function of a few key macroeconomic variables, changes in the supply of money appeared to have significant short-run effects on output and inflation appeared to be closely related to the trend rate of money growth (see, e.g. Binner *et al.*, 2010, for more details). But many economists now believe that the link between the quantity of money and economic indicators has weakened over the last two decades due in part to rapid innovations in the financial sector, see Binner *et al.* (2004). In the mid-1980s, economies throughout the developed world began experiencing financial innovation that has had substantial effects on the relative user-costs ('prices') of the increasingly broad portfolio of monetary

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assets. The substantial financial innovations of the 1980s introduced instability into estimated demand functions for broad money, and it was largely because of this instability that monetary aggregates have been discounted as macroeconomic indicators, (see, e.g. Friedman, 1996).

Recent empirical work (see, e.g. Keating *et al*., 2014), however, argues that the breakdown in the demand for money functions during the 1980s outlined above is mainly attributable to the use of conventional simple sum monetary aggregates. These aggregates assume that the monetary portfolio is comprised of perfect substitutes; and hence, each component asset should appear in aggregate money with equal weights. It is now widely acknowledged that the simple sum procedure traditionally used by central banks is inappropriate in the absence of perfect substitutability between the component assets, (see, e.g. Binner *et al*., 2010 and Barnett and Chauvet 2011). The latter contend that most recessions in the past 50 years were preceded by more contractionary monetary policy than was indicated by simple-sum monetary data. More recently over the last few years, a number of other contributions have shown that broad money when measured correctly, can contribute significantly to the understanding of macroeconomic fluctuations, see e.g. Belongia and Ireland (2014) and El-Shagi *et al*. (2015).

Diewert (1976, 1978) and Barnett (1978, 1980) have demonstrated that the index formulation devised by Divisia (1925) is a theoretically consistent means to encapsulate a monetary aggregate and its dual price index. A Divisia index of money measures the flow of monetary services from a stock of money holdings and has its roots firmly based in microeconomic aggregation and statistical index number theory. Barnett *et al*. (1992) provides a survey of the relevant literature, whilst Hancock (2005) reviews the construction of Divisia indices and associated problems. For example, the choice of the benchmark asset is a research problem of great academic interest. To assign user costs to each constituent asset, an asset which does not yield any transactions services has to be selected against which the opportunity cost of these services can be measured. In continuous time, the user cost of a monetary asset is then simply the difference between the return on the non-monetary asset 'benchmark' less its own rate of return. The construction of the user cost of each constituent component asset to be included in the Divisia aggregate has still not been optimized and is beyond the scope of this current empirical application to the Taiwan economy, although a problem worthy of future research. Improvements to the construction of Divisia indices are high on the agenda at the Bank of England and are documented in Berar (2013).

In principle, the benchmark asset has to be capital certain in order to make it comparable to other monetary assets, and not to offer any transactions services. Assets which offer some transactions services should themselves be included in the Divisia aggregate. This implies that assets for which there are active secondary markets cannot be considered, since the existence of a secondary market would enable holdings of this asset to be converted readily

into (more liquid) assets that could be used for transactions. There are not many assets which satisfy these two criteria. Some of the earlier work on Divisia (see e.g. Spencer, 1989 and Batchelor, 1988a and 1988b) used the local authority deposit rate as the benchmark asset's return. It is difficult to explain why some studies use corporate bond yields (see e.g. Belongia and Chalfont (1989)), since these include significant default premia and are traded in an active secondary market. The benchmark asset will not in general be the same asset in different periods since money holders will in principle select the highest yielding non-monetary asset. Although advocates of the Divisia approach recognize this, in practice, most studies use one single benchmark rate since there are few non-monetary assets that are capital certain and for which there is no active secondary market. More recent work has adopted the approach of utilizing the maximum available rate from a given data set of interest rates as the benchmark asset; see e.g. Bissoondeeal *et al*. (2010).

New empirically weighted monetary aggregates have been developed for 11 countries (Belongia and Binner, 2000), and further extensions to allow for the risk of holding capital uncertain assets have been derived by Barnett and Liu (2000) for the USA and Elger and Binner (2004) for the UK.

