International Inflation Spillovers Through Input Linkages

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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

- Develop a theoretical framework of inflation shock transmission through input linkages and pricing-to-market (Corsetti and Dedola, 2005, Berman et al., 2012)
- Assemble an unique database that combines sectoral PPI inflation for 30 countries and 16 sectors with the World Input-Output matrix (WIOD)
- Assess empirically the role of cross-border input linkages in inflation synchronization
- Main idea:

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

Preview of Results

- Transmission of country shocks
  - A shock that increases a 'core' country's inflation by 1% moves foreign inflation rates by 0.015-0.04%
  - Large heterogeneity: closer trading partners (e.g., Canada for USA, Hungary for Germany) tend to have an elasticity of around 0.1
- How much input linkages synchronize inflation depends crucially on the extent of pricing to market:
  - $\beta \approx 1$: input linkages explain about 50% of observed comovement
  - $\beta \approx 0.3$: input linkages explain about 10–15% of observed comovement
- 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), Ciccarelli and Mojon (2010), Mumtaz and Surico (2009, 2012), Mumtaz, Simonelli and Surico (2011), Borio and Filardo (2007), Bianchi and Civelli (2015)
- International business cycle comovement through input linkages: Kose and Yi (2006), Burstein, Kurz and Tesar (2008), di Giovanni and Levchenko (2010), Johnson (2014)

Theory: Salient Issues

- Pricing to Market based on local value added – Corsetti and Dedola (2005)
- Heterogeneity across firms in PTM, export selection, and aggregation
  - Atkeson and Burstein (2008), Berman et al. (2012), Amiti et al. (2014), Auer and Schoenle (2013)

Theory: Setup

- Monopolistically competitive firms, output:

$$x_j = \varphi_j \left(\sum_{i \in I_c} \theta_{j,i} \left(x_{j,i}^A \right)^{(\sigma-1)/\sigma} \right)^{(1-\alpha)\sigma/(\sigma-1)} \left(\widetilde{L}_j^S \right)^{\alpha}$$

- Importing requires (competitive) local assembly services:

$$x_{j,i}^A = \min \left[x_{j,i}; \mu_{c,i}^{-1} L_{j,i}^S \right]$$

$$\mu_{c,i} = \begin{cases} \mu \text{ if } i \notin J_c \\ 0 \text{ if } i \in J_c \end{cases}$$

Pricing

- Final and at-the-dock prices:

$$p^F_{c,i} = p^I_{c,i} + w_c \mu_{c,i}$$

- Profit-maximizing import price:

$$p^I_{c,i} = \frac{\sigma}{\sigma - 1} \tau_{c,i} mc_i + \frac{1}{\sigma - 1} w_c \mu_{c,i}$$

- Change in purchaser's price:

$$\widehat{p}^F_{c,i} = \left(1 - \beta^F_{c,i}\right) \widehat{w}_c + \beta^F_{c,i} \widehat{mc}_i$$

where

$$\beta^F_{c,i} \equiv \frac{\partial p^F_{c,i}}{\partial mc_i} \frac{mc_i}{p^F_{c,i}} = \frac{\tau_{c,j} mc_i}{\tau_{c,j} mc_i + w_c \mu_{c,i}} < 1$$

Pass-Through

- Producer j's cost function:

$$mc_j \propto \varphi_j^{-1} \left(\sum_{i \in I_c} \theta_{j,i}^{\sigma} \left(p_{c,i}^{F} \right)^{-(\sigma-1)} \right)^{-\frac{1-\alpha}{\sigma-1}} \quad w_c^{\alpha}$$

- Change in marginal cost:

$$\begin{aligned} \widehat{mc}_j &= -\widehat{\varphi}_j + \alpha \widehat{w}_c + (1-\alpha) \sum_{i \in I_c} \gamma_{j,i}^{F} \widehat{p}_{c,i}^{F} \\ &= -\widehat{\varphi}_j + \widetilde{\alpha}_j \widehat{w}_c + \sum_{i \in I_c} \gamma_{j,i}^{I} \beta_{c,i}^{I} \widehat{mc}_i \end{aligned}$$

