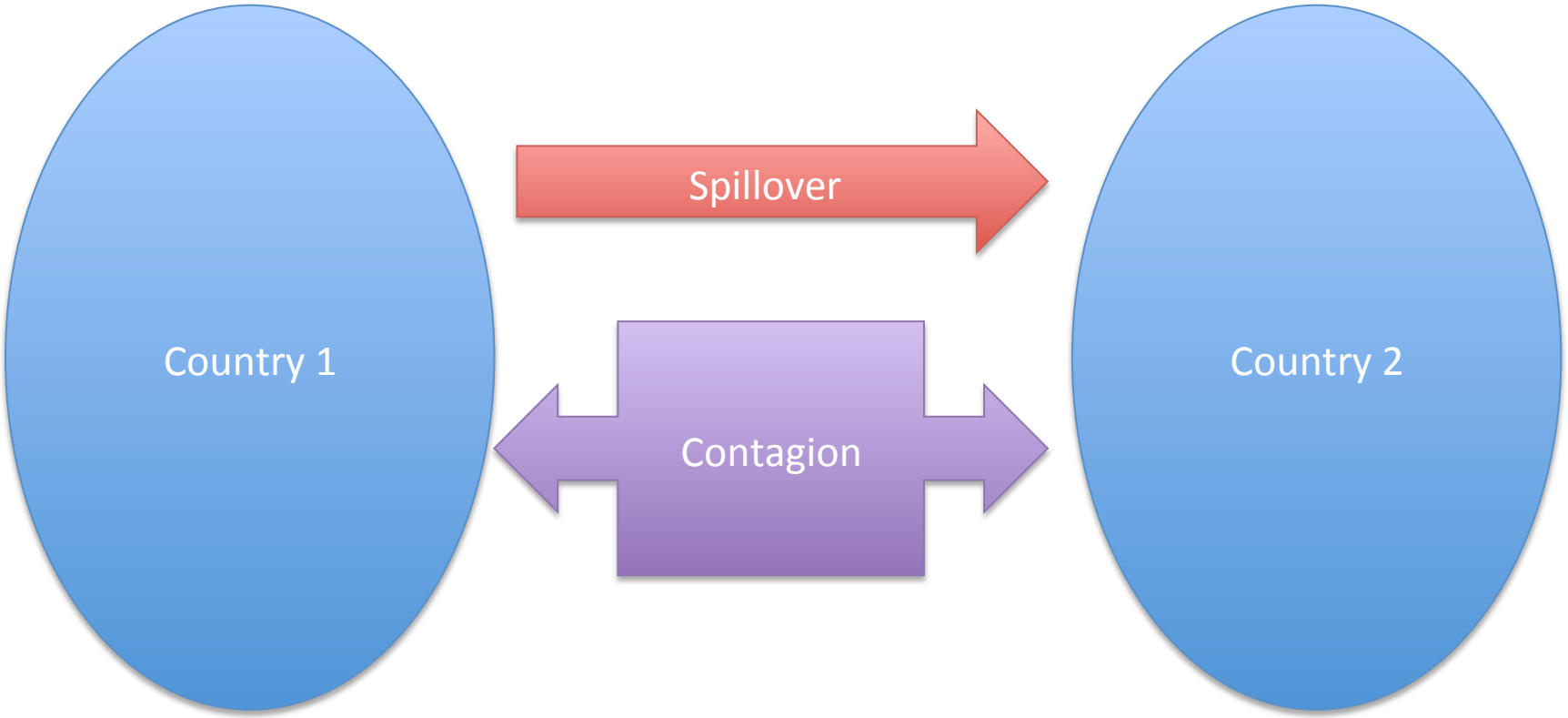
Contagion and Spillovers

Definitions



Spillover:

Transmission mechanism

Contagion:

Unexpectedly large transmission

Change in the transmission

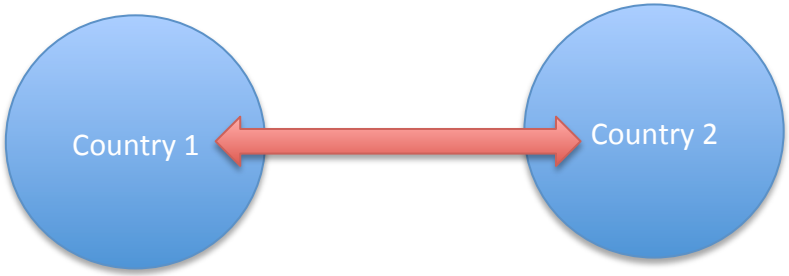
Policy Importance

- Global Contagion and Spillover
  - Terms of Trade Spillovers (IMF Report)
  - Central Banks:
    - Measurement of Systemic Risk
    - Monetary Spillovers in recent times
  - Macro Prudential Regulation
    - Social and Economic insurance for extreme events
    - Regulation to minimize extreme events

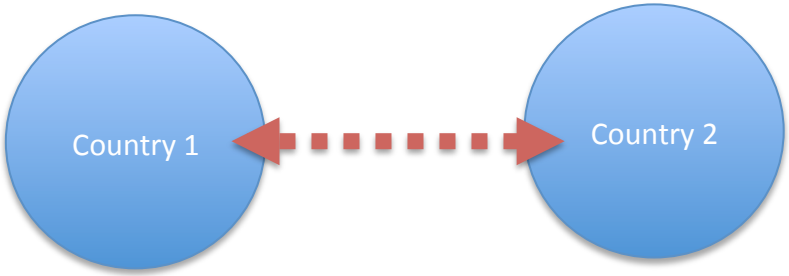
Theories of contagion and spillover

- Fundamental view
  - General Equilibrium models of trade
  - International Monetary Models
- Financial view
  - Financial Intermediaries
    - Common Lenders
    - Common Financial Intermediaries
- Coordination view
  - Monetary Policy coordination
  - Political contagion
- Network view
  - Financial and Technological

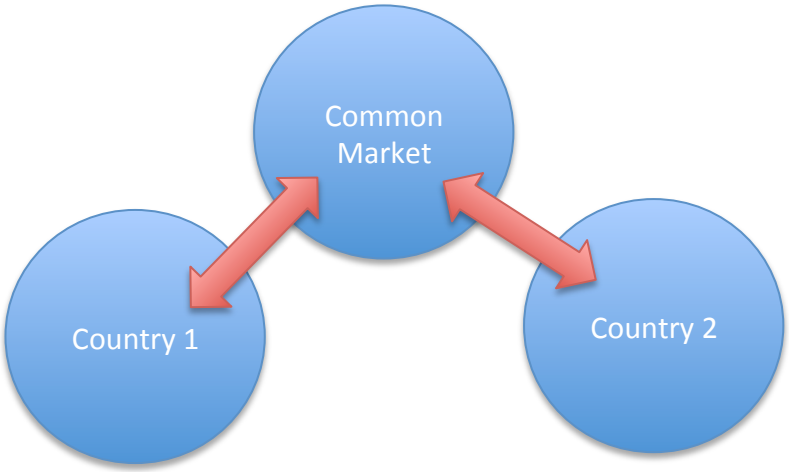
Fundamental



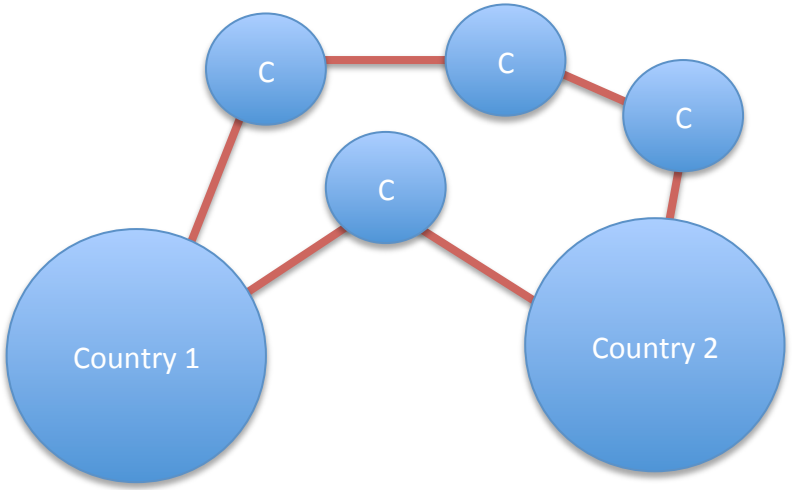
Coordination



Financial



Network



Formally

- Two empirical depictions
  - Endogeneity (from RBC models)