This study is motivated by a desire to gather further empirical evidence of the relevance of Divisia money as a macroeconomic policy tool. Specifically, we investigate the econometric performance of Divisia indices in Taiwan, extending the work of Shih (2000), Binner *et al*. (2004) and Kelly *et al*. (2014) to consider the case of the performance of a new Divisia aggregate for Taiwan in an open economy framework. This is an important advance because it demonstrates the information contained in monetary aggregates about monetary shocks in a small open economy such as Taiwan is vastly different from the US economy studied in the earlier work. The shift to M2 as a policy target in Taiwan has aroused concern about whether or not the traditional simple sum measure of money which gives each component asset of the M2 aggregate an equal weight can serve as an appropriate measure of monetary services flow in society (Shih, 2000, p. 227). We explore the relevance of the Divisia monetary aggregate by applying a new structural VAR approach developed by Keating *et al*. (2014) for the first time to Taiwan over the period 1985M01 to 2016M06. The Keating *et al*. (2014) model is adapted to a small open economy by adding the New Taiwan Dollar/US Dollar exchange rate to the block of economic activity indicators. Our hypothesis developed over a series of studies and summarized in Binner *et al*. (2010) is that measures of money constructed using the Divisia index number formulation are superior indicators of monetary conditions when compared to the central bank's main policy rate, in this current case, the Taiwanese discount rate. This hypothesis is reinforced by a growing body of evidence from empirical studies around the world that demonstrate weighted index number measures ability to overcome the drawbacks of the simple sum (Belongia and Binner, 2000). Ultimately, such evidence could reinstate money as a valid

macroeconomic indicator containing non-redundant information about the economy. In this current work, we find that using properly measured monetary data solves short-run price, output and exchange rate puzzles and leads to sensible long-run impulse responses to monetary shocks. Interested readers are referred to e.g. Brissimis and Magginas (2006) for a definition of the 'puzzle' terminology which is widely used in macroeconomic debates.

The remainder of this paper is organized as follows. Section 2 provides a brief summary of monetary history in Taiwan. Section 3 explains the construction of the Divisia quantity and user cost monetary aggregates. Section 4 provides a description of the empirical experiment including a description of the data used, and the VAR identification. The results and discussions of our econometric experiment are presented in Section 5 whilst Section 6 concludes and offers suggestions for future research.

2 Financial Innovation and the Divisia Monetary Aggregate in Taiwan

The banking system in Taiwan was heavily regulated by the Taiwanese Central Bank and the Ministry of Finance until September 1989 when the revised Banking Law was introduced. At the beginning of the 1980s, drastic economic, social and political changes took place creating a long-term macroeconomic imbalance. Rising oil prices caused consumer prices to rise by 16.3 per cent in 1981, followed by a period of near zero inflation in the mid-eighties, although from the nineties onwards inflation has fluctuated around five per cent. The control of inflation has not been the mainstay of recent economic policy in Taiwan, in contrast to the experience of the western world. Rather, policy has focused more on achieving balanced economic and social development; see Shih (2000) for further details of the financial innovation in Taiwan during the late 1980s.

Major financial liberalization measures were implemented in Taiwan in the late 1980s. In July 1987, trade related foreign exchange controls were abolished and capital flow related foreign exchange controls were greatly relaxed. The entry of new securities firms was permitted in January 1988, and as a result the number of securities firms increased from 60 to 150 within the first year (Shih, 2000, p. 227). The limit on daily fluctuations in stock prices was raised from 3 per cent to 5 per cent in 1988 and to 7 per cent the following year. In December 1990, foreign institutional investors were allowed to invest directly in the local stock market. The revised Banking Law, implemented September 1989, resulted in liberalization of controls interest rates paid by banks on deposits and charged by banks on loans. The revised Banking Law also allowed new private commercial banks to be established, by the end of 1993, 16 new private banks had begun operating.

This financial revolution in Taiwan over the last three decades has yielded new types of financial instruments and new markets, as outlined above. These changes have manifested themselves throughout the global

economy in the emergence of competition between and mergers of traditional commercial banks and previously distinct financial institutions. For example, the banks introduced interest payments on formerly non-interest bearing demand deposit accounts together with a wide range of new financial products, stimulating product innovation.

Along with the process of price and entry deregulation, local financial markets expanded rapidly and financial price variables (such as interest rates, exchange rates and stock prices) became flexible and increasingly sensitive to market conditions. The resultant volatility in these financial prices in the second half of the 1980s, unparalleled in the Taiwanese post Second World War history, deeply affected the portfolio choice of households and firms. Consequently, the narrowly defined monetary aggregate, M1B, which is vulnerable to deposit-shift behaviour, fluctuated significantly, Shih (2000, p. 227).