Aggregation

- Assume: $\theta_{j,i} = \theta_i \theta_{c,u,e,s}$; $\tau_{c,i} = \tau_{c,e,s}$

$$\begin{aligned} \widehat{mc}_{c,u} &\equiv \sum_{j \in J_{c,u}} \omega_j \widehat{mc}_j \\ &= \widehat{\varphi}_{c,u} + \widetilde{\alpha}_{c,u} \widehat{w}_c + \sum_{e \in C, s \in S} \sum_{i \in I_{c,e,s}} \gamma^I_{c,u,i} \beta^I_{c,i} \widehat{mc}_i \\ &= \widehat{\varphi}_{c,u} + \widetilde{\alpha}_{c,u} \widehat{w}_c + \sum_{e \in C, s \in S} \beta^I_{c,u,e,s} \gamma^I_{c,u,e,s} \widehat{mc}_{e,s} \end{aligned}$$

where

$$\gamma^I_{c,u,e,s} \equiv \sum_{i \in I_{c,u,e,s}} \gamma^I_{c,u,i}$$

$$\beta^I_{c,u,e,s} \equiv \frac{\sum_{i \in I_{c,u,e,s}} \gamma^I_{c,u,i} \beta^I_{c,i}}{\sum_{i \in I_{c,u,e,s}} \gamma^I_{c,u,i}}$$

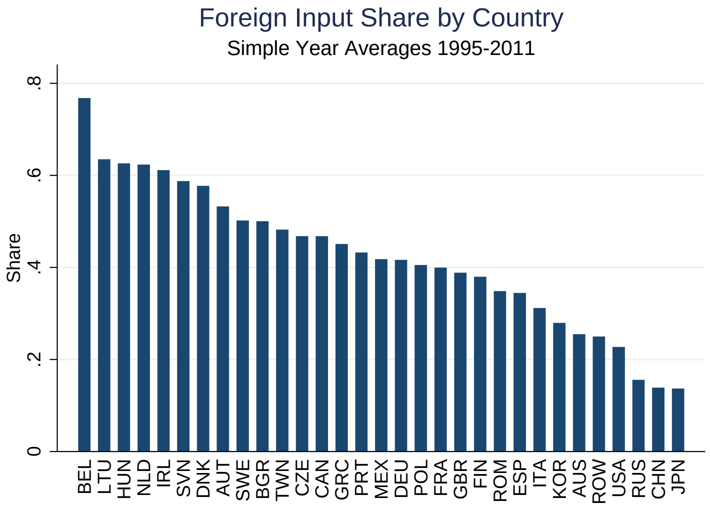
Data

- 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: 16 sectors, 30 countries + ROW; 1995m1-2011m12

