The International Transmission of Business Cycles : What are the Facts?

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The Problem

The quantity anomaly as documented by Backus, Kehoe and Kydland (1995):

$$\text{cor}(y, y^*) > \text{cor}(z, z^*) > \text{cor}(c, c^*), \tag{1}$$

This is a puzzle for modern general equilibrium models that emphasize risk sharing

Is this stylized fact robust? Backus, Kehoe and Kydland rely mostly on US data and do not perform formal tests.

We use data from 19 industrialized countries to check this.

Methodology :

Simple Correlations :

$$\theta = \frac{1}{(\sum_{i=1}^{N} w_i)} \sum_{i=1}^{N} w_i \theta_i, \tag{2}$$

Cross-Correlations :

$$\phi = \frac{1}{(\sum_{ij} w_i w_j)} \sum_{ij} w_i w_j \phi_{ij}, \tag{3}$$

Correlations are estimated by GMM and in pairs to construct the variances-covariance matrix of the correlations.

Standard Deviations — Simple Correlations :

$$\mathsf{var}(\theta) = \mathsf{var}\left(\frac{1}{(\sum_{i=1}^{N} w_i)} \sum_{i} w_i \theta_i\right)$$

$$= \left(\frac{1}{\sum_{i=1}^{N} w_i}\right)^2 \left(\sum_{i} (w_i)^2 \,\mathsf{var}(\theta_i) + 2 \sum_{ij} (w_i w_j)\,\mathsf{cov}(\theta_i, \theta_j)\right), \tag{4}$$

Standard Deviations — Cross-Correlations :

$$\mathsf{var}(\phi) = \mathsf{var}\left(\frac{1}{(\sum_{ij} w_i w_j)} \sum_{ij} w_i w_j \phi_{ij}\right)$$

$$= \left(\frac{1}{\sum_{ij} w_i w_j}\right)^2 \left(\sum_{ij} (w_i w_j)^2 \,\mathsf{var}(\phi_{ij}) + 2 \sum_{ij,kl} (w_i w_j)(w_k w_l)\mathsf{cov}(\phi_{ij}, \phi_{kl})\right), \tag{5}$$

Hypothesis Tests :

$$\mathsf{chistat} = \frac{(\mathsf{ccor}(x) - \mathsf{ccor}(y))^2}{\mathsf{var}(\mathsf{ccor}(x)) + \mathsf{var}(\mathsf{ccor}(y))}, \tag{6}$$

Table 1: BKK Data Set

	Correlation of Each Country's Variable with Same U.S. Variable					
Country	y	c	x	g	n	z
Australia	.51	-.19	.16	.23	-.18	.52
Austria	.38	.23	.46	.29	.47	.17
Canada	.76	.49	-.01	-.01	.53	.75
France	.41	.39	.22	-.20	.26	.39
Germany	.69	.49	.55	.28	.52	.65
Italy	.41	.02	.31	.09	-.01	.35
Japan	.60	.44	.56	.11	.32	.58
Switzerland	.42	.40	.38	.01	.36	.43
United Kingdom	.55	.42	.40	-.04	.69	.35
Europe	.66	.51	.53	.18	.33	.56
baseline model	-.21	.88	-.31	—	-.31	.25

See Backus, Kehoe and Kydland (1995, p.366).

y: output; c: consumption; x: investment;

g: government spending; n: employment; z: Solow residual

Table 2: Simple correlations

	Weighting scheme					
Variable	simple	trade	output	observ.	obs. trade	obs. output
output,	0.61	0.62	0.68	0.61	0.63	0.69
consumption	(0.02)	(0.03)	(0.03)	(0.02)	(0.03)	(0.03)
	0.00	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*
output,	0.67	0.74	0.79	0.68	0.75	0.80
investment	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
	0.00	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*
output,	0.31	0.33	0.30	0.32	0.33	0.30
exports	(0.04)	(0.04)	(0.05)	(0.03)	(0.04)	(0.05)
	0.00	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*
output,	0.59	0.64	0.65	0.60	0.65	0.66
imports	(0.03)	(0.04)	(0.04)	(0.03)	(0.04)	(0.04)
	0.00	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*
output,	-0.02	-0.01	-0.03	-0.03	-0.02	-0.04
terms of trade	(0.04)	(0.06)	(0.08)	(0.04)	(0.06)	(0.08)
	0.63	*0.90*	*0.70*	*0.48*	*0.60*	*0.48*
output,	-0.29	-0.32	-0.33	-0.29	-0.32	-0.34
trade balance	(0.03)	(0.05)	(0.06)	(0.03)	(0.04)	(0.06)
	0.00	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*
terms of trade,	-0.32	-0.19	-0.09	-0.30	-0.16	-0.06
trade balance	(0.04)	(0.05)	(0.06)	(0.03)	(0.04)	(0.06)
	0.00	*0.00*	*0.13*	*0.00*	*0.00*	*0.30*
savings,	0.44	0.55	0.63	0.46	0.56	0.64
investment	(0.04)	(0.04)	(0.04)	(0.03)	(0.03)	(0.03)
	0.00	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*
savings/output,	0.15	0.33	0.44	0.17	0.35	0.47
investment/output	(0.04)	(0.03)	(0.03)	(0.04)	(0.03)	(0.03)
	0.00	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*

