International Inflation Spillovers Through Input Linkages

Raphael A. Auer   Andrei A. Levchenko   Philip Sauré[1]

BIS, U Michigan, SNB

September 30, 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:

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

- 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. **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

2. **Tracking the Global Component of Inflation**: input linkages account for about half of observed inflation comovement.
    - A single common factor accounts for about 50% of the variance of PPI inflation, but less than 50% of the variance of the underlying cost shocks

Preview of Results (continued)

3. **Mechanisms**:

   - Exchange rate movements do not contribute to global price comovment: $\beta = 0.3 \rightarrow$ 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. **Distribution**: 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

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

- 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:

  1. $\widehat{PPI}_{c,u,t} = \widehat{W}_{c,u,t}$ (constant markups)
  2. Imported 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:

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

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
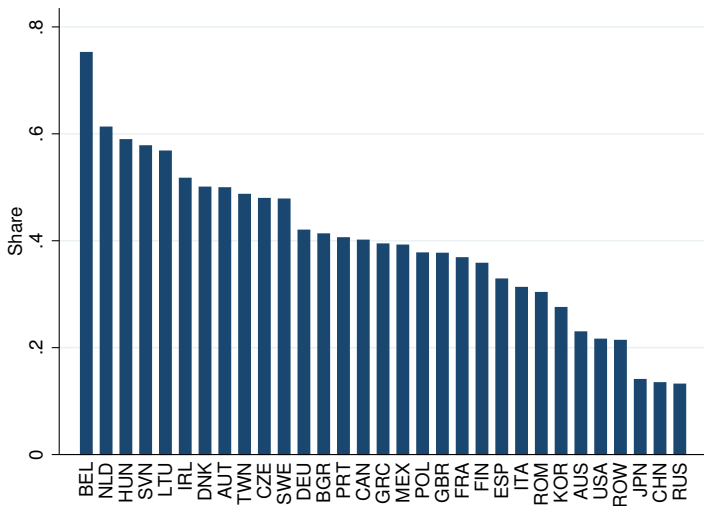
Result 1. Transmission of Hypothetical Shocks Through IO Matrix

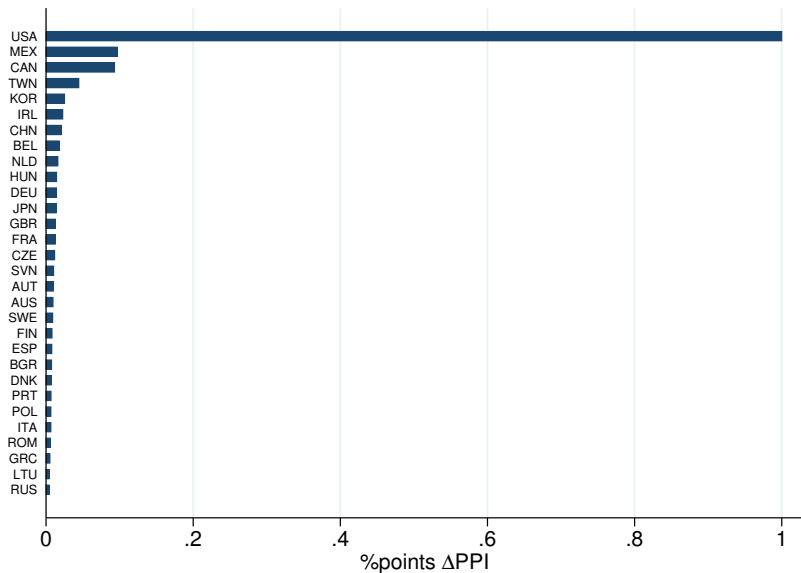- Equilibrium $\widehat{\mathbf{PPI}}$:

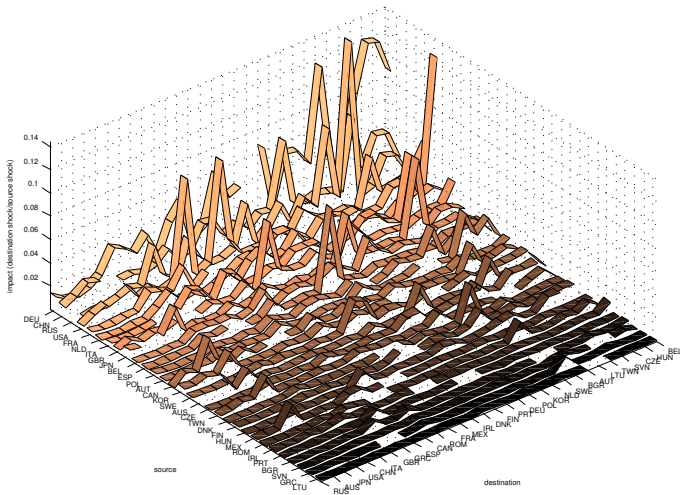$$\widehat{\mathbf{PPI}} = (\mathbf{I} - \mathbf{\Gamma}')^{-1}\widehat{\mathbf{C}}$$