$$y_t = \alpha x_t + \varepsilon_t$$

$$x_t = \beta y_t + \eta_t$$

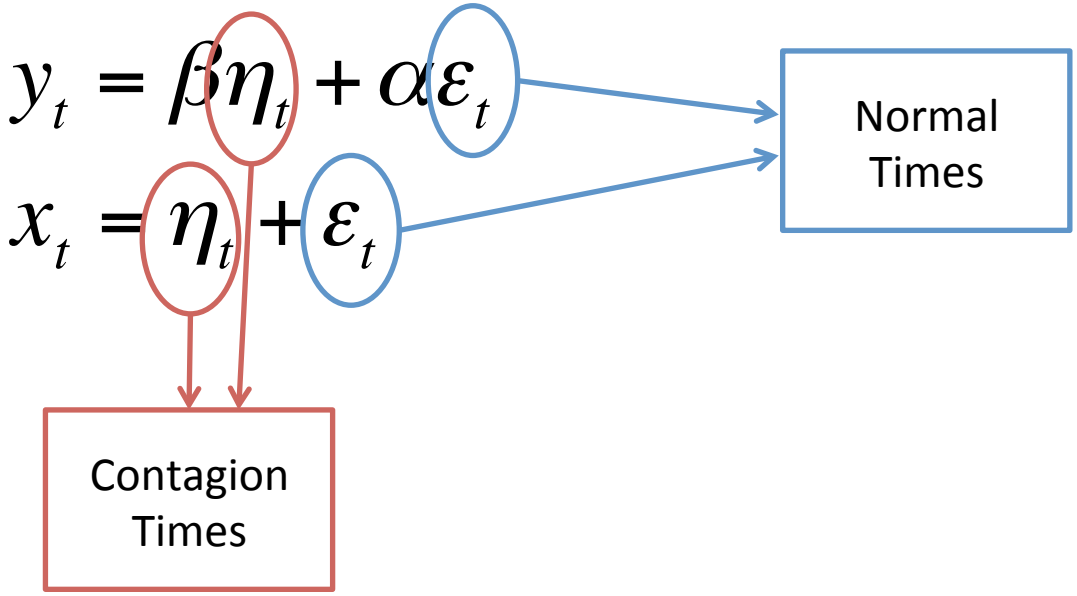
  - Omitted Variables (from finance/factor models)

$$y_t = \beta \eta_t + \alpha \varepsilon_t$$

$$x_t = \eta_t + \varepsilon_t$$

Formally

- Omitted Variables/Factor Model



  - Spillover: what we estimate? (on average)
  - Contagion: can we detect parameter instability?

Empirical Problems

- Source of the problems
  - Measurement of Spillovers or testing contagion
    - Omitted Variables
    - Endogeneity
  - Estimation
    - Spillover will be biased
    - Contagion will be biased
- Contagious events imply heteroskedasticity

$$\theta = \sigma_{\eta}^{2} / \sigma_{\varepsilon}^{2}$$

Possible Techniques

		Spillover	Contagion
Non Parametric	Correlation	✔	✔
	Principal Components	✔	✔
	Factor Analysis	✔	✔
Linea Regression Models	OLS / VAR	✔	✔
	Arch / Garch	✔	✔
	Extreme Events		✔
	Network	✔	
Probability Models	Probit / Logit / Concurrence		✔
	Copulas	✔	
Non-Linear	NLS	✔	
	Bayesian	✔	
	Tree / Random Forest	✔	

Linear Models

- Estimation and Bias (under OV)

$$y_t = ax_t + \nu_t$$

$$\hat{a} = \alpha + (\beta - \alpha)\frac{\theta}{1+\theta} \text{ where } \theta = \frac{\sigma_\eta^2}{\sigma_\varepsilon^2}$$

- What it can detect?
  - The estimate of a is NOT the spillover (α) unless η=0
  - Weighted average between the effects of both factors.
  - The weight changes with heteroskedasticity
  - Parameter instability could be the outcome of heteroskedasticity (θ)
  - Unbiased if α=β or θ=0.

