Panel VAR: Methods and Applications

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Outline

- Basic panel data set up
- Panel VARs and estimation
- Applications
- Stata package of programs

Papers on VAR

- Package of programs for Stata: "Estimation of panel vector autoregression in Stata" by Michael Abrigo and Inessa Love, *The Stata Journal*, 2016, 16(3), 1-27.

1. Firm-level data: “Financial Development and Dynamic Investment Behaviour: evidence from Panel VAR” by Inessa Love and Lea Ziccino, *The Quarterly Review of Economics and Finance,* 46(2), pp. 190-210, 2006.
2. Bank-level and aggregate data: “Macro-financial linkages in Egypt: A panel analysis of economic shocks and loan portfolio quality” by Inessa Love and Rima Turk Ariss. *Journal of International Financial Markets, Institutions and Money* 28, pp.158–181. 2014.
3. Country-level data: Inessa Love, Roberto Rocha, Erik Feyen, Samuel Munzele Maimbo, and Raquel Letelier , 2016, “Financial Crisis Transmission: Foreign Ownership vs. Foreign Funding?”, *Review of Economics & Finance*. 2016, vol. 6, 63-80.
4. Country-level data: “The Dynamics of Exchange Rate Volatility: A Panel VAR Approach” by Axel Grossmann, Inessa Love, and Alexei Orlov, *Journal of International Financial Markets, Institutions and Money.* Volume 33, November 2014, Pages 1–27.

Basic panel data set up

$$Y_{it}=\beta x_{it}+c_i+u_{it}$$

- c_i is a "fixed effect" - time-invariant unobservable determinant of Y_{it}

- Standard OLS assumption is exogeneity of regressors, i.e. x_{it} has to be uncorrelated with $u_{it.}$
- "contemporaneous exogeneity" is not enough

- Available estimators: FD, FE, RE require "strict exogeneity":
- u_{it} has to be independent of all x_{it} for all t (i.e. past and future)
- This will fail if a current shock to Y will affect future realization of x

examples

- Foreign aid and growth:
  - Growth = F(Aid, human capital, etc.)
  - Current realization of growth (say very low growth, i.e. low u_{it}) will lead to higher future realization of aid
- Finance and Growth
  - Growth= F(financial development, etc)
  - High growth today may affect future financial development
- Micro production function
  - Output= F(labor, Capital),
  - a good year of harvest, i.e. high u_{it} will affect future values of labor and capital
- => Strict exogeneity is violated.

Lagged dependent variable

- $Y_{it}=\beta y_{it-1}+c_i+u_{it}$

- Any model that implies slow adjustment
- Rewrite as $Y_{it}=\beta x_{it}+c_i+u_{it}$
- Where $x_{it}=y_{it-1}$
- Strict exogeneity is violated because u_{it} is correlated with Y_{it} which is x_{it+1}
- So current shock to Y is correlated with future realization of X
- Cannot use FD, FE, RE

FD with lagged dep var

- $\Delta Y_{it} = \beta \Delta y_{it-1} + \Delta u_{it}$

- Now we have that $\Delta u_{it} = u_{it} - u_{it-1}$

is (negatively) correlated with $\Delta y_{it-1} = y_{it-1} - y_{it-2}$

Because high u_{it-1} will result in high y_{it-1}

- in FE case, we subtract the average of all periods, the average contains all future realizations

IV approach: Anderson and Hsiao (1982)

- Procedure: difference the equation (FD) and use lagged levels as instruments for differences (IV)

- IF u_{it} are serially uncorrelated
  - i.e. idiosyncratic shocks
- can use y_{it-2} as an instrument for Δy_{it-1}
- Because y_{it-2} is uncorrelated with $\Delta u_{it} = u_{it} - u_{it-1}$

- Any problems with this approach?
- Alternative approaches to improve predictive power:
  - Differenced GMM, Arellano-Bond (1991)
  - "system GMM", Blundell and Bond (1998)

Another transformation

- So far we talked about IV/GMM with first differencing (FD).
  - However lagged levels are usually not good predictors for differences (especially if original variables are close to unit root)
- Forward Orthogonal Deviation (FOD) transformation introduced by Arellano and Bover (1995)
  - Also referred to as Helmert procedure
  - Borrowed from Hayashi and Sims (1983) in the time-series literature
- Each observation Y_{it} is transformed by subtracting the (weighted) mean of all future $Y_{it+1} \ldots Y_{iT}$

FOD /Helmert transformation

- Transformed unit is equal to

$$u_{it}^{*} = c_t\left[u_{it} - \frac{1}{(T-t)}(u_{i(t+1)} + \cdots + u_{iT})\right], \qquad t = 1, \ldots, T-1,$$

- Where weights are chosen to equalize the variances

$$c_t^2 = (T-t)/(T-t+1).$$

- This preserves orthogonally between transformed variables and lags of predetermined untransformed levels
  - The lags of untransformed variables (i.e. levels) can be used as instruments in IV or GMM estimation

FOD vs FD

- FOD preserves the orthogonality among the transformed errors: if the original U_{it} are not autocorrelated and have constant variance, so are the transformed errors
  - This is in contrast to FD which induces first order serial correlation which then have to be dealt with.
  - Arellano and Bover say FOD can be regarded as a combination of the FD to eliminate fixed effects and GLS to eliminate induced serial correlation
- FOD preserves more data if there are gaps in the data (i.e. missing observations for one year)
  - In the case of FD two years of data will be dropped for each missing observation because y_t-y_{t-1} and y_{t+1}-y_t will be missing
- Both transformations lose one year of data
  - FD loses the first year, FOD loses the last year
- FOD is better the closer the process is to random walk
  - since in random walk the differences are unpredictable by definition

VAR simply speaking

- In VAR models all variables are treated as endogenous and interdependent
  - Allows for feedback effects among all the variables in the model
- It is a system of N equations, one for each of the N dependent variables
- Each equation contains p lags of each of the dependent variables (including its own)

Vector Autoregression Model

Panel data

$$Y_{it} = \sum_{l=1}^{p} A_l Y_{it-l} + g_i + dt + e_{it}$$

where

$E[e_{it}] = 0,\ E[e_{it}e'_{it}] = \Omega,\ E[e_{it}e'_{it-k}] = 0$

g_i - fixed effects, (individual heterogeneity)

d_t – time dummies (to capture aggregate shocks)

p – number of lags,

Y is a vector of N dependent variables $y_1 \ldots y_N$.

PVAR estimation

- This set up is a dynamic panel with lagged dependent variable
- Lagged dep variables are correlated with fixed effects
- Have to remove fixed effects
- Pooled OLS ("dummy variable") estimator is biased/inconsistent
- Cannot remove them by mean differencing either
  - Demeaning creates correlation between regressors and error term

Panel VAR estimation issues

- Transform the equation using First Differencing (FD) or Forward Orthogonal Deviation (FOD)
  - FOD has some advantages: preserves more data, preserves variance, does not induce first order autocorrelation, more robust the closer the data is to random walk
- Use IV or GMM
  - Untransformed variables can be used as valid instruments because of assumption of predetermined variables
    - (i.e. current shock does not affect past realizations of Y, but can affect future realizations)

Orthogonal shocks

- We are interested in how variable Y_k affects all other variables in the model keeping everything else constant
- Coefficient estimates are unusable because of cross-correlated shocks across equations u'u
- Have to use impulse-response functions
  - Isolate the Impact of a shock in one variable on another variable in the model, keeping other things constant (i.e. no other shocks)
  - Several ways of imposing restrictions on the var-covariance matrix:
    - Structural – coming from a model
    - Reduced form – coming from ordering of the variables in the model

Choleski decomposition: recursive ordering, 1

- A "theory-free" way to impose structure on the model
  - The key identifying assumption is that the variables that come earlier in the ordering affect the following variables contemporaneously, while the variables that come later affect the previous variables only with a lag.
    - allocates all correlation between the residuals of any two variables to the variable that comes first in the ordering.
  - So while all variables still affect each other, the timing of the effect is restricted – this allows for casual interpretation of the shocks.
    - Another interpretation: the variables that appear earlier in the systems are more exogenous and the ones that appear later are more endogenous

Choleski decomposition: EXAMPLE

- EXAMPLE: foreign aid and growth.
  - If foreign aid is first in the model, it will affect growth in the same period, but will only be affected by growth with a lag of one period.
  - If growth is first in the model, it will affect the foreign aid in the same period, but will only be affected by foreign aid with a lag of one period.
- Which one is more sensible ordering?
  - It depends on your "model/theory/intuition" on how the world works.
  - For example, it may take some time for the foreign aid to impact growth. This suggest that foreign aid should only affect growth with a lag of one period. This suggests putting growth first.
  - One another side, foreign aid may respond to past growth with a lag. Perhaps agencies allocate foreign aid after looking at performance results for the past year and give more aid to underperforming countries. In this case foreign aid should be first in the model, since it will only be affected by growth with a lag, but will affect growth right away.
  - These are mutually exclusive assumptions!

