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China's macroeconomic stability – an empirical study based on survey data

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A complete financial stability analysis should include investigation on macroeconomic stability since macroeconomic development and potential imbalance can increase the financial instability and trigger a financial crisis. Survey data of rating on China's macroeconomic stability is analyzed by estimating an ordered logit model with random effect. Among the candidate macroeconomic indicators, we found that inflation is the key variable that determines China's macroeconomic stability, followed by the change in budget balance and GDP growth gap.

Keywords: China's macroeconomic stability; financial stability; ordered logit panel model; random effect

JEL codes: E44; G43; G00

1. Introduction and Summary

Since the Asian currency crisis in 1997, study of financial stability has become one of the main tasks for central bankers. IMF and World Bank initiated financial sector assessment program in 1999, aimed to increase the effectiveness of efforts to promote the soundness of financial systems in member countries. In the core of this program lies the analysis of macro-prudential indicators. According to the publication of IMF in 2000, macro-prudential analysis of a financial sector includes surveillance on two sets of indicators: aggregated micro-prudential indicators and macroeconomic indicators. There are 34 aggregated micro-prudential indicators, almost all related to CAMELS (capital adequacy, asset quality, management soundness, earning and profitability, liquidity and sensitivity to market risk). Another set in IMF's macro-prudential indicators contains 19 macroeconomic indicators. Presumably, macroeconomic development and potential imbalances can increase the financial instability and trigger a financial crisis. Thus, these macroeconomic indicators can be used to conduct certain stress tests to evaluate the macroeconomic shock absorbing ability of a financial system.

Both in financial theories and practices, the definition of 'stability' is ambiguous and descriptive (Minsky 1992; Schinasi 2004, etc.). Most proposed definitions are concerning its opposite side, 'instability', or focusing on the 'identifiable instability', that is, financial crisis. By financial stability in this article, we mean the strength of a financial system, including all financial intermediaries and organized and informal financial markets, to stand or endure the financial disturbance; practically it can be characterized by the

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aggregated micro-prudential indicators or the financial soundness indicators endorsed by IMF (published in 2001). Similarly by macroeconomic stability we mean the macroeconomic risk characterized by the macroeconomic indicators of IMF to which a financial system is exposed. We prefer to think financial stability and macroeconomic stability as continuous latent variables, and treat currency or banking crisis as identifiable financial instability. In other words, financial crisis is an observable binary state variable. When either one sense of instability, financial or macroeconomic, is present, the economy becomes highly vulnerable. Financial crisis can easily arise if both fail. We believe that a study on financial stability should include micro-prudential analysis on the financial system based on CAMELS indicators and also macroeconomic stability analysis.

In this article, we study China's macroeconomic stability. We attempt to evaluate the risk of macroeconomic environment in which the financial system operates based on IMF's macroeconomic indicators and other relevant indicators documented in the literature such as Kaminsky and Reinhart (1999) and Bauer, Herz, and Karb (2007). Since macroeconomic stability is a latent variable, it is tempting to conduct factor analysis on such a large pool of macroeconomic indicators. However, the results of factor analysis are quite sensitive to dimensionality and the subsample check. Specifically in our preliminary investigation, omitting the last few observations can yield very different factor results. Furthermore, there was no genuine financial crisis sample in China, empirical strategies such as the adjusted signal-to-noise ratio used in Kaminsky, Lizondo, and Reinhart (1998) or the probit modeling in Frankel and Rose (1996) cannot be employed to identify important macroeconomic indicators.

Another approach is to assign subjective scores to individual macroeconomic indicators, similar to giving a grade report. A measure for macroeconomic stability is built through aggregation of these scores. The grade report can be very controversial unless there is an agreed rating system, though this method is not uncommon in some CAMELS analysis on the banking sector.

Cast into regression terms, the problem is that we have potentially useful explanatory variables, that is, a pool of macroeconomic indicators, but we don't observe the dependent variable of macroeconomic stability. To approach this problem, we are reluctant to use either factor analysis or any score method to extract a proxy for macroeconomic stability. We instead use the survey data as a proxy of underlying 'macroeconomic stability'. In this survey, we asked the respondents to rate the macroeconomic stability in each year from one (very stable) to five (very unstable) over the period from 1987 to 2008. This panel data of the survey is categorical; ratings represent the relative degree of macroeconomic stability. A rating of four in a year does not mean that it is twice as unstable as another year that is given a rating of two.

It is conceivable that these survey data exhibit tremendous heterogeneity since interviewees in our survey include scholars, government officials and higher management in financial institutions and it is quite plausible that their senses of macroeconomic stability are very different. Moreover, we are also concerned with the problem of non-comparability of subjective evaluation in the survey data because one person's rating cannot be compared to another's. One may well question if these survey data are a good proxy, but we shall work on it before we can find a better data set.

The identified key macroeconomic indicators in this article can be used in further macro stress-testing. Documented in Sorge and Virolainen (2006), macro stress-testing methods include: time-series technique, panel data technique, structural model technique and integrated approach. All of them require a set of macroeconomic indicators that properly characterize macroeconomic environments. Therefore, selecting an informative set of macroeconomic indicators helps to conduct the macro stress-testing in relatively small sample. We believe this is important since high-frequency macroeconomic indicators are rare, particularly in China.

The main finding of this article is that over the period 1987–2008, China's macro stability is driven by three key macroeconomic indicators: the budget balance, GDP growth gap and inflation rate. The rest of this article is organized as follows. In section 2 we give a detailed description about the data set and the pool of macroeconomic indicators compiled from the previous work. Section 3 contains econometric analysis and further discussions. Section 4 ends this article.

2. Data

2.1. Survey on macroeconomic stability

In April 2009, we conducted a survey on China's macroeconomic stability. The respondent was asked to rate the macroeconomic stability in each year from one (very stable) to five (very unstable) over the period from 1987 to 2008. More than 300 questionnaires were distributed to a group of economists, the government officials and the professionals in finance industry. We managed to collect 37 (about 11.4% out of total) valid questionnaires; it is not a large data set indeed.

Although it is not entirely legitimate to calculate the cross-section average over years due to non-comparability of subjective rating, we plot the time series of average rating in Figure 1.

This curve shows four peaks from 1987 to 2008 which well match historical instable periods in China: two overall economic overheat, the Asian financial crises and the subprime crisis.