- Methodologies affected
  - OLS, VAR (structural or not), Arch, Garch
  - NLS will also be biased

Correlation

- Estimation and Bias

$$\rho = \left(\frac{(\alpha + \theta\beta)^2}{(\alpha + \theta\beta)^2 + \theta(\beta - \alpha)^2} \right)^{1/2} \quad where \quad \theta = \frac{\sigma_\eta^2}{\sigma_\varepsilon^2}$$

- What it can detect?
  - Correlation is average between the two effects.
  - The weight changes with heteroskedasticity
  - Non-monotonic on θ.
  - Correlation instability could be the outcome of heteroskedasticity (θ)
  - Unbiased if α=β or θ=0.

- Correction
  - If the heteroskedasticity is known the correlation can be corrected to determine parameter stability under factor model but not under endogeneity

Principal Components

- Estimation and Bias
  - Variance of the first principal component

$$pc = \frac{1}{2} + \sqrt{1 - \frac{4(\alpha - \beta)^2 \theta}{\left(1 + \alpha^2 + (1 + \beta^2)\theta\right)^2}}$$

- What it can detect?
  - Variance Share is average between the two effects.
  - Non monotonic with variance of structural shocks
  - The weight changes with heteroskedasticity
  - PC instability could be the outcome of heteroskedasticity (θ)
  - Unbiased if α=β or θ=0.

- Correction
  - None

Event Studies

- Estimation and Bias
  - Estimate probability that an "extreme" event occurs
  - Given that X has an extreme event, compute the impact on Y
  - Near identification

$$y_t = ax_t + \nu_t \qquad \hat{a} = \alpha \frac{1}{1+\theta} + \beta \frac{\theta}{1+\theta}$$

$$\theta \to \infty \Rightarrow \hat{a} \to \beta$$

$$\theta \to 0 \Rightarrow \hat{a} \to \alpha$$

- What it can detect?
  - Good for extreme events
  - Unclear what exactly "extreme" means

- Correction
  - None

Concurrence/Probability Models

- Estimation and Bias
  - Estimate probability that an “extreme” occurs
  - Similar to the event study but here we compute the conditional distribution
  - Methodologies: Probit, Logit, Copulas, Concurrence
  - Conditional probability that X and Y have jointly a very bad event

$$if\ \ \theta \to \infty \Rightarrow \Pr\left(y < \lambda \mid x < \lambda\right) \text{ explained by } \beta \wedge \eta_t$$

$$if\ \ \theta \to 0 \Rightarrow \Pr\left(y < \lambda \mid x < \lambda\right) \text{ explained by } \alpha \wedge \varepsilon_t$$

- What it can detect?
  - Good for extreme events
  - Unclear what exactly “extreme” means