Faced with the increasing instability of money demand for M1B, in 1990 the central bank replaced M1B with the broadly defined monetary aggregate M2 as the intermediate target variable of monetary policy. Since differing degrees of monetary services are provided by the component assets under the definition of the broad aggregate, M2, this shift to M2 as a policy target has aroused concern as to whether the traditional M2, which sums the balances of component assets with equal weights, can serve as an appropriate measure of monetary service flows in society. One solution to this is to apply a Divisia weighting strategy to the component assets to create 'admissible' monetary aggregates, see e.g. Elger *et al*. (2008) for further information on what constitutes an admissible monetary aggregate.

Our objective is to provide an updated picture of the policy relevance of Divisia monetary aggregates and to offer insights into how measuring and managing the liquidity services provided by each constituent component asset can be enhanced in the future across different asset classes and different risk regimes as a comparative approach to obtain valuable feedback for policy implementation in Taiwan. To this end, as a useful point to start, we apply the Divisia monetary aggregate which allows us to measure the liquidity services provided by a spectrum of different asset classes of relevance for monetary policymakers in Taiwan. It is to the construction of the Divisia monetary aggregate and associated user costs of holding the different constituent component assets that we now turn in Section 3.

3 Constructing Divisia Money and Divisia User Costs

Following Anderson and Jones (2011) and Barnett (1980), we construct Divisia money using the Törnquist-Theil discrete time approximation of the continuous time Divisia service flow index number (see Törnquist, 1936; Theil, 1967),

$$M_t = M_{t-1} \prod_{n=1}^{N} \left(\frac{m_{n,t}}{m_{n,t-1}} \right)^{\frac{\omega_{n,t}+\omega_{n,t-1}}{2}} \tag{1}$$

where $m_{n,t}$ is the quantity of monetary asset n held in period t, and

$$\omega_{n,t} = \frac{\psi_{n,t} m_{n,t}}{\sum_{i=1}^{N} \psi_{i,t} m_{i,t}} \tag{2}$$

is the total expenditure share on monetary asset n held in period t. The Törnquist-Theil index is simply Simpson's rule applied to the Divisia index number.

Key to the construction of this aggregate is $\psi_{n,t}$, the user cost of monetary asset n held in period t,

$$\psi_{n,t} = \frac{R_t - r_{n,t}}{1 + R_t}, \tag{3}$$

which was formally derived by Barnett (1978). The user cost of a monetary asset is a function of $r_{n,t}$, which is the own rate of return on of monetary asset n held in period, t, and R_t, which is the rate of return of a pure investment asset, i.e. a 'benchmark asset' that provides no liquidity service. While the own rate of return on such a benchmark asset is not available as an observable series, we proxy the benchmark rate by adding a liquidity premium of 100 basis points to the maximum own rate of return of the monetary assets included in the aggregate (see, e.g. El-Shagi and Kelly (2013) or Hancock (2005) for more information on the construction of the benchmark rate).

In order to construct Divisia monetary aggregates for Taiwan, component assets based on the definition of M2 have been classified into the following categories provided in Table 1 below. According to the historical definitions of money in Taiwan, M2 comprises all assets, that is, deposit-money plus quasi-money listed here in each of the ten categories. All data are monthly and seasonally adjusted and are available from DataStream and the Central Bank of the Republic of China (Taiwan) online database.[1]

4 Empirical Model Setup

4.1 Data Description

The data set includes the following Taiwanese data: natural log of seasonally adjusted industrial production, the natural log of seasonally adjusted consumer price index (CPI), the New Taiwan Dollar (NT$)/US Dollar (US$) exchange rate, to the central bank's main policy rate, i.e. the Taiwanese

[1]See http://www.cbc.gov.tw/ct.asp?xItem=1869&ctNode=511&mp=2 for more on the Central Bank of the Republic of China (Taiwan) online database.

TABLE 1
LIST OF COMPONENT ASSETS AND ASSOCIATED RATES OF RETURN FOR CENTRAL BANK OF TAIWAN MONETARY AGGREGATES

Taiwanese central bank grouping	*Quantity description*	*Description of interest rate or interest rate proxy*
Deposit money	Currency held by the public	Interest rate is zero
	Checking accounts[a]	Interest rate is zero
	Passbook deposits	Interest rate on passbook deposits of 1st Commercial Bank
	Passbook savings deposits	Interest rate on passbook saving deposits of first Commercial Bank
Quasi-money	Postal savings deposits[b]	Interest rate on passbook saving deposits of Chunghwa Post Co.
	1 month to 3 year N.T. Dollar deposits by non-residents[c]	3-month interest rate on time saving deposits of Chunghwa Post Co.
	Time and savings deposits	3-month interest rate on time saving deposits of Chunghwa Post Co.
	Money market mutual funds[d]	Commercial paper rate in the primary market (31–90 days to maturity)
	Repurchase agreements[e]	Commercial paper rate in the primary market (31–90 days to maturity)
	Foreign currency deposits	3-month interest rate on US dollar deposits of first Commercial Bank