1987–1989 overheat. Due to huge money demand resulting from the wage reform and transition to market economy, money supply increased over 170% (compared with 1983) in

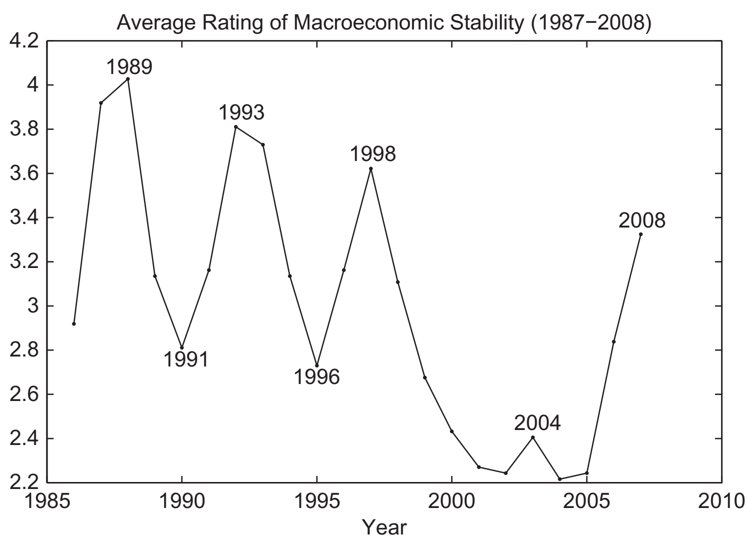


Figure 1. Average rating of macroeconomic stability.

1988 and inflation reached the highest level in 40 years. Tightened fiscal policy was carried out in late 1989 to stop the overheat at a cost of sharp drop in GDP growth.

1993–1994 overheat. In 1992, higher price owing to market liberation induced a surge in investment and increasing wage caused a fierce expansion in aggregate demand and money supply. Worse, large depreciation of exchange rate in 1994 reform resulted in a rapid growth in foreign reserve (through surplus in international trade) and indirectly increased the money base. The inflation in 1994 reached an unprecedented 24.2%. With deflation policies, the economy smoothly returned to normal in 1996 (known as 'soft landing').

1997–1998 Asian financial crisis. Asian financial crisis hit all Asian countries in 1997. Thanks to the strict capital control and a series of reform, mainly in the banking sector, aimed to strengthen the financial system, negative impacts of the crisis are well contained.

2007–2008 subprime crisis. Subprime crisis caused a devastating turmoil in international financial system and real economy. China experienced a large scale recessions in exporting sector, crash in stock market and decline in GDP growth.

2.2. Candidate macroeconomic indicators

Useful indicators for macroeconomic stability are widely documented in literatures. Kaminsky, Lizondo, and Reinhart (1998) and Kaminsky and Reinhart (1999) selected 16 core macroeconomic and financial variables that have high warning ability for financial crisis. The IMF also suggested a set of macroeconomic indicators in 2001 (IMF 2001).

Bauer, Herz, and Karb (2007) examined the behavior of eight economic variables' pre-financial-crisis behavior in comparison to their average level over the non-crisis period and found that five variables were sensitive enough to have 'early warning capacity'. They are GDP growth rate, budget balance (fiscal surplus over GDP), import cover (foreign exchange reserve over monthly import), overvaluation of currency and the ratio of short-term to total external debt.

Kaminsky, Lizondo, and Reinhart (1998) variables, Bauer, Herz, and Karb (2007) variables[1] and IMF indicators add up to a total of 40 candidate indicators. It is statistically inefficient to consider such a large pool of indicators in the subsequent econometric analysis. It is also not necessary due to high correlations in many pairs of variables. Our empirical strategy is to be considered relevant in at least two articles, as shown in Table 1.

Consider the intersection of all three sets: BHK set, KLR set and IMF set. GDP growth and foreign exchange reserves appear in all three sets, we surely include them in our pool of

Table 1. Pool of candidate variables as intersections of previous literatures.

KLR	(1998)	GDP growth
BHK	(2007)	Foreign reserve
IMF	(2001)	
BHK	(2007)	External debt
IMF	(2001)	Overvaluation(exchange rate sustainability)
BHK	(2007)	Budget balance
KLR	(1998)	
KLR	(1998)	Terms of trade
IMF	(2001)	Stock market prices (Asset booms) Real interest rate (Real deposit rate) Lending booms (Domestic loans)

indicators. The intersection of BHK and IMF set contains external debt and overvaluation. Unfortunately, China changed its statistical scope of measuring external debt several times since the Asian currency crises. It is extremely difficult to adjust the data of external debt without knowing the very details how Statistics Bureau of China did the change. We had to leave out external debt series though reluctantly. Data on overvaluation are available and included.

There is no dispute to include budget balance, the intersection of BHK and KLR set.

There are four indicators belonging to the intersection of IMF and KLR set. We do not include stock market prices (or asset booms in IMF) because there have been so many institutional changes in rather immature China's stock market over the sampling period. Close co-movement of lending booms or domestic loans with M2 and greater accuracy in M2 data make us include M2 in our pool. We do not hesitate to include real deposit rate and terms of trade.

Thus, our pool of candidate indicators consists of GDP growth, foreign exchange reserve, overvaluation, budget balance, real exchange rate, M2, real deposit rate and terms of trade. In addition, we include CPI in our pool. CPI is a macroeconomic indicator in IMF set and is also the most important target variable of China's macroeconomic policy.

Dataset is mainly retrieved from the Economic Intelligence Unit database. Some variables are transformed due to the modeling purpose. Details are gathered in Appendix 1.

3. Modeling respondent's rating

3.1. Individual model

To avoid possibly tremendous heterogeneity across individuals, we first model respondent's rating individually.

Following an ordered logit model, a macro financial stability is a latent variable $y^*{}_{\mathrm{t}}$ which is determined by some macroeconomic indicators $\mathbf{X}_t$. Specifically,

$$y^*_{it} = x_t\beta_i + \epsilon_{it}, \tag{3.1}$$

where the disturbance ϵ_{it} follows a standard logistic distribution. The observed score y_{it} is then generated by y^*_{it} and some cutoff points $\mu_{i,0} < \mu_{i,1} < \ldots < \mu_{i,5}$, that is,

$$y_{it} = j, \text{ if } \mu_{i,j-1} < y^*_{it} \leq \mu_{i,j}, \tag{3.2}$$

where $\mu_{i,0} = -\infty, \mu_{i,5} = \infty$.