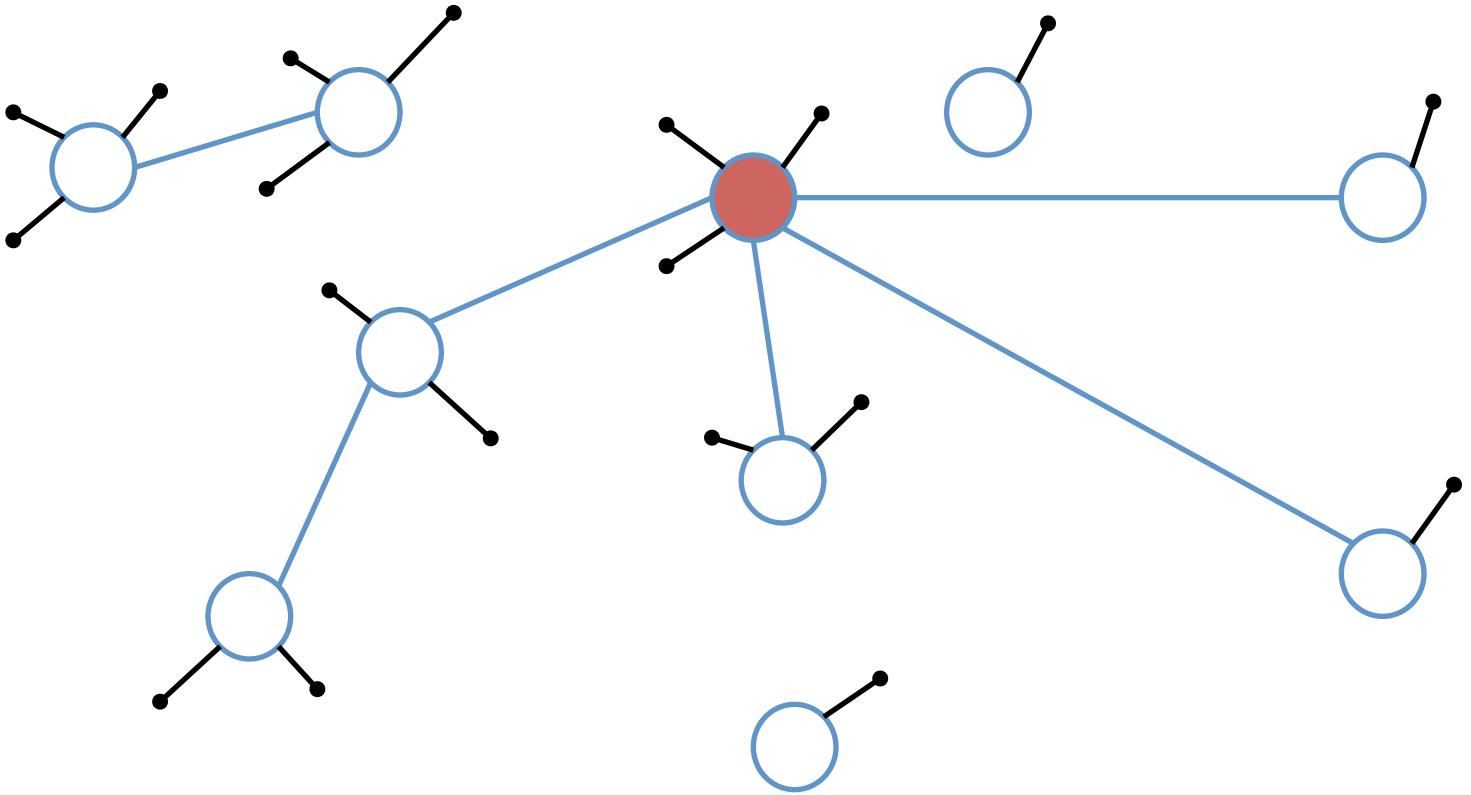
- Correction
  - None

Network

- Conditional Networks
  - Transmission in the network is conditional to the shock
    - Financial Network
      - Exchange Rate Shock
      - Real Estate Shock
      - Interest Rate Shock
      - Bank Run Shock