Choleski decomposition: recursive ordering, 3

- The ordering assumption is untestable!!!
- You don’t know what the “right” ordering is
- Have to justify based on theory/intuition
- Results may change with different orderings

“Financial Development and Dynamic Investment Behavior: evidence from Panel VAR”

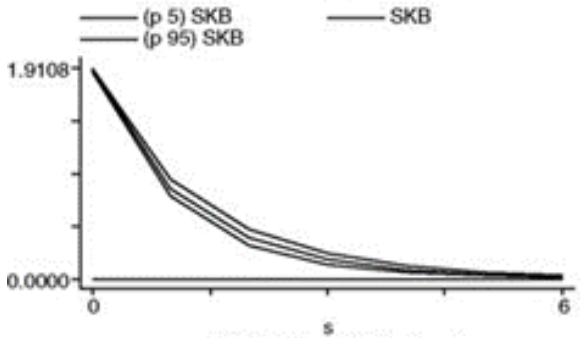
“Financial Development and Dynamic Investment Behavior: evidence from Panel VAR”

- Firm-level data across countries
- Investigate the sensitivity of investment to “fundamental factors” (marginal profitability) and “financial factors” (i.e. cash flow)
- If financial markets work well, firms’ investment should respond to fundamental factors and not financial factors
  - i.e. capital will be efficiently allocated to the most productive firms
- In developing countries financial markets are weaker so we should observe weaker sensitivity to fundamental factors and stronger sensitivity to financial factors.
- Split the sample

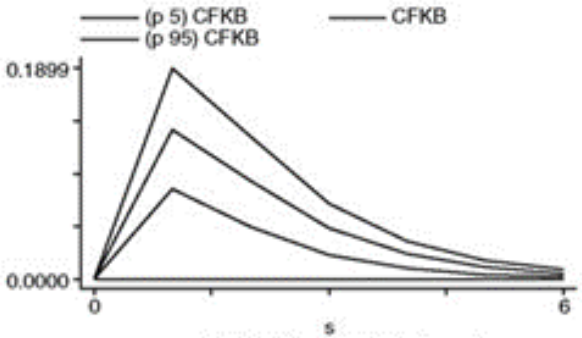
methodology

- Run a VAR model on 3 key variables:
- Investment (IK), cash flow (CF), and sales to capital (SK) to proxy for marginal product of capital
  - Also used model with 4 variables adding Tobin's Q as a second fundamental factor.
- Ordering is SK, CF, IK
  - SK, marginal profitability, is the most exogenous (like an outside shock to the model, often outside of firm's control – eg. shock to demand), while IK is the most endogenous in our model
  - IK will only affect SK with a lag (it takes time for investment to become most effective)

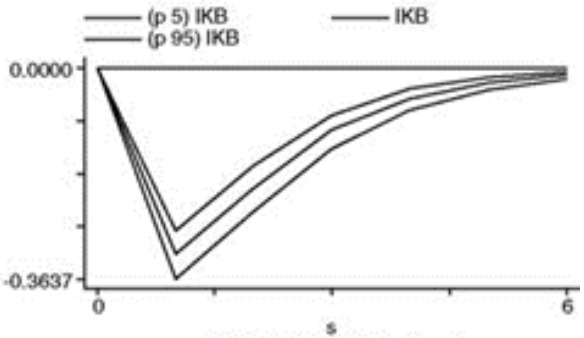
Impulse-responses for 1 lag VAR of SKB CFKB IKB
Sample : if develop==1



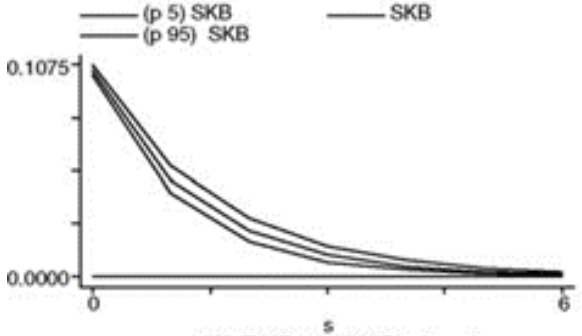
response of SKB to SKB shock



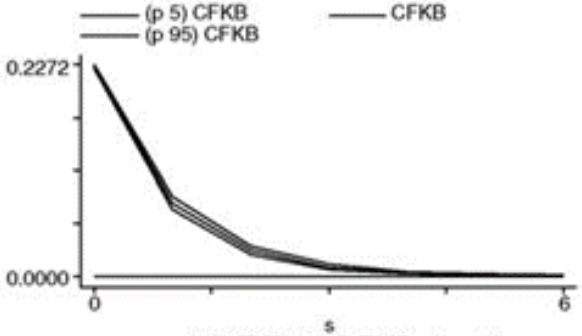
response of SKB to CFKB shock



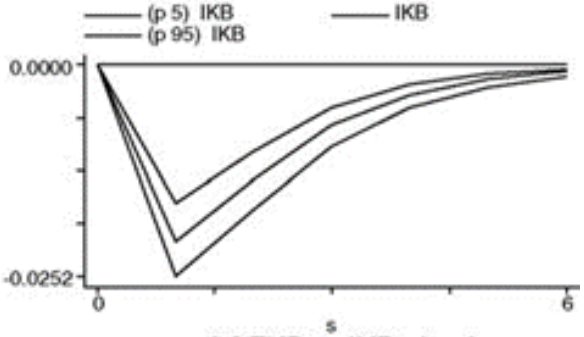
response of SKB to IKB shock



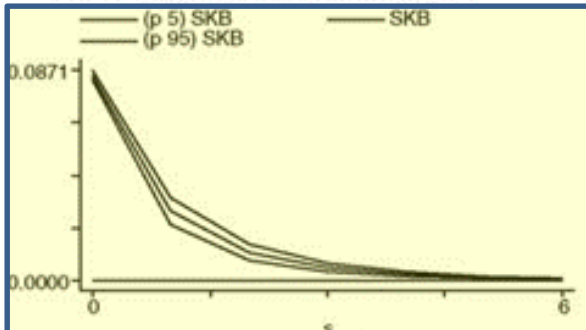
response of CFKB to SKB shock



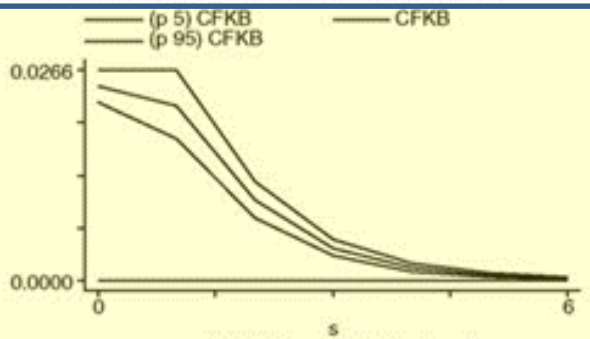
response of CFKB to CFKB shock



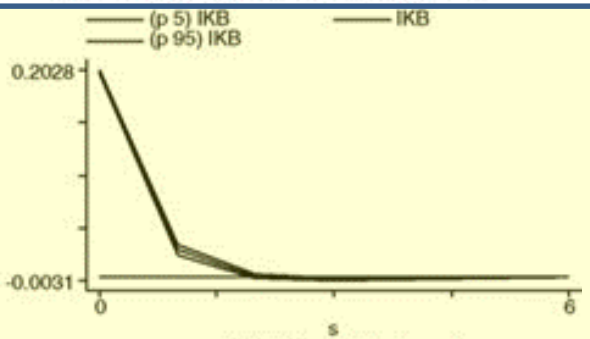
response of CFKB to IKB shock



response of IKB to SKB shock



response of IKB to CFKB shock

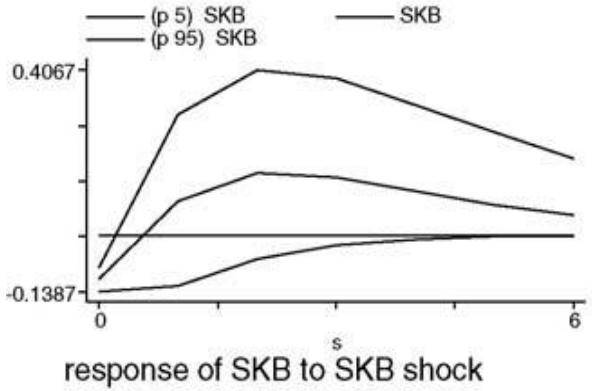


response of IKB to IKB shock

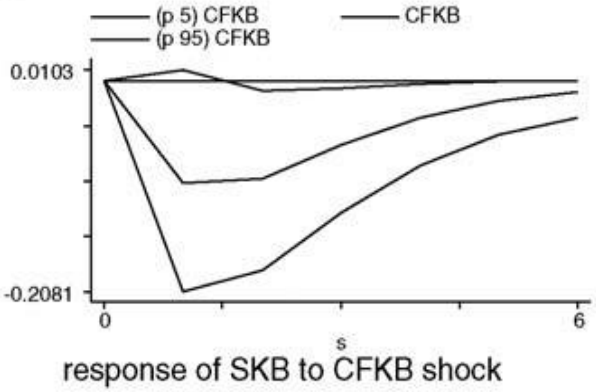
Errors are 5% on each side generated by Monte-Carlo with 1000 reps