However, there are two problems in this standard ordered logit model; it may not be entirely applicable to our data set. First, some respondents never give a rating of 1 or 5 to any year. Consequently, only two cutoff point parameters $\mu_{i,2}$ and $\mu_{i,3}$ can be identified. Second, estimation of ordered logit model is generally invariant to any order-preserving transformation. Such an invariance property in our survey data does not seem plausible, however. The respondent's ratings, in fact, contains some kind of 'cardinal' information. For example, given that year t has a rating of 2, if a respondent assigns a rating of 5 instead of 3 to year $t + 1$, it means the instability level has a much greater increase from year t to $t + 1$. A rating of 5 is considered much closer to a break-out of financial crises than 3.

In order to consider such a 'cardinal' property and the unidentifiablility of some cutoff points, we assume that the distances between adjacent cutoff point are the same, that is, the latent stability level's gaps are equal across ratings. This assumption is equivalent to the following constraint:

$$\begin{pmatrix} -1 & 2 & -1 & 0 \\ 0 & -1 & 2 & -1 \end{pmatrix} \begin{pmatrix} \mu_{i,1} \\ \mu_{i,2} \\ \mu_{i,3} \\ \mu_{i,4} \end{pmatrix} = \begin{pmatrix} 0 \\ 0 \end{pmatrix}. \quad (3.3)$$

Reparameterize the cutoff points by letting $\alpha_i = \mu_{i,1}$ and $\delta_i = \mu_{i,j} - \mu_{i,j-1}, j = 2, 3, 4$. We also estimate ordered logit models in which (3.2) is replaced with

$$y_{it} = \begin{cases} 1, & \text{if } y^*_{it} \leq \alpha_i; \\ 2, & \text{if } \alpha_i < y^*_{it} \leq \alpha_i + \delta_i; \\ 3, & \text{if } \alpha_i + \delta_i < y^*_{it} \leq \alpha_i + 2\delta_i; \\ 4, & \text{if } \alpha_i + 2\delta_i < y^*_{it} \leq \alpha_i + 3\delta_i; \\ 5, & \text{if } y^*_{it} > \alpha_i + 3\delta_i. \end{cases} \quad (3.4)$$

As there is no theory to guide a proper specification of $\mathbf{X}$ in (3.1). We implement the following steps to engage specification search:

(1) For each individual respondent, we estimate the models ((3.1) combined with (3.2) or (3.4)) with all possible combinations of candidate indicators. There are $2^9 - 1 = 511$ logit models for each respondent.
(2) Of the 511 models, eliminate those with p-value of the likelihood ratio statistics greater than 5% since these models are statistically insignificant from the benchmark model that contains no indicators. Furthermore, we eliminate those models with completely determined (or called 'perfect prediction') problem because the estimates of their coefficients as well as the corresponding standard errors are unreliable.
(3) Select the 'best' model using BIC criteria from the remaining specifications, and identify significant indicators from the selected model by a predetermined 5% significance level.
(4) Steps 1 through 3 are repeated for all individuals, we count the frequency of significance of each candidate indicator across each individual's best model to evaluate the importance of macroeconomic indicators.

Respondents may agree on the importance of a particular indicator but their opinions about the directional relation of the indicator to macroeconomic stability can be quite different. We shall also look into respondents' consensus on the parameter sign.

We first apply standard ordered logit model, (3.1) and (3.2) to explain indi vidual's rating. In this case, if an individual only gives n ($n < 5$) ratings over the sample years, we estimate an ordered n-nominal logit model for this individual. Among 511 models estimated for each respondent, we select the best model by BIC criterion in which we identify the significant macroeconomic indicators that best explain a respondent's ratings. The final 37 best models corresponding to 37 respondents are reported in Appendix 2 (Table 7 and 8). For some respondents, their best model contains as many as six indicators; some as few as two.

From the results in Appendix 2, we calculate how often a candidate indicator is included as a significant explanatory variable in the best models. As shown in Table 2, change in CPI was identified as a significant macroeconomic indicator in 20 out of 37 best models. Moreover, it enters all 20 but one respondent's best models with a significant positive coefficient. Thus we found that higher inflation makes respondents give greater instability

Table 2. Individual ordered logit model (unconstrained).

Variable	Inclusion frequency	Significant inclusion frequency	Frequency of positive sign	Frequency of negative sign
Budget balance	17	12	1	11
Overvaluation	9	6	4	2
GDP growth rate gap	15	12	11	1
M2 growth rate	10	8	6	2
Real deposit interest rate	9	8	5	3
Real effective exchange rate	11	6	4	2
Foreign exchange reserve	11	8	3	5
Inflation rate	23	20	19	1
Terms of trade	13	10	1	9

Conventional, significance level 5%.

Table 3. Individual ordered logit model (constrained).

Variable	Inclusion frequency	Significant inclusion frequency	Frequency of positive sign	Frequency of negative sign
Budget balance	17	13	1	12
Overvaluation	6	4	4	0
GDP growth rate gap	15	13	12	1
M2 growth rate	10	8	6	2
Real deposit interest rate	10	7	4	3
Real effective exchange rate	8	5	3	2
Foreign exchange reserve	8	6	2	4
Inflation rate	21	19	18	1
Terms of trade	11	10	1	9

Constrained, significance level 5%.

rating, well conformed with intuition. Change in budget balance has the second highest inclusion frequency, 17 times, followed by GDP growth gap, 15 times. However, both were included with significance in 12 out of 37 best models. Coefficient of changes in budget balance has the expected negative sign as a significant indicator in 11 out of 12 significant inclusions. Similar results for GDP growth gap with decidedly positive coefficient. Terms of trade came in the third place, appearing significant in 10 final models with a plausible sign.

We also estimate the ordered logit model specified in (3.1) and (3.4). Similar to Table 2, we summarize the results in Table 3. Comparing Table 3 and Table 2, we observe that change in CPI still has the highest inclusion frequency. Change in budget balance, GDP growth rate gap and terms of trade have relatively higher inclusion frequency and greater respondents' consensus on the coefficient sign, compared to the rest of macroeconomic indicators.

In short, ordered logit models, with or without constraint (3.3), yield very similar results.

Results on individual modeling indicated that inflation seems to be the key macroeconomic indicator in shaping China's macrostability. Change in budget balance and GDP growth gap are also important indicators. Moreover, we cannot easily dismiss the relevance of terms of trade.

While informative and interesting, previous results from individual modeling are based on a rather small sample (22 years). Furthermore, to establish the relative importance of macroeconomic indicators, we are interested in seeing if panel estimation would result in a different perspective.

