International Inflation Spillovers Through Input Linkages[1]

Raphael A. Auer Andrei A. Levchenko Philip Sauré

BIS, U Michigan, SNB

[1]The views expressed here are those of the authors and do not necessarily reflect those of the BIS or the SNB.

Motivation

- Inflation is highly synchronized across countries
- Important to know why
  - Inflation forecasting
  - Monetary policy and its international coordination
  - Currency unions

Hypothesis: inflation comoves across countries due to input linkages.

This Paper

- Assess empirically the role of cross-border input linkages in inflation synchronization
- Main idea:

$$\widehat{PPI}_c = \gamma_{c,e} \times \widehat{PPI}_e + (1 - \gamma_{c,e}) \times \widehat{C}_c$$

- A unique database that combines sectoral PPI inflation for 30 countries and 17 sectors with the World Input-Output matrix (WIOD)

Preview of Results

1. Tracking the Global Component of Inflation
    - Input linkages account for about half of observed inflation comovement.
    - A single common factor accounts for about 40% of the variance of PPI inflation, but about 20% of the variance of the underlying cost shocks
2. Mechanisms:
    - Heterogeneity in input linkages matters somewhat, but most of the effect is driven by their average level
    - Both the comovement of PPI, and the contribution of linkages to comovement, are driven by common sectoral shocks

Literature

- International inflation synchronization: Monacelli and Sala (2009), Burstein and Jaimovich (2012), Andrade and Zachariadis (2015), and Beck, Hubrich and Marcellino (2015); Ciccarelli and Mojon (2010), Mumtaz and Surico (2009, 2012) and Mumtaz, Simonelli and Surico (2011); Borio and Filardo (2007) and Bianchi and Civelli (2015);
- Input linkages and international relative prices: Bems and Johnson (2012, 2015) and Patel, Wang and Wei (2014)
- International business cycle comovement through input linkages: Kose and Yi (2006), Burstein, Kurz and Tesar (2008), di Giovanni and Levchenko (2010), Johnson (2014)

Cost Function and PPI

C countries, indexed by c (e), and S sectors, indexed by u (s).

- Cost function of sector u in country c

$$W_{c,u,t} = W(C_{c,u,t}, \mathbf{p}_{c,u,t}), \qquad \textit{with} \qquad \mathbf{p}_{c,u,t} = (p_{c,u,e,s,t})_{e,s}$$

- In changes:

$$\widehat{W}_{c,u,t} \approx \gamma^{C}_{c,u,t-1} \widehat{C}_{c,u,t} + \sum_{e,s} \gamma^{I}_{c,u,e,s,t-1} \widehat{p}_{c,u,e,s,t}$$

- Assumptions (constant markups):
  1. $\widehat{PPI}_{c,u,t} = \widehat{W}_{c,u,t}$
  2. Imported input prices: $\widehat{p}_{c,u,e,s,t} = \widehat{W}_{e,s,t} + \widehat{E}_{c,e,t}$

Recovering the Cost Shocks

- Cost shock recovered directly

$$\widehat{C}_{c,u,t} = \frac{1}{\gamma^{C}_{c,u,t-1}} \left[\widehat{PPI}_{c,u,t} - \sum_{e \in C, s \in S} \gamma^{I}_{c,u,e,s,t-1} \left(\widehat{PPI}_{e,s,t} + \widehat{E}_{c,e,t} \right) \right]$$

- Simplified matrix notation

$$\widehat{\mathbf{C}} = (\mathbf{I} - \mathbf{\Gamma}')\widehat{\mathbf{PPI}}$$

- 12-month changes ($X = \{PPI, C\}$):

$$\widehat{X12}_{c,u,t} = \prod_{\tau=0}^{11} (1 + \widehat{X}_{c,u,t-\tau}) - 1$$

- Aggregated:

$$\widehat{X12}_{c,t} = \sum_{u \in S} \omega_{c,u} \widehat{X12}_{c,u,t}$$

Data

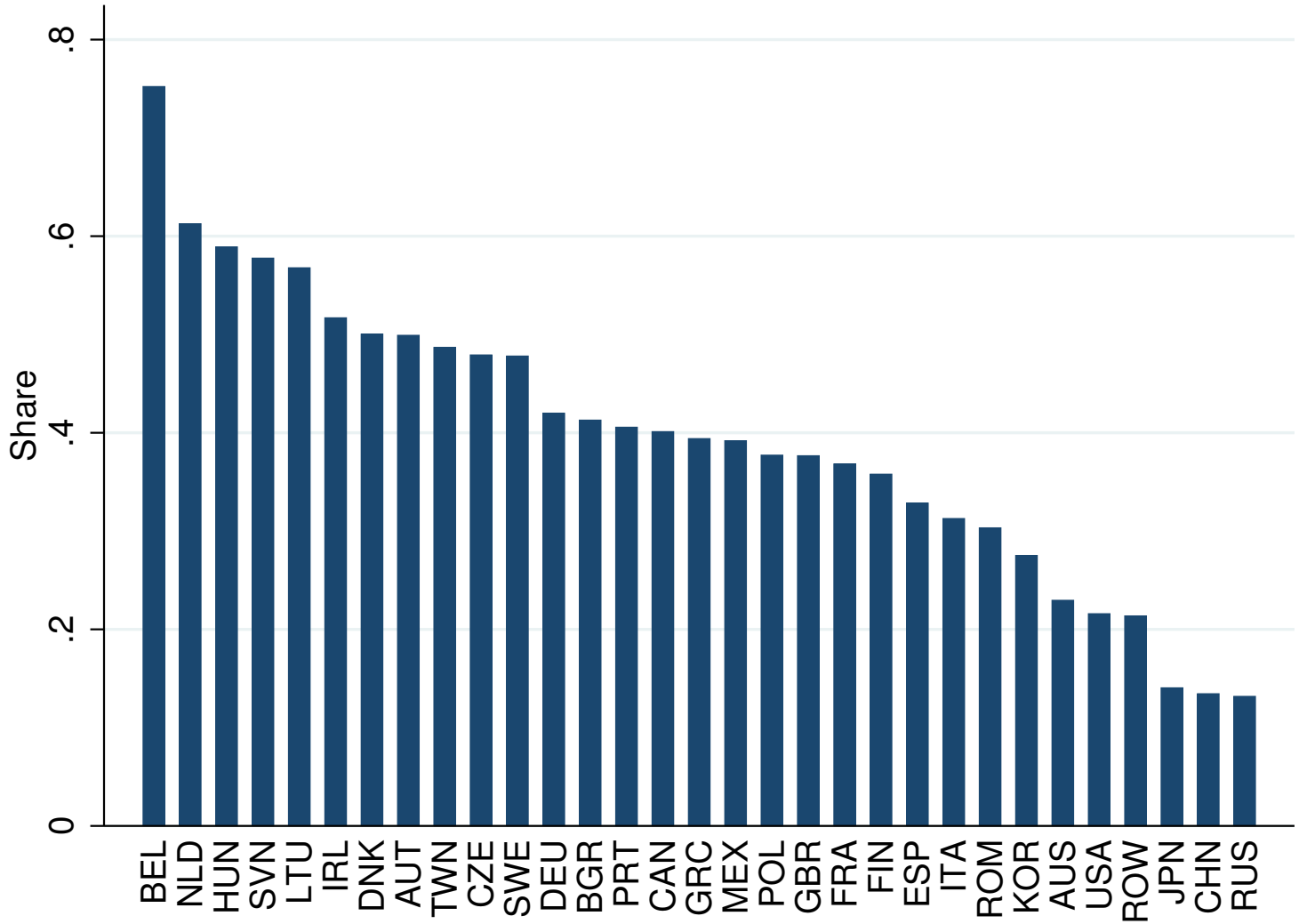
- PPI data: National statistical offices (Eurostat, BLS, StatCan, ...)
  - Country-specific product classification
  - Frequency: monthly
- Cross-border trade and output data: World Input-Output database (WIOD)
- Final sample: 17 sectors, 30 countries + ROW; 1995m1-2011m12

Countries and Sectors

Country	Code
Australia	AUS
Austria	AUT
Belgium	BEL
Bulgaria	BGR
Canada	CAN
China	CHN
Czech Republic	CZE
Denmark	DNK
Finland	FIN
France	FRA
Germany	DEU
Greece	GRC
Hungary	HUN
Ireland	IRL
Italy	ITA
Japan	JPN
Korea	KOR
Lithuania	LTU
Mexico	MEX
Netherlands	NLD
Poland	POL
Portugal	PRT
Rest of the World	ROW
Romania	ROM
Russian Federation	RUS
Slovenia	SVN
Spain	ESP
Sweden	SWE
Taiwan, POC	TWN
United Kingdom	GBR
United States	USA

Sector
Agriculture, Hunting, Forestry, and Fishing
Basic Metals and Fabricated Metal
Chemicals and Chemical Products
Coke, Refined Petroleum and Nuclear F..
Electrical and Optical Equipment
Electricity, Gas and Water Supply
Food, Beverages and Tobacco
Leather, Leather and Footwear
Machinery, Nec
Manufacturing, Nec; Recycling
Mining and Quarrying
Other Non-Metallic Mineral
Pulp, Paper, Paper , Printing and Pub..
Rubber and Plastics
Textiles and Textile Products
Transport Equipment
Wood and Products of Wood and Cork