[a]Checking Accounts include cashier's checks, certified and traveler's checks.
[b]Postal savings deposits include giro accounts, passbook savings deposits and time savings deposits of Chunghwa Post Co.
[c]Non-residents N.T. dollar deposits include demand and time deposits held by foreign non-financial institutions.
[d]Money market mutual funds represents net present value of money market mutual funds, issued since October 2004, held by enterprises, individuals and non-residents.
[e]Data on represents repurchase agreements sold to enterprises and individuals by monetary institutions and Chunghwa Post Co. prior to January 1994 is not available.

discount rate, natural log of Divisia money, natural log of Divisia user cost, and the natural log of monetary base. Plots of each variable are presented here in Fig. 1. In the cases of industrial production, CPI and monetary base, seasonally adjusted series were not available; hence, each series was seasonally adjusted using the US Census Bureau, X-13 algorithm. Both the seasonally adjusted and not seasonally adjusted series in these cases appear in Fig. 1.

Our sample period is 1985M01 to 2016M6. The sample begins in 1985M1 because this is the earliest available monthly data on the New Taiwan Dollar (NT$)/US Dollar (US$) exchange rate,[2] and ends with the latest data available at the writing of this paper. As a robustness check, we also estimate two sub-samples, 1990M1-2016M6 and 1985M1-2007M1. The first sub-sample, 1990M1-2016M6, is chosen because of the shift to M2 as a

[2]Data on the New Taiwan Dollar (NT$) / US Dollar (US$) exchange rate is available beginning in 1983, but gaps exist in the monthly data from 1983 to 1984, hence our decision to start our sample period in 1985 for this current study.

