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A new monetary aggregates measurement: Application to Taiwanese data

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Abstract

This paper compares the different dynamics of simple sum monetary aggregates and PLS indexes over the business cycle, which have turning points at economic expansion and recession phases. We also investigates the long run relationship between monetary aggregates and GDP, to utilize the data in the most efficient manner via the nonparametric rank test of cointegration analysis proposed by Breitung (2001), and the impulse response functions to find the response of GDP to innovations in PLS and simple sum aggregates from 1969Q1 to 2010Q3.

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1. Introduction

The literature is vast on the appropriateness of simple un-weighted sum aggregation under the unreasonable assumption that user-cost prices of individual money assets do not change over time. Central banks and monetary policymakers acknowledge that monetary policy strictly influences economic activities, such as business cycles. In most situations, they universally disagree about the role of simple sum monetary aggregates in money policy. Central banks use money supply as an intermediate target to control each level of money supply in varying degrees, and to increase or decrease money supply changes that affect economic growth, price stability, and employment objectives. Therefore, money supply and monetary policy objectives are strongly related. However, another problem of money supply as an intermediate target involves the loss of a stable relationship between money supply and nominal GDP.

The traditional simple sum method assumes that all types of monetary assets are complete substitutes; consequently, this assumption is not rational. In both accuracy and precision, simple sum aggregates cannot meet monetary intermediation goals. Policy makers need new monetary aggregates, which are better than simple sum aggregates, such as PLS aggregrates, to meet policy work.

There are already some comparisons of these two series sometimes suggests that simple sum and PLS monetary aggregates share similar dynamics, important differences exhibit during certain periods, such as turning points of inflation rates (Yang *et al.*, 2010a; Yang *et al.*, 2010b). This paper compares the different dynamics of simple sum monetary aggregates and PLS indexes not only over time, but also over the business cycle. If PLS indexes correspond to be a better measure of money, the differences of the two monetary aggregates increase the already considerable uncertainty regarding the effectiveness and appropriateness of monetary policy. This information about the state of monetary aggregates growth is prolific, particularly when policymakers wish to change monetary policy, such as inflation entering a high growth phase or a weakening economy. We aim to conclude a clear consensus on PLS aggregates is more suitable for predicting business cycles.

Therefore, the implied moneyness of various monetary currency accounts can be used to calculate the weights of distinct monetary aggregates using PLS (partial least squares). The weights of each monetary asset inform as to what the makeup and relative importance are for each indicator in creating the latent variables (LVs). Without considering any distributional assumption of the observed variable, partial least squares path-modeling methodology allows both reflective and formative computations for measuring LVs (Lohmöller, 1989, Chin and Newsted, 1999). The reflective LV is assumed to cause reflective indicators.

Bollen and Lenox (1991) and Chin (1998) illustrated the reflective concept of outer model, expressed as:

$$x = \Lambda_x \xi + \varepsilon_x ,$$
$$y = \Lambda_y \eta + \varepsilon_y . \tag{1}$$

where x and y =indicators for exogenous and endogenous LVs ξ and η respectively, Λ_x and Λ_y = the loading matrices representing LVs' effects on indicators, ξ, η = exogenous and endogenous LVs, and ε_i = measurement error for indicator i. Chin (1998) and Diamantopoulos and Winklhofer (2001) presented the formative concept (weight relations) of outer model, expressed as:

$$\xi = \sum_i^n \gamma_i x_i + v . \tag{2}$$

where ξ = the formative LV, γ_i = weights for items, x_i = items, v= a disturbance term.

In the outer model, interpreting the weights is more suitable for formative index, while loading is more appropriate for interpreting the reflective indicators formation (Chin, 1998). The weights denote the shared contributions of each item to the total contributions of all components. According to weights calculated from the moneyness of various money stocks, PLS monetary aggregates lead to enhanced measurement of monetary aggregates.

