International Transmission Through Relative Prices
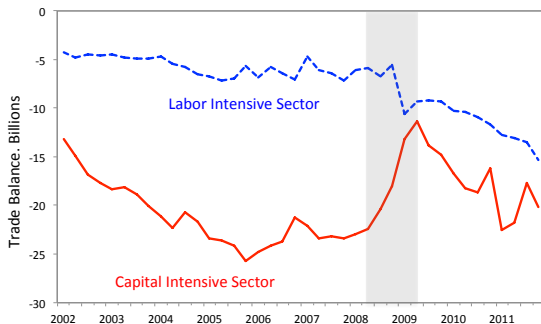
Keyu Jin (LSE) and Nan Li (OSU and IMF)
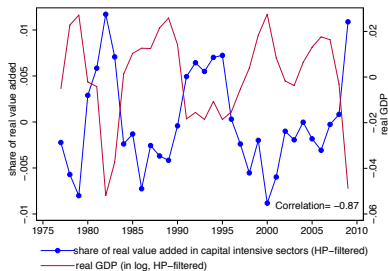
Composition of Trade and Business Cycle
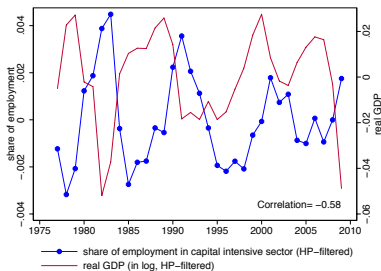
Figure: U.S. Sectoral Trade with EU15

Change in prices: export (import) price of K-intensive goods $\downarrow 3.9\%(7.8\%)$, price of L-intensive goods $\uparrow 6.2\%(3.9\%)$

Composition of Production and Business Cycle

Figure: Employment share and output share of capital intensive sector are strongly countercyclical

Robust to tradable goods or manufacturing goods

Cross-country comovement

- Standard International Business Cycle models:
- Backus Kehoe and Kydland (1992, 1994)
- **Quantity Anomalies**: Cross-country comovement

International Correlations	Data	BKK
Home and Foreign GDP	0.39	-0.46
Home and Foreign Employment	0.18	-0.58
Home and Foreign Investment	0.30	-0.99

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- "Resource shifting effect" leads to a negative transmission of shocks

This Paper

1. Presents and investigates a new transmission mechanism of shocks across countries, which dominates the "resource shifting" effect

- Distinguishes multiple sectors by factor intensities

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- Important demarcation from the existing literature

    - Composition of trade and production evolves **endogenously** (vs. exogenously predetermined pattern of trade, as in standard Armington multi-tradables models)

    - Propagation mechanics through relative price of capital-intensive goods to labor-intensive goods (vs. via terms of trade fluctuations, importance of elasticity of substitution and asset market structure)

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2. Assesses each segment of the transmission channel in the data

New Mechanism–"Composition Effects"

Consider $A \uparrow$ (labor-augmenting productivity shock)

- *Changes in composition of production and trade:*

- **domestic compositional change**, $Y_l/Y \uparrow, Y_k/Y \downarrow$

- Price of labor-intensive good falls, capital-intensive good rises $P_l/P_k \downarrow$

- **Foreign compositional change** $Y_l/Y \downarrow, Y_k/Y \uparrow$

- Home becomes a net importer of capital intensive goods

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- *Aggregate feedback:*

- Foreign investment demand rises, output rises, $I^* \uparrow, Y^* \uparrow$

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$\Rightarrow$ Positive comovement across countries in investment and output

Three Main Pieces of Empirical Evidence

Consistent with our mechanism

- **Relative prices**: $\rho(P_k/P_l, Y) > 0$

- **Composition of production**: Labor-intensive sector is more responsive to productivity shocks

  - Strongly countercyclical share of capital intensive sectors $\rho(Y_k/Y, Y) < 0, \rho(L_k/L, Y) < 0$