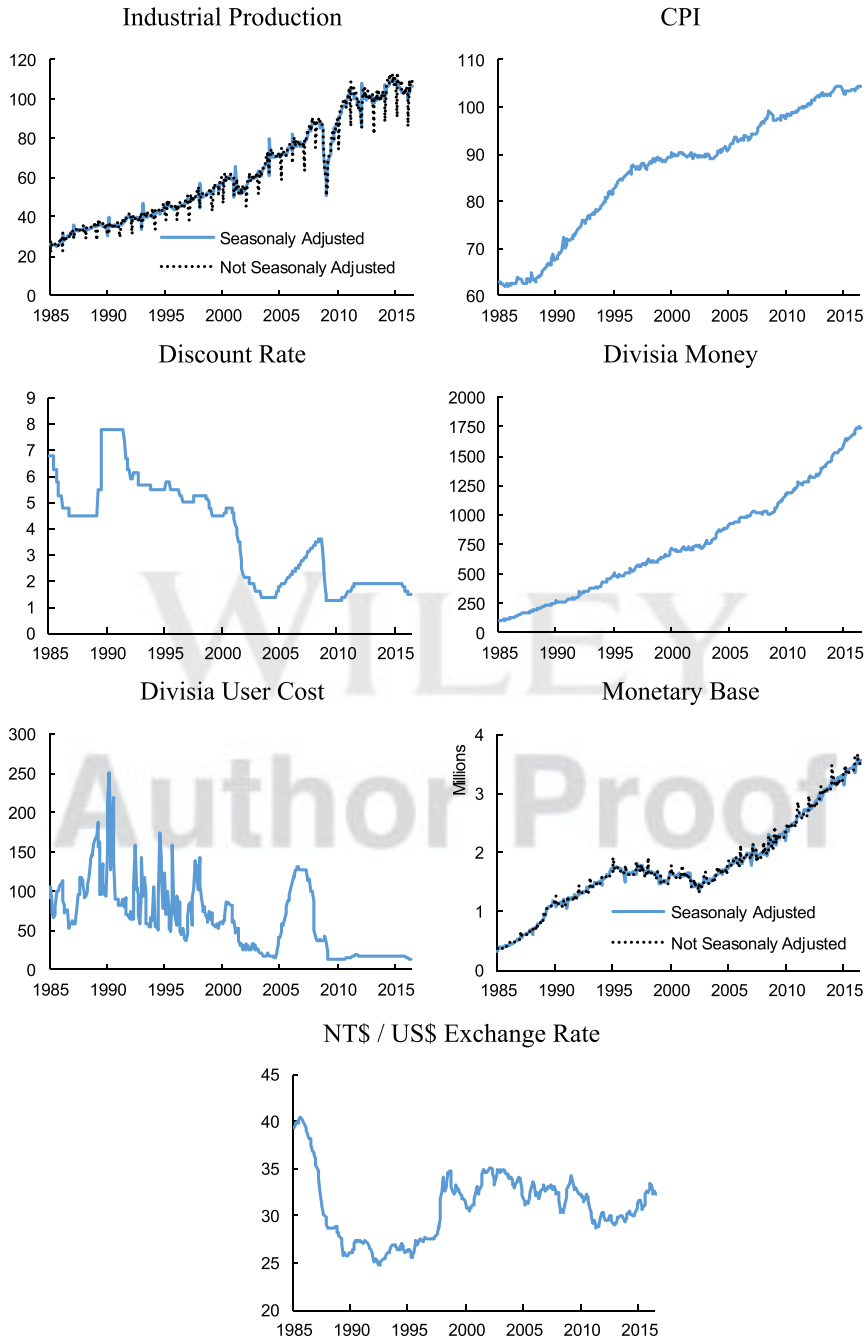

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Fig. 1. Data Used in this Study (1985M01–2016M06) [Colour figure can be viewed at wileyonlinelibrary.com]

policy target occurred in 1990. The second sub-sample is chosen to ensure that distortions from the financial crisis are not driving our results.

4.2 VAR Identification

We follow the general methodology outlined in Keating *et al*. (2014) to obtain Z_t, where Z_t is an n-vector of variables. The variables in the model are subdivided into three blocks:

$$Z_t = \begin{pmatrix} EA_t \\ imp_t \\ MI_t \end{pmatrix} \tag{4}$$

where EA_t represents a vector of *Economic Activity* variables, imp_t represents a single variable that serves as an indicator of monetary policy and MI_t represents a vector of *Monetary Information* variables all providing informational content to the Taiwanese Central Bank. If the policy instrument is a single variable, CEE (1999) show that a Cholesky factorization will identify the dynamic responses of all variables in Z to monetary policy shocks for any ordering of EA_t or MI_t blocks. The block-recursive structure model of this model implies that the central bank may react contemporaneously to the economic activity variable, but can only affect those variables with a lag. We use the Akaike information criterion (AIC) to determine the lag order of
T2 the VAR, see Table 2.

4.3 Variable Selection

We develop a progression of four models. The Economic Activity block, EA_t, for each model consists of the log of industrial production, the log of the consumer price index and the Taiwan/US exchange rate. Note that, following Keating *et al*. (2014), we exclude a commodity prices from EA_t. In the first two of our models, Discount Rate Model 1 and Discount Rate Model 2, the policy indicator block is occupied by the Taiwanese discount rate. In Discount Rate Model 1, the Monetary Information block, MI_t, incudes monetary base, and simple sum M2. Discount Rate Model 2 replaces simple sum M2 with Divisia money. The third and fourth of our models include Divisia money in the policy indicator block. In Divisia Model 1, Divisia money is used as the policy indicator variable and Discount Rate is moved to the monetary information block, MI_t. Finally, in Divisia Model 2, we replace Discount Rate with the Divisia user cost. Variable selection for
T3 each model is summarized in Table 3.

We follow Keating *et al*. (2014) and Chistiano *et al*. (1999) in using the log level of all variables with the exception of the Discount Rate. Sims *et al*. (1990) show that for a model estimated in levels, standard asymptotic theory

Table 2
AIC, BIC, HQC Lag Selections

	AIC	*BIC*	*HQC*
Discount Rate Model 1	12	2	2
Discount Rate Model 2	12	2	3
Divisia Model 1	12	2	3
Divisia Model 2	3	2	3

may be used to perform many standard statistical tests even when the series are non-stationary. Further, Sims *et al*. show that the danger in differencing the series is that if a series is not difference stationary you get inconsistent estimates. The advantage of differencing is that if series is difference stationary you obtain gains in efficiency, but given the low power of unit root tests, there is a non-trivial probability of imposing a false unit root. Thus, the dangers of inconsistency from incorrectly differencing may out-weigh the potential efficiency gains from differencing when that restriction is valid. We further demonstrate the stability of our final model (Divisia Model 2) by showing that shocks largely dissipate within 240 months (see Fig. 3).[3]

5 Results and Discussion

In this section, we will demonstrate the usefulness of this new data set by applying it to a simple VAR framework inspired by the system used by Christiano *et al*. (1999) and later adapted for the post crisis events by Keating *et al*. (2014). New insights are provided in the discussion of the results.