First line is average correlation.
(Second line is standard deviation of average correlation.)
Third line is p-value of a χ^2 test for $H_0 = 0$.

Table 3: Cross-correlations

	Full Sample			Post-1973		
	Weighting scheme			Weighting scheme		
Variable	simple	trade	output	simple	trade	output
output	0.23	0.30	0.31	0.30	0.45	0.49
	(0.03)	(0.06)	(0.07)	(0.03)	(0.04)	(0.05)
	0.00	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*
Investment	0.16	0.21	0.23	0.21	0.29	0.33
	(0.03)	(0.05)	(0.06)	(0.03)	(0.05)	(0.06)
	0.00	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*
Consumption	0.14	0.20	0.25	0.15	0.21	0.27
	(0.03)	(0.04)	(0.06)	(0.03)	(0.04)	(0.06)
	0.00	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*
Employment	0.20	0.19	0.17	0.21	0.24	0.23
	(0.03)	(0.04)	(0.05)	(0.03)	(0.04)	(0.06)
	0.00	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*
Total hours	0.23	0.30	0.33	0.23	0.30	0.33
	(0.03)	(0.06)	(0.07)	(0.03)	(0.06)	(0.07)
	0.00	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*
Employment[1]	0.25	0.23	0.21	0.21	0.23	0.21
	(0.03)	(0.05)	(0.06)	(0.03)	(0.05)	(0.06)
	0.00	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*
Productivity	0.16	0.28	0.28	0.20	0.38	0.44
(from y and n only)	(0.03)	(0.06)	(0.07)	(0.03)	(0.05)	(0.06)
	0.00	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*
Productivity	0.07	0.20	0.22	0.09	0.27	0.35
(best available)	(0.02)	(0.04)	(0.06)	(0.02)	(0.04)	(0.05)
	0.00	*0.00*	*0.00*	*0.00*	*0.00*	*0.02*

First line is average correlation.
(Second line is standard deviation of average correlation.)
Third line is p-value of a χ^2 test for $H_0 = 0$.
1: For those countries for which total hours are measured.

Table 4: Cross-correlations quantiles

	Full Sample			Post-1973		
	Weighting scheme			Weighting scheme		
Variable	simple	trade	output	simple	trade	output
25%						
output	0.10	0.21	0.25	0.15	0.34	0.40
Consumption	-0.02	0.01	0.07	-0.04	0.02	0.08
Investment	-0.02	0.09	0.14	0.03	0.19	0.22
Employment	0.02	0.00	-0.02	0.02	0.00	0.00
Productivity	0.05	0.15	0.15	0.06	0.23	0.35
Hours	0.09	0.18	0.23	0.07	0.20	0.24
50%						
output	0.26	0.31	0.31	0.34	0.48	0.52
Consumption	0.14	0.22	0.33	0.17	0.24	0.37
Investment	0.18	0.26	0.26	0.22	0.32	0.37
Employment	0.20	0.17	0.11	0.22	0.21	0.18
Productivity	0.18	0.29	0.31	0.20	0.42	0.47
Hours	0.24	0.28	0.29	0.26	0.40	0.49
75%						
output	0.37	0.42	0.40	0.46	0.61	0.61
Consumption	0.33	0.40	0.40	0.34	0.43	0.44
Investment	0.32	0.34	0.31	0.38	0.44	0.53
Employment	0.36	0.37	0.37	0.40	0.51	0.52
Productivity	0.29	0.37	0.36	0.37	0.51	0.60
Hours	0.35	0.40	0.40	0.41	0.54	0.54