Impulse-responses for 1 lag VAR of SKB CFKB IKB

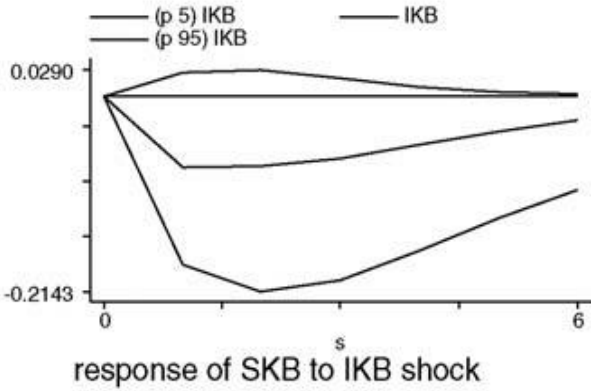
Sample : Difference of Undeveloped - Developed



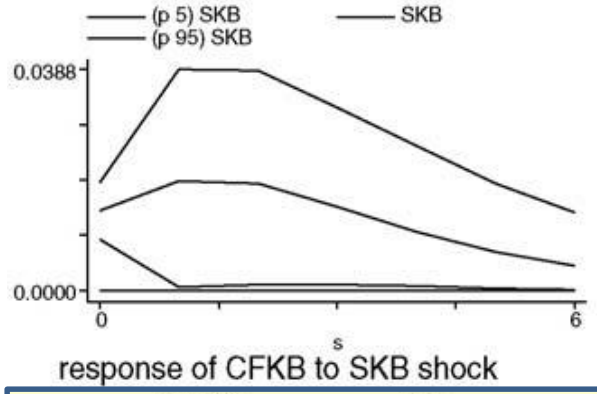
response of SKB to SKB shock



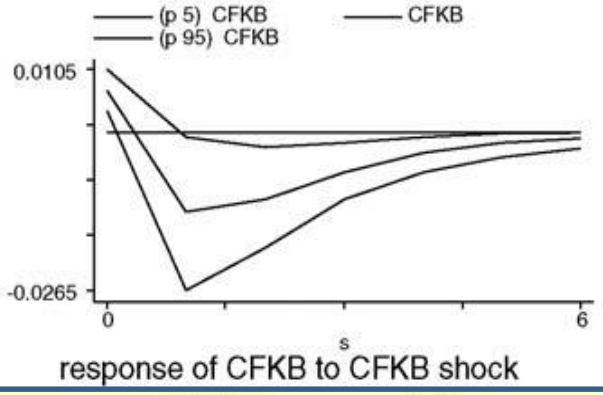
response of SKB to CFKB shock



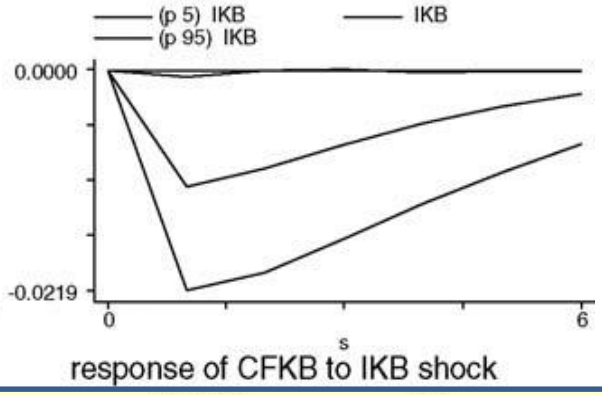
response of SKB to IKB shock



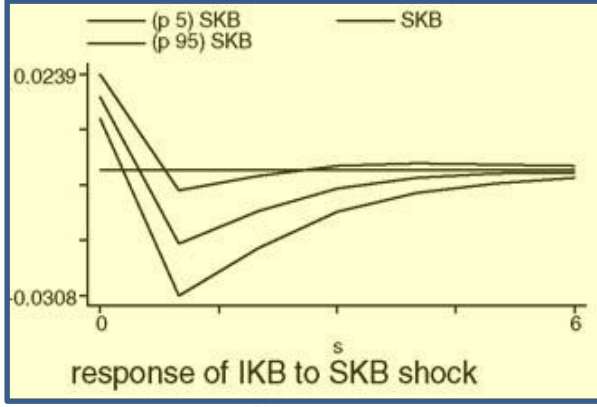
response of CFKB to SKB shock



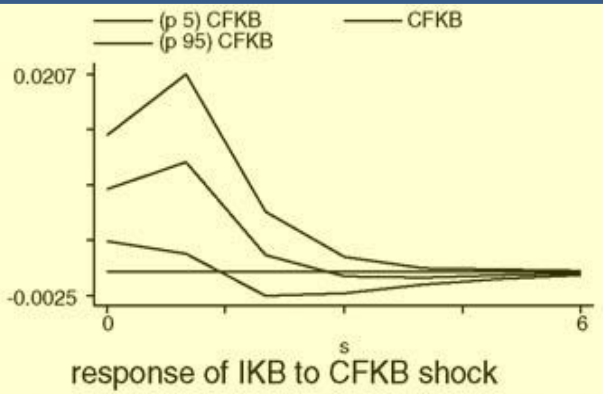
response of CFKB to CFKB shock



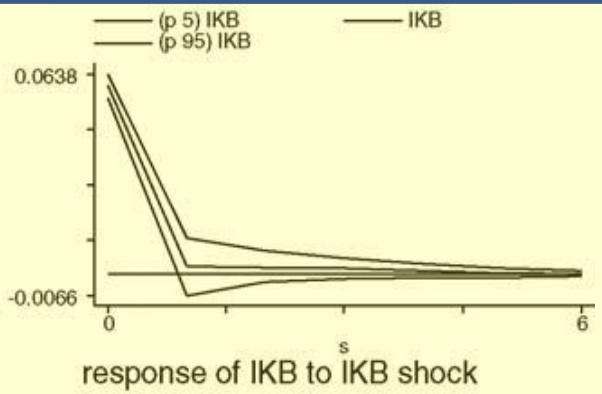
response of CFKB to IKB shock



response of IKB to SKB shock



response of IKB to CFKB shock



response of IKB to IKB shock

Errors are 5% on each side generated by Monte-Carlo with 1000 reps

variance decompositions

- variance decompositions show the percent of the variation in one variable that is explained by the shock to another variable, accumulated over time.
  - Cumulative response (the area under the impulse response cure)
  - A bit like an R^2

Variance decompositions

	SKB	CFKB	IKB
Panel A: Low financial development sample			
SKB	0.940	0.000	0.061
CFKB	0.263	0.713	0.024
IKB	0.131	0.029	0.840
Panel B: High financial development sample			
SKB	0.959	0.006	0.035
CFKB	0.194	0.796	0.010
IKB	0.162	0.024	0.814

Percent of variation in the row variable explained by the column variable (after 10 periods)

Main results

- ‘fundamental’ factors have less effect on investment in countries with low financial development sample.
  - Firms may pass on profitable opportunites
- Financial factors have stronger effect on investment in countries with low financial development
  - Firms will invest more when they have more cash
- Implication: financial markets do not work as efficiently in challenging the recourses to their most productive uses.

“Macro-Financial Linkages in Egypt: A Panel Analysis of Economic Shocks and Loan Portfolio Quality”

- Investigate the interaction of banking sector performance and macroeconomic variables (foreign capital inflows, growth)
- Two main questions:
  - How macroeconomic shocks are transmitted to the banking sector
  - How the banking sector shocks subsequently affect macroeconomic performance.
- VAR is well suited for this analysis because it allows for endogenous responses of all variables in the model.
- Main novelty: a hybrid model that has bank-level data and aggregate macroeconomic data.

- Main model includes three macro variables and three bank-level variables.
- On the macro side we use the capital inflows $(CapInfl)$, GDP growth rate $(GDPGr)$ and the aggregate lending rate $(LendRate)$.
- For the bank-level variables we use $LoanGr$, $Reserves$ (our proxy for loan quality), and $ROAE$.