5.1 Results

The VAR within sample fit is quite good, i.e. R^2 is greater than 0.8. Plots of our fitted versus actual results are available upon request. Our focus is on the impulse responses generated from these VAR models. The Discount Rate Model 1, see Table 3 for definition, is very much in the spirit of Chistiano *et al*. (1999): using a block recursive structure and including standard macroeconomic variables in the first block, standard monetary variables in the third block and the Taiwanese discount rate in policy indicator block. We can see from the impulse response functions, see Fig. 2, that we have

[3]As a final check of the stability of the system, we estimate a vector error correction model with the same variable and lag order selections. The resulting impulse response functions (IRF's) are qualitatively similar to those reported in this paper in terms of significance and signs of the responses, with the exception that in the vector error correction model the liquidity puzzle is also eliminated. The vector error correction model estimation and IRF's are available from the authors upon request.

Table 3
Variable Selection by Model

	Discount Rate Model 1	*Discount Rate Model 2*	*Divisia Model 1*	*Divisia Model 2*
Economic activity variables	Industrial production Consumer price index Taiwan/US exchange rate	Industrial production Consumer price index Taiwan/US exchange rate	Industrial production Consumer price index Taiwan/US exchange rate	Industrial production Consumer price index Taiwan/US exchange rate
Policy indicator variable	Interbank overnight rate	Interbank overnight rate	Divisia money (M2)	Divisia money (M2)
Monetary information variables	Monetary base Simple sum M2	Monetary base Divisia money (M2)	Monetary base Interbank overnight rate	Monetary base Divisia user cost

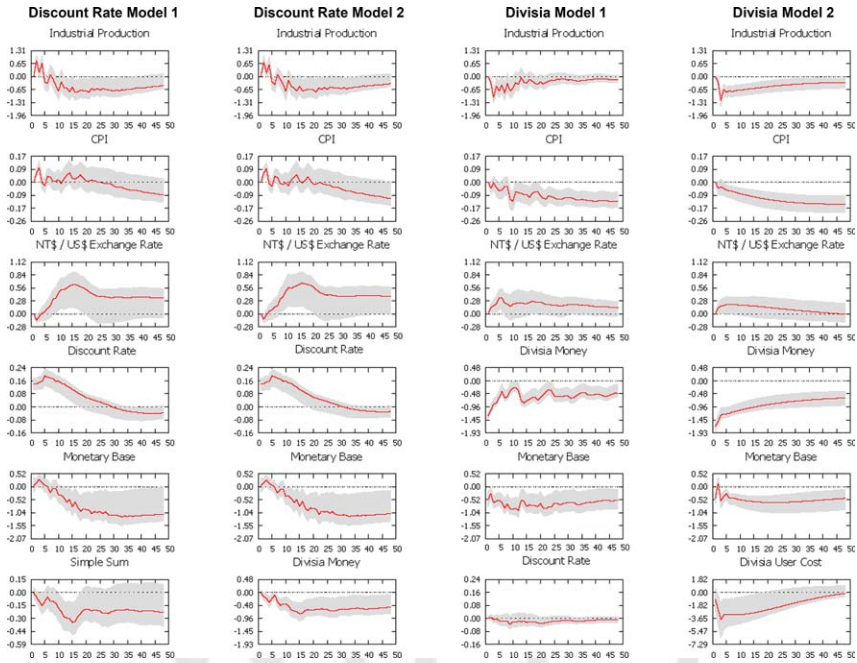

Fig. 2. Impulse Responses to a Contractionary Monetary Shock for Various Identifications For each model, the policy indicator is in the fourth position, and the shock is a on standard deveation reduction to the policy variable (Log data). [Colour figure can be viewed at wileyonlinelibrary.com]

some puzzling results.[4] The model exhibits statistically significant output, price and exchange rate puzzles that remains significant for two to five months after the initial shock.

Keating *et al*. (2014) demonstrated that price and output puzzles can be solved by eliminating measurement error arising from theoretically inferior simple sum measure of money. Thus, in Discount Rate Model 2, we replace simple sum M2 with the more sophisticated Divisia money in the third block. This substitution does not improve the puzzling responses observed in Discount Rate Model 1. A result that is consistent with Keating *et al*. (2014).

Simply eliminating the simple sum aggregate does not eliminate the puzzling responses of the economic activity variables, so the next step in following the process of Keating *et al*. (2014) is to place the Divisia money into the policy indicator position and move the discount rate into the third block.