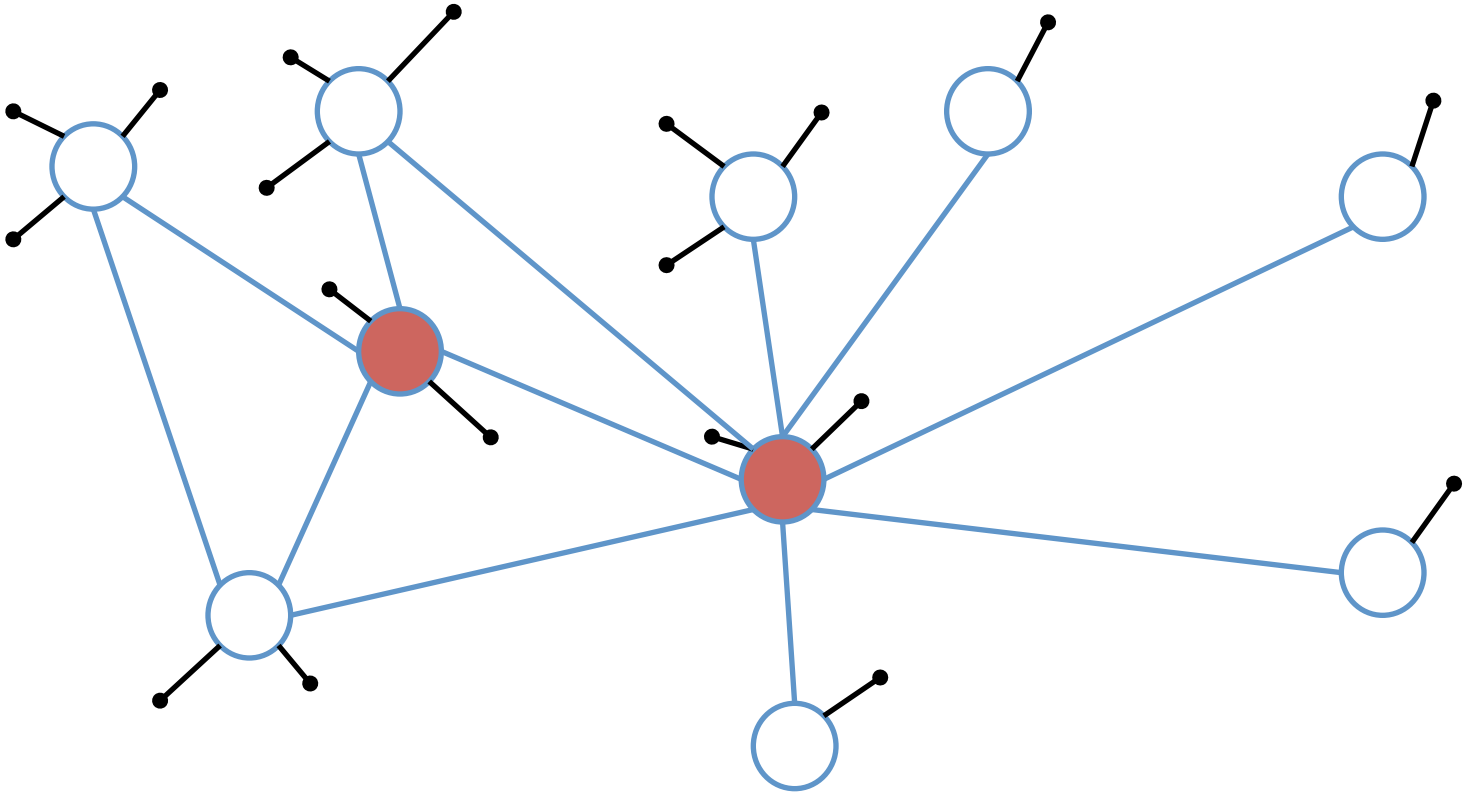
Network

- Conditional Networks



Network

- Conditional Networks



Network

- Conditional Networks
  - Transmission in the network is conditional to the shock
    - Financial Network
      - Exchange Rate Shock
      - Real Estate Shock
      - Interest Rate Shock
      - Bank Run Shock
  - Which network is estimated?
    - Average or Conditional?
  - How the network is estimated?
    - Correlations
    - Probabilities
    - Concurrence

Spillovers and Contagion

- The estimation of spillovers is severely biased
  - Endogeneity
  - Omitted Variables / Factor Models
    - Theory implies that asset prices (and real variables) are jointly determined
- Problem of identification cannot be solved with standard techniques
  - No valid IV
  - No experiment
- Can we at least estimate parameter stability?
  - No!
    - Biases shift with the heteroskedasticity
- Need additional information
  - Conditioning on the event is not enough?
  - Conditioning on “crisis country”?

Asymmetric Models

- Estimation and Bias
  - Assume we estimate in two sub-samples (crises and normal times)
  - Can we detect parameter instability?
    - Assume parameters are stable
    - Biases shift in the sample due to heteroskedasticity

$$y_t = ax_t + bx_t \cdot 1\left[c_t\right] + \nu_t$$

$$\hat{a} = \alpha + (\beta - \alpha)\frac{\theta_1}{1+\theta_1} \qquad \hat{b} = (\beta - \alpha)\left(\frac{\theta_2}{1+\theta_2} - \frac{\theta_1}{1+\theta_1}\right)$$

Some alternatives

- Estimation of “stable” relationships
  - Estimation of spillovers
  - Emphasis on identification
    - Use Heteroskedasticity
- Estimation of change in relationship
  - Estimation of contagion
  - Tests robust to OV and Endogeneity
    - DCC
    - Quantile based approach
- Estimation of Network
  - Correlations, Concurrence, Conditional Probabilities are the outcomes of conditional networks NOT a measure of the intensity of the connection.
  - Machine Learning – Simple Model Selection Estimations

Identification through Heteroskedasticity

- How does it work?

$$y_t = \beta\eta_t + \alpha\varepsilon_t$$

$$x_t = \eta_t + \varepsilon_t$$

Covariance Matrix

$$\Omega = \begin{bmatrix} \beta^2\sigma_\eta^2 + \alpha^2\sigma_\varepsilon^2 & \beta\sigma_\eta^2 + \alpha\sigma_\varepsilon^2 \\ & \sigma_\eta^2 + \sigma_\varepsilon^2 \end{bmatrix}$$

Unknowns: 4, $\alpha, \beta, \sigma_\eta, \sigma_\varepsilon$

Knowns: 3, Ω

Identification through Heteroskedasticity

- How does it work?