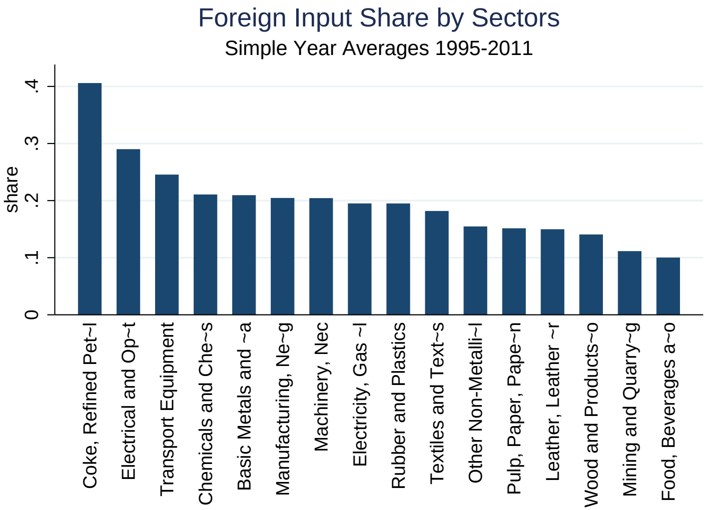
Countries and Sectors

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

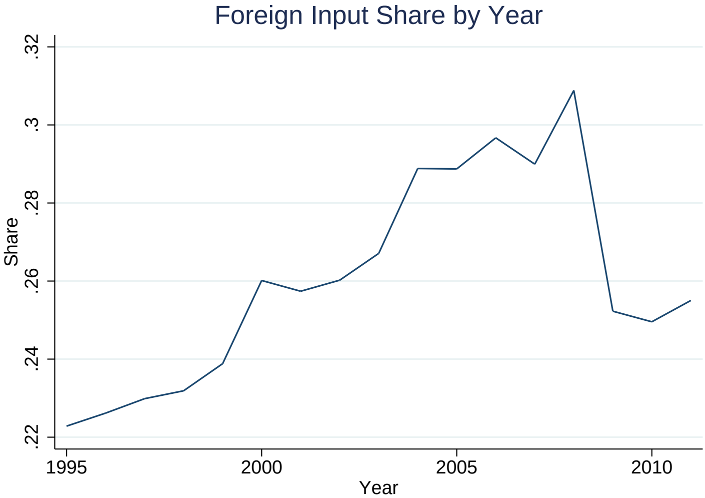
Imported Input Use by Country



Imported Input Use by Sector



Imported Input Use over Time



Transmission of Shocks Through IO Linkages

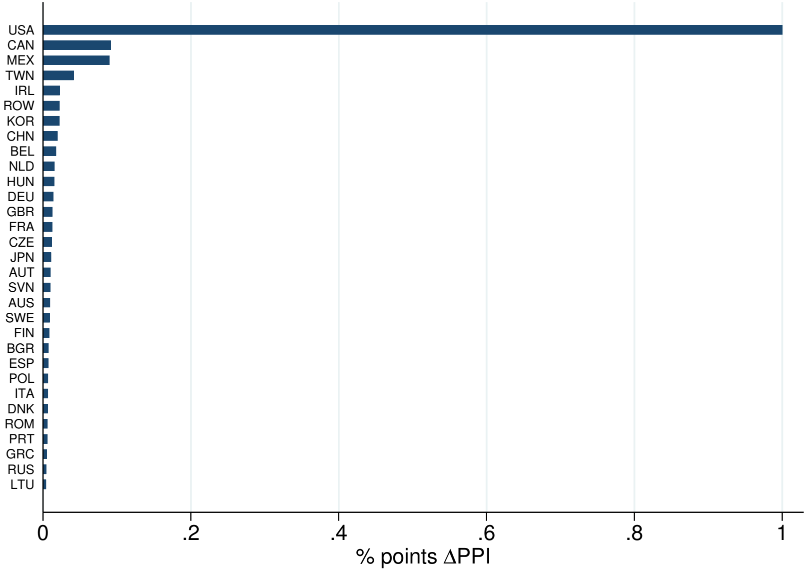
- Equilibrium $\widehat{\mathbf{PPI}}$:

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

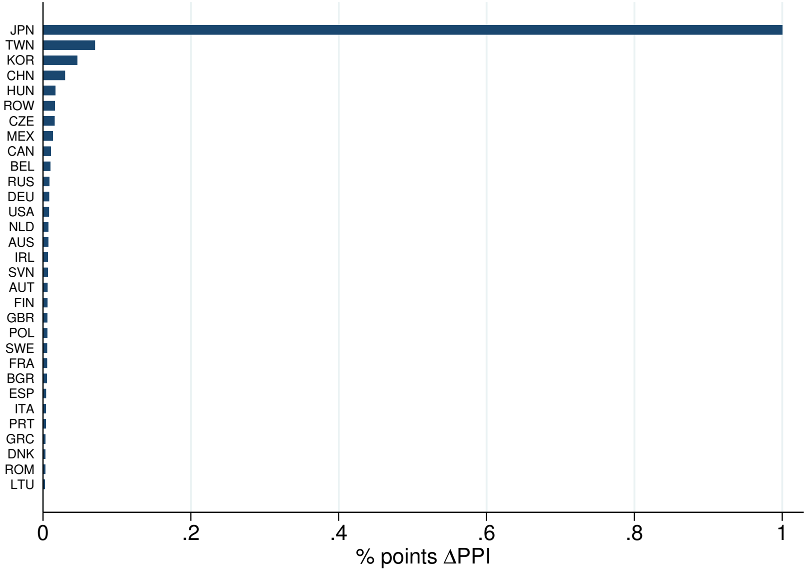
- Hypothetical shock to an individual country:

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

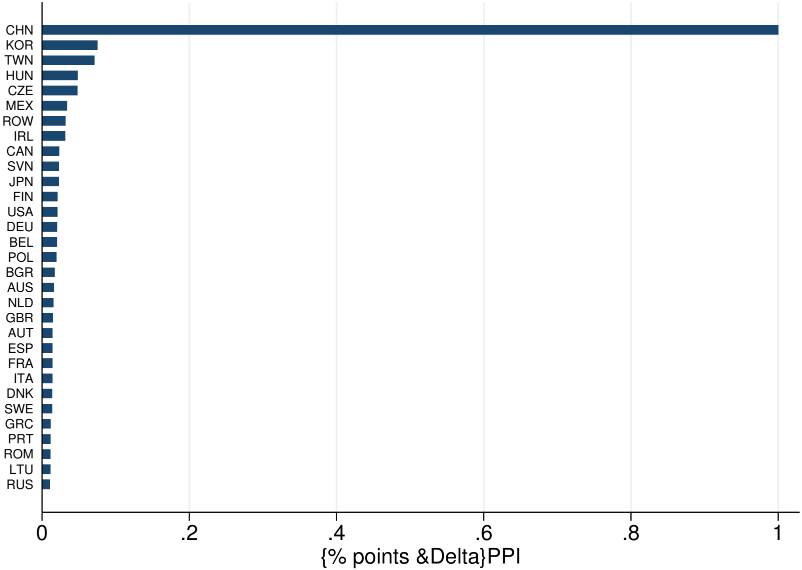
1% US Inflation



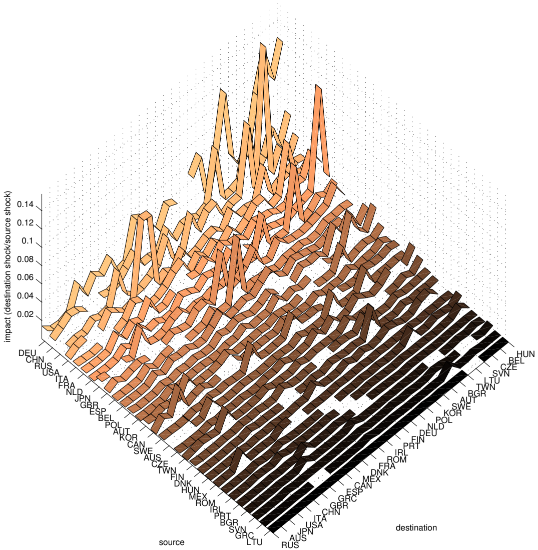
1% Japan Inflation



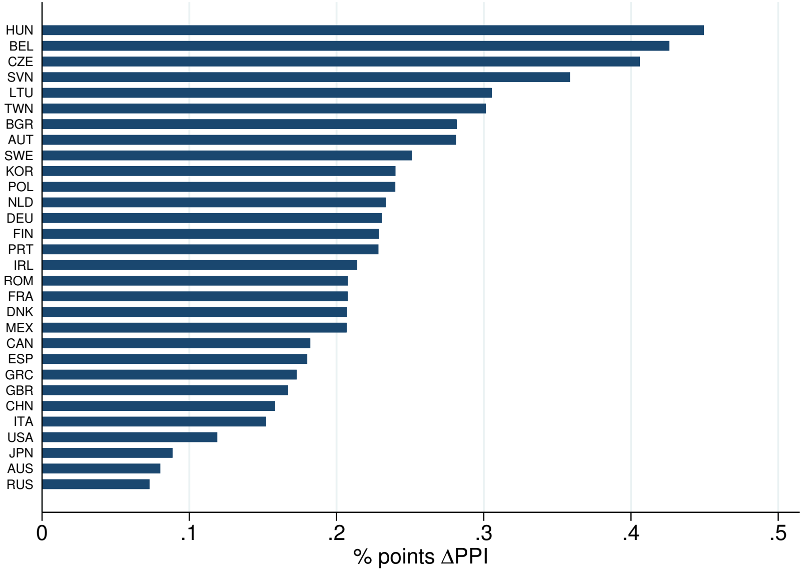
1% China Inflation



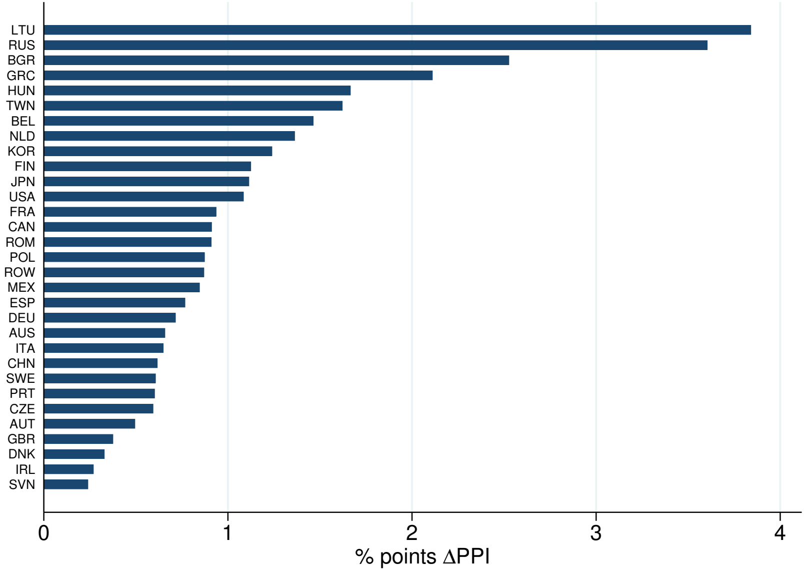
Each Country on Each Country



1% Worldwide Inflation



10% Global Energy Shock



Empirical Shocks and Synchronization

- Recover underlying shocks (month-to-month):

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

- Annual changes:

$$\widehat{PPI12}_{c,u,t} = \prod_{\tau=0}^{11} (1 + \widehat{PPI}_{c,u,t+\tau}) - 1$$

$$\widehat{C12}_{c,u,t} = \prod_{\tau=0}^{11} (1 + \widehat{C}_{c,u,t+\tau}) - 1$$

Empirical Shocks and Synchronization

- Aggregate up to country×time level:

$$\widehat{PPI12}_{c,t} = \sum_{u \in S} \omega_{c,u} \widehat{PPI12}_{c,u,t}$$

$$\widehat{C12}_{c,t} = \sum_{u \in S} \omega_{c,u} \widehat{C12}_{c,u,t}$$

- Two metrics of comovement:
  - R^2 of a regression of a country's $\widehat{PPI12}$ on simple average world $\widehat{PPI12}$
  - Share of the variance explained by one common factor

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

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

Results: Synchronization, $\beta = 1$

	R^2			Factor Model		
Country	$\widehat{PPI12}_{c,t}$	$\widehat{C12}_{c,t}$	Difference	$\widehat{PPI12}_{c,t}$	$\widehat{C12}_{c,t}$	Difference