The inner model depicts the relationship among LVs based on the substantive theory (Chin, 1998),

$$\eta = B\eta + \Gamma\xi + \zeta . \tag{3}$$

where B denotes the matrix of coefficients of their relationships between endogenous LVs, Γ denotes the matrix of coefficients of their relationships between exogenous and endogenous LVs, and ζ represents the inner model residuals.

2. Model, Methodology and Data

The monetary aggregates in our research, published by the Central Bank of the Republic of China (Taiwan), include M1A, M1B, and M2. M1 is a narrow and lowest level definition of money that includes M1A and M1B. The M1A money supply category consists of currency in circulation, checking accounts, and demand deposits with the highest liquidity. The M1B consists of monetary aggregate M1A and passbook savings deposits of individuals and non-profit organizations. The M2, which consists of M1 and quasi-money, is a broadened and high-level definition of money that includes assets such as quasi-money that may convert into cash more slowly than M1. Money monetary aggregates (MA) consist primarily of (1) M1A: currency in circulation (CU), checking accounts (CA), and passbook deposits (PD), (2) M1B: M1A + passbook savings deposits (PSD), and (3) M2: M1B + quasi-money (QM). Hence, the LV of money monetary aggregates captures concepts embodied by five diverse indicators: CU, CA, PD, PSD and QM.

We adopted a structural equation modeling (SEM) approach in modeling the measurement model (outer model) and the structural model (inner model) of the new monetary aggregates, using PLS tool for this exploratory study. The measures were tested using SmartPLS 2.0 (Ringle, Wende, and Will, 2005) by running the full research model consists of inner and outer model, with data consisting of quarterly data during 1969Q1 to 2010Q3 from the AREMOS database in Taiwan. Assuming that there are n monetary assets (m_i), expenditure on monetary asset i is given by the product, and the total expenditure (M) on monetary assets is given by:

$$M = \sum_{i=1}^{n} \pi_i m_i \,. \tag{4}$$

m_i denotes the account of monetary asset i, π_i denotes the weights of m_i used to form M.

The monetary aggregates can be precisely tracked by the PLS index (Yang *et al.*, 2010a; Yang *et al.*, 2010b), which solves the equation (values of t-statistics in parentheses[1]):

$$\mathrm{MA} = \underset{(89.323)}{0.753}(\underset{(18.840)}{0.521}\,\mathrm{CU} + \underset{(6.422)}{0.091}\,\mathrm{CA} + \underset{(21.864)}{0.407}\,\mathrm{PD}) + \underset{(0.265)}{0.002}\,\mathrm{PSD} + \underset{(34.502)}{0.251}\,\mathrm{QM} \,. \tag{5}$$

3. Results

Validity, Reliability and Significance

The adequacy of the reflective LV was evaluated by the criteria of reliability and convergent validity. A rule of thumb is to accept reflective constructs with factor loadings of 0.7 or more, which implies more shared variance between the construct and its measures than error variance (Barclay *et al.*, 1995). In this research, all factor

[1] The t-statistics for testing statistical significance of estimates for path coefficients were obtained by running a bootstrapping routine, which represents a nonparametric approach for estimating the precision of PLS estimates (Chin and Frye, 2001) with 1000 samples, each containing 500 observations.

loadings above 0.7 were considered good measures of their latent construct to ensure the proportion of variance (R^2) in the observed (manifest) variables. This is accounted for by the LVs influencing them to estimate reliability of the observed variables (items) with R^2 values above 0.49 (almost 50%), and R^2 values above 0.67 evidenced acceptable reliability as substantial (Chin, 1998; Henseler *et al.*, 2009).

Composite reliability (Werts *et al.*, 1974) accounts for indicators with different loadings and is used as an internal consistency reliability of reflective LVs in PLS modeling, which is considered adequate with a value above 0.7 (Fornell and Larcker, 1981). Convergent validity of the scales was verified by the two criteria proposed by Fornell and Larcker (1981): (1) all indicator loadings should be significant and exceed 0.7, suggesting good measures of their LV and (2) the average variance extracted (AVE) for each construct should exceed 0.50, implying that a reflective LV can explain more than half of the variance of its indicators on average (Götz *et al.*, 2009; Henseler *et al.*, 2009).