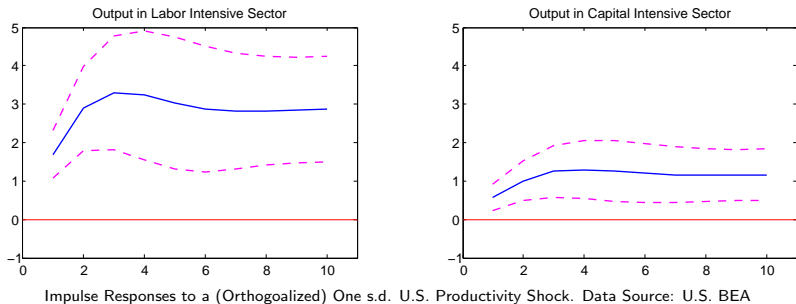- **Composition of trade**: $TB_k \uparrow$ increases, $TB_l \downarrow$ during recessions

  Evidence robust to OECD countries, different levels of disaggregation...

Data

- Disaggregated sectoral production: U.S. BEA, 61 private sectors, 1977-2009, employment and real value added

- *Schott's (2003) critic*
  Robustness: U.S. NBER-CES Manufacturing Industry Data, NAICS 6-digit, 1958-2005

- Disaggregated trade: U.S. ITC, NAICS 6-digit, 1989Q1-2011Q4

- Labor share in industry value added, adjusted for proprietor's income

- All sectors are recast into two larger sectors: labor-intensive sector and capital-intensive sector.

Domestic Composition Effect

Figure: Labor-intensive sectors disproportionally expand more

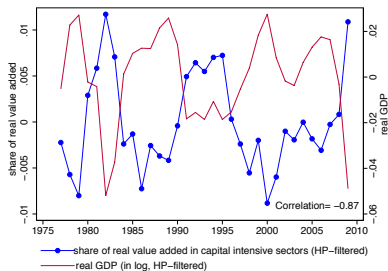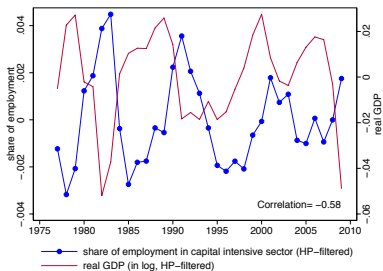Impulse Responses to a (Orthogoalized) One s.d. U.S. Productivity Shock. Data Source: U.S. BEA

Source: U.S. BEA

Composition of Production and Business Cycle

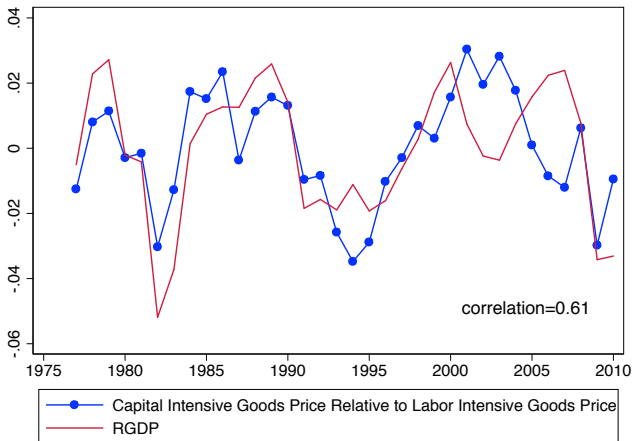Figure: Employment share and output share of capital intensive sector are strongly countercyclical

Robust to tradable goods or manufacturing goods

Robustness Across Countries

country	$\rho(\frac{l_K}{l}, y)$	$\rho(\frac{y_K}{y}, y)$	$\sigma(y_l)/\sigma(y_k)$
Austria	-0.561	-0.703	1.604
Canada	-0.434	-0.737	1.309
Denmark	-0.482	-0.365	0.962
Finland	-0.893	-0.933	3.057
France	-0.393	-0.390	1.259
Germany	-0.067	-0.325	0.977
Italy	-0.286	-0.487	1.379
Netherlands	-0.528	-0.696	2.007
Norway	-0.651	-0.606	1.336
Spain	-0.845	-0.811	1.835
UK	-0.656	-0.582	1.502
USA	-0.580	-0.870	2.101
average	**-0.531**	**-0.625**	**1.611**