Imported Input Use by Country



Data: Transmission of Hypothetical Shocks Through IO Matrix

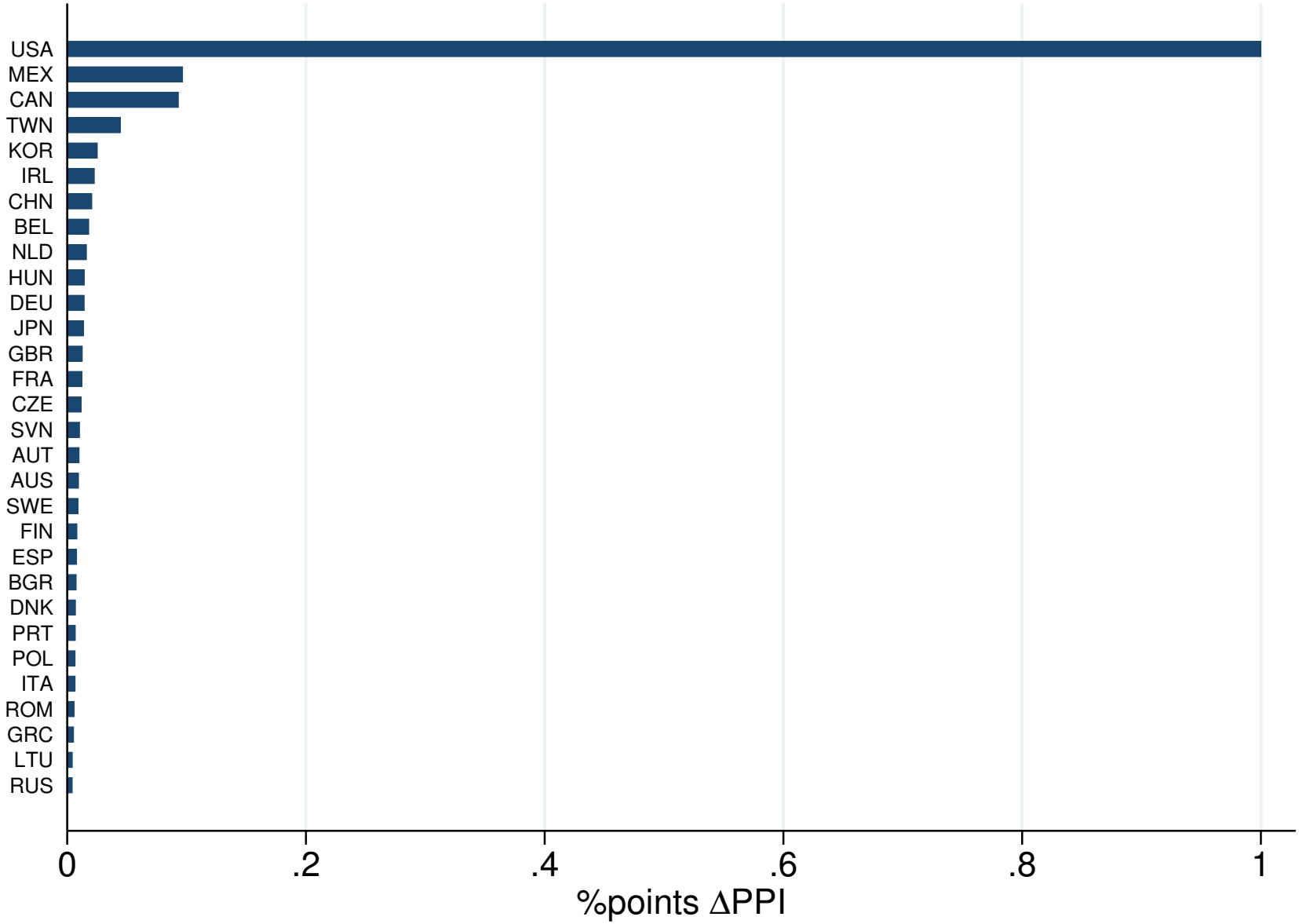
- Equilibrium $\widehat{\mathbf{PPI}}$:

$$\widehat{\mathbf{PPI}} = (\mathbf{I} - \mathbf{\Gamma}')^{-1}\widehat{\mathbf{C}}$$

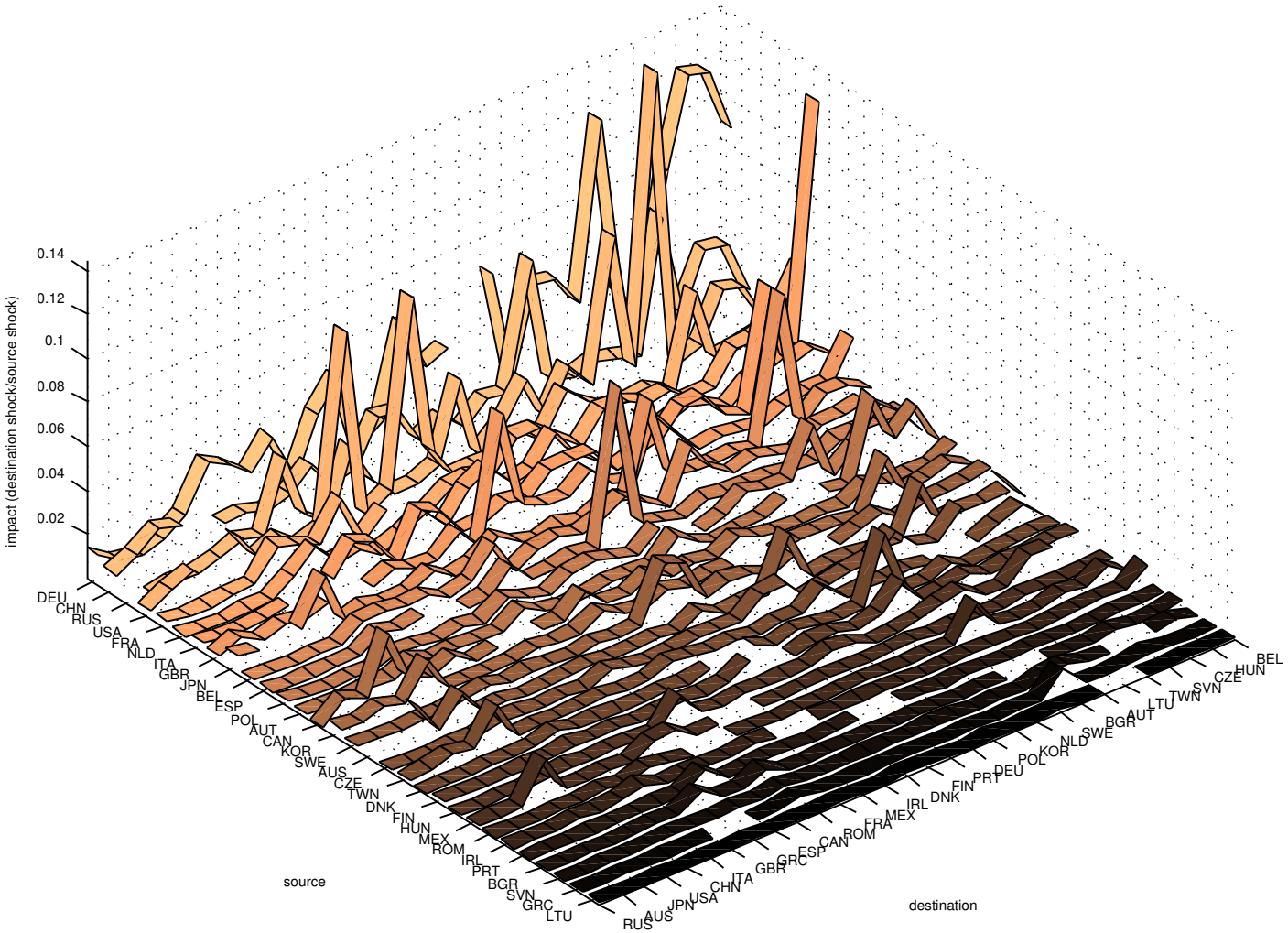
- Hypothetical shock to an individual country:

$$\widehat{\mathbf{C}} = \begin{pmatrix} 0 \cdots 0 & \widehat{C}_{s,1} \cdots \widehat{C}_{s,J} & 0 \cdots 0 \end{pmatrix}'$$

1% US Inflation



Each Country on Each Country



Result 2. Tracking the Global Component of Inflation

Metrics of synchronization

1. R^2 of the country's $\widehat{PPI}(\widehat{C})$ on world average $\widehat{PPI}(\widehat{C})$ (Ciccarelli-Mojon, 2010)

2. Static factor

   Share of the variance explained by a world factor:

$$X_{c,t} = \lambda_c F_t + \epsilon_{c,t}$$

$$\frac{Var(\lambda_c F_t)}{Var(X_{c,t})}$$

3. Dynamic factor

Result 2: Synchronization, Country-Level

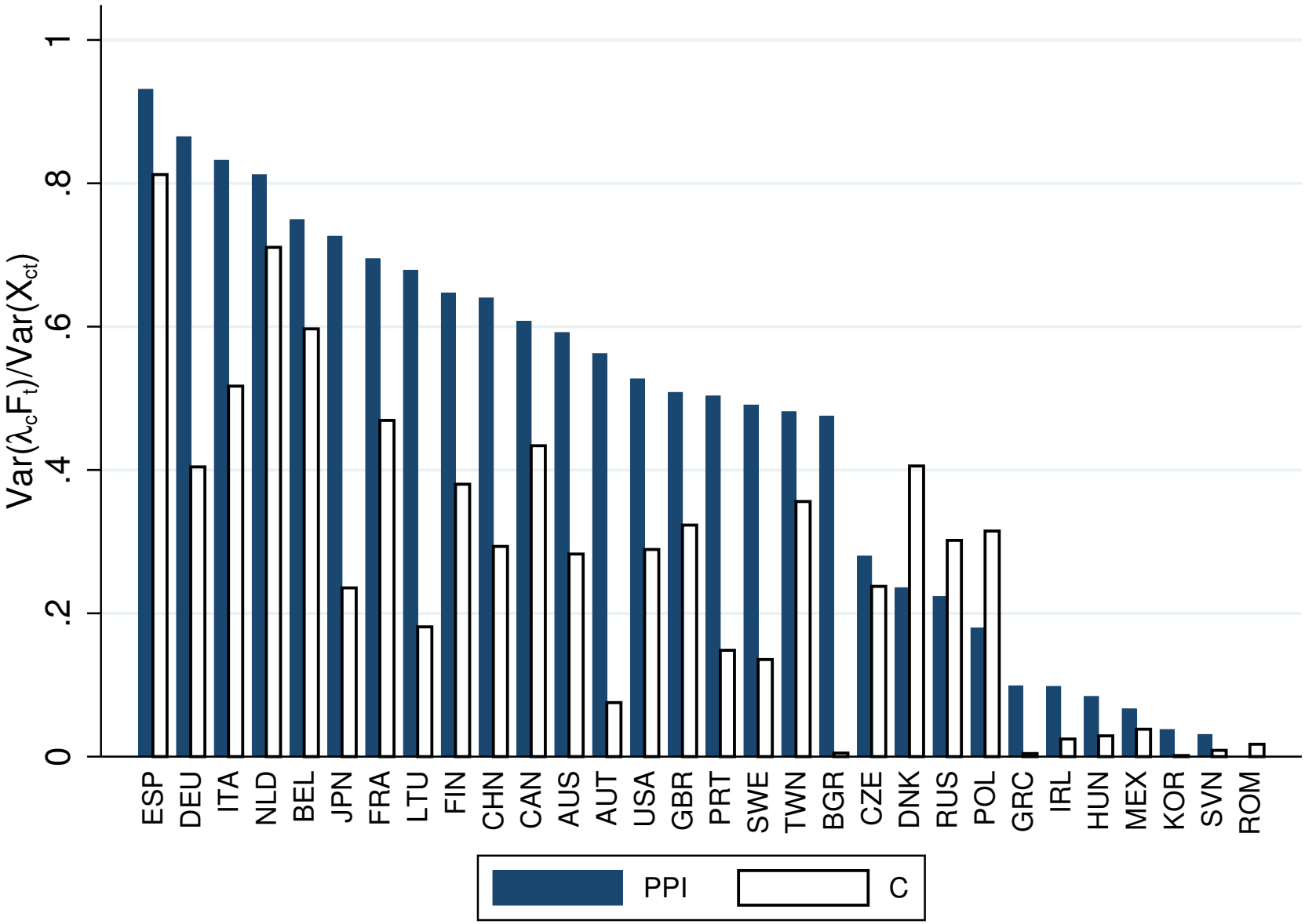
Input linkages account for at least half of observed inflation comovement.