In PLS analysis, the coefficients of structural paths and the R^2 scores of endogenous variables assess the explanatory power of a structural model. The coefficients of structural paths reflect the direct effects of exogenous LVs to endogeneous LVs. The R^2 coefficient reflects the level of the endogeneous LV's explained variance and therefore estimates the fitness of the regression function against these empirically obtained manifest variables (Backhaus *et al*., 2008).

Figure 1: Full Model for PLS Monetary Aggregates

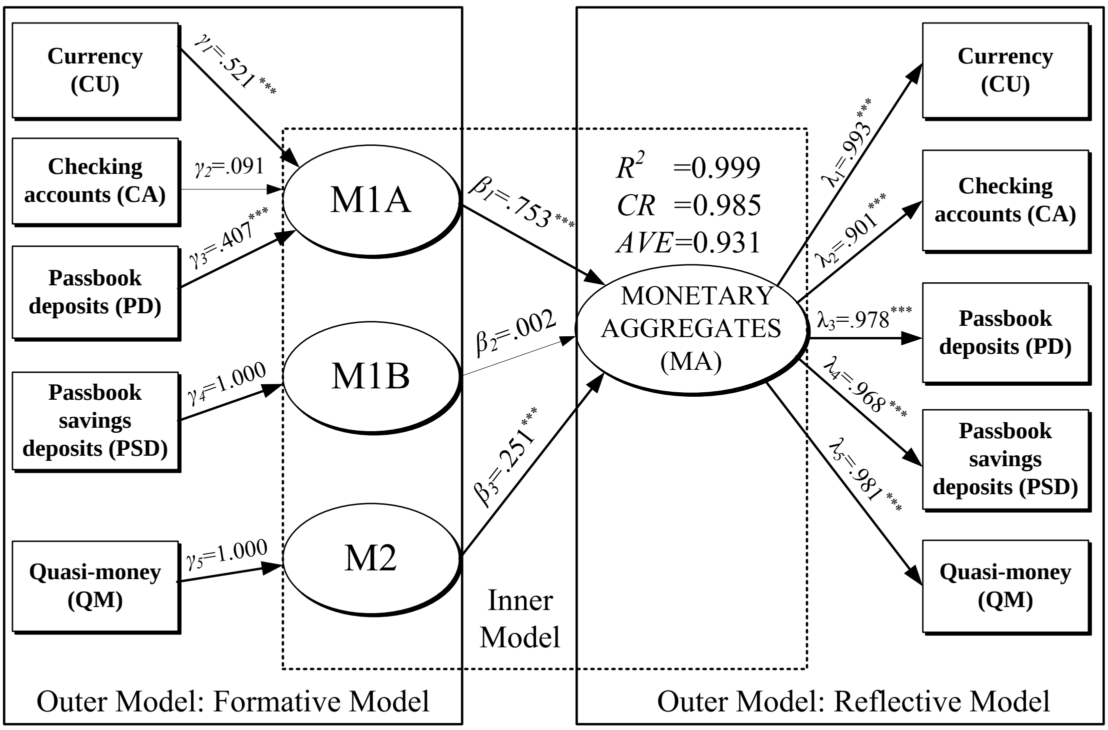

Figure 1 depicts the results of the structural path analysis: the estimated values for each of the path relationships, as well as the amount of variance (R^2) explained for the endogeneous construct, and the results of further tests for reliability and validity measures. As shown in Figure 1, all reflective items exhibited loadings higher than 0.7 on their respective construct, evidencing acceptable item convergence on the intended constructs and adequate reliability. AVE was 0.931 and CR was 0.985, meeting both conditions for convergent validity and reliability. The R^2 of the endogeneous LV (MA) we constructed was 0.999 which can be considered to have reliability as substantial and be perfectly well explained by the exogenous LVs (M1A, M1B, and M2).

