International Inflation Spillovers Through Input Linkages

Raphael A. Auer Andrei A. Levchenko Philip Sauré

BIS, SNB, Michigan

June 25, 2016

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:

$$\widehat{PPI}_c = \gamma_{c,s} \times \beta \times \widehat{PPI}_s + \widehat{C}_c$$

- A unique database that combines sectoral PPI inflation for 30 countries and 16 sectors with the World Input-Output matrix (WIOD)

Preview of Results

1. Transmission of hypothetical shocks
    - A 1% global inflation shock raises average country PPI by 0.23%
    - Shocks to large individual countries matter for their closest smaller trading partners
        - E.g. Canada wrt USA, Hungary wrt Germany have an elasticity of around 0.1
        - A shock that increases a 'core' country's inflation by 1% moves foreign inflation rates by 0.015-0.04% in the full sample

Preview of Results

2. Observed input linkages can account for about half of observed inflation comovement
   - A single common factor accounts for about 50% of the variance of PPI inflation, but only about 25% of the variance of the underlying cost shocks
3. Mechanisms:
   - Pass-through of cost shocks matters: $\beta = 0.3 \rightarrow$ linkages explain only about 15-20% of comovement
   - 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
4. Inflation behavior exhibits fat tails (relative to a normal distribution). Input linkages preserve fat-tailedness of underlying shocks, rather than average them out.

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 and e, and S sectors, indexed by u and s.
- Sector u in country c cost function

$$W_{c,u,t} = W(C_{c,u,t}, \mathbf{p}_{c,u,t}),$$

- 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:
  1. $\widehat{PPI}_{c,u,t} = \widehat{W}_{c,u,t}$ (MC pricing, constant markups)
  2. Input prices: $\widehat{p}_{c,u,e,s,t} = \beta^{I}_{c,u,e,s} \left(\widehat{W}_{e,s,t} + \widehat{E}_{c,e,t} \right)$

Recovering the Cost Shocks

- Cost shock recovered directly

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

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

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

- Aggregated:

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

Metrics of synchronization

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

   Share of the variance explained by a world factor:

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

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

2. Static factor

3. Dynamic factor

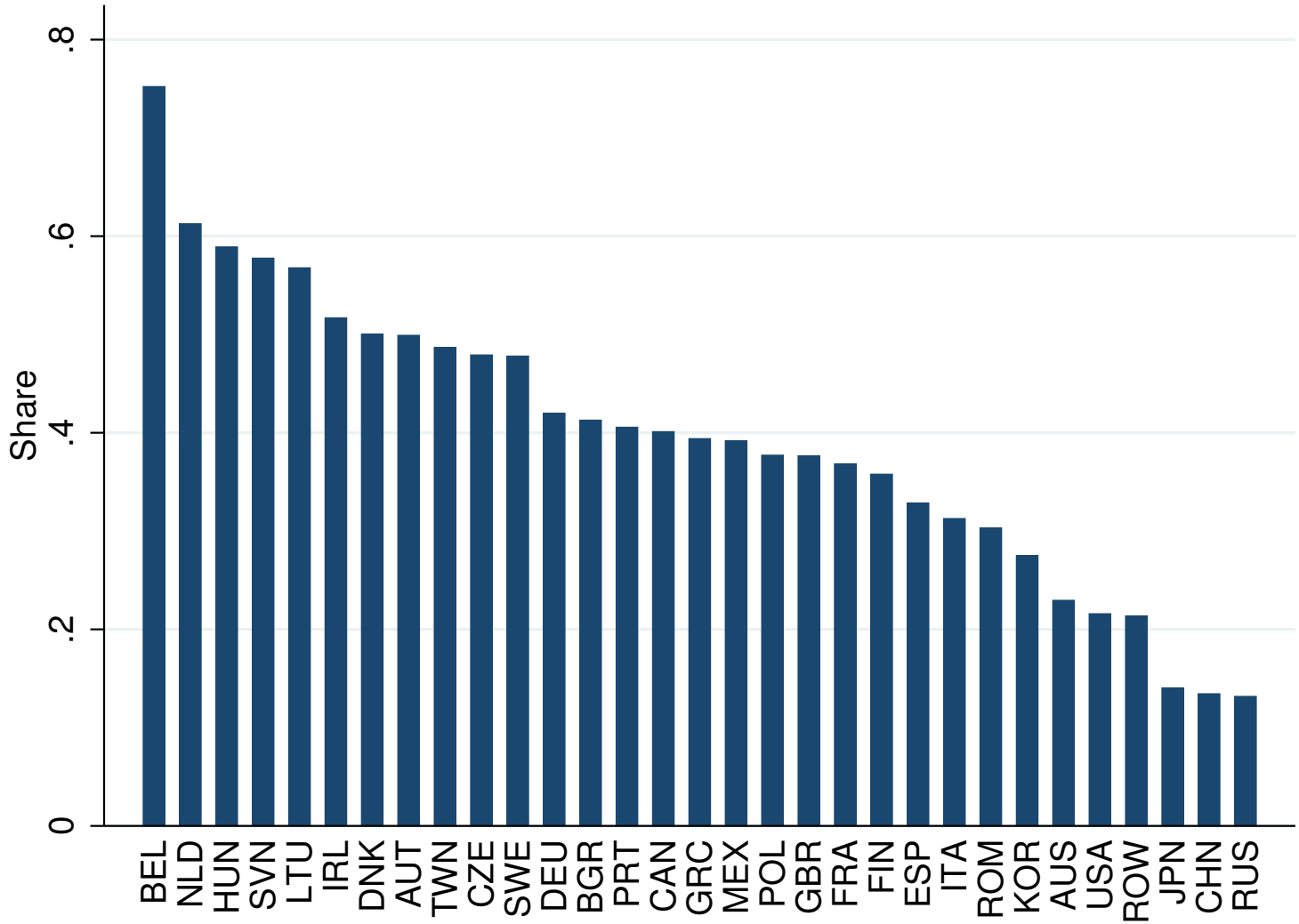
Data

- 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	Sector
Australia	AUS	Agriculture, Hunting, Forestry, and Fishing
Austria	AUT	Basic Metals and Fabricated Metal
Belgium	BEL	Chemicals and Chemical Products
Bulgaria	BGR	Coke, Refined Petroleum and Nuclear F..
Canada	CAN	Electrical and Optical Equipment
China	CHN	Electricity, Gas and Water Supply
Czech Republic	CZE	Food, Beverages and Tobacco
Denmark	DNK	Leather, Leather and Footwear
Finland	FIN	Machinery, Nec
France	FRA	Manufacturing, Nec; Recycling
Germany	DEU	Mining and Quarrying
Greece	GRC	Other Non-Metallic Mineral
Hungary	HUN	Pulp, Paper, Paper , Printing and Pub..
Ireland	IRL	Rubber and Plastics
Italy	ITA	Textiles and Textile Products
Japan	JPN	Transport Equipment
Korea	KOR	Wood and Products of Wood and Cork
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	