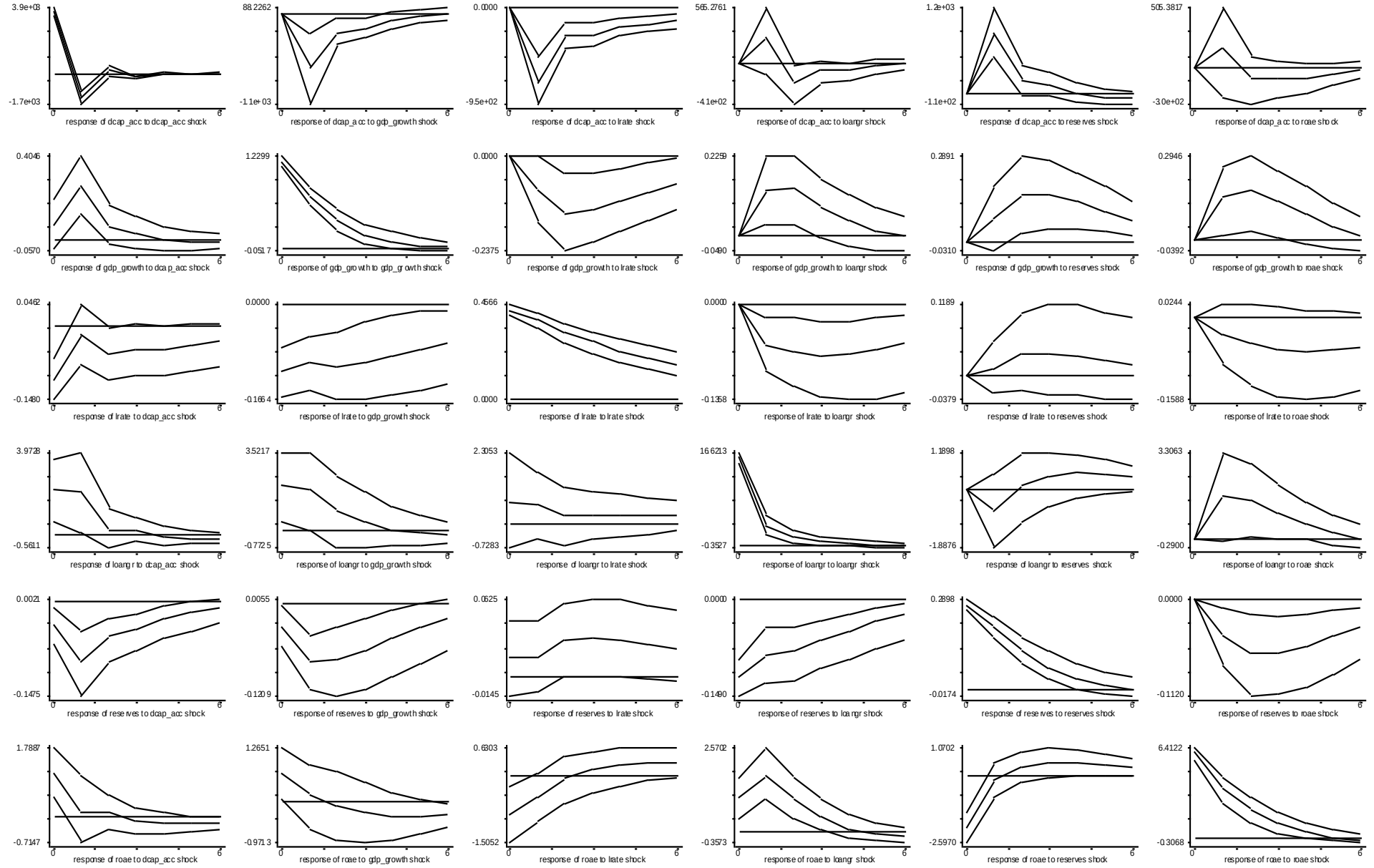
Variable ordering

- we assume in our baseline ordering that the original shock comes from the change in $CapInfl$. This shock has a contemporaneous impact on $GDPGr$, $LendRate$, and all bank-level variables. However, all other variables only impact the capital account with a lag.
- The shock to $GDPGr$ is assumed to have a contemporaneous impact on $LendRate$ and all bank variables, while it is affected by others with a lag.

Variable ordering, cont

- on the bank level, the shock comes from loan growth, which affects loan reserves and profitability contemporaneously, while reserves and profitability affect loan growth only with a lag.
- However, because all macroeconomic variables are entered first in the system, they have an immediate impact on bank variables, while the feedback from bank-level variables on macroeconomic variables occurs only with a lag.
- This assumption makes sense because macro shocks are more likely to be transmitted to individual banking firms (immediately) while individual bank problems may be reflected in the macro aggregates with a lag.

pVAR L(1) of dcap_acc gdp_growth lrate loangr reserves roae



Errors are 5% on each side generated by Monte-Carlo with 500 reps

Main results, macro (top left 3x3)

- GDP growth responds positively to a capital account shock (the response lasts 1-3 years),
- lending rates decline significantly in response to a capital account shock.
- Both of these results are expected and show a positive influence of capital inflows on the Egyptian economy.
- The lending rate declines in response to a positive GDP growth shock, while GDP growth responds negatively to a positive lending rate shock.
  - Contractionary macroeconomic policies (i.e. increased interest rates) negatively affect growth and discourage capital inflows

Main results, bank level (bottom right 3x3)

- We observe that reserves decline (i.e. loan quality improves) in response to a positive shock to profitability or loan growth,
- loan growth increases in response to a positive shock to profitability,
- and that profitability increases in response to a positive shock in loan growth.
- Interestingly, there is a changing response of profitability to reserves over time. The immediate response is negative, meaning that an increase in reserves (i.e. a poorer loan quality) has an immediate negative response on profitability.
  - taking a “hit” today in terms of the higher reserves implies that there likely to be less need for write-offs (and hence higher profitability) in the future.

Macro effect on banks

- First, a positive shock to capital account results in higher loan growth, a drop in reserves (i.e. improvement in loan quality) and an increase in profitability, suggesting that capital inflows improve bank performance on all three dimensions (loan growth, loan quality and profitability).
- Second, a positive shock to GDP growth triggers a positive loan growth response, a negative response in reserves (i.e. improvement in portfolio quality), and a positive improvement in bank profitability that is only significant in period zero or at the time of the shock.
- Third, a lending rate increase has an immediate negative impact on profitability and results in higher reserves (i.e. lower portfolio quality) over time.

Who is to Blame: Foreign Ownership or Foreign Funding?

Inessa Love, Roberto Rocha, Erik Feyen, Samuel Munzele Maimbo, and Raquel Letelier

Motivation

- Most countries across the world experienced a contraction of credit during the recent global financial crisis,
- However, the Eastern Europe and Central Asia (ECA) region was hit harder than most of the developing countries
- This paper seeks to understand whether foreign ownership or foreign funding of banks played a role in this protracted contraction in ECA

What is different about ECA?

- Strong financial ties with the Western Europe through high foreign ownership and foreign funding
- Foreign banks have
  - contributed to rapid credit growth prior to crisis
  - contributed to credit contraction during the crisis as foreign banks “rushed for the exit”

The government's dilemma

- governments have to weigh the liquidity and growth benefits of foreign bank presence against the fears that such banks may prove unreliable sources of capital in times of crisis

- What if this is not the foreign bank issue *per se*, but how they are financed?
- Allow foreign banks, but regulate how they are financed.

Ownership vs. Funding

- High foreign ownership does not have to automatically result in high foreign funding
  - How foreign banks finance themselves could be more important than mere presence of foreign banks
  - ECA vs LAC model
- The answer to this question has very different policy implications
  - Limit entry of foreign banks (i.e. limits on foreign equity)

    vs
  - Limit foreign funding (i.e. limit on foreign liabilities)

Advantages of panel VAR

- In VAR, all variables are treated as endogenous and interdependent and all the feedback effects are explicitly included in the model;
- VAR can distinguish between the short-term impacts of each of the factors based on the impulse response functions and the long-term cumulative impacts of shocks based on variance decompositions.
- VAR model can include the demand factors (e.g. GDP) and supply factors (e.g. foreign liabilities and deposits) in modeling of the private credit growth.
- Panel VAR approach can be used with relatively short time-series.
- Panel VAR allows us to control for country- and year- fixed effects.
  - Country fixed effects will capture time-invariant country characteristics that can explain credit growth, such as institutions, rule of law, credit information, etc.
  - Year-fixed effects will capture global shocks affecting finance and growth, such as the effect of the recent financial crisis that is common for all countries in the same time period.