AUS	0.374	0.143	0.231	0.467	0.329	0.138
AUT	0.407	0.020	0.388	0.560	0.185	0.375
BEL	0.731	0.340	0.391	0.768	0.664	0.104
BGR	0.489	0.035	0.455	0.437	0.000	0.437
CAN	0.636	0.352	0.285	0.668	0.445	0.223
CHN	0.453	0.137	0.316	0.474	0.336	0.139
CZE	0.330	0.172	0.157	0.285	0.056	0.229
DEU	0.826	0.148	0.678	0.900	0.423	0.477
DNK	0.271	0.363	-0.091	0.315	0.438	-0.124
ESP	0.842	0.381	0.461	0.934	0.868	0.066
FIN	0.666	0.370	0.296	0.804	0.660	0.143
FRA	0.747	0.528	0.220	0.783	0.745	0.038
GBR	0.230	0.093	0.137	0.381	0.188	0.193
GRC	0.350	0.005	0.345	0.362	0.007	0.355
HUN	0.199	0.078	0.121	0.130	0.001	0.129
IRL	0.136	0.024	0.112	0.133	0.148	-0.015
ITA	0.857	0.272	0.585	0.869	0.685	0.184
JPN	0.673	0.070	0.604	0.815	0.146	0.669
KOR	0.131	0.012	0.119	0.158	0.043	0.115
LTU	0.467	0.106	0.361	0.645	0.145	0.500
MEX	0.004	0.015	-0.011	0.005	0.002	0.003
NLD	0.768	0.419	0.349	0.815	0.872	-0.057
POL	0.098	0.418	-0.320	0.088	0.197	-0.109
PRT	0.711	0.118	0.592	0.733	0.415	0.318
ROM	0.006	0.134	-0.127	0.012	0.056	-0.044
RUS	0.012	0.013	0.000	0.012	0.118	-0.106
SVN	0.113	0.006	0.107	0.081	0.057	0.024
SWE	0.418	0.200	0.218	0.569	0.137	0.432
TWN	0.468	0.037	0.431	0.550	0.245	0.305
USA	0.660	0.155	0.505	0.732	0.239	0.492
Mean	0.436	0.172	0.264	0.473	0.286	0.187
Median	0.436	0.135	0.290	0.474	0.188	0.143