	Panel A: R^2		Panel B: Static Factor		Panel C: Dynamic Factor	
	$\widehat{PPI12}_{c,t}$	$\widehat{C12}_{c,t}$	$\widehat{PPI12}_{c,t}$	$\widehat{C12}_{c,t}$	$\widehat{PPI12}_{c,t}$	$\widehat{C12}_{c,t}$
Mean	0.385	0.172	0.455	0.268	0.444	0.235
Median	0.365	0.110	0.506	0.286	0.500	0.181
Min	0.006	0.000	0.000	0.002	0.002	0.002
Max	0.776	0.527	0.931	0.812	0.916	0.761

Recall:

$$\widehat{\mathbf{PPI}} = (\mathbf{I} - \mathbf{\Gamma}')^{-1}\widehat{\mathbf{C}}$$

Variance Shares: Cross-Country Heterogeneities



Result 3: Mechanisms

1. Heterogeneity in linkages
2. Sectoral vs. global shocks

Exchange Rate Movements and Unbalanced Linkages

	R^2	Static Factor	Dynamic Factor
		Baseline	
$\widehat{PPI12}_{c,t}$			
mean	0.385	0.455	0.444
median	0.365	0.506	0.500
$\widehat{C12}_{c,t}$			
mean	0.172	0.268	0.235
median	0.110	0.286	0.181
		Alternative input linkages	
Balanced 1 (sectors), $\widehat{PPI12}^{counter}_{c,t}$			
mean	0.266	0.364	0.350
median	0.210	0.387	0.359
Balanced 2 (countries+sectors), $\widehat{PPI12}^{counter}_{c,t}$			
mean	0.318	0.405	0.394
median	0.284	0.446	0.435

$$\widehat{\mathbf{PPI}} = (\mathbf{I} - \mathbf{\Gamma}')^{-1}\widehat{\mathbf{C}}$$

Sectoral vs. Global Shocks

- Factor model at sector level ($X = \{PPI, C\}$):

$$X_{c,u,t} = \alpha_{c,u} + \lambda^{w}_{c,u} F^{w}_{t} + \lambda^{c}_{c,u} F^{c}_{t} + \lambda^{u}_{c,u} F^{u}_{t} + \epsilon_{c,u,t}$$

- Bayesian estimation procedure following Jackson, Kose, Otrok, and Owyang (2015)