Preview of results

- Private credit growth is highly sensitive to cross-border funding shocks around the world
- This sensitivity is higher in ECA
- This sensitivity is higher in countries that relied more on foreign funding and market-based funding, but not significantly different in countries with high foreign ownership.
- Foreign funding and market-based funding are more important in explaining ECA differences than foreign ownership

Data

- 41 countries in various regions

AFR	1
ASIA	7
ECA	22
LAC	7
MENA	4

- about 11 years of data available for most countries 2000-2011
- Quarterly data From IFS and World Bank

Variables

- PVAR variables (quarterly)
  - PRIVATE CREDIT
  - FOREIGN LIABILITIES (supply factor)
  - DEPOSITS (supply factor)
  - GDP (demand factor)
- Country-level variables, measured at pre-crisis levels
  - LDR (Loan to Deposit Ratios)
  - FOREIGN OWNERSHIP
  - FOREIGN FUNDING
    - Foreign liabilities/(Deposits + Foreign liabilities)

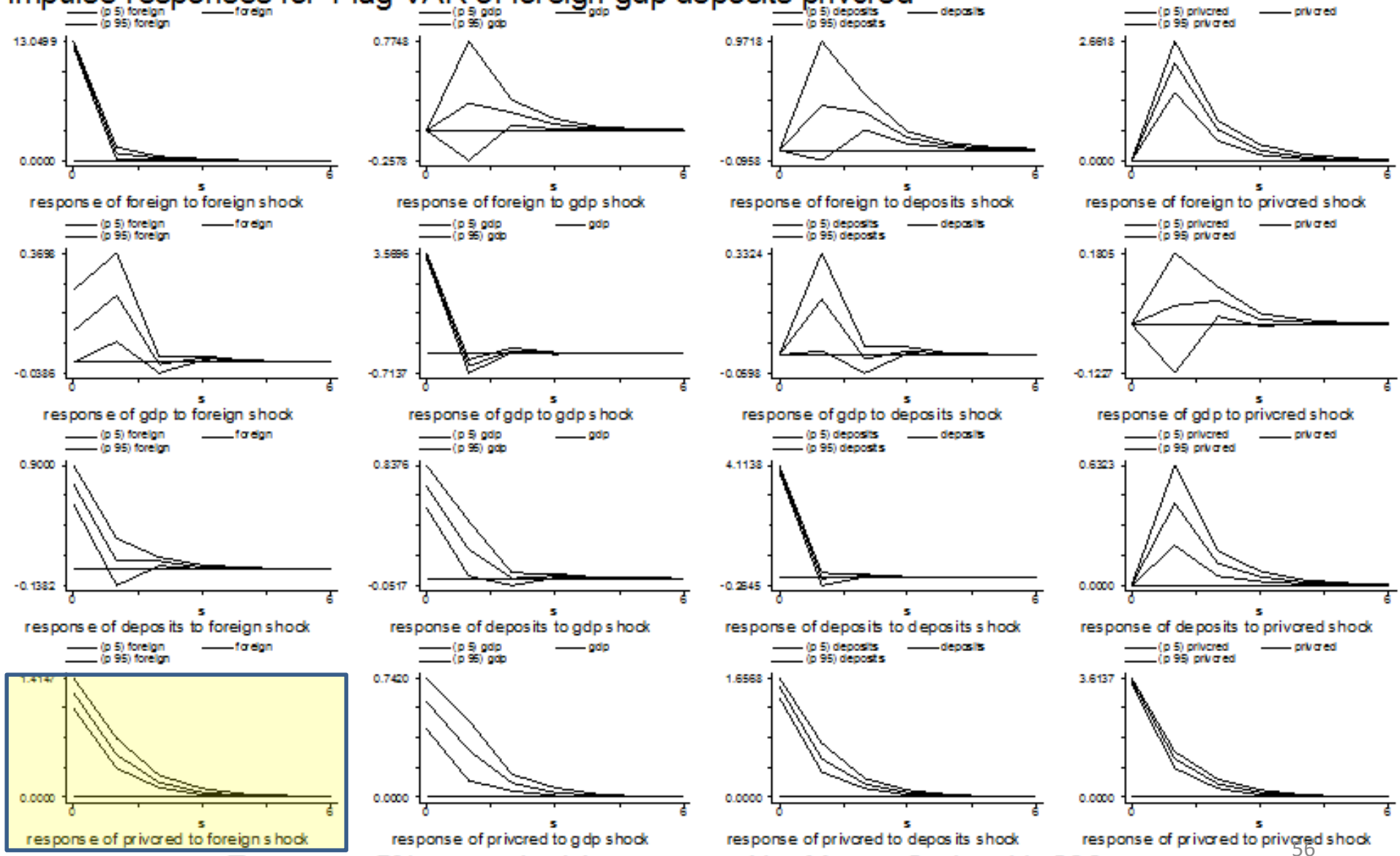
Assumed ordering

- FOREIGN LIABILITIES, GDP, DEPOSITS and PRIVATE CREDIT.
- We place FOREIGN LIABILITIES first
- it is to a large extent driven by external supply factors such as global risk appetite, parent bank health, economic home conditions, and global funding markets.
- This assumption implies that FOREIGN LIABILITIES affects all other variables contemporaneously.
- In contrast, the other variables can only affect FOREIGN LIABILITIES with a 1-quarter lag. This is a reasonable assumption since reversing the flow of foreign liabilities is likely to take some time.

Assumed ordering, cont

- We place PRIVATE CREDIT last in the order because arguably it can react to all other factors quickly, i.e. in the same quarter;
- however, the PRIVATE CREDIT only affects other variables with a 1-quarter lag.
  - Typically there is a delay between loan origination and loan deployment, so an impact on other variables can only be expected with a lag.
- GDP goes before deposits because deposits can react quickly to bad economic news, while changes in DEPOSITS are likely to affect GDP only with a lag.
  - Results are robust to switching the order of these two variables

Impulse-responses for 1 lag VAR of foreign gdp deposits privcred



Errors are 5% on each side generated by Monte-Carlo with 200 reps

Focus on private credit responses

- PRIVATE CREDIT has a positive and significant response to a shock in FOREIGN LIABILITIES.
  - a one standard deviation shock in FOREIGN LIABILITIES results in a 1.24% increase in PRIVATE CREDIT growth at time zero which
    - average PRIVATE CREDIT growth in our entire sample is 3.2% (std of 5.12%).
- A positive response of PRIVATE CREDIT responds positively to GDP, which captures the demand for credit.
  - 0.59% at time zero.
- PRIVATE CREDIT responds positively to a DEPOSITS shock:
  - 1.53% at time zero.

Variance Decompositions: Long-run cumulative responses.

Each cell shows the percent of variation in the row variable explained by a shock of the column variable after 10 quarterly periods

	FOREIGN LIABILITIES	GDP	DEPOSITS	PRIVATE CREDIT
Baseline Model				
FOREIGN LIABILITIES	96.7%	0.0%	0.1%	3.1%
GDP	0.5%	99.2%	0.2%	0.0%
DEPOSITS	3.2%	3.0%	92.6%	1.2%
PRIVATE CREDIT	9.7%	2.4%	14.2%	73.8%

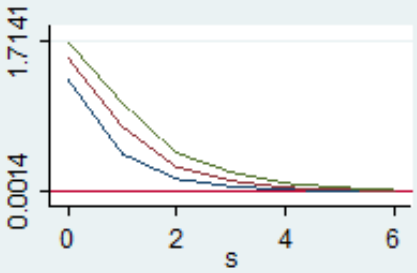
- These are akin to R2.
- We do a reasonably good job predicting growth in private credit, but really poor job predicting GDP growth.
- Deposits explain the largest portion of credit growth variation, followed by foreign liabilities – close to 10%
- GDP growth explains a relatively small portion (a bit of a puzzle).

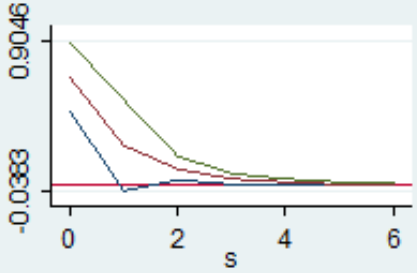
Is ECA different?

