Macro-Financial Modeling of the Singapore Economy: A GVAR Approach*

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Globalization has greatly increased interdependencies across countries.

National economic issues should be considered from a global perspective, and particularly so for small open economies such as Singapore.

Modern economies feature strong macro-financial interactions.

Monetary policy must take into account the way its transmission operates within the domestic banking system.
Against this background, the Monetary Authority of Singapore (MAS) is interested in having at its disposal a modeling tool which would tackle two main issues:

**On the macroeconomic side**

Provide a compelling representation of the interactions between the Singapore economy and the rest of the world

**On the banking side**

Characterize the network of Monetary and Financial Institutions (MFIs) & the two-way feedback loop with the real economy
### The Challenge

Examining the monetary policy transmission requires considering many MFIs and complex interactions among them:

- Trade and financial linkages
- Common shocks (e.g., oil or food prices)
- Other channels (technology, uncertainty...)

**Problem:** "curse of dimensionality"

Too many parameters to estimate for too few data.

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<th>On the macroeconomic side</th>
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<td>Many countries &amp; many transmission channels to take into account:</td>
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The GVAR Approach

We overcome this issue via the Global Vector Autoregressive (GVAR) modeling approach

The GVAR is a simple yet effective way of capturing interactions in high-dimensional systems

Originally developed as a model for the global economy...

... it can deal with large networks of regions, sectors, firms, banks...

Foreign variables capture interactions

- Each country is linked to others by foreign variables: weighted averages of other countries’ variables
- Weights capture the relative role of each country (e.g. trade- or financial-based)

2-step modelling strategy

1. Estimation on a country-by-country basis (under small open economy assumption)
2. Combine estimates to form the global VAR
Inspired on the GVAR, we build the SINGVAR: a tractable model of the Singapore economy

**Macroeconomic side**

A VARX model for the key macroeconomic indicators of the Singapore economy

The model is linked to the rest of the world via foreign variables that capture the relative role of key partners of Singapore

**Banking side**

Model each MFI as a VARX, using data on credit, lending rates, non-performing loans

Each MFI is connected to others via foreign variables that capture the relative importance of the rest of MFIs
Inspired on the GVAR, we build the SINGVAR: a tractable model of the Singapore economy

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Macroeconomic aggregates affects all MFIs (common factors)
In turn, developments in the banking sector feed back to the real economy.
The SINGVAR Model

Inspired on the GVAR, we build the SINGVAR: a tractable model of the Singapore economy

Macroeconomic side

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Banking side

Model each MFI as a VARX, using data on credit, lending rates, non-performing loans

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The model is suited to answer several interesting questions, for instance

- Effects of US or China shocks to the Singapore economy
- Effects of Singapore downturns to the distributions of MFIs’ credit flows & lending rates
Schematic Overview of SINGVAR

Macro Block

US

China

Euro Area

Financial Block

Bank 1

Bank 3

Bank 2

Bank 4
The Macro Block

Each country-specific model is a VAR with (weakly) exogenous variables (VARX)

\[ \Phi_i (L, p_i) x_{it} = a_{i0} + a_{i1} t + \Lambda_i (L, q_i) x^*_{it} + \Psi_i (L, q_i) d_t + u_{it} \]

**Domestic variables**
- Real output & inflation, real equity prices & FX wrt USD, short- & long-term rates

**Foreign variables**
- Weighted averages of other countries’ domestic variables (trade-based weights)

**Global variables**
- Oil price
- Raw material price
- Metal price

**Twist for the Macro Block of SINGVAR**, which
- Real Credit
- Real Property Price
- Real Private Consumption

also includes
- Uses the Nominal Effective Exchange Rate instead of bilateral FX (NEER is the monetary policy lever)

Explicitly model 33 world countries as in Dées et al. (2007)
- Cross-country quarterly data over 1979Q2-2013Q1 (available in the GVAR Toolbox 2.0 of Smith & Galesi, 2014)
- For Singapore, extend up to 2016Q4 (MAS data)
Each bank-specific model is also a VAR with (weakly) exogenous variables (VARX)

\[ A_j (L, p_j) y_{jt} = b_{j0} + b_{j1}t + B_j (L, q_j) y^*_{jt} + C_j (L, q_j) x_{SING,t} + v_{jt} \]