Sectoral vs. Global Shocks

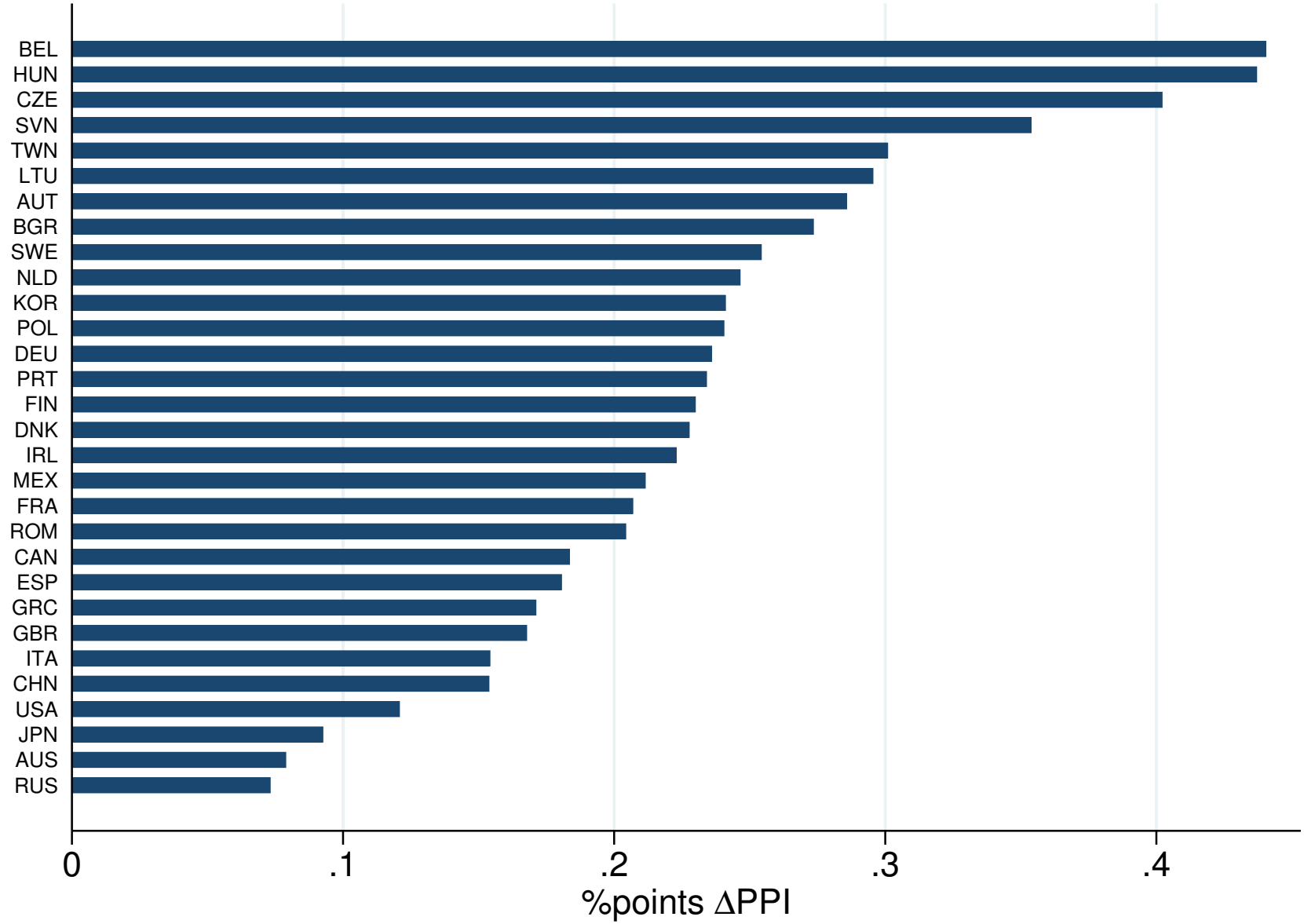
Comovement of PPI and the contribution of linkages to comovement are driven by common sectoral shocks.

	$\widehat{PPI12}_{c,u,t}$			$\widehat{C12}_{c,u,t}$		
	World	Sector	Country	World	Sector	Country
Mean	0.072	0.421	0.343	0.096	0.234	0.356
Median	0.028	0.485	0.292	0.050	0.169	0.295
Min	0.001	0.006	0.023	0.000	0.001	0.000
Max	0.398	0.849	0.945	0.505	0.713	0.902