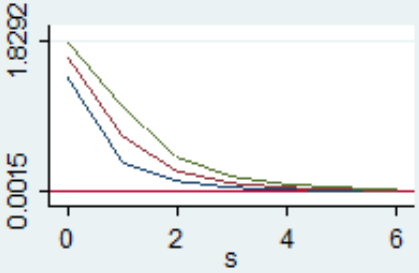
- Split the sample on ECA vs. non-ECA
- Generate the differences in impulse-responses
  - Samples are independent
  - Point estimate is equal to the difference in point estimates
  - Error bands are constructed by Monte-Carlo (merge two Monte-Carlo distributions and take a difference)
  - Focus only on private credit responses (last row of graphs)

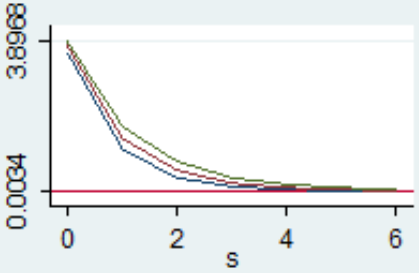
Split by Region: ECA vs. non ECA

Sample: ECA

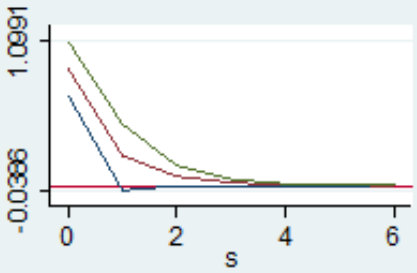


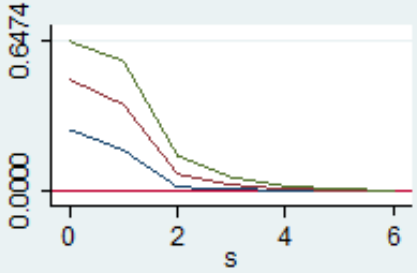


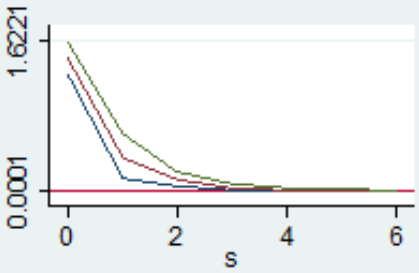


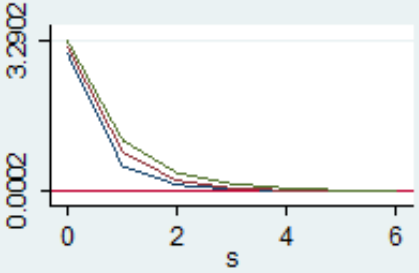


Sample: nonECA

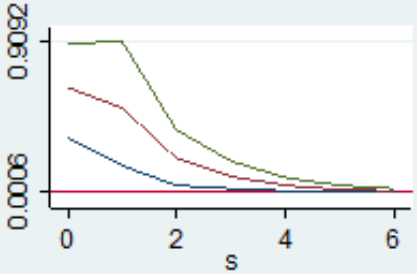


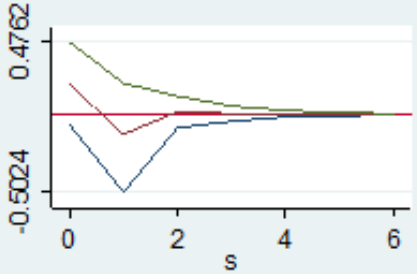


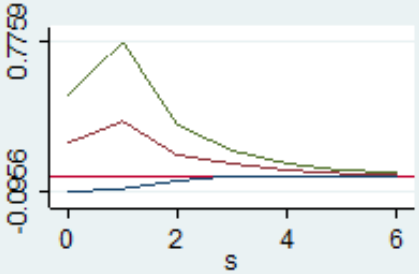


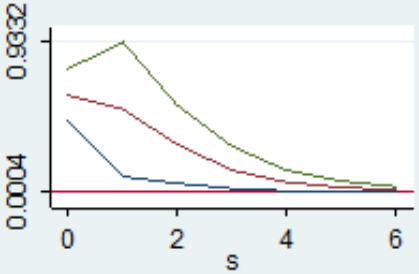


Sample: Difference









Summary of ECA vs non-ECA

- Stronger response of private credit to foreign funding shock in ECA
  - Point estimates for impulse-response at time zero are 1.53 and 0.89 in ECA and non-ECA, respectively.
  - The ECA response is thus 0.64 percentage points higher (72%)
- ECA response is more prolonged – after one quarter the difference is even larger
  - At time 1, ECA response is 0.74, while in non-ECA it is 0.23, which is about 3 times lower

ECA vs. non-ECA variance decompositions

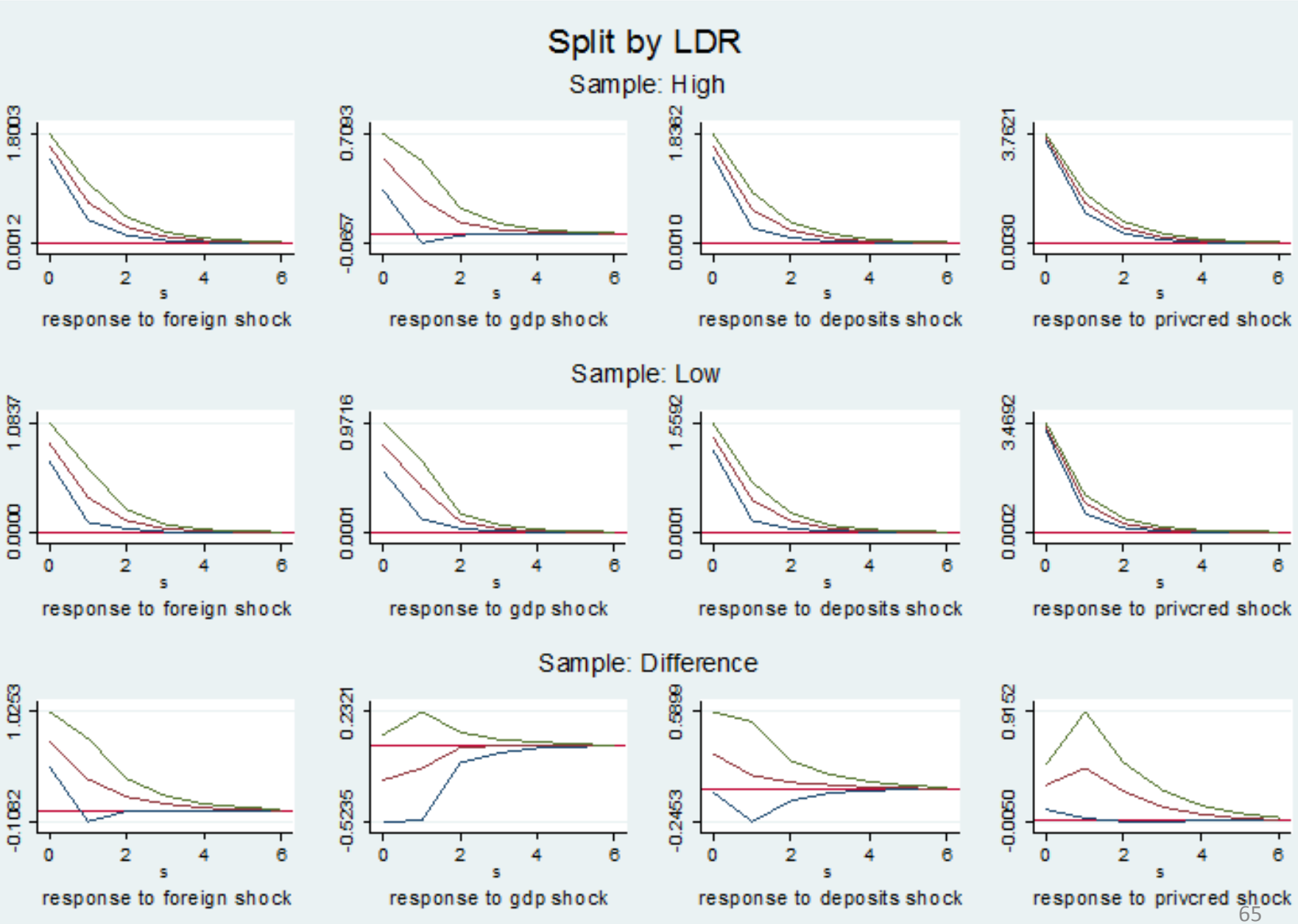
Only report responses of private credit to shock in column variable