Source: OECD STAN

Cyclicality of sectoral prices (ex-oil)

correlation=0.61

Legend:
- Capital Intensive Goods Price Relative to Labor Intensive Goods Price
- RGDP

Source: U.S. BEA

Cyclicality of Sectoral Trade Balance, 10 sectors
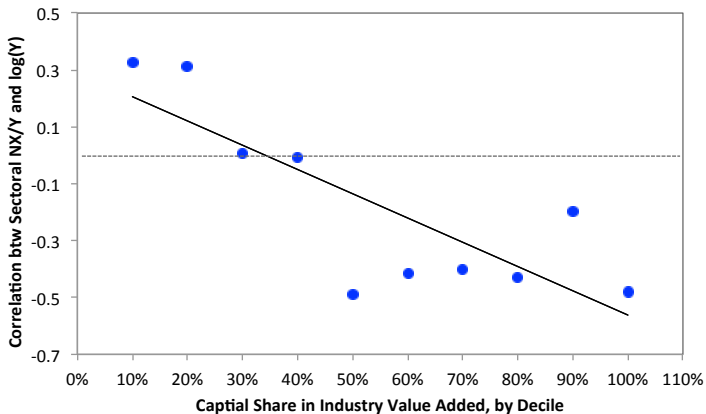
Source: U.S. ITC NAICS 6-digit, US trade with EU15, 1989:1-2011:4.

Impulse Response of Trade Balance of EU15's Capital Intensive Sector to U.S. Productivity Shocks
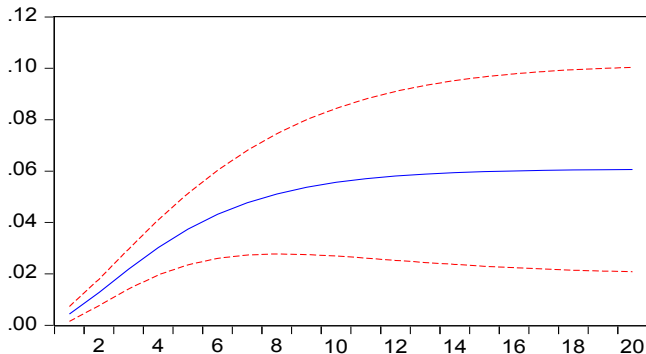
Source: U.S. ITC NAICS 6-digit, US trade with EU15, 1989:1-2011:4.

Model Ingredients

Benchmark: BKK + multiple sectors

- Symmetric two countries

- Multiple sectors: ranked by factor intensity

- Aggregate labor productivity shocks drive compositional changes of production and trade

- Two scenarios: complete asset market and bond economy

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Extensions:

- TFP shocks with sector-specific adjustment costs (or other frictions)

- Nontradable goods

Stochastic Two-country Multi-Sector Model

- Preference

$$\sum_{t=0}^{\infty} \sum_{s^t} \beta^t \pi(s^t) \frac{[c(s^t)^\mu (1-l(s^t))^{1-\mu}]^{1-\sigma}}{1-\sigma}$$

- Intermediate goods:

$$Y_i^j(s^t) = (K_i^j(s^{t-1}))^{\alpha_i} (A^j(s^t) l_i^j(s^t))^{1-\alpha_i}$$

where $\alpha_1 > \alpha_2 > ... > \alpha_m$

- Intermediate goods are combined for consumption or investment:

$$c^j = \left[\sum_{i=1}^m \gamma_i^{\frac{1}{\theta}} \left(c_i^j \right)^{\frac{\theta-1}{\theta}} \right]^{\frac{\theta}{\theta-1}}, \ x_i^j = \left[\sum_{k=1}^m \gamma_k^{\frac{1}{\theta}} \left(z_{ki,t}^j \right)^{\frac{\theta-1}{\theta}} \right]^{\frac{\theta}{\theta-1}}$$