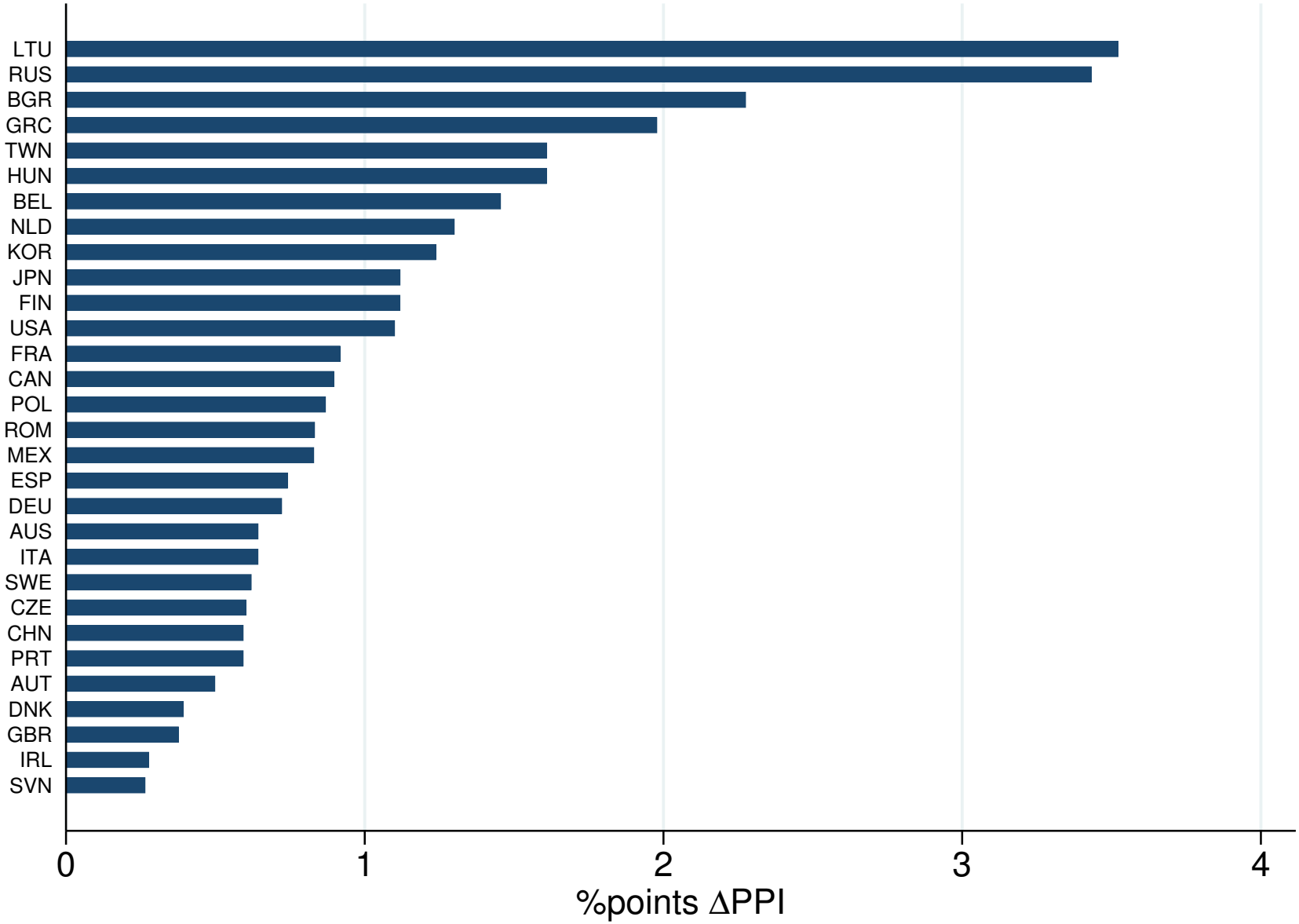
Conclusion

- Inflation is synchronized across countries and it important to know why.
- Input linkages matter for inflation transmission
  - Explain half of observed PPI comovement in our sample
- Machanisms:
  - Linkage heterogeneity less important
  - Global component primarily consists of sector-specific shocks

Additional Material: 1% Worldwide Inflation

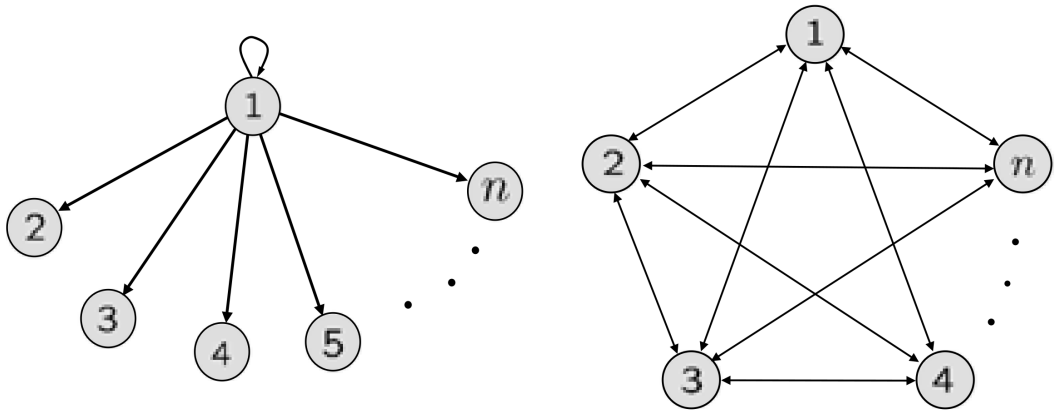


Additional Material: 10% Change in Energy Prices



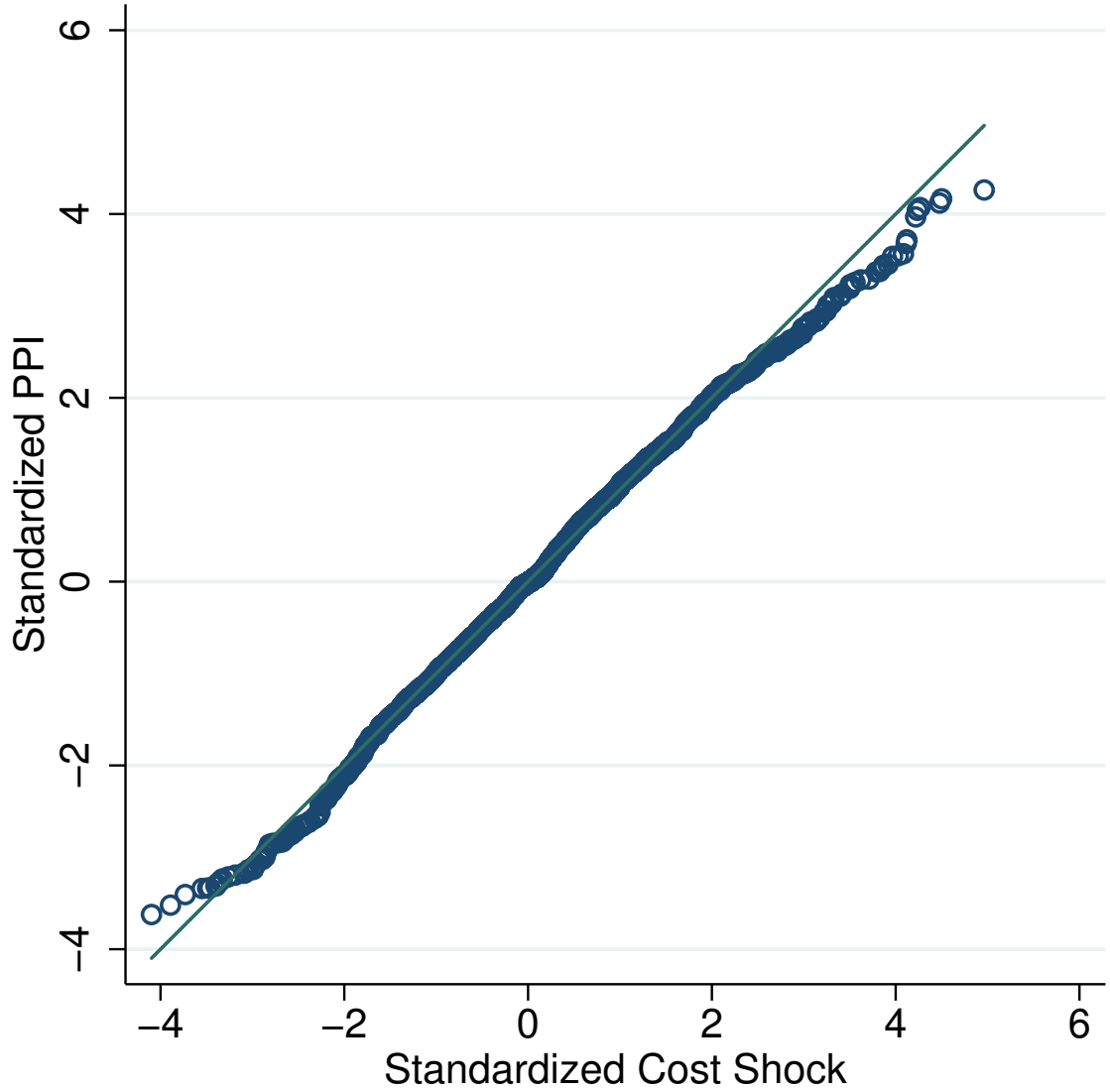
Additional Material: Fat Tails in PPI and Cost Shocks