Imported Input Use by Country



Transmission of Shocks Through IO Linkages

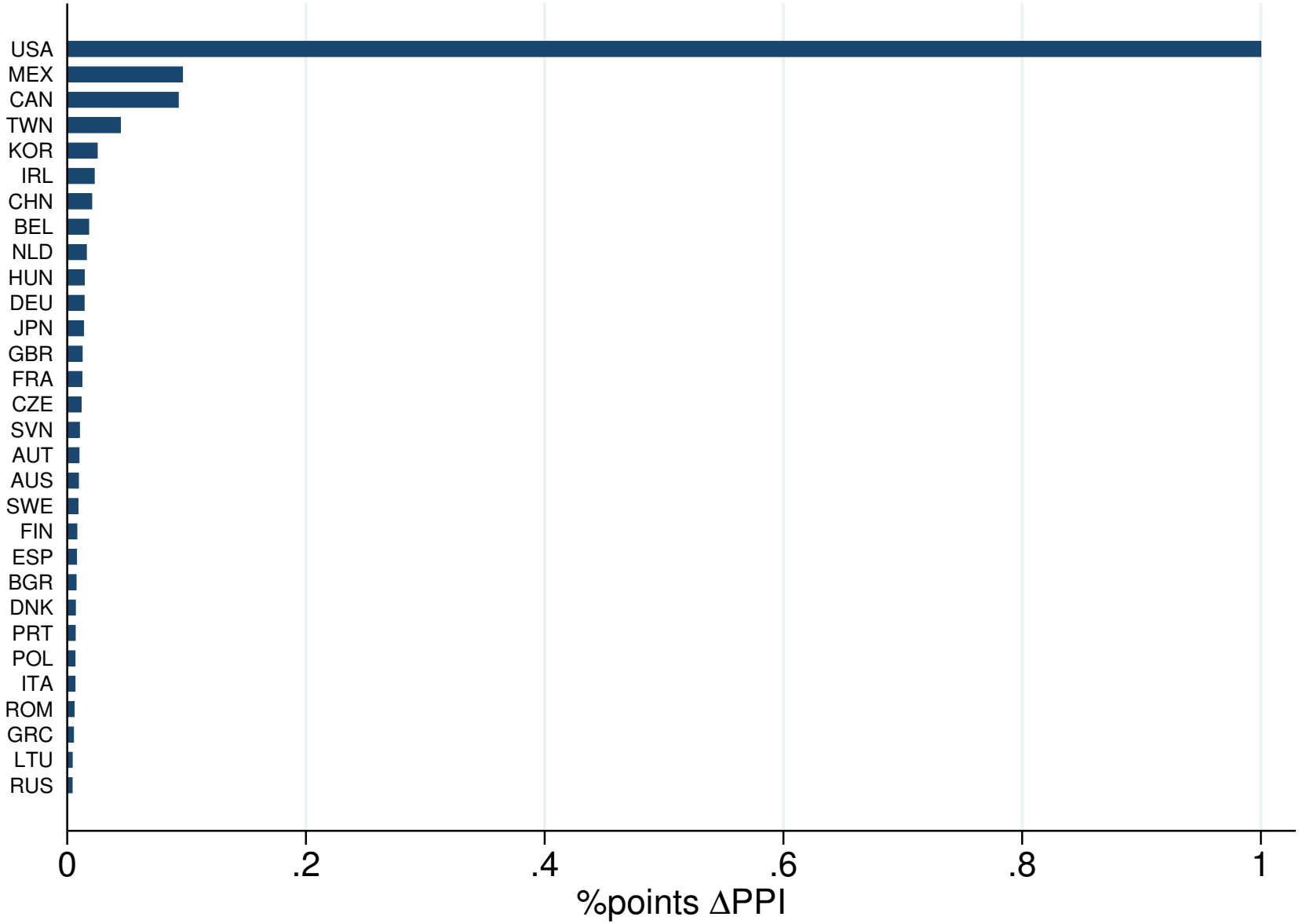
- Equilibrium $\widehat{\mathbf{PPI}}$:

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

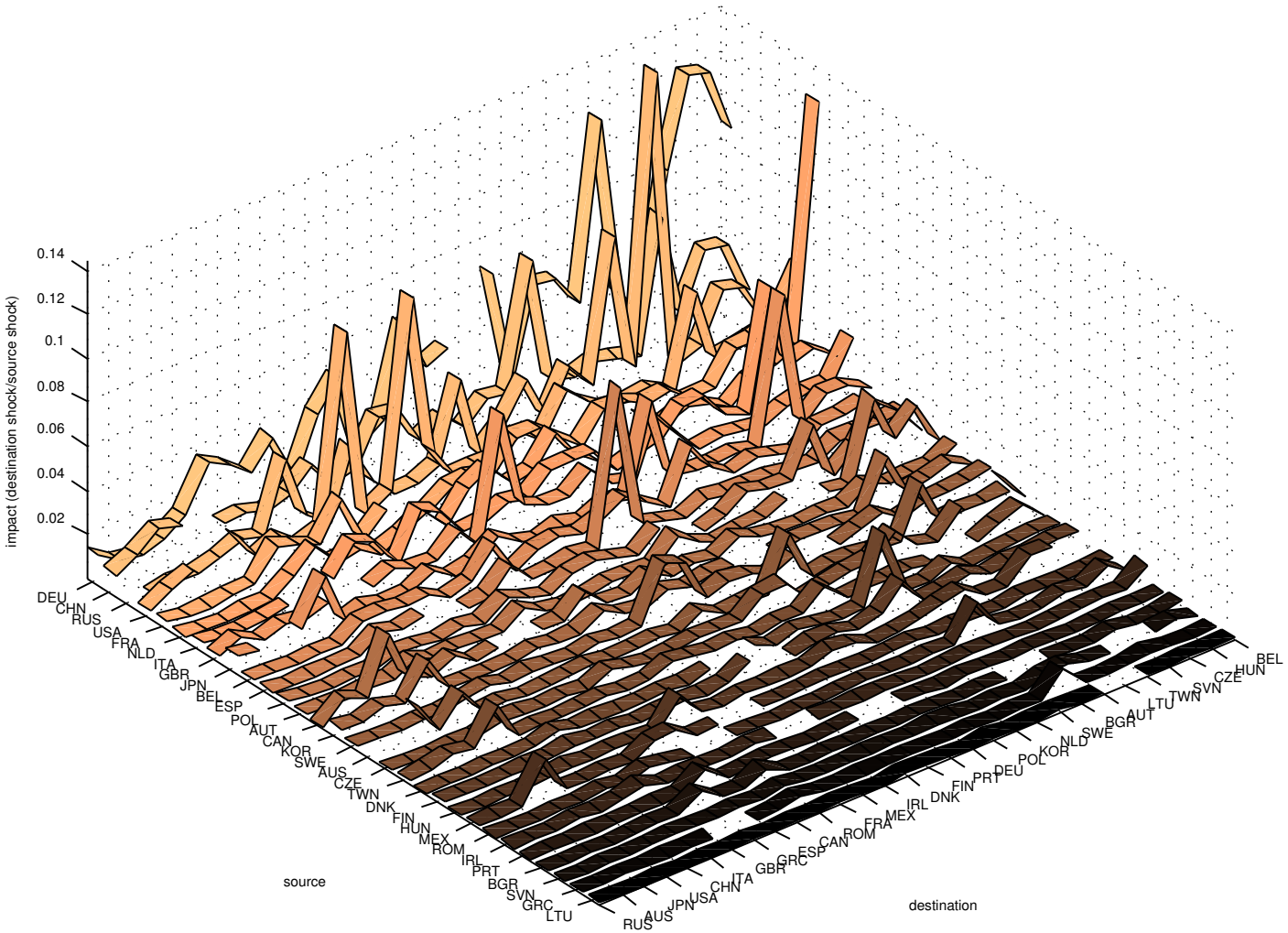
- Hypothetical shock to an individual country:

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

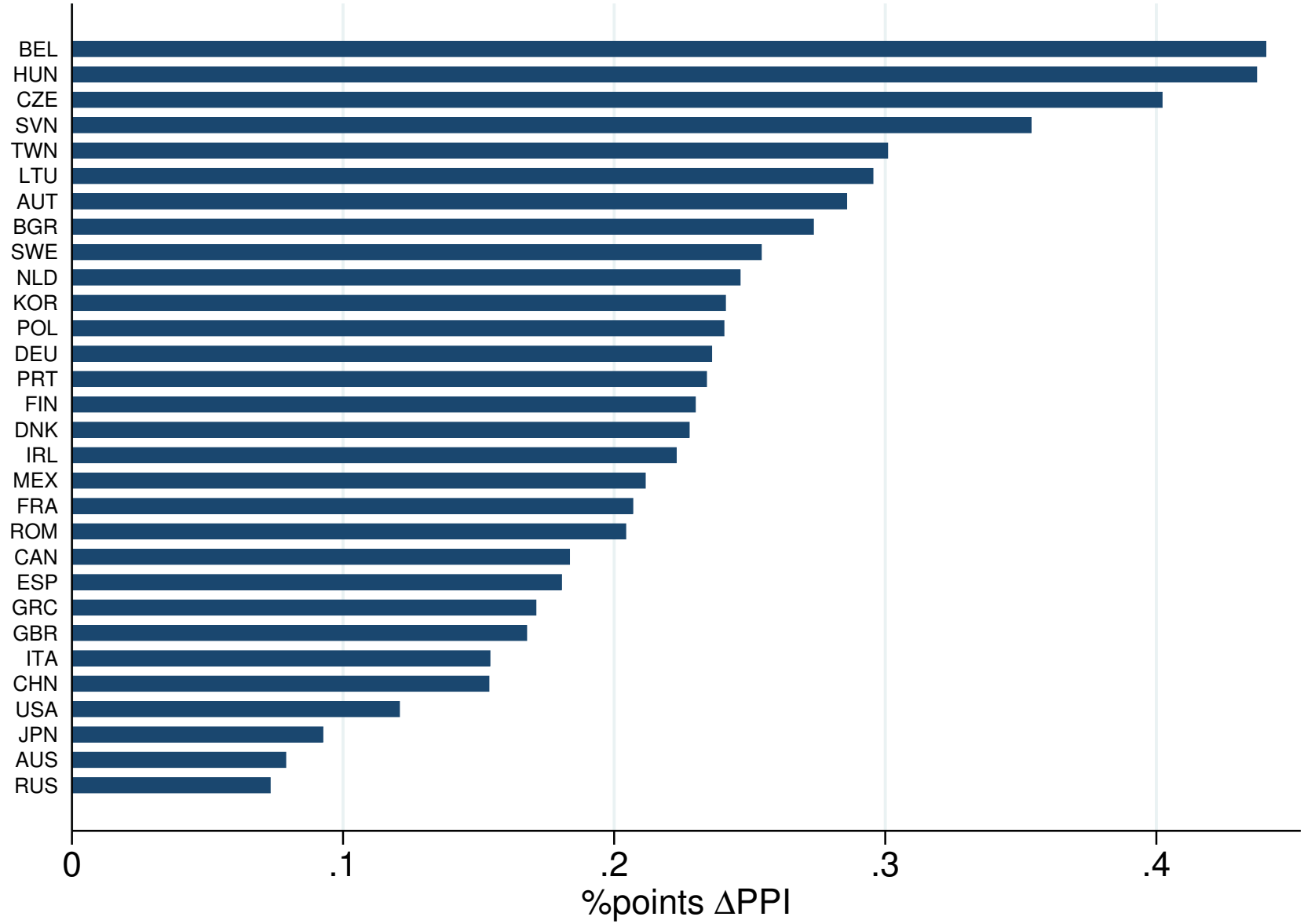
1% US Inflation



Each Country on Each Country



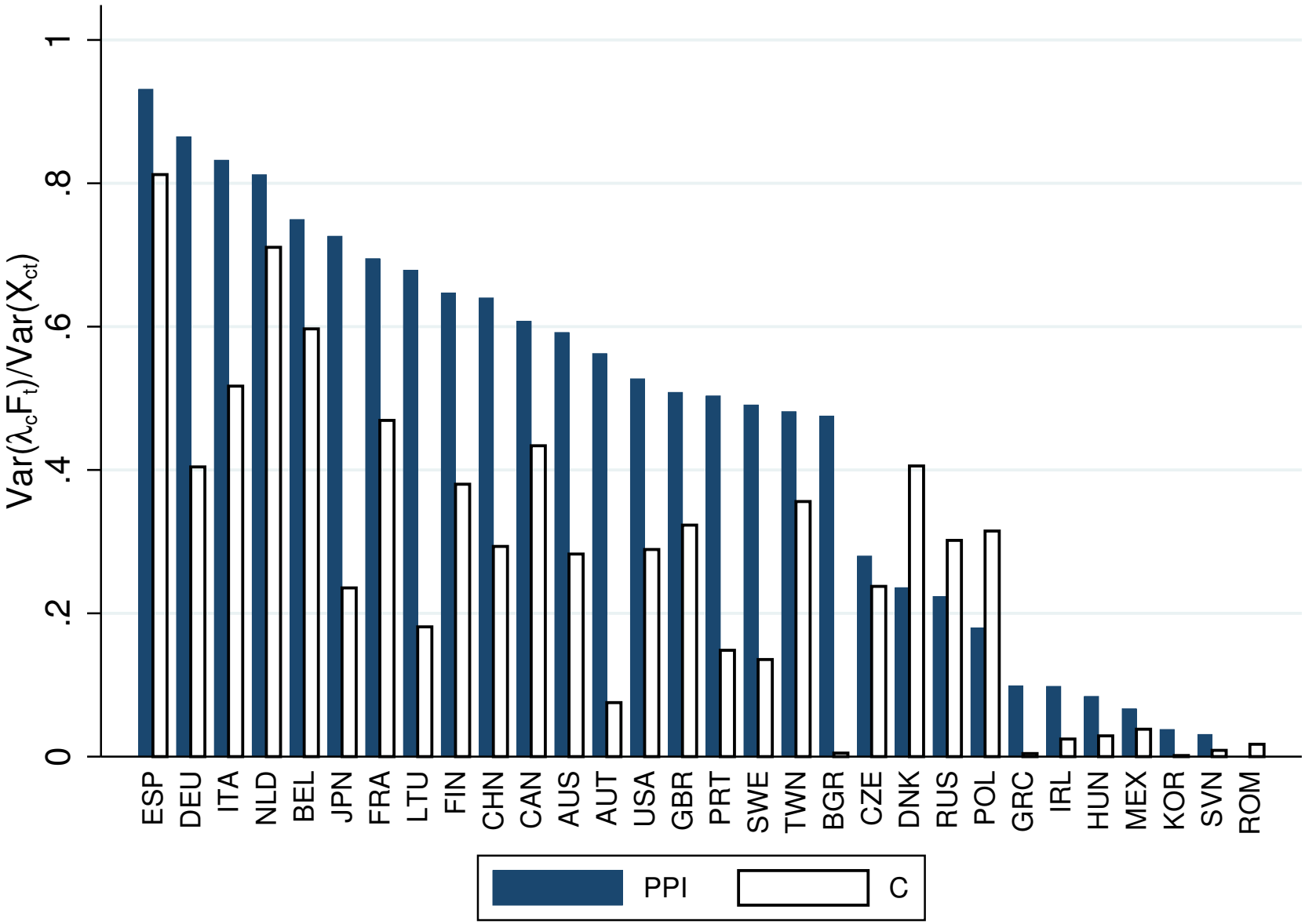
1% Worldwide Inflation



Results: Synchronization, $\beta = 1$

	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

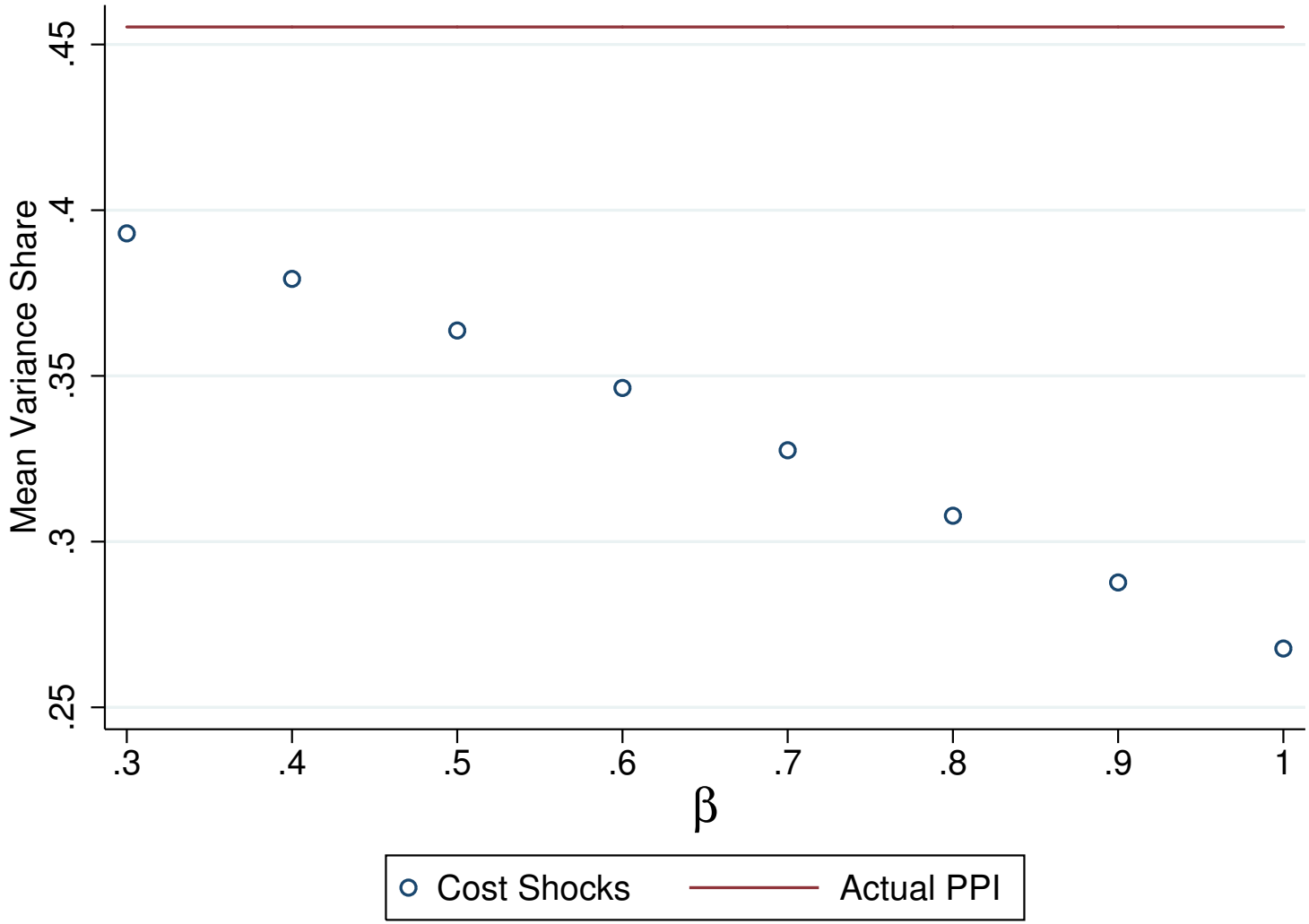
Variance Shares



Mechanisms

1. Imperfect cost pass-through ($\beta < 1$)
2. Exchange rates vs. cost shocks
3. Heterogeneity in linkages
4. Sectoral vs. global shocks

Imperfect Cost Pass-Through



Exchange Rates and Linkage Heterogeneity

	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
		Alt. cost shocks: No $\widehat{E}_{c,e,t}$	
$\widehat{C12}_{c,t}$			
mean	0.169	0.297	0.269
median	0.086	0.256	0.225
		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

Sectoral vs. Global Shocks

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

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

- Aggregation:

$$\begin{aligned} X_{c,t} &= \sum_{u \in S} \omega_{c,u} X_{c,u,t} \\ &= \sum_{u \in S} \omega_{c,u} \lambda^{w}_{c,u} F^{w}_{t} + \sum_{u \in S} \omega_{c,u} \lambda^{c}_{c,u} F^{c}_{t} \\ &\quad + \sum_{u \in S} \omega_{c,u} \lambda^{u}_{c,u} F^{u}_{t} + \sum_{u \in S} \omega_{c,u} \epsilon_{c,u,t} \end{aligned}$$

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

Sectoral vs. Global Shocks

	$\widehat{PPI12}_{c,t}$			$\widehat{C12}_{c,t}$		
	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; important to know why
- Input linkages can matter quite a bit for inflation transmission
  - Potentially explain about half of observed PPI comovement
- Machanisms:
  - Pass-through
  - Linkage heterogeneity
  - Sectoral rather than global shocks