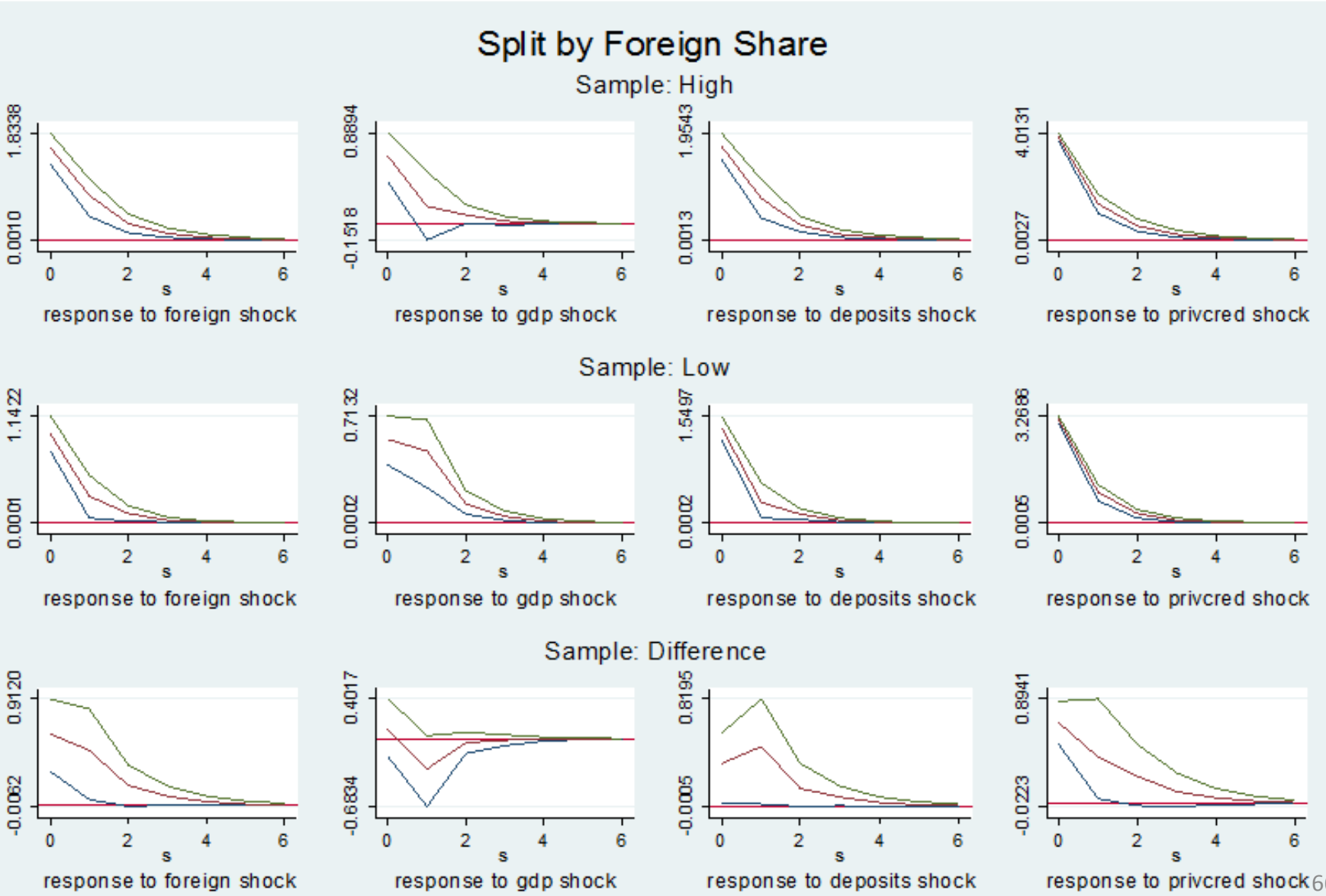
	Obs	FOREIGN LIABILITIES	GDP	DEPOSITS	PRIVATE CREDIT
Full Sample	1,767	9.7%	2.4%	14.2%	73.8%
ECA	947	12.9%	2.3%	13.9%	70.9%
Non-ECA	820	6.0%	2.6%	15.7%	75.6%

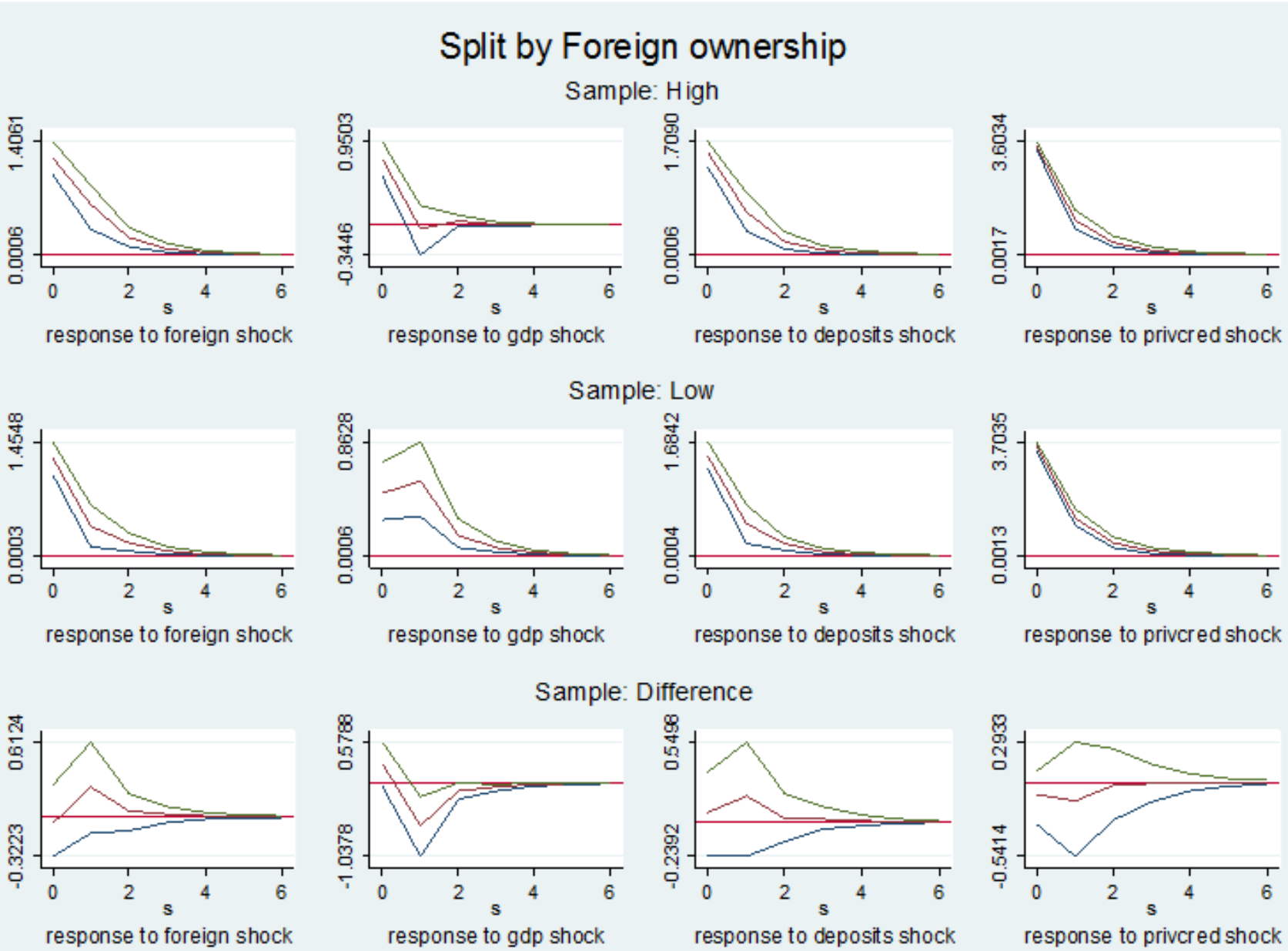
- Confirm impulse-response results: foreign liabilities explains more than twice as much variation in ECA relative to non-ECA
- Not much difference in other factors.

Why ECA is different?

- Split the whole sample based on three characteristics
  - LDR, Foreign Ownership and Foreign Funding
  - If a characteristic produces different results, it is suggestive that it is driving the differences


Split by LDR
Sample: High
1.8003
0.0012
0
2
4
6
s
response to foreign shock
0.7093
-0.0657
response to gdp shock
1.8362
0.0010
response to deposits shock
3.7621
0.0030
response to privcred shock
Sample: Low
1.0837
0.0000
response to foreign shock
0.9716
0.0001
response to gdp shock
1.5592
0.0001
response to deposits shock
3.4692
0.0002
response to privcred shock
Sample: Difference
1.0253
-0.1082
response to foreign shock
0.2321
-0.5235
response to gdp shock
0.5898
-0.2453
response to deposits shock
0.9152
-0.0050
response to privcred shock


Split by Foreign Share
Sample: High
1.8338
0.0010
0.8894
-0.1518
1.9543
0.0013
4.0131
0.0027
0 2 4 6
s
response to foreign shock
response to gdp shock
response to deposits shock
response to privcred shock
Sample: Low
1.1422
0.0001
0.7132
0.0002
1.5497
0.0002
3.2686
0.0005
response to foreign shock
response to gdp shock
response to deposits shock
response to privcred shock
Sample: Difference
0.9120
-0.0062
0.4017
-0.6834
0.8195
-0.0005
0.8941
-0.0223
response to foreign shock
response to gdp shock
response to deposits shock
response to privcred shock


Split by Foreign ownership
Sample: High
0.0006
1.4061
-0.3446
0.9503
0.0006
1.7090
0.0017
3.6034
0
2
4
6
s
response to foreign shock
response to gdp shock
response to deposits shock
response to privcred shock
Sample: Low
0.0003
1.4548
0.0006
0.8628
0.0004
1.6842
0.0013
3.7035
Sample: Difference
-0.3223
0.6124
-1.0378
0.5788
-0.2392
0.5498
-0.5414
0.2933

Sample splits decompositions

	Obs	FOREIGN LIABILITIES	GDP	DEPOSITS	PRIVATE CREDIT
High LDR	895	14.1%	1.6%	13.9%	70.5%
Low LDR	872	5.6%	4.8%	13.2%	76.3%
High FOREIGN FUNDING	799	12.9%	1.9%	14.7%	70.4%
Low FOREIGN FUNDING	968	6.9%	3.8%	13.8%	75.5%
High FOREIGN OWNERSHIP	886	10.0%	3.0%	15.2%	71.8%
Low FOREIGN OWNERSHIP	881	9.1%	3.0%	12.8%	75.2%

- LDR split and foreign funding split produces much higher sensitivity of private credit to foreign liabilities shock
- Foreign ownership split does not produce significant differences

summary

- Splitting on LDR and foreign funding makes a difference in sensitivity of private credit response to foreign funding shocks
- However, splitting on foreign ownership does not produce significant differences.
  - Foreign ownership does not lead to higher sensitivity of private credit to foreign funding shocks.
- The results suggest that foreign ownership per se does not result in higher sensitivity of private credit to funding shock.