- Capital accumulation:

$$K_i^j(s^t) = (1-\delta) K_i^j(s^{t-1}) + x_i^j(s^t) - \frac{b}{2} K_i^j(s^{t-1}) \left(\frac{x_i^j(s^t)}{K_i^j(s^{t-1})} - \delta \right)^2$$

Stochastic Two-country Multi-Sector Model

- Intermediate goods are traded

$$Y_i^w = \sum_{j=H,F} c_i^j + \sum_{j=H,F} \sum_{k=1}^{m} x_{ki}^j + \sum_{j=H,F} G(nx^j)$$

Consider $G(nx^j) = 0$

- Intermediate good prices are equalized across countries

$$\frac{p_i}{p_j} = \left(\frac{\gamma_i Y_j^w}{\gamma_j Y_i^w} \right)^{\frac{1}{\theta}}$$

- However, FPE does not necessarily hold, due to
  (a) adjustment cost (b) uninsured risk

- Labor market clearing

$$\sum_{i=1}^{m} l_i^j = l^j$$

Stochastic Two-country Multi-Sector Model

- Specification I: Complete Market Economy – Planner's Problem

$$\max \lambda^H \sum_{t=0}^{\infty} \sum_{s^t} \beta^t \pi(s^t) U(c^H(s^t), l^H(s^t)) + \lambda^F \sum_{t=0}^{\infty} \sum_{s^t} \beta^t \pi(s^t) U(c^F(s^t), l^F(s^t))$$

subject to

$$\sum_{j=H,F} c^j(s^t) + \sum_{j=H,F} \sum_{i=1}^{m} x_i^j(s^t) + \sum_{j=H,F} G(nx^j(s^t)) = Y^w(s^t)$$

- Specification II: A Bond Economy:

$$c^j(s^t) + x^j(s^t) + q(s^t) b^j(s^t)$$
$$\leq \ w^j(s^t) l^j(s^t) + R_k^j(s^t) K^j(s^{t-1}) + b^j(s^{t-1}) - G(nx_t^j)$$
$$b^H(s^t) + b^F(s^t) = 0$$

Parameter Values

- Productivity Shocks

$$\begin{pmatrix} \log A_{t+1}^H \\ \log A_{t+1}^F \end{pmatrix} = \begin{pmatrix} a_1 & a_2 \\ a_2 & a_1 \end{pmatrix} \begin{pmatrix} \log A_t^H \\ \log A_t^F \end{pmatrix} + \begin{pmatrix} \epsilon_{t+1}^H \\ \epsilon_{t+1}^F \end{pmatrix}$$

- Baseline Parameters

Preferences	$\beta = 0.99$, $\mu = 0.36$, $\sigma = 2$, $\theta = 1$
Technology	$\gamma_1 = 0.44$, $\alpha_1 = 0.59$, $\alpha_2 = 0.16$ (output-weighted avg of α_i in 31 K-int sectors and 30 L-int sectors) $b = 1.8$, $\delta = 0.025$, $\tau = 0.001$
Productivity Shocks	$a_1 = 0.95$,$a_2 = 0$ var(ϵ^H)= var(ϵ^F)=0.009^2 corr(ϵ^H, ϵ^F) = 0.25 (Kehoe and Perri, 2005)

- - - one-sector model   —— two-sector model

Complete Markets, Fixed Labor, corr(ϵ^H, ϵ^F)=0
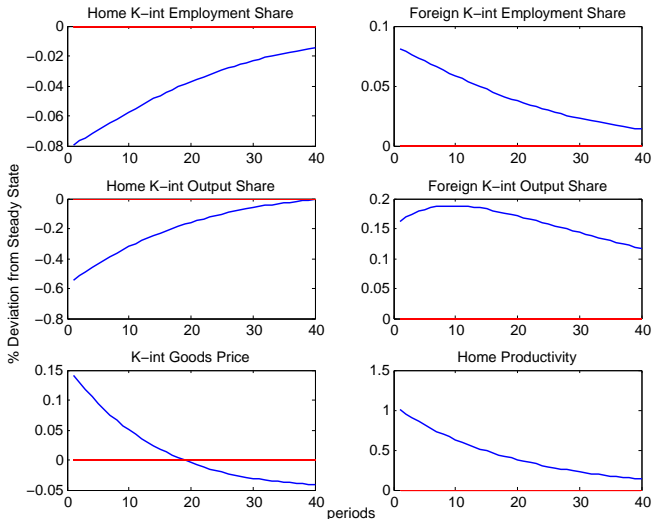
Fixed Labor Case