3.2. Panel model

It is common to use the fixed effect to account for individual specific effect. Unfortunately, an ordered logit or probit model with fixed effect lacks a sufficient statistic to condition out the fixed effects from the log likelihood. Moreover, fitting the fixed effects in a straightforward manner by including the dummy variables in the model would induce the bias due to the incidental parameter problem (Greene and Hensher 2008). Currently available fixed effect estimators are based on a transformation of multi-category respond into a set of binary cases then use conditional likelihood to estimate the slope coefficients, see Das and van Soest (1999), Ferrer-i-Carbonell and Frijters (2004). However, such transformation will lead to sizeable data loss. Our data are not large enough to warrant such an approach. We consider the random effect model instead.

$$y_{it}^* = x_t\beta + u_i + \epsilon_{it}, \tag{3.5}$$

$$y_{it} = j \text{ if } \mu_{j-1} < y_{it}^* \leq \mu_j,\ j = 1, 2, \ldots, 5, \tag{3.6}$$

$$\epsilon_{it} \sim \text{Logistic distribution},$$
$$u_i \sim N(0, \sigma^2),$$

where u_i is individual i's specific effect, ϵ_{it} is a random disturbance. $u_i \perp \epsilon_{it}$, $\forall t, \epsilon_{it} \perp \epsilon_{js},\ \forall i \neq j,\ t \neq s$, and cutoff point $\mu_0 = -\infty$, $\mu_5 = \infty$.

To allow individual heterogeneity on weighting the impacts of macroeconomic variables, we also let the slope coefficients be randomly distributed. Specifically, we combine the random individual effect and random coefficient. Let

$$y_{it}^* = (x_t, 1)\tilde{\beta} + \epsilon_{it}.$$

where

$$\tilde{\beta} = \begin{pmatrix} \beta \\ u_i \end{pmatrix} \sim N\left(\begin{pmatrix} \beta_0 \\ 0 \end{pmatrix}, \Sigma \right), \tag{3.7}$$

Covariance matrix $\mathbf{\Sigma} = \mathbf{LL}'$ and $\mathbf{L}$ is $\mathbf{\Sigma}$'s Cholesky lower triangle decomposition.

Let ϕ^* $(\mathbf{w}_i)$ be the density function of a $(k+1)$-dimension multivariate normal distribution, $\mathbf{w}_i \sim N(0_{k+1}, \mathbf{I}_{k+1})$. The log likelihood function can be written as

$$\ln L^* = \sum_{i=1}^{37} \ln \left\{ \int_{\mathbb{R}^{k+1}} \prod_{t=1}^{22} [F(\mu_{j_{it}} - x_t\beta_0 - (x_t, 1)(\mathbf{Lw}_i)) - F(\mu_{j_{it}-1} - x_t\beta_0 - (x_t, 1)(\mathbf{Lw}_i))]\phi^*(\mathbf{w}_i)d\mathbf{w}_i \right\} \tag{3.8}$$

where $F(x) = (1 + e^{-x})^{-1}$ is the cumulative distribution function of Logistic distribution.

It is difficult to maximize (3.8) directly since it involves high-dimensional integration. Because the integration in (3.8) is essentially the expectation of

$$\prod_{t=1}^{22} [F(\mu_{j_{it}} - x_t\beta_0 - (x_t, 1)(\mathbf{Lw}_i)) - F(\mu_{j_{it}-1} - x_t\beta_0 - (x_t, 1)(\mathbf{Lw}_i))], \tag{3.9}$$

we can approximate it by averaging (3.9) based on R realization of $\mathbf{w}_i, \{\mathbf{w}_{i1}, \ldots, \mathbf{w}_{iR}\}$, drawn from $(k+1)$-dimension multivariate standard normal distribution. Maximizing the simulated log likelihood function below

$$\ln L_s^* = \sum_{i=1}^{37} \ln \left\{ \frac{1}{R} \sum_{r=1}^{R} \prod_{t=1}^{22} [F(\mu_{j_{it}} - x_t\beta_0 - (x_t, 1)(\mathbf{Lw}_{ir})) - F(\mu_{j_{it}-1} - x_t\beta_0 - (x_t, 1)(\mathbf{Lw}_{ir}))] \right\} \tag{3.10}$$

yields the simulated maximum likelihood estimates (SMLE).

Similar to the individual modeling, we estimate the panel model with all possible combinations of candidate indicators ($2^9 - 1 = 511$ models in total).

Next, we eliminate the models with p-value of the likelihood ratio statistics greater than 5%. Finally, we rank remaining models in the BIC.

The top 10 BIC favorite models are displayed in Table 4. Parameter estimates in the table are the means of the corresponding random coefficients with their standard errors (associated with those means) in the parentheses.

Inspecting Table 4, the first noticeable feature is that overvaluation and M2 growth rate never appeared in any of the top 10 models. In fact, inflation (10) > GDP growth gap (7) > change in budget balance (6) > terms of trade (5) > real deposit rate (2) > foreign exchange reserve (1) = real effective exchange rate (1) > M2 growth (0) = overevaluation (0), in terms of their inclusion frequencies in parenthesis in the top 10 models.

We observe a clear boundary in such an ordering that separates nine candidate indicators to two categories in terms of inclusion frequency. More important indicators are inflation, GDP growth gap, change in budget balance and terms of trade. The rest five indicators are less important. Interestingly, the set of more important indicators identified from panel estimation coincides with previous finding from individual modeling.

We make further comments on the candidate indicators. The true means of the random coefficient associated with real deposit rate (appeared in the fourth and fifth best model) and that of foreign exchange reserve (appeared in the sixth best model) are not significantly different from zero. Though real effective exchange rate has a random coefficient with mean significantly different from zero, it shows up just once in the top 10 models. On the other hand, the coefficients of more important indicators all have means significantly different from zero and exhibit unanimous signs.

Results in Table 4 seem to suggest that inflation is the leading indicator in determining China's macroeconomic stability, followed by the change in budget balance, GDP growth gap (three indicators in the BIC-best model). Terms of trade could be equally important. Panel estimation delivers strikingly similar indicator identification results as individual modeling.

Table 4. Panel random effect ordered logit model with random coefficients.