Two Regimes with constant parameters.

$$\Omega_1 = \begin{bmatrix} \beta^2\sigma^2_{\eta,1} + \alpha^2\sigma^2_{\varepsilon,1} & \beta\sigma^2_{\eta,1} + \alpha\sigma^2_{\varepsilon,1} \\ & \sigma^2_{\eta,1} + \sigma^2_{\varepsilon,1} \end{bmatrix}$$

$$\Omega_2 = \begin{bmatrix} \beta^2\sigma^2_{\eta,2} + \alpha^2\sigma^2_{\varepsilon,2} & \beta\sigma^2_{\eta,2} + \alpha\sigma^2_{\varepsilon,2} \\ & \sigma^2_{\eta,2} + \sigma^2_{\varepsilon,2} \end{bmatrix}$$

Unknowns: 6, $\alpha, \beta, \sigma_{\eta,1}, \sigma_{\varepsilon,1}, \sigma_{\eta,2}, \sigma_{\varepsilon,2}$

Knowns: 6, Ω_1, Ω_2

Identification through Heteroskedasticity

- When it works?
  - Pure heteroskedasticity
    - Arch and Garch (Sentana and Fiorentini)
  - Identification assumption depends on number of structural shocks, endogenous variables, and heteroskedasticity regimes
  - Cannot test parameter instability unless more information is available
    - Homoskedasticity of some of the coefficients – achieves overidentified restrictions
    - More than two regimes

Identification through Heteroskedasticity

- What do you need to be careful about?
  - IH can be used as a form of statistical identification as opposed to economic identification
    - Parameter Stability is crucial
    - Cross-sectional applications are much harder to justify than time series applications
  - Linear models and non-linear models are identified but be careful with identification
    - You do not want to identify a linear model because it is an incorrectly specified non-linear one
  - Estimation of covariance matrices becomes a first order problem
    - Bayesian approach to regime identification, but it is robust and consistent to misspecification of regimes

Identification through Heteroskedasticity

- Where do I use it?
  - Monetary policy and Macro announcements
    - Evaluation of impact of monetary policy domestically
    - When ECB makes an announcement it is reasonable to assume that in that instant the only heteroskedastic shock is the monetary policy shock
    - Same for some important macroeconomic announcements

Identification through Heteroskedasticity

- Where do I use it?
  - Monetary policy and Macro announcements
    - Assume η is the heteroskedastuc shock

$$y_t = ax_t + \varepsilon_t$$

$$a_{ols} = \frac{\mathrm{cov}\left(y_t, x_t\right)}{\mathrm{var}\left(x_t\right)} = \beta + (\alpha - \beta)\frac{1}{1+\theta}$$

$$a_{ih} = \frac{\Delta\,\mathrm{cov}\left(y_t, x_t\right)}{\Delta\,\mathrm{var}\left(x_t\right)} = \beta$$

Identification through Heteroskedasticity

- Where do I use it?
  - Monetary policy and Macro announcements
    - Evaluation of impact of monetary policy domestically
    - When ECB makes an announcement it is reasonable to assume that in that instant the only heteroskedastic shock is the monetary policy shock
    - Same for some important macroeconomic announcements
  - Systemic Risk and Cross-Country Spillovers
    - Average estimation robust to omitted variables and endogeneity concerns
      - Feedback effects
      - Network estimation
  - Real propagation of shocks

Determinant of the Change in the Covariance Matrix

- How does it work?
  - The overidentified test from IH.
  - No identification of individual parameters but mostly a test of parameter stability

$$\text{Assume } \sigma_{\eta,1}^2 = \sigma_{\eta,2}^2$$

$$\Omega_1 = \begin{bmatrix} \beta^2\sigma_\eta^2 + \alpha^2\sigma_{\varepsilon,1}^2 & \beta\sigma_\eta^2 + \alpha\sigma_{\varepsilon,1}^2 \\ & \sigma_\eta^2 + \sigma_{\varepsilon,1}^2 \end{bmatrix}$$

$$\Omega_2 = \begin{bmatrix} \beta^2\sigma_\eta^2 + \alpha^2\sigma_{\varepsilon,2}^2 & \beta\sigma_\eta^2 + \alpha\sigma_{\varepsilon,2}^2 \\ & \sigma_\eta^2 + \sigma_{\varepsilon,2}^2 \end{bmatrix}$$