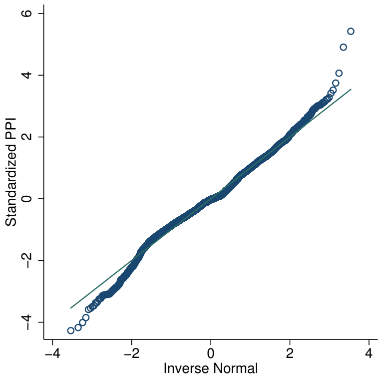
Results: Synchronization, $\beta = 0.92$

	R^2			Factor Model		
Country	$\widehat{PPI12}_{c,t}$	$\widehat{C12}_{c,t}$	Difference	$\widehat{PPI12}_{c,t}$	$\widehat{C12}_{c,t}$	Difference
AUS	0.374	0.166	0.208	0.467	0.356	0.111
AUT	0.407	0.035	0.372	0.560	0.182	0.378
BEL	0.731	0.398	0.333	0.768	0.661	0.107
BGR	0.489	0.031	0.458	0.437	0.000	0.437
CAN	0.636	0.391	0.245	0.668	0.510	0.157
CHN	0.453	0.164	0.288	0.474	0.408	0.067
CZE	0.330	0.172	0.158	0.285	0.094	0.191
DEU	0.826	0.204	0.622	0.900	0.438	0.462
DNK	0.271	0.375	-0.104	0.315	0.453	-0.138
ESP	0.842	0.449	0.393	0.934	0.861	0.073
FIN	0.666	0.413	0.253	0.804	0.673	0.131
FRA	0.747	0.572	0.176	0.783	0.738	0.045
GBR	0.230	0.118	0.111	0.381	0.266	0.115
GRC	0.350	0.010	0.341	0.362	0.035	0.327
HUN	0.199	0.074	0.125	0.130	0.001	0.129
IRL	0.136	0.035	0.101	0.133	0.117	0.015
ITA	0.857	0.332	0.526	0.869	0.699	0.170
JPN	0.673	0.107	0.567	0.815	0.265	0.550
KOR	0.131	0.016	0.115	0.158	0.054	0.104
LTU	0.467	0.128	0.339	0.645	0.233	0.412
MEX	0.004	0.015	-0.011	0.005	0.007	-0.002
NLD	0.768	0.472	0.295	0.815	0.850	-0.036
POL	0.098	0.411	-0.313	0.088	0.241	-0.152
PRT	0.711	0.163	0.547	0.733	0.429	0.304
ROM	0.006	0.115	-0.108	0.012	0.046	-0.034
RUS	0.012	0.007	0.006	0.012	0.080	-0.068
SVN	0.113	0.006	0.107	0.081	0.028	0.053
SWE	0.418	0.220	0.198	0.569	0.197	0.372
TWN	0.468	0.069	0.399	0.550	0.352	0.198
USA	0.660	0.201	0.459	0.732	0.352	0.380
Mean	0.436	0.196	0.240	0.473	0.312	0.161
Median	0.436	0.164	0.249	0.474	0.265	0.129

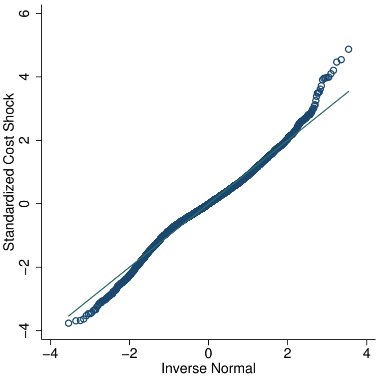
Results: Synchronization, $\beta = 0.30$