**Endogenous variables**
- Lending Rate
- Real Credit (housing & other loans)
- Non-performing Loans Ratio

**Foreign variables**
Weighted averages of other banks’ endogenous variables (weights based on **cross-bank lending exposure data**)

**Common variables**
Variables of the Macro Block (excluding Real Credit, which will be endogenously determined by banks)

The Financial Block includes 30 major MFIs (18 banking groups) over the period 2004Q1-2016Q4

**Highly representative sample:** it covers 97% of total assets & 99.9% of credit by all MFIs shortlisted by MAS
We allow for developments at the banking level to feed back to the real economy

2-step procedure of Chudik and Pesaran (2013):

1) Estimate the Macro Block by allowing for potential cointegration among variables

2) For each Macro variable (indexed by $i$) estimate the following **augmented regression**

\[
\Delta x_{SING, t}^{(i)} = c_i + \sum_{j=1}^{\tilde{q}_i - 1} \theta_{j, i}^{t, t-j} + \sum_{j=1}^{\tilde{p}_i - 1} \gamma_{j, i}^{t, t-j} \Delta x_{SING, t-j}^{SING} + \sum_{s=1}^{r} \delta_{s, i} E \hat{C} M_{s, t-1} + e^{(i)}_t
\]

**Feedback variables**

Weighted averages of banks’ variables

They capture feedbacks of the banking sector to real economy

Weights are based on size (assets) of each bank in the sector

**Estimated error correction terms**

Estimation deals with missing observations prior to 2004 for the Financial Block
The transmission channels of a monetary policy shock

A monetary policy shock (NEER) hits all banks (common shock)

Effects are heterogenous due to bank-specific conditions (leverage, profitability...)

Macro Block

Financial Block

Bank 1

Bank 2

Bank 3

Bank 4
The transmission channels of a monetary policy shock

Bank-to-bank interactions transmit & amplify the shock
The transmission channels of a monetary policy shock

In turn, developments in the banking sector **feed back** to the macroeconomy

Financial Block

- Bank 1
- Bank 2
- Bank 3
- Bank 4

Aggregate volume of loans and lending rate
The Effects of Shocks through the Lens of the SINGVAR

We analyze the properties of the model by considering three simulations:

- A fall in US real equity prices
- A rise in US interest rate
- A rise in Singapore’s real GDP

Two foreign shocks

A domestic shock

A note about identification of shocks

Shocks are “geographically” identified ...

- The var-cov matrix of residuals is close to be diagonal
- This is because the GVAR approach “cleans” the contemporaneous correlations of residuals (via foreign & common variables)

... but not structurally identified

- We do not dig deeper on primal causes of these shocks (demand, supply, financial shocks…)
- However, structural identification could be accommodated (e.g. via sign restrictions on IRFs)
A 1% Fall in US Real Equity Prices

The US equity shock has an almost 1-to-1 impact on Singapore’s equity prices.

Singapore’s real consumption and GDP drop, partly also because US GDP drops (not reported).

Similarly, real credit and property prices fall.
A 1% Rise in US Interest Rate

Singapore’s interbank & long-term rates increase in tandem with the US rate rise, but by a smaller amount.

Credit & property prices decrease (even though not significantly).

Also consumption and GDP fall, but not significantly.
A 1% Increase in Singapore’s Real GDP

The rise in GDP is accompanied by higher inflation, as well as by rises in consumption & property prices.

The large majority of banks extend more loans (even though with substantial heterogeneity).

At the same time, more favorable macro conditions are associated with a reduction in the share of bad loans for most of banks.
Conclusions

The SINGVAR is the latest addition to MAS’ suite of macroeconometric models

It provides a very parsimonious yet compelling characterization of the Singapore economy, its interactions with the rest of the world & with its banking sector

It is entirely based on the GVAR Toolbox 2.0 (Smith and Galesi, 2014) which allows for further refinements and applications, for instance

- Forecasting & scenario analysis
- Monetary policy & macroprudential analysis
Thank you very much for your attention!