Rank	BIC	Budget balance	Overvaluation	GDP growth rate gap	M2 growth rate	Real deposit interest rate	Real effective exchange rate	Foreign exchange reserve	Inflation rate	Terms of trade
1	2.8134	−0.822		37.193					7.936	
		(0.125)		(6.157)					(1.068)	
2	2.82								14.875	−0.093
									(1.137)	(0.014)
3	2.8238	−0.659							14.684	−0.073
		(0.148)							(1.289)	(0.015)
4	2.8246	−0.894		39.288		−0.011			10.294	
		(0.148)		(6.939)		(0.014)			(1.288)	
5	2.8325					0.001			15.609	−0.098
						(0.012)			(1.258)	(0.015)
6	2.8348	−0.744		40.997			0.023		6.027	
		(0.152)		(7.511)			(0.008)		(1.278)	
7	2.8359			23.798					12.102	−0.067
				(6.635)					(1.331)	(0.015)
8	2.8371	−0.708		30.270					11.769	−0.047
		(0.154)		(7.060)					(1.458)	(0.016)
9	2.838			35.441					8.344	
				(6.699)					(1.086)	
10	2.8436	−0.807		35.757				−0.494	10.361	
		(0.145)		(7.876)				(0.307)	(1.258)	

Standard error in parentheses.

Table 5. Partial effects of (BIC-best) panel model.

Variable	Budget balance	GDP growth rate gap	Inflation rate
Mean of coefficient	−0.8217	37.1932	7.9356
$\frac{\partial \Pr(y=1)}{\partial x_k}$	0.04856	−0.90388	−0.07553
$\frac{\partial \Pr(y=2)}{\partial x_k}$	0.12446	−3.59446	−0.36189
$\frac{\partial \Pr(y=3)}{\partial x_k}$	−0.01592	−4.78096	−1.20834
$\frac{\partial \Pr(y=4)}{\partial x_k}$	−0.12585	5.99211	0.27312
$\frac{\partial \Pr(y=5)}{\partial x_k}$	−0.03125	3.28708	1.37265

We also calculate the partial effects in the BIC-best model evaluated at indicators' mean:

$$\frac{\partial \Pr(y=j)}{\partial x_k} = -\beta_{0k}[f(\mu_j - \bar{x}\beta_0) - f(\mu_{j-1} - \bar{x}\beta_0)]$$

The result is shown in Table 5. The partial effects of the GDP growth rate gap and the inflation rate are positive for ratings of 4 or 5 and negative for ratings of 1 or 2. The partial effects of budget balance are exactly the opposite. This means a greater of budget balance surplus (or a greater reduction of deficit), a smaller GDP growth rate gap or a lower rate of inflation will make the respondent tend to choose a better evaluation to China's macroeconomic financial stability since it reduces the probability that she or he gives a high rating to the instability.

Based on the BIC-best panel ordered logit model, we calculate the expectation of the latent variable $\left(y_{it}^*\right)$ given the macroeconomic indicators, $t = 1987, \ldots, 2008$. Specifically, we named this expectation macroeconomic stability index (MSI):

$$\text{MSI}_t = E(y_{it}^*|\mathbf{x}_t) = E(\mathbf{x}_t\beta + u_i + \epsilon_{it}|\mathbf{x}_t) = \mathbf{x}_t\beta_0 \tag{3.11}$$

Such a time series can serve a measure of China's macroeconomic stability and is plotted in Figure 2. This curve shows that China's macroeconomic experienced 1988–1989, 1993–1994 and 2007–2008 three distinct unstable periods. We also implement subsample estimation, and calculate MSI based on the BIC-best model. Results are summarized in Figure 3. Except, for a few years, changing estimation window results in little alteration in the macroeconomic stability index.

4. Discussion and comments

Having determined the three core indicators in determining China's macroeconomic stability, we plot change in budget balance, GDP growth gap and inflation in Figure 4 and list the corresponding data in Table 6. In Figure 2, we observe that MSI escalating from 1987 to 1988 dramatically, then reached to a local peak in 1989. During this time period, we see from Figure 4 that there was a big change in budget balance, from 1987's surplus to

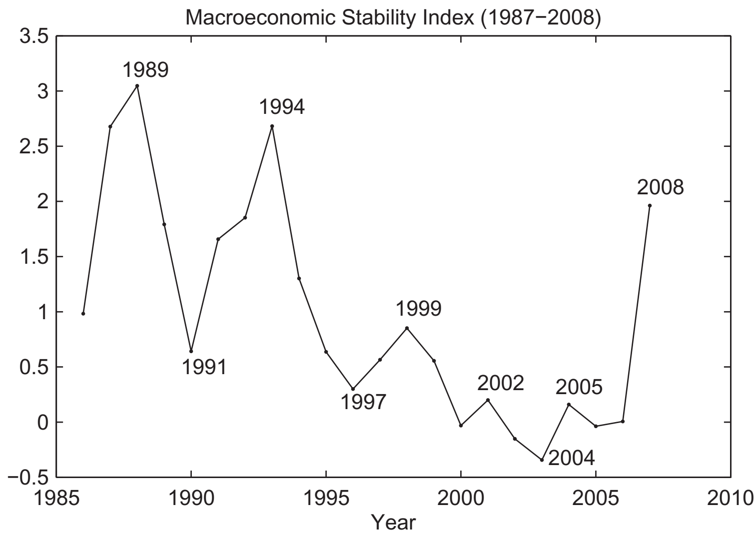


Figure 2. Macroeconomic stability index.