Note that for M1A, M1B, and M2 formative constructs, the weights are replaced for loadings and the causality direction is from construct to items. Because the constructs were modeled as formative, the important indicators are the weights, and the criterion considers whether or not the weights are statistically significant (Henseler *et al.*, 2009). Bootstrapping is the re-sampling method to test significance in PLS (Chin and Frye, 2001).

Breitung (2001) Cointegration Test

When PLS, simple sum aggregates and GDP time series have nonstationarity, it would seem that a spurious regression problem exists. Before identifying a possible long-term relationship, we need to verify that monetary aggregates and GDP time series integrate at order one levels. Enders and Granger (1998) stated that standard tests of linear cointegration have lower power in the presence of mis-specified dynamics. This is important since the linear relationship is inappropriate if prices are sticky in the one direction (upward), but not in the other direction (downward). Therefore, Breitung (2001) proposed a two-sided version of the test statistic, constructed using the residuals of a cointegration regression on the ranks.

To test for cointegration between two time series, y_t and x_t, consider y_t as a function of x_t, which may be represented by:

$$y_t = f(x_t) + u_t. \tag{6}$$

where y_t and $f(x_t)$ are both integrated of order one, that is, $y_t \sim I(1)$ and $f(x_t) \sim I(1)$, and u_t represents stochastic disturbances, $y_t \sim I(0)$.

Breitung (2001) based the rank test on a measure of the squared distance between the ranked series. The test statistic that takes on a value smaller than the appropriate critical value evidences against the null hypothesis of no cointegration in favor of the alternative hypothesis of cointegration because in this case the variables move closely together over time and do not drift too far apart. Following the Breitung

(2001), we define a ranked series as $R(w_t)$=rank of w_t among (w_1, w_2 ,..., w_T), where w={y, x}. For this situation, Breitung (2001) proposed a two-sided version of test statistic, expressed as:

$$\Xi_T^* = T^{-3}\sum_{t=1}^{T}\left(\tilde{u}_t^R\right)^2 / \left\{\tilde{u}_{\Delta u}^2\right\} \qquad (7)$$

where T is the sample size with $\tilde{u}_t^R$ the least squares residuals from a regression of $R_T(y_t)$ on $R_T(x_t)$, $\tilde{u}_t^R = R(y_t) - \sum_{j=1}^{k}\tilde{b}_j R(x_{jt})$, $\tilde{u}_{\Delta u}^2$ is the variance of $\Delta\tilde{u}_t^R$, $\tilde{u}_{\Delta\tilde{u}}^2 = T^{-2}\sum_{t=2}^{T}\left(\tilde{u}_t^R - \tilde{u}_{t-1}^R\right)^2$, and $\tilde{b}_T$ is estimated from a regression of $R_T(y_t)$ on $R_T(x_t)$.

The null hypothesis of this rank test is that the monetary aggregates and GDP are not cointegrated, as compared to the alternative hypothesis of cointegration between these two variables.

Table 1: Result of Breitung (2001) Rank Tests of Cointegration

	Two-sided test		
	$\ln GDP_{t-1}$	$\ln GDP_t$	$\ln GDP_{t+1}$
$\ln PLS_t$	0.0163**	0.0207*	0.0185**
$\ln SUM_t$	0.0178**	0.0195**	0.0192**

Critical Values for the rank test statistic from Breitung (2001):
*** significant at 0.01 (two-tails): 0.0136
** significant at 0.05 (two-tails): 0.0197
* significant at 0.1 (two-tails): 0.0248

Table 1 reports the summary statistics of rank tests of linear or nonlinear cointegration. We find that both PLS and simple sum indexes have linear (or nonlinear) dependencies with GDP in the Breitung (2001) rank test. As shown in Table 1, the null hypothesis is rejected for the two monetary aggregates examined in this study, since the test statistics are smaller than the critical values at the 5 % and 10 % levels of significance, respectively.