Determinant of the Change in the Covariance Matrix

- How does it work?
  - Change in Covariance Matrix has determinant zero

$$\Delta\Omega = \Omega_2 - \Omega_1 = \begin{bmatrix} \alpha^2 & \alpha \\ \alpha & 1 \end{bmatrix} \left(\sigma^2_{\varepsilon,2} - \sigma^2_{\varepsilon,1} \right)$$

  - So, the model can have more structural shocks than observed variables
    - If a subset of them (large enough) is homoskedastic parameter stability can be tested
    - In some cases coefficients can be estimated, but those situations are rare.

Determinant of the Change in the Covariance Matrix

- When does it work?
  - Some shocks need to be assumed heteroskedastic and some homoskedastic
  - Null hypothesis is parameter stability
  - Robust to misspecification of “regimes”
- What do you need to be careful about?
  - Homoskedasticity assumption
- When do I use it?
  - Macro Shocks
    - The DCC in conjunction with the IH allows for identification and test of stability for monetary and macroeconomic shocks

Quantile regression approach

- How does it work?
  - Test parameter stability between large and small, positive and negative shocks

$$y_t = ax_t + \nu_t \quad \text{for } \nu_t \in q$$

$$\hat{a} = \frac{\alpha Var\left(\varepsilon_t \mid \nu_t \in q\right) + \beta Var\left(\eta_t \mid \nu_t \in q\right)}{Var\left(\varepsilon_t \mid \nu_t \in q\right) + Var\left(\eta_t \mid \nu_t \in q\right)}$$

$$v_t = y_t - \hat{a}x_t$$

Quantile regression approach

- How does it work?
  - Bias changes with the quintile

$$\operatorname{cov}\left(x_t, v_t \mid v_t \in q\right) \neq \operatorname{cov}\left(x_t, v_t \mid v_t \in q'\right) \Rightarrow$$
$$\hat{a}(q) \neq \hat{a}(q')$$

  - Unless β=0 where the coefficients are the same irrespectively of the quantile

Quantile regression approach

- When does it work?
  - Coefficients are assumed to be the same and we need to test for it
  - Quantile regression assumptions are needed
- What do you need to be careful about?
  - Assumptions behind quantile regression require stronger exogeneity than OLS

$$E\left[x_t' v_t\right] = 0 \text{ OLS exogeneity assumption}$$

$$E\left[x_t \mid v_t\right] = 0 \text{ Quantile exogeneity assumption}$$

Conditional Networks

- Estimation using Lasso in panel data
  - *N* banks in the data
  - Matrix *A* describes the linkages (from x_i to x_j).
    - *A* has many zeros (the linkages are sparce)
  - *Y* represent the observed outcomes
  - Estimation

$$\min\left[\left(y_t - Ax_t\right)^2 - \lambda|A|\right]$$

Monetary Policy Transmission

- Channels
  - Fundamental View
    - Exchange rate channel (currency wars)
    - Interest rate channel (carry trade)
  - Financial and Network's View
    - Banking system is interconnected internationally
    - Contracts are not very well observed
  - Coordination View
    - Regulation and regulatory retaliation

Monetary Policy Transmission

- Measurement
  - Contagion
    - Be prepared for the unmeasured
      - If we can measure a linkage, then the expected impact of such linkage will be taken into account by market participants
      - Interest rates and stock prices will reflect such expected transmission
      - Contagion can only occur through the unobserved or mismeasured channel.
  - Spillovers and Networks
    - Measurement contingent to shocks
      - Different networks depending on different shocks

Policy Implications

- For central banks
  - Contagion will occur
    - It cannot be measured ex-ante
    - Build “economic” insurance (real resources) as a buffer
    - Spillovers are only a proxy for the averaged observed linkage
- For regulators
  - Counter-Cyclicality of regulation is crucial