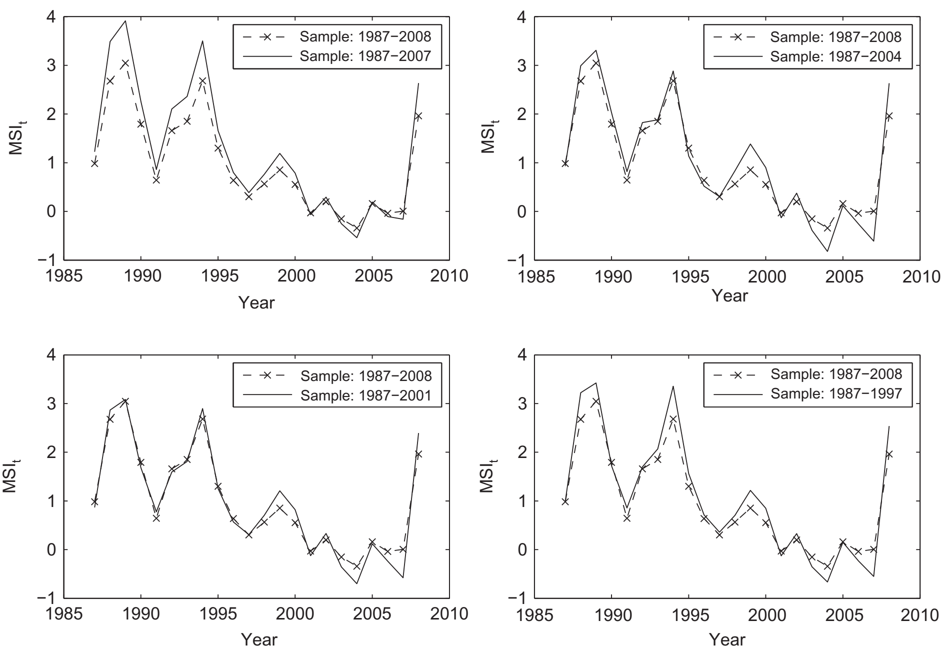
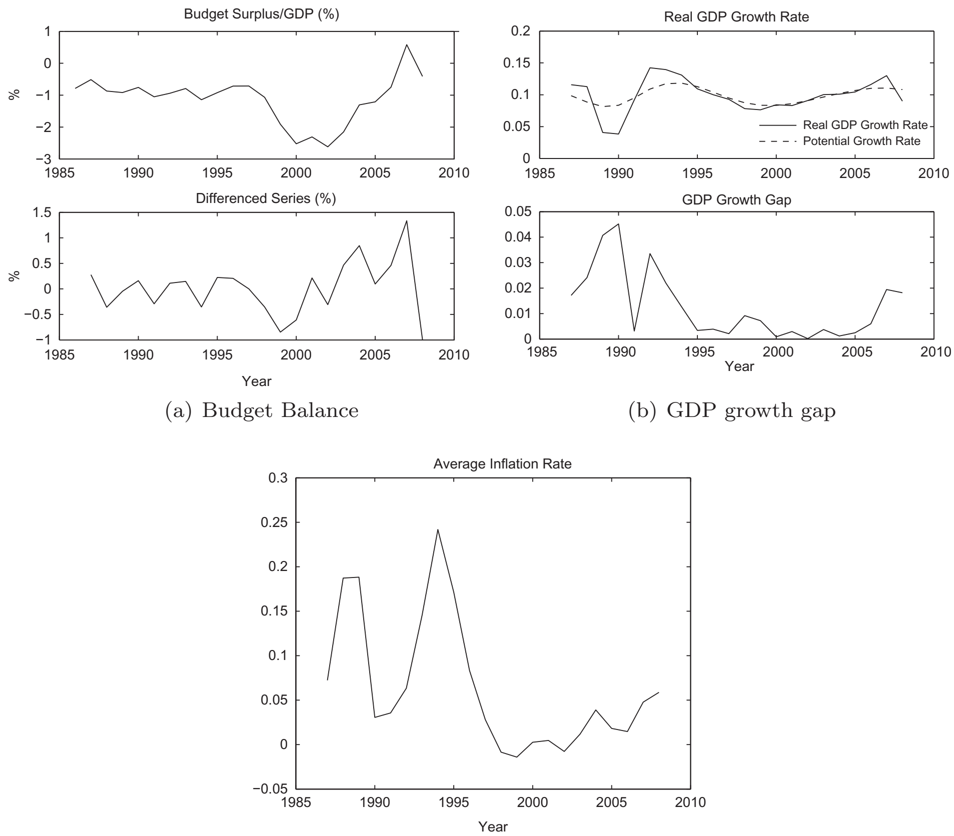


Figure 3. Subsample macroeconomic stability index.

1988's deficit and inflation went up explosively from 7% in 1987 to almost 19% in 1988. Moreover, GDP growth gap also increased quite substantially. This unhappy combination increased China's macroeconomic instability as shown in Figure 2. In 1989, though the budget balance changed little, wider GDP growth gap and continuously high inflation at 19% pushed China's macro instability level to its peak. At the local peak of 1994, though the GDP growth gap was a quarter of that in 1989, we observed a big negative change in



(a) Budget Balance

(b) GDP growth gap

(c) Inflation

Figure 4. Series of core indicators.

budget balance (−0.358, compared to the sample mean 0.017) and astounding inflation at 24%. Each of the three core indicators played different role of influencing China's macroeconomic stability over the sample period. We shall make comments on each indicator in turn.

Local peaks of inflation series at 1989 and 1994 well coincides with those in Figure 1 and 2. This is a statistical reason that inflation has been identified as the most important indicator in the previous section. However, inflation alone cannot completely explain macro instability. Take 1995 as an example, inflation was at 17%, close to 1988 and 1989's level of inflation and is the fourth highest in the sample period, but the level of instability was much lower than 1988 and 1989 due to positive change in budget balance and narrow GDP growth gap.

GDP growth gap, averaging 0.0127 over the sample period, exhibits two obvious local peaks at 0.0452 in 1990 and at 0.0335 in 1992. Since GDP growth gap at 1989 was the second highest at 0.0407, it explains the local peak at 1989 in Figures 1 and 2 well enough. However, the peak at 1992 was the third highest gap, yet a positive change in budget balance and moderate inflation in that year attenuate the risk caused by wide growth gap. Rising instability level in 2007 and 2008 can also partially be explained by the higher than average growth gap.

Table 6. Data of the three core variables.

Year	1987	1988	1989	1990	1991	1992	1993	1994
Budget Balance	0.277	−0.359	−0.047	0.161	−0.293	0.111	0.148	−0.353
GDP growth gap	0.017	0.024	0.041	0.045	0.003	0.034	0.022	0.013
Inflation	0.072	0.187	0.188	0.031	0.036	0.063	0.146	0.242
Year	1995	1996	1997	1998	1999	2000	2001	2002
Budget Balance	0.224	0.206	0.001	−0.353	−0.847	−0.61	0.214	−0.308
GDP growth gap	0.003	0.004	0.002	0.009	0.007	0.001	0.003	0.000
Inflation	0.171	0.083	0.028	−0.009	−0.014	0.003	0.005	−0.008
Year	2003	2004	2005	2006	2007	2008		
Budget Balance	0.465	0.848	0.095	0.459	1.335	−0.996		
GDP growth gap	0.004	0.001	0.003	0.006	0.02	0.018		
Inflation	0.012	0.039	0.018	0.015	0.048	0.059		

It may not be surprising to find that inflation and growth gap are significant risk factors of macroeconomic instability. After all, these two indicators are the major concern of Chinese government, and any other country too. On the other hand, the indicator of budget balance is perhaps specific to China. China government has been playing an active role in tuning the economy. In fact, China's government expenditure considered by many is still a big engine of China's economic growth. Model-matching speaking, we observe that local peaks in Figure 1 at 1989, 1993, 1998 were associated with huge negative change in budget balance at 1988, 1994 and 1999 with magnitude −0.359, −0.353 and −0.847, respectively. The rising China's macroeconomic instability in 2008 is due to historically largest negative change in budget balance. We attribute such a huge change to the four trillion stimulus program to counter the global financial crisis.