Summary

- Private credit is sensitive to foreign funding shocks
- This sensitivity is higher in ECA
- The sensitivity is increased by high reliance on foreign funding and high LDR (reliance on market funding), but is not related to foreign ownership per se.
- The main takeaway: Foreign ownership is not the factor responsible for the differences between ECA and non-ECA and does not amplify sensitivity to foreign funding shocks.

pVAR Estimation

- Michael Abrigo and Inessa Love, "Estimation of panel vector autoregression in Stata" co-authored with Michael Abrigo, *The Stata Journal*, 2016, 16(3), 1-27.

pVAR package

- pVAR Programs for STATA available on
- https://sites.google.com/a/hawaii.edu/inessalove
- http://www.stata-journal.com/article.html?article=st0455
- package st0455 from http://www.stata-journal.com/software/sj16-3
- In Stata type: search pvar
- SJ-16-3 st0455 . . . . . Estimation of panel vector autoregression in Stata
- Click on install

Example: use built in data used in Holtz-Eakin, Newey and Rosen (1988)

Investigate the relationship between wages and hours worked.

Setup

```
. webuse psidextract
. gen lwks=ln(wks)
```

Estimate panel VAR model for men only, with 3 laggs, using Helmert transformation (default)

```
. pvar lwks lwage if fem==0, lag(3)
```

- Panel vector autoregresssion

- GMM Estimation

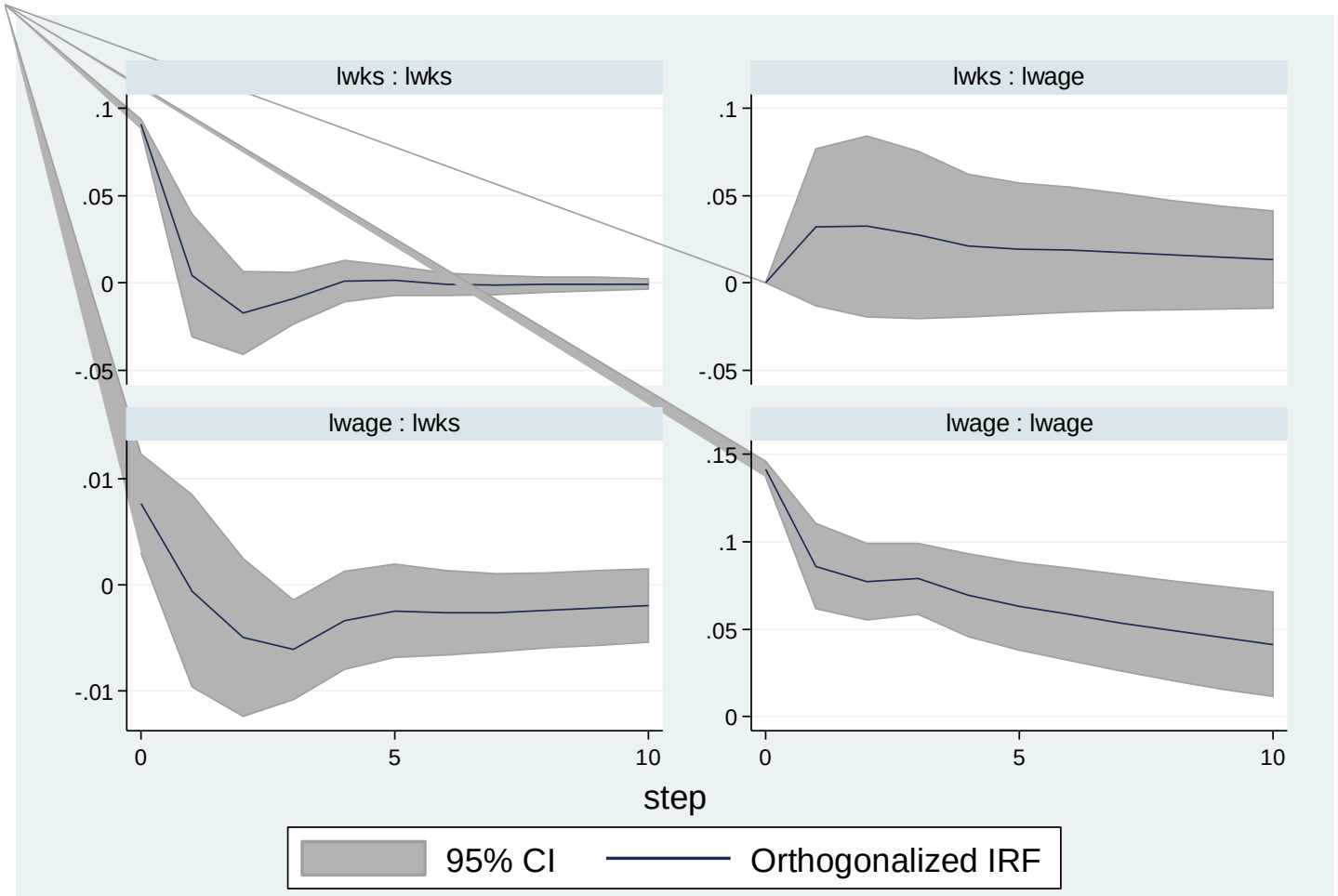
- Final GMM Criterion Q(b) = 1.11e-32
- Initial weight matrix: Identity
- GMM weight matrix: Robust
- No. of obs = 1584
- No. of panels = 528
- Ave. no. of T = 3.000

- --
- | Coef. Std. Err. z P>|z| [95% Conf. Interval]
- -------------+--
- lwks |
- lwks |
- L1. | .0477872 .1816701 0.26 0.793 -.3082796 .4038541
- L2. | -.1891446 .1002787 -1.89 0.059 -.3856872 .007398
- L3. | -.0694588 .0554891 -1.25 0.211 -.1782155 .0392979
- |
- lwage |
- L1. | -.0069066 .0249964 -0.28 0.782 -.0558987 .0420855
- L2. | -.0206062 .0137029 -1.50 0.133 -.0474633 .0062509
- L3. | -.0224254 .0141702 -1.58 0.114 -.0501985 .0053476
- -------------+--
- lwage |
- lwks |
- L1. | .3516101 .2541961 1.38 0.167 -.146605 .8498253
- L2. | .1322435 .123261 1.07 0.283 -.1093435 .3738306
- L3. | .0890408 .063914 1.39 0.164 -.0362283 .2143099
- |
- lwage |
- L1. | .5894378 .0820801 7.18 0.000 .4285638 .7503119
- L2. | .1818445 .0480188 3.79 0.000 .0877293 .2759597
- L3. | .1337024 .0367614 3.64 0.000 .0616515 .2057533
- --
- Instruments : l(1/3).(lwks lwage)

Create orthogonalized impulse response functions

- need to decide on the ordering (note for coefficient estimation the order is no relevant)
  - Assume wage levels have direct impact on contemporaneous hours worked, while current work effort affects wages only in the future. This implies that wages should go first in the order

pvarirf, oirf mc(200) byop(yrescale) porder(lwage lwks)


lwks : lwks
lwks : lwage
lwage : lwks
lwage : lwage
.1
.05
0
-.05
.01
-.01
.15
5
10
step
95% CI
Orthogonalized IRF
impulse : response

- pvargranger: Granger causality test
- Pvarirf: Create and graph impulse response functions (IRFs)
- pvarfevd: Calculate variance decompositions

Other relevant Stata Packages

- Built-in
  - xtabond: Arellano-Bond estimator
  - xtdpdsys: Arellano-Bover/Blundell-Bond estimator
  - xtdpd: General linear DPD estimator

- Contributed (among others)
  - xtabond2 (Roodman, 2009 Stata Journal)
  - pvar (Abrigo and Love, 2016 Stata Journal)

Notes from experience with VARs

- The results could be sensitive to outliers so always examine the distributions before running VARs
- The results will be sensitive/unstable the closer the data generating process is to the unit root
  - One common solution is to transform the variables into differences or growth rates prior to running VAR
- The results could be sensitive to ordering or number of lags (do robustness checks on those)
- The result will be only as good as your theory/model/intuition about the ordering