Impulse Response Function

Empirical literature widely uses impulse response functions (IRFs) to uncover the dynamic relationship between macroeconomic variables within vector autoregressive (VAR) models. Usually IRFs can be used to measure the time profile of shock effect (impulse) on the expected future values of a variable (Stock and Watson, 2001). Hence, we used the IRFs to examine the time series evidence that changes in the PLS money supply are a more predictive factor in generating business cycles than simple sum monetary aggregates.

Figure 2: The Responses of GDP to the Impulses of PLS and SUM Aggregates Innovations Respectively

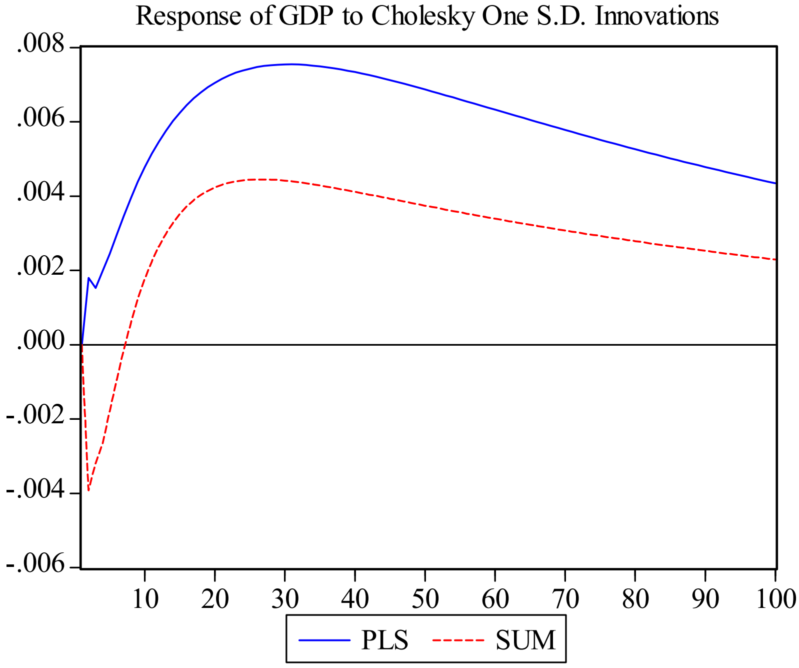

Figure 2 shows that, following monetary shocks, response of GDP to PLS shocks tend to grow more quickly than simple sum aggregate shocks. The response of GDP to PLS aggregates is much quicker than the simple sum aggregates: there is no discernible lag and the responses are strongest at the earlier thirty-quarter horizon. The PLS monetary growth rate by one percentage point of impact has a positive effect on the response of GDP. In the first quarter, PLS aggregates allowed GDP to grow by about 0.2 %. Some larger but smooth fluctuations that followed maintained a positive impact, consistent with macroeconomic theory. By contrast, at first the simple sum aggregates had a negative impact on GDP and GDP declined in response to simple sum aggregates innovations in the first quarter, contradicting economic theory.

Idiosyncratic Terms of Monetary Aggregates

Comparing different dynamics of the simple sum monetary aggregates and the PLS monetary aggregate indexes over time in the business cycle, an equilibrium relationship needs to exist between the aggregates and business cycle for a monetary aggregate to be more useful as an intermediate target of monetary policy.