- 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

%points ΔPPI
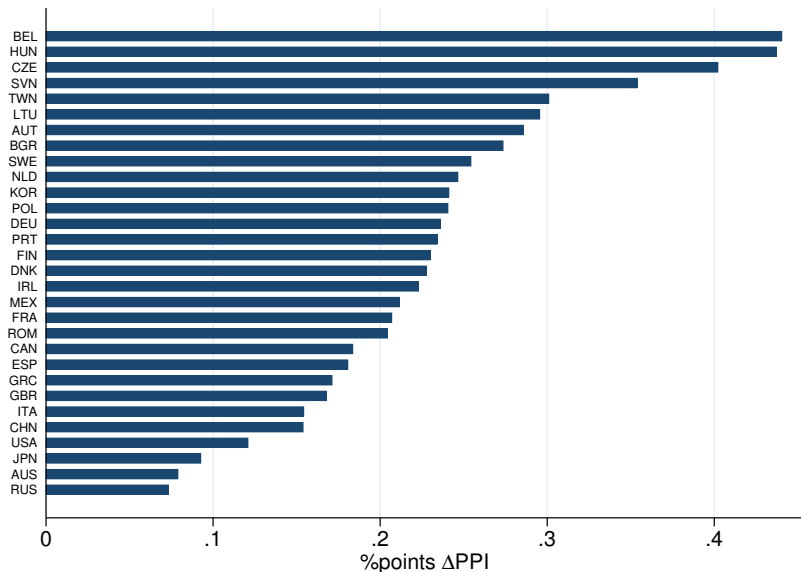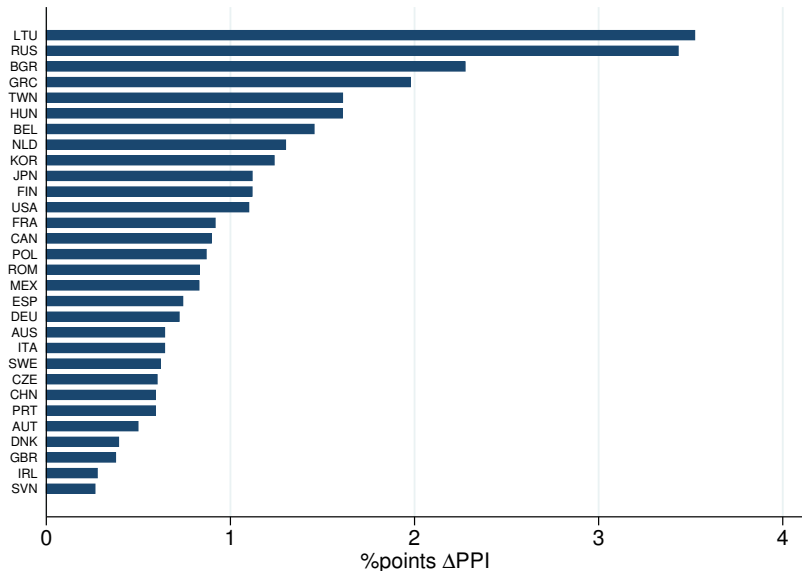
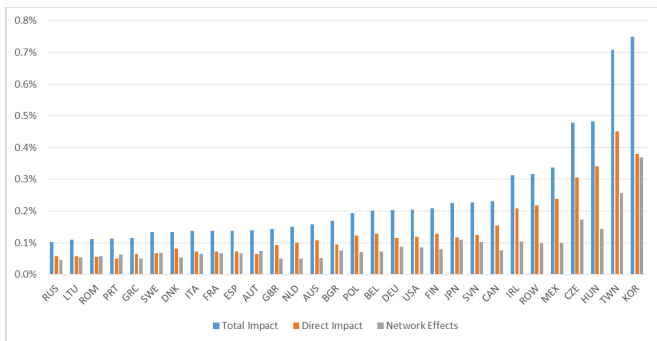# Each Country on Each Country

1% Worldwide Inflation

10% Change in Energy Prices

Decomposition Direct and Indirect Effects

10% PPI Inflation Shock in China

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)

   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

Result 2: Synchronization, Country-Level, $\beta = 1$

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:

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

Variance Shares: Cross-Country Heterogeneities
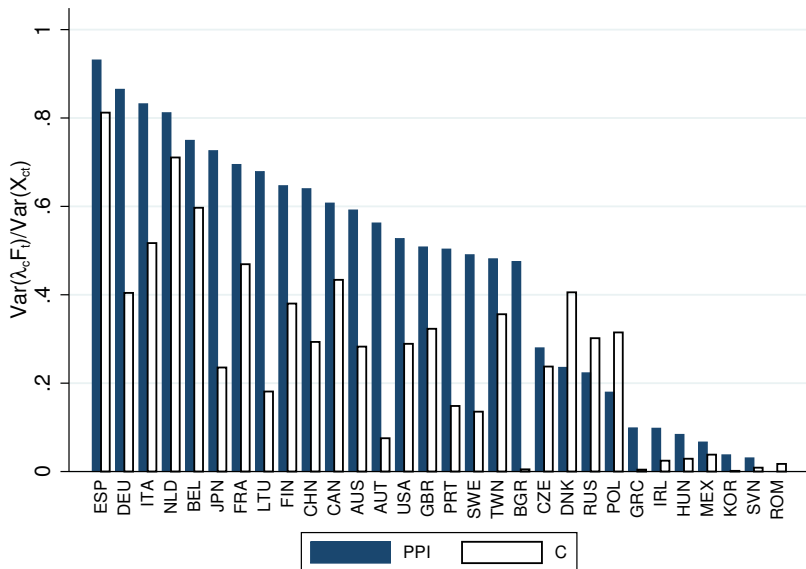
Result 3: Mechanisms

1. Exchange rate movements

2. Heterogeneity in linkages

3. 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
		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), $\widehat{PPI12}_{c,t}^{counter}$			
mean	0.266	0.364	0.350
median	0.210	0.387	0.359
Balanced 2 (countries+sectors), $\widehat{PPI12}_{c,t}^{counter}$			
mean	0.318	0.405	0.394
median	0.284	0.446	0.435

$$\widehat{PPI}_{c,u} = \beta \times \gamma_{c,u,e,s} \times \widehat{PPI}_{e,s} + \widehat{C}_{c,u}$$

Sectoral vs. Global Shocks

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

$$X_{c,u,t} = \alpha_{c,u} + \lambda_{c,u}^w F_t^w + \lambda_{c,u}^c F_t^c + \lambda_{c,u}^u F_t^u + \epsilon_{c,u,t}$$

- 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.

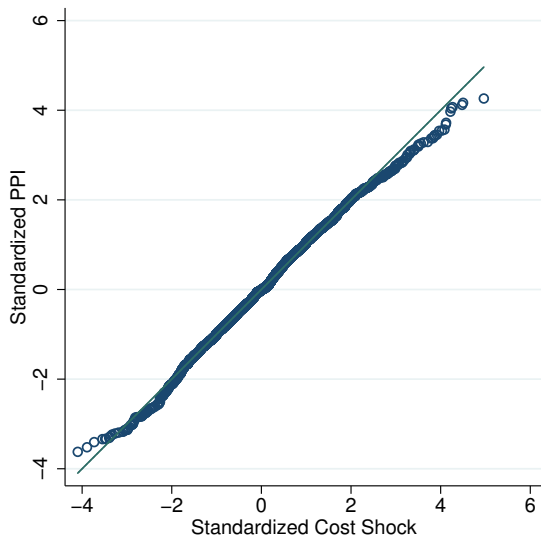|	$\widehat{PPI12}_{c,u,t}$			$\widehat{C12}_{c,u,t}$		
	World	Sector	Country	World	Sector	Country
Mean	0.072	0.421	0.343	0.096	0.234	0.356
Median	0.028	0.485	0.292	0.050	0.169	0.295
Min	0.001	0.006	0.023	0.000	0.001	0.000
Max	0.398	0.849	0.945	0.505	0.713	0.902

Fat Tails in PPI and Cost Shocks

The concentration of input linkages matters for the transmission of shocks
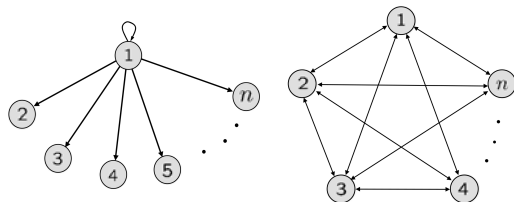
From Acemoglu et al. 2012

PPI vs. Cost Shocks

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:
  - Cross-border pass-through key
  - Linkage heterogeneity less important
  - Global component primarily consists of sector-specific shocks