	R^2			Factor Model		
Country	$\widehat{PPI12}_{c,t}$	$\widehat{C12}_{c,t}$	Difference	$\widehat{PPI12}_{c,t}$	$\widehat{C12}_{c,t}$	Difference
AUS	0.374	0.332	0.041	0.467	0.453	0.014
AUT	0.407	0.303	0.104	0.560	0.403	0.157
BEL	0.731	0.727	0.004	0.768	0.767	0.001
BGR	0.489	0.046	0.443	0.437	0.027	0.411
CAN	0.636	0.615	0.021	0.668	0.668	0.000
CHN	0.453	0.328	0.125	0.474	0.419	0.056
CZE	0.330	0.273	0.056	0.285	0.274	0.011
DEU	0.826	0.761	0.066	0.900	0.818	0.082
DNK	0.271	0.340	-0.069	0.315	0.336	-0.021
ESP	0.842	0.850	-0.008	0.934	0.947	-0.013
FIN	0.666	0.653	0.013	0.804	0.767	0.037
FRA	0.747	0.767	-0.020	0.783	0.805	-0.023
GBR	0.230	0.236	-0.006	0.381	0.380	0.002
GRC	0.350	0.220	0.130	0.362	0.320	0.042
HUN	0.199	0.087	0.112	0.130	0.054	0.076
IRL	0.136	0.141	-0.005	0.133	0.113	0.019
ITA	0.857	0.757	0.101	0.869	0.811	0.057
JPN	0.673	0.593	0.080	0.815	0.793	0.022
KOR	0.131	0.071	0.060	0.158	0.095	0.064
LTU	0.467	0.385	0.082	0.645	0.614	0.031
MEX	0.004	0.013	-0.009	0.005	0.002	0.003
NLD	0.768	0.730	0.037	0.815	0.823	-0.008
POL	0.098	0.287	-0.189	0.088	0.263	-0.174
PRT	0.711	0.585	0.126	0.733	0.663	0.070
ROM	0.006	0.021	-0.014	0.012	0.021	-0.009
RUS	0.012	0.001	0.011	0.012	0.009	0.003
SVN	0.113	0.052	0.061	0.081	0.025	0.056
SWE	0.418	0.420	-0.002	0.569	0.522	0.047
TWN	0.468	0.408	0.060	0.550	0.493	0.057
USA	0.660	0.585	0.075	0.732	0.688	0.044
Mean	0.436	0.386	0.050	0.473	0.436	0.037
Median	0.436	0.336	0.049	0.474	0.419	0.031

Fat Tails in PPI and Cost Shocks

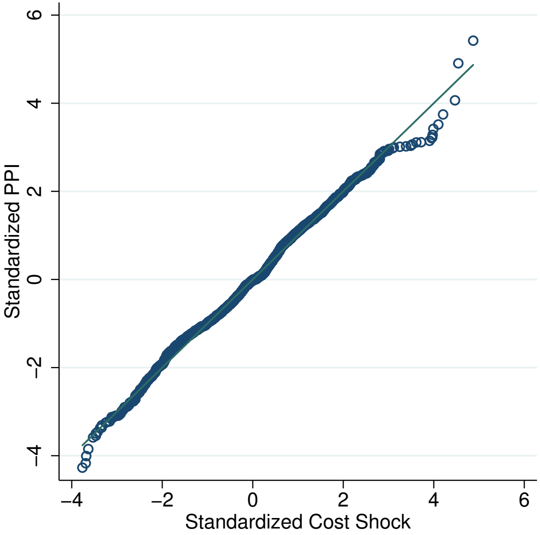


PPI vs. Normal

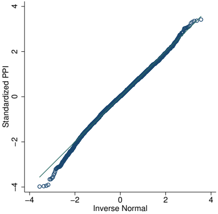


Cost vs. Normal

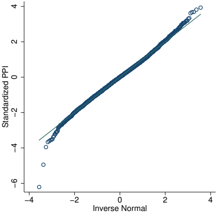
PPI vs. Cost Shocks



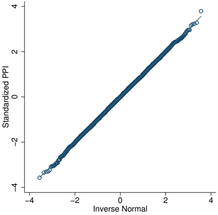
Simulated PPI



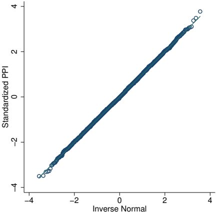
Laplace, st.dev = observed



Laplace, st.dev = 0.1



Normal, st.dev = observed



Normal, st.dev = 0.1

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
- Depends crucially on pass-through; need to know more about that parameter
- Input linkages appear to preserve fat tails in cost shocks