The concentration of input linkages matters for the transmission of shocks



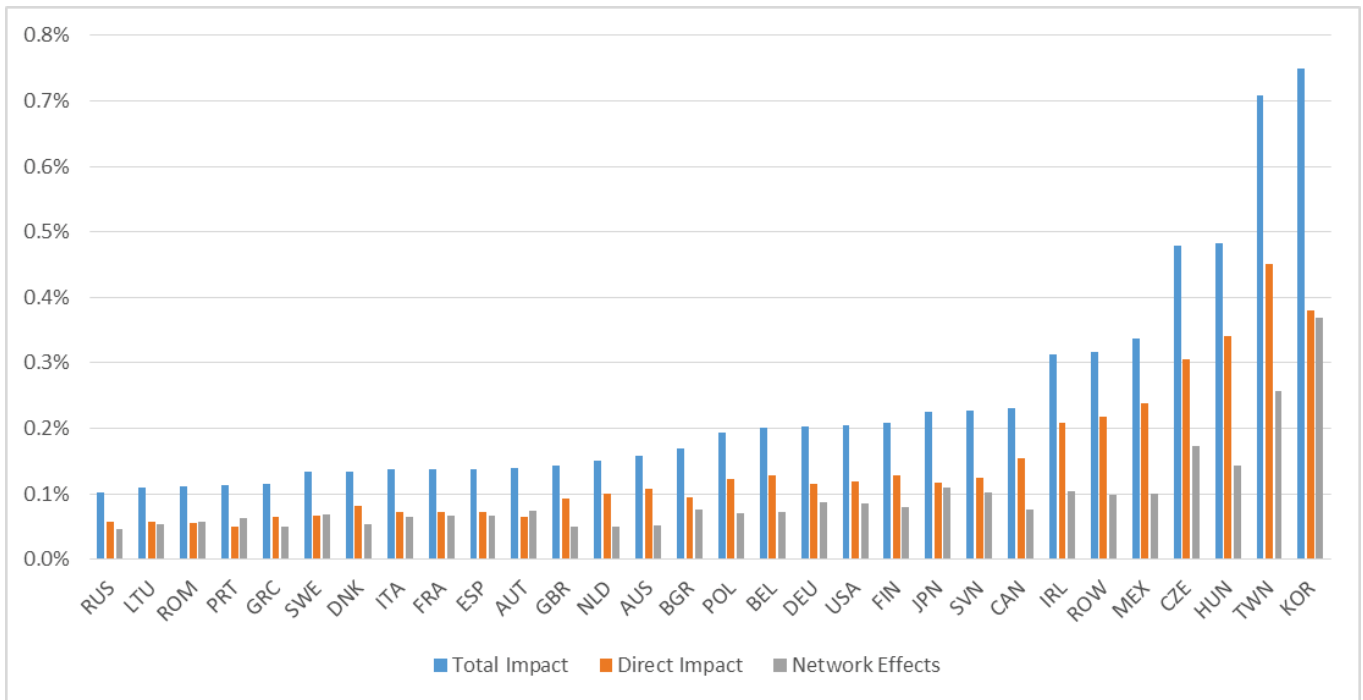
From Acemoglu et al. 2012

Additional Material: PPI vs. Cost Shocks



Additional Material: Decomposition Direct and Indirect Effects

10% PPI Inflation Shock in China



8