	Data	Complete Markets	Bond Economy		
			Baseline	High Persistence	
				Adj. Cost	No Adj. Cost
% Standard deviations					
GDP	1.57	075	0.82	0.82	0.82
Net Export/GDP	0.37	0.23	0.03	0.08	0.05
% Standard deviations (relative to GDP)					
Consumption	0.81	0.36	0.49	0.76	0.73
Investment	3.33	3.02	3.35	2.75	2.19
Employment	0.65	–	–	–	–
Relative Price	1.10	0.61	0.63	0.63	0.63
Domestic Comovement Correlations with GDP					
Consumption	0.87	0.79	0.99	0.99	0.99
Investment	0.93	0.96	0.99	0.98	0.98
Employment	0.88	–	–	–	–
Net Exports/GDP	-0.45	0.60	0.13	-0.23	0.21
Relative Price	0.61	0.78	0.80	0.80	0.80
International Correlations					
Home and Foreign Y	0.39	0.29	0.31	0.31	0.32
Home and Foreign C	0.26	1.00	0.44	0.27	0.15
Home and Foreign I	0.30	0.33	0.22	0.20	0.57
Home and Foreign N	0.18	–	–	–	–

Endogenous Labor Case

	Two Sectors			One Sector	
	Complete Mkt	Bond Economy		Complete Mkt	Bond Economy
		CRRA	GHH		
% Standard deviations					
GDP	1.20	1.21	1.13	1.37	1.34
Net Export/GDP	0.42	0.19	0.11	0.36	0.33
% Standard deviations / GDP					
Consumption	0.34	0.43	0.62	0.27	0.29
Investment	3.18	3.4	3.45	3.42	3.24
Employment	0.57	0.5	0.43	0.52	0.49
Dometic Comovement					
Correlations with GDP					
Consumption	0.87	0.97	0.99	0.90	0.94
Investment	0.95	0.97	0.97	0.95	0.95
Employment	0.96	0.96	0.99	0.99	0.99
Net Exports/GDP	0.66	0.57	-0.13	-0.02	-0.05
International Correlations					
Home and Foreign Y	-0.06	0.11	0.23	0.09	0.12
Home and Foreign C	0.79	0.44	0.23	0.17	0.62
Home and Foreign I	0.12	0.23	0.13	-0.17	-0.09
Home and Foreign N	-0.60	-0.37	0.07	-0.05	-0.04

Impulse Responses to a Home Productivity Shock
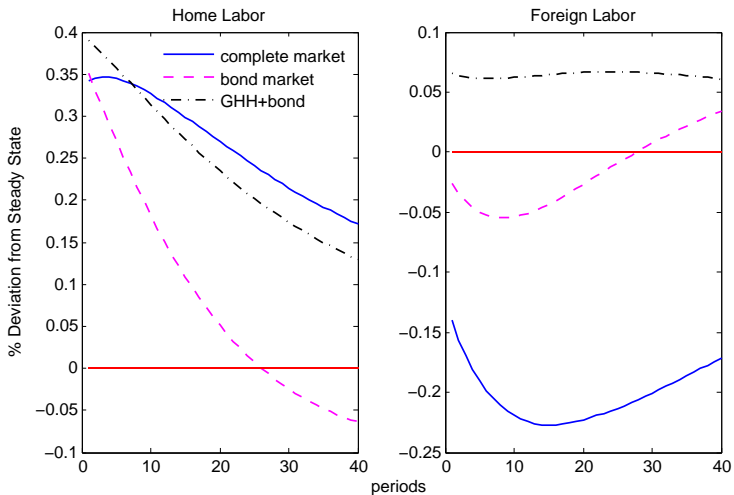
Sectoral Statistics: Data and Baseline Model