The equation of growth rates (G) of monetary aggregates may be defined to be

$$G = \frac{M_t - M_{t-1}}{M_{t-1}}, \text{ for quartely data.} \tag{8}$$

Figure 3: Idiosyncratic Terms for PLS, Simple Sum Aggregates Growth Rates, and Recessions (Shaded Area)

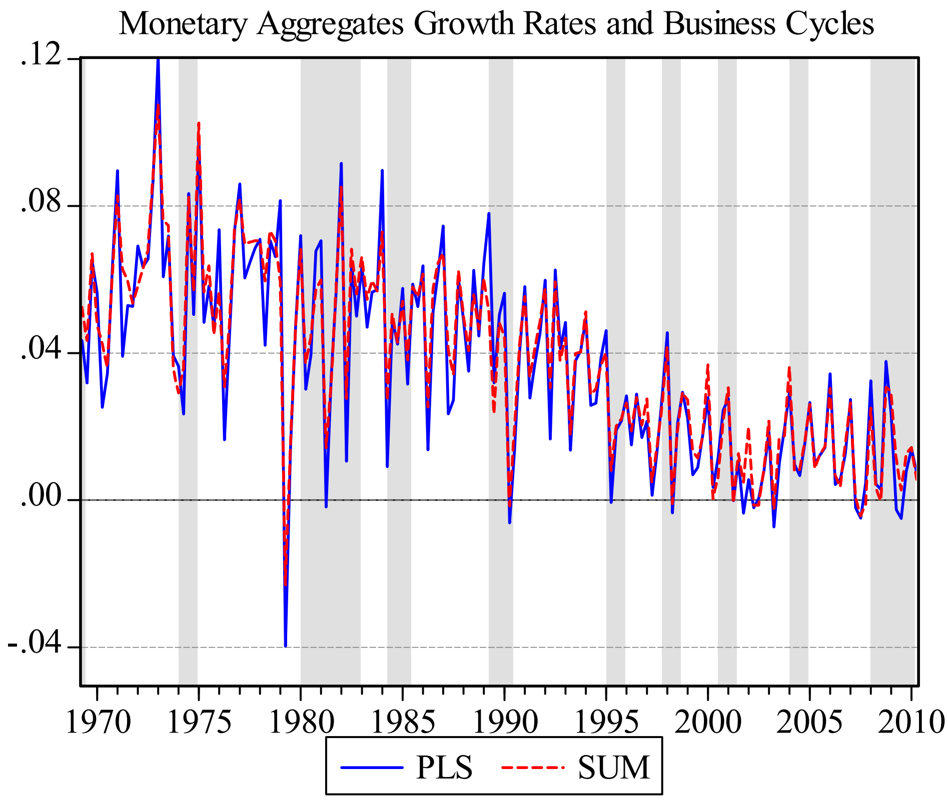

Figure 3 shows the idiosyncratic terms for PLS and simple sum monetary aggregates growth rates over the business cycle. The term corresponding to PLS is sharper and has larger fluctuations than simple sum aggregates. The growth rates of PLS indexes display a business cycle pattern, rising higher than simple sum indexes before recessions, falling more sharply during recessions, and fluctuating gradually to converge to their average during expansion. To this end, PLS currency aggregate indices provide a good alternative.

4. Conclusions

Although summation quantity aggregation is inappropriate, traditional monetary aggregates are still in use of sums. Accordingly, we compare summation versus PLS aggregation of monetary assets. Our results provide support that there is more predictive power in PLS monetary aggregates when forecasting business cycles. The velocity behavior and the information content of the PLS index are superior to those of the summation index.

This paper also adopted nolinear cointegration test and IRFs to explore the performance of PLS aggregates and simple sum aggregates for predicting business cycles by use of Taiwan data from monetary aggregates theory. In the past 40 years, we find that most economic recessions were preceded by more contractionary monetary policy and expansions were preceded by more expansionary monetary policy, indicated by PLS monetary data than simple sum monetary data. Hence, monetary policy was more explainable using PLS indexes as a monetary instrument.

Future research on monetary aggregation and policy can extend moneyness and its implications for using SEM method modeling by PLS. It would be interesting to use PLS aggregates to survey an international application to distinguish various types of markets (developed, developing and emerging countries, capital-based, and bank-based financing)[2].

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