[4]All impulse response function plots report the response of the given variable to a one standard deviation shock to the policy variable. In the case of Discount Rate Model 1 and Discount Rate Model 2, this is a one standard deviation shock to the overnight interbank rate. In the case of Divisia Model 1 and Divisia Model 2, this is a one standard deviation shock to the log of Divisia money.

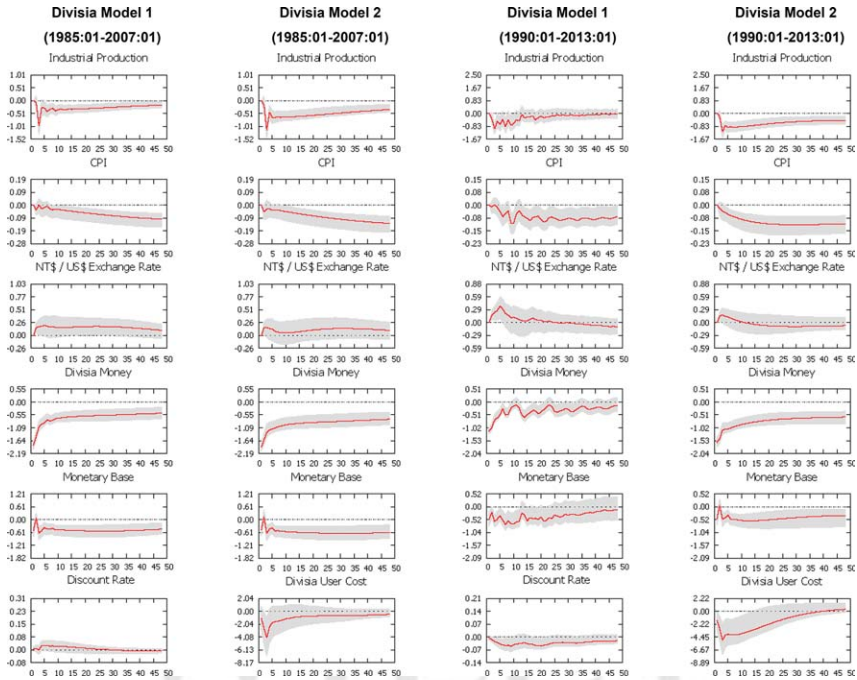

FIG. 3. IRF Sub-Sample Analysis (Log Data) [Colour figure can be viewed at wileyonlinelibrary.com]

We make this exchange in Divisia Model 1. The output, price and exchange rate puzzles are eliminated; see Fig. 2. There is a significant negative response in output, and a negative response in the price level that becomes significant approximately six months after the initial shock, and a significant positive response in the exchange rate. On the other hand, the Divisia Model 1 does exhibit a liquidity puzzle.

Hence, we replace the Discount rate with the Divisa user cost, as the user cost may well be superior to the Discount rate in that it represents a micro-theoretic measure of the cost of monetary services and is composed of a weighted basket of interest rates rather than a single interest rate. Including the Divisia user cost leads to several outcomes: (i) the output and price level have immediate and significant negative responses, (ii) the Taiwan/US exchange rate exhibits a positive response that remains significant for two to three months and (iii) the lag order selected by AIC is reduced demonstrably from 12 lags (Divisia Model 1) to 3 lags (Divisia Model 2). Thus, we have eliminated the output puzzle, the price puzzle and the exchange rate puzzle, by utilizing Divisia monetary data.

The liquidity puzzle remains in Divisia model 2. The response of the Divisia user cost is negative and significant. This, however, can be explained