5. Conclusions

It is a challenging task to quantify the unobserved macrostability. Extracting principal components from a set of macroeconomic indicators documented in financial crisis literature and IMF's macro-prudential analysis of financial sector is convenient. However, such a routine data analysis usually offers very little insight on extracted components. It is also quite arbitrary to use grading report based on a researcher's subjective score on individual macroeconomic indicators to measure the macrostability.

In this article however, we analyze the survey data on macrostability ratings from 37 leading Chinese scholars, government officials and higher management in financial firms. Results from estimating different types of ordered logit models seem to converge to one important point that during 1987–2008 China's macrostability is mainly related to change in budget balance, GDP growth rate gap and inflation rate.

Disregard whether or not our survey data are a good proxy of macrostability and despite the tremendous heterogeneity, our results turn out quite sensible. Stability of the macroeconomic environment in which China's financial sector operates can be characterized by three indicators. We believe that a reasonable stress test on the stability of the financial sector in China should focus on inflation, growth gap and budget balance. The first two are the bonafide objectives of China's economic planning, while the last one considered by many is the most powerful countercyclical policy instrument in the past two decades.

Note

1. To be concise, KLR stands for Kaminsky, Lizondo, and Reinhart (1998) while BVK stands for Bauer, Herz, and Karb (2007).

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Appendix 1. Candidate variables

This section provides detail information about the nine candidate variables.
Budget balance is equal to the general government receipts minus the general government outlays, as a percentage of GDP. We difference it once to achieve stationary.

Overvaluation We use the covered interest rate parity to calculate the forward exchange rate and take the difference between the spot rate and the forward rate as a measure of the expected appreciation of RMB against USD. In particular, the overvaluation of year i

$$o_i = \frac{1}{12}\sum_{j=1}^{12}\left[e_{ij} - \frac{1 + r_{\mathrm{RMB},ij}}{1 + r_{\mathrm{USD},ij}} e_{ij}\right]$$

where e_{ij}, $r_{\mathrm{RMB},ij}$ and $r_{\mathrm{USD},ij}$ are respectively the nominal spot exchange rate of USD-RMB, the one-year nominal deposit interest rate of RMB and the one-year Constant Maturity Treasury rate of the United States in month j of year i. This variable is first-order differenced to a stationary series.

GDP growth rate gap is defined as $\mathrm{gap}_i = |g_i - g_i^*|$ where g_i is the growth rate of real GDP (in 1995 price) and g_i^* is the underlying trend of GDP growth in year i. The trend is approximated by the Hodrick-Prescott filtered trend of original growth rate series. According to Ravn and Uhlig (2002), the λ parameter is set to 6.25. As substantial higher or lower deviation from the underlying trend may have the similar impact on macroeconomic stability. We use its absolute value in the subsequent econometric modeling.

M2 growth rate is the percentage change of M2 compared with the year earlier.

Real deposit interest rate is the average of the difference between the nominal deposit interest rate in each month of current year and corresponding 'ex post' inflation rate for one year starting from this month.

$$r_i^* = \frac{1}{12}\sum_{j=1}^{12}\left[r_{i,j} - \frac{\mathrm{CPI}_{i+1,j} - \mathrm{CPI}_{i,j}}{\mathrm{CPI}_{i,j}}\right]$$

where r_i^* is the one-year real deposit interest rate in year i, *ri,j* is the one-year nominal deposit rate in month j of year i, $(\mathrm{CPI}_{i+1,j} - \mathrm{CPI}_{i,j}) / \mathrm{CPI}_{i,j}$ is the year-over-year CPI change in month j of year $i+1$. This variable is first-order differenced to achieve stationarity.

Real effective exchange rate is the CPI-based real effective exchange rate in EIU database. We use 1997 as the base year to rescale the raw data. First-order difference of this time series is required.

Foreign exchange reserve. We quoted the balance of China's foreign exchange reserve (in USD terms) at the end of each year from EIU. We transform the raw data by taking natural logarithm and first-order differencing.

Inflation rate is the yearly average change of CPI. The inflation rate of year i is:

$$\pi_i = \frac{1}{2}\sum_{j=1}^{12}\frac{\mathrm{CPI}_{i,j} - \mathrm{CPI}_{i-1,j}}{\mathrm{CPI}_{i-1,j}}$$

Terms of trade is the ratio of the export price index to the import price index ($1990 = 100$). Data are first-order differenced in later use.

Appendix 2. Individual models' results

Table 7. Individual ordered logit model summary.

ID[a]	Individual Type[b]	Budget balance	Overvaluation	GDP growth rate gap	M2 growth rate	Real deposit interest rate	Real effective exchange rate	Foreign exchange reserve	Inflation rate	Terms of trade
1	G		10.301 (0.068)	210.420 (0.020)	39.999 (0.109)		0.122 (0.137)		51.281 (0.010)	−2.866 (0.026)
2	E	−1.915 (0.026)		125.515 (0.005)						
3	P			80.164 (0.050)				−5.285 (0.042)	13.905 (0.083)	
4	P		19.105 (0.010)	173.125 (0.041)		−0.500 (0.008)	0.227 (0.016)	7.152 (0.071)	42.758 (0.003)	
5	G								86.616 (0.001)	
6	G	−0.660 (0.484)					−0.222 (0.009)	−14.760 (0.009)	32.926 (0.006)	
7	G	−1.263 (0.169)	6.333 (0.147)					−2.470 (0.129)		
8	U								28.252 (0.005)	−0.982 (0.068)
9	E				−43.170 (0.035)	−0.290 (0.063)		11.795 (0.040)	85.401 (0.006)	−1.610 (0.056)
10	G	−1.243 (0.229)		87.197 (0.114)	47.964 (0.004)			−8.825 (0.034)		
11	U	−2.045 (0.028)					0.081 (0.054)			
12	U								29.708 (0.005)	−0.796 (0.089)
13	G	−2.880 (0.006)		132.050 (0.004)			0.071 (0.095)			
14	E	−2.919 (0.023)		89.736 (0.042)	25.227 (0.031)	0.349 (0.007)			−34.973 (0.009)	

(*Continued*)

Table 7. (*Continued*).