Table 5: Cross-correlations, alternative tests

Test	Full Sample Weighting scheme simple	trade	output	Post-1973 Weighting scheme simple	trade	output
P-values						
$H_0 : \text{cor}(y, y^*) = \text{cor}(c, c^*)$	0.03	0.15	0.50	0.00	0.00	0.00
$H_0 : \text{cor}(y, y^*) = \text{cor}(z, z^*)$	0.13	0.75	0.79	0.02	0.32	0.47
$H_0 : \text{cor}(z, z^*) = \text{cor}(c, c^*)$	0.60	0.28	0.70	0.21	0.01	0.04
$H_0 : \text{cor}(y, y^*) = \text{cor}(n, n^*)$	0.44	0.11	0.12	0.06	0.00	0.00
$H_0 : \text{cor}(y, y^*) = \text{cor}(i, i^*)$	0.12	0.22	0.41	0.04	0.01	0.04
% of occurrences						
$\text{cor}(y, y^*) > \text{cor}(c, c^*)$	0.70	0.69	0.60	0.75	0.87	0.90
$\text{cor}(y, y^*) > \text{cor}(z, z^*)$	0.74	0.71	0.72	0.78	0.69	0.58
$\text{cor}(z, z^*) > \text{cor}(c, c^*)$	0.58	0.62	0.54	0.58	0.74	0.79
$\text{cor}(y, y^*) > \text{cor}(n, n^*)$	0.57	0.70	0.73	0.57	0.69	0.75
$\text{cor}(y, y^*) > \text{cor}(i, i^*)$	0.64	0.65	0.58	0.68	0.77	0.82
$\text{cor}(c, c^*) > \text{cor}(z, z^*) > \text{cor}(y, y^*)$	0.04	0.04	0.04	0.04	0.01	0.01
$\text{cor}(y, y^*) > \text{cor}(z, z^*) > \text{cor}(c, c^*)$	0.37	0.36	0.30	0.30	0.45	0.39

y: output; c: consumption; n: employment;
z: total productivity (defined from y and n).

Table 6: The J-curve: correlations of terms of trade at t with the trade balance at $t + x$

Weight scheme	x										
	-5	-4	-3	-2	-1	0	+1	+2	+3	+4	+5
simple	-0.11	-0.16	-0.22	-0.25	-0.27	-0.32	-0.10	0.05	0.16	0.24	0.27
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.04)	(0.03)	(0.03)	(0.03)	(0.03)	(0.04)
	0.00	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.10*	*0.00*	*0.00*	*0.00*
trade	-0.08	-0.12	-0.17	-0.20	-0.22	-0.19	-0.04	0.12	0.25	0.33	0.32
	(0.04)	(0.04)	(0.04)	(0.03)	(0.03)	(0.05)	(0.05)	(0.04)	(0.04)	(0.03)	(0.04)
	0.04	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.49*	*0.00*	*0.00*	*0.00*	*0.00*
output	-0.06	-0.07	-0.09	-0.10	-0.12	-0.09	0.05	0.20	0.32	0.39	0.36
	(0.05)	(0.05)	(0.05)	(0.04)	(0.04)	(0.06)	(0.07)	(0.05)	(0.04)	(0.04)	(0.04)
	0.29	*0.21*	*0.09*	*0.02*	*0.00*	*0.13*	*0.46*	*0.00*	*0.00*	*0.00*	*0.00*
simple obs.	-0.09	-0.15	-0.21	-0.23	-0.25	-0.30	-0.09	0.06	0.17	0.24	0.27
	(0.04)	(0.03)	(0.03)	(0.02)	(0.02)	(0.03)	(0.03)	(0.03)	(0.02)	(0.03)	(0.03)
	0.00	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.03*	*0.00*	*0.00*	*0.00*
trade obs.	-0.07	-0.11	-0.15	-0.17	-0.19	-0.16	-0.01	0.14	0.25	0.33	0.32
	(0.04)	(0.04)	(0.03)	(0.03)	(0.03)	(0.04)	(0.05)	(0.04)	(0.03)	(0.03)	(0.03)
	0.05	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.84*	*0.00*	*0.00*	*0.00*	*0.00*
output obs.	-0.05	-0.05	-0.06	-0.08	-0.09	-0.06	0.08	0.22	0.33	0.40	0.36
	(0.06)	(0.05)	(0.05)	(0.04)	(0.04)	(0.06)	(0.07)	(0.05)	(0.04)	(0.04)	(0.04)
	0.39	*0.38*	*0.23*	*0.08*	*0.02*	*0.30*	*0.27*	*0.00*	*0.00*	*0.00*	*0.00*

First line is average correlation.
(Second line is standard deviation of average correlation.)
Third line is p-value of a χ^2 test for $H_0 = 0$.