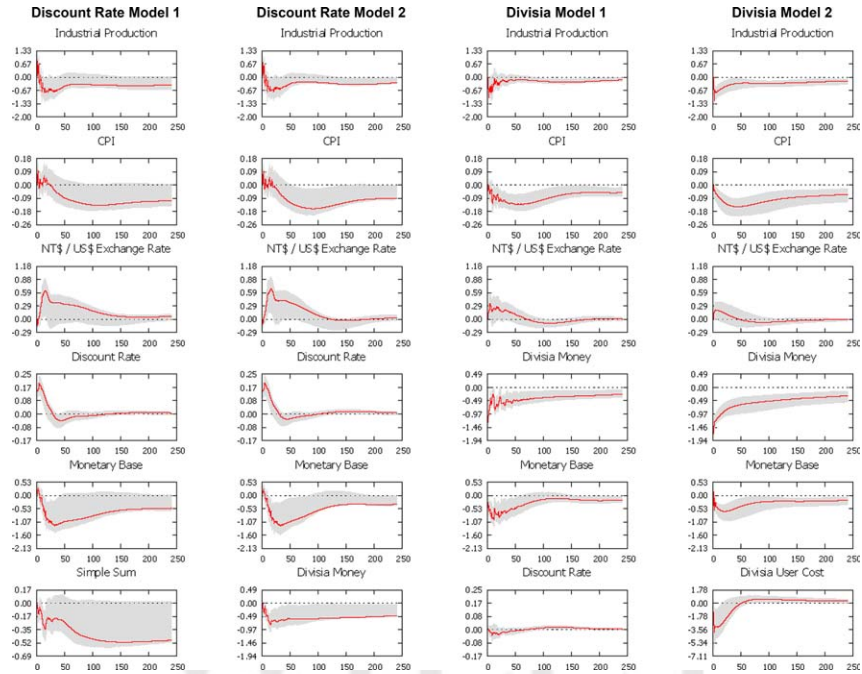

FIG. 4. IRF Stability (Log Data) [Colour figure can be viewed at wileyonlinelibrary.com]

by the reduction in price level, i.e. the Fisher effect may be dominating the liquidity effect. The user cost's response remains negative only so long as the price response is falling. Once the price response levels out and then begins to rise the response of the user cost ceases to be significantly negative and eventually becomes significantly positive (see Fig. 4).

As a check on the robustness of our model, we estimate the Divisia Model 1 and the Divisia Model 2 over two sub-samples, 1990M1–2016M6 and 1985M1–2007M1. The first sub-sample, 1990M1–2016M6, is motivated by the shift to M2 as a policy target that occurred in 1990. The second sub-sample, 1985M1–2007M1, is chosen to ensure that the financial crisis period is not driving our results. Figure 3 plots the impulse response functions from the estimation of both Divisia models, estimated over both the sub-sample periods. The results of the sub-sample analysis are consistent with the results found in the full sample.

As a tentative result, we can say that by internalizing the portfolio dynamics within the construction of the Divisia money quantity index and the Divisia user cost price dual, properly measured monetary aggregates permit a more parsimonious model, i.e. the lag order needed to fully identify monetary shocks is reduced. Furthermore, the Divisia user cost captures information from a portfolio of interest rates rather than just one arbitrarily

chosen interest rate. Therefore, including the user cost allows a better estimation of the true money demand relationship.

5.2 Discussion

Why does using Divisia money as a policy indicator and including Divisia user cost resolve the puzzles? There are probably two answers to these questions. One, by including a properly measured monetary aggregate we eliminate measurement error inherent in simple sum aggregates and we account for shifts in the monetary portfolio. The second answer is more speculative. We contend that by using the Divisia quantity aggregate as the policy indicator, we are able to measure true monetary shocks, rather than the intended policy of the central bank. While the policy rate may well indicate the central bank's intentions, the policy rate may not always indicate the actual policy outcome, e.g. consider the zero lower bound problems.

6 Conclusions and Suggestions for Future Research

We present new evidence on the usefulness of appropriately measured money and monetary user cost aggregates in the identification of monetary shocks. In a block recursive structural VAR, we show that using money as a policy indicator variable and user cost in a monetary information block solves the output, price and exchange rate puzzles and yields sensible long-run responses to monetary shocks. By contrast, models using the overnight interbank rate as the policy indicator, exhibit longer lag-order selections and more oscillatory behaviour, which may be as a result of over fitting and long-run puzzles.

We add value to the earlier findings of Keating *et al*. (2014) as we extend their framework to model a small open economy by including the exchange rate in the economic activity indicator block. This is the first work in the field to make this contribution and is an important advance because it demonstrates that the information contained in monetary aggregates about monetary shocks in a small open economy such as Taiwan can play an important role in monetary policy formation. Taiwan is an important case to study because of its differences from the US. Despite those differences our results are broadly similar to that found by previous work that focused on the US.

With continual innovation in financial markets, the impact on the measurement of monetary aggregates will continue to present problems in empirical studies. The more sophisticated Divisia monetary aggregates, illustrated here, have the potential to make a valuable contribution to future studies on money demand. Ideally, future work should focus on finding enhanced methods of capturing the true user cost of money by e.g. finding enhanced ways of incorporating the risk of holding the asset and more thorough theoretical treatment of the modelling of the opportunity costs for Divisia money, including improvements on measuring the benchmark rate in the

construction. Taken together, our results indicate that future research into improved constructions of monetary aggregates is promising and is a worthwhile route to pursue.

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