ID[a]	Individual Type[b]	Budget balance	Overvaluation	GDP growth rate gap	M2 growth rate	Real deposit interest rate	Real effective exchange rate	Foreign exchange reserve	Inflation rate	Terms of trade
15	E	−11.869 (0.007)		660.675 (0.012)			0.246 (0.024)	18.742 (0.022)	31.688 (0.023)	
16	E			73.961 (0.035)			0.071 (0.090)	6.054 (0.037)		
17	G		11.020 (0.027)	92.624 (0.017)			0.101 (0.011)			
18	P	−1.845 (0.047)							13.606 (0.039)	
19	U	2.832 (0.030)							28.119 (0.005)	−1.805 (0.012)
20	U		8.205 (0.093)						48.247 (0.009)	−1.909 (0.010)
21	P				28.145 (0.012)	0.283 (0.015)	0.092 (0.041)			−2.245 (0.003)
22	U				57.909 (0.002)	0.792 (0.003)			−22.825 (0.074)	−2.645 (0.005)
23	P	−2.122 (0.030)							22.845 (0.011)	
24	G				27.886 (0.010)		0.080 (0.075)			
25	P	−2.076 (0.101)	−12.093 (0.046)		39.069 (0.016)	0.504 (0.011)				−3.409 (0.003)
26	P	−2.918 (0.012)		70.724 (0.062)		0.217 (0.015)				
27	U	−1.758 (0.054)				−0.301 (0.022)			47.854 (0.004)	
28	P							−5.112 (0.029)	20.938 (0.007)	−1.676 (0.008)

29	U			−92.651 (0.021)						
30	E					−0.347 (0.042)			50.391 (0.011)	−1.437 (0.011)
31	G	−11.326 (0.008)	−22.079 (0.031)	545.250 (0.017)	−80.774 (0.018)			9.828 (0.054)	94.196 (0.018)	
32	G	−2.533 (0.033)	11.137 (0.026)	94.129 (0.029)						1.268 (0.030)
33	P						−0.214 (0.045)	−22.533 (0.028)	120.421 (0.040)	
34	E		34.114 (0.011)	216.681 (0.019)					105.819 (0.009)	−2.381 (0.032)
35	E				−12.719 (0.088)				27.445 (0.002)	
37	G	−2.759 (0.014)							−12.611 (0.061)	

Conventional type. *P*-value in parentheses.
a All models for No.36 are insignificant. Thus it is omitted in this table.
b Individual type: E = Economists, G = Government officials, P = Professionals in financial industry, U = Unable to identify.

Table 8. Individual ordered logit model summary.

ID[a]	Individual Type[b]	Budget balance	Overvaluation	GDP growth rate gap	M2 growth rate	Real deposit interest rate	Real effective exchange rate	Foreign exchange reserve	Inflation rate	Terms of trade
1	G			170.059 (0.008)					41.235 (0.003)	−0.210 (0.049)
2	E	−1.897 (0.029)		127.027 (0.004)						
3	P			116.494 (0.007)						
4	P		18.480 (0.011)	173.872 (0.043)		−0.529 (0.000)	0.235 (0.027)	7.290 (0.045)	43.927 (0.005)	
5	G								84.608 (0.001)	
6	G	−2.670 (0.012)		73.324 (0.044)	16.114 (0.033)					
7	G			−116.285 (0.006)			−0.185 (0.002)	−13.402 (0.001)	20.568 (0.008)	
8	U								30.248 (0.001)	−0.189 (0.035)
9	E				−37.280 (0.025)	−0.292 (0.067)		6.971 (0.006)	77.160 (0.003)	−0.243 (0.022)
10	G	−1.024 (0.276)		87.578 (0.081)	47.492 (0.004)			−8.385 (0.024)		
11	U	−2.084 (0.019)					0.082 (0.048)			
12	U								17.929 (0.027)	
13	G	−2.785 (0.010)		130.830 (0.004)			0.079 (0.074)			
14	E	−2.464 (0.025)		98.257 (0.017)	22.064 (0.067)	0.331 (0.008)			−32.750 (0.014)	

15	E	−4.148 (0.001)		105.299 (0.012)					21.732 (0.004)	
16	E					0.104 (0.072)		2.382 (0.297)		
17	G		11.241 (0.016)	95.327 (0.010)			0.105 (0.007)			
18	P	−1.850 (0.022)							14.009 (0.036)	
19	U	2.648 (0.026)							29.500 (0.004)	−0.316 (0.007)
20	U		8.158 (0.086)						35.535 (0.002)	−0.298 (0.007)
21	P	−1.904 (0.827)			26.838 (0.013)	0.228 (0.110)	0.099 (0.728)			−0.372 (0.481)
22	U				36.568 (0.001)	0.517 (0.001)				−0.388 (0.003)
23	P	−2.137 (0.024)							21.188 (0.005)	
24	G				25.773 (0.006)		0.074 (0.087)			
25	P		−7.656 (0.082)		33.626 (0.022)	0.373 (0.001)				−0.575 (0.001)
26	P	−2.728 (0.002)				0.186 (0.013)				
27	U						−0.119 (0.017)	−8.747 (0.035)	32.818 (0.001)	
28	P							−5.320 (0.014)	21.231 (0.004)	−0.301 (0.005)
29	U	1.635 (0.052)		−100.324 (0.501)						
30	E					−0.218 (0.016)			36.310 (0.001)	−0.249 (0.016)
31	G	−3.606 (0.000)		155.037 (0.002)	−34.239 (0.021)	−0.274 (0.029)			44.888 (0.003)	

(*Continued*)

Table 8. (*Continued*).

ID[a]	Individual Type[b]	Budget balance	Overvaluation	GDP growth rate gap	M2 growth rate	Real deposit interest rate	Real effective exchange rate	Foreign exchange reserve	Inflation rate	Terms of trade
32	G	−2.506 (0.011)	12.092 (0.030)	107.821 (0.025)						0.240 (0.018)
33	P	−99.019 (0.223)			1433.439 (0.161)			−303.250 (0.149)	1126.722 (0.138)	
34	E		11.245 (0.010)	140.157 (0.005)					44.685 (0.000)	
35	E								17.525 (0.002)	
37	G	−2.725 (0.009)							−12.392 (0.068)	

Constrained type. *P*-value in parentheses.
a All models for No.36 are insignificant. Thus it is omitted in this table.
b Individual type: 1 = Economists, 2 = Government officials, 3 = Professionals in financial industry, 0 = Unable to identify.