Sectoral Statistics	Data	Model
% Standard deviations relative to GDP		
L-Intensive Production Share	0.45	0.64
L-Intensive Employment Share	0.25	0.12
% Standard deviations		
K-Intensive Net Export/GDP	0.29	0.09
L-Intensive Net Export/GDP	0.24	0.28
Correlations with GDP		
K-Intensive Employment Share	0.58	0.60
K-Intensive Production Share	0.46	0.64
K-Intensive Net Export/GDP	-0.61	-0.49
L-Intensive Net Export/GDP	0.05	0.60

Table: Based on Baseline Complete Market Model

Sensitivity

		$\theta = 2$	$\theta = 0.5$	No Adj. Cost	TFP	Initial Endowment	
						Labor Abundant	Capital Abundant
		(1)	(2)	(3)	(4)	(5)	(6)
Home and Foreign Y	Complete Mkts	0.26	0.30	–	0.31	0.29	0.29
	Bond Economy	0.31	0.31	0.32	0.31	0.30	0.31
Home and Foreign I	Complete Mkts	0.20	0.37	–	0.22	0.33	0.32
	Bond Economy	0.34	0.16	0.4	0.20	0.23	0.23
Home and Foreign Y-C	Bond Economy	0.08	0.07	0.08	0.02	0.02	0.03
Corr (NX, Y)	Complete Mkts	0.23	0.56	–	0.56	0.72	0.4
	Bond Economy	-0.21	-0.30	0.14	-0.3	-0.23	-0.30

What Drives the Strength of Composition Effects?
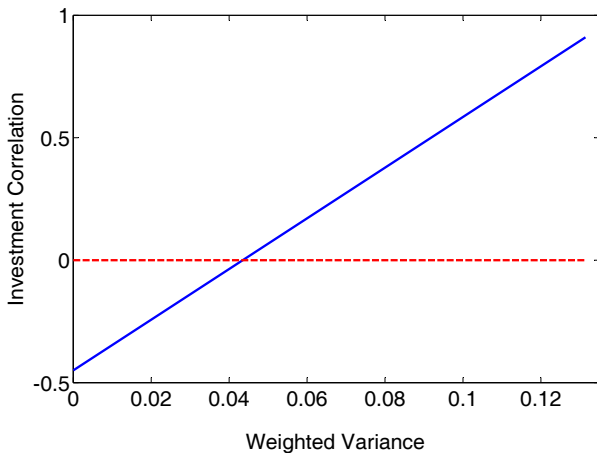
Note: regression line using a five-sector model

Concluding Remarks

- Distinguishing sectors by factor intensities goes a long way to resolve IRBC puzzles

    - Novel mechanism: composition effect

- Key implications consistent with the data

    - New observations at the sectoral level.
    - New observation of the relationship between dynamics of trade structure and international comovement.

- **Other implications**: trade and IRBC synchronization; positively correlated and relatively volatile imports and exports

- Future work: Understanding the source of sectoral compositional changes

Backup Slides

Adding Nontradables

- Nontradable production:

$$Y_N^j = (K_N^j)^{\alpha_N} (A^j N_N^j)^{1-\alpha_N}$$

- Composite goods used for consumption and tradables for investment

$$Y^j = \left[\gamma_T^{\frac{1}{\zeta}} \left(Y_T^j \right)^{\frac{\zeta-1}{\zeta}} + (1-\gamma_T)^{\frac{1}{\zeta}} \left(Y_N^j \right)^{\frac{\zeta-1}{\zeta}} \right]^{\frac{\zeta}{\zeta-1}}$$

- Price index

$$
\begin{aligned}
P^j &= (\gamma_T + (1-\gamma_T)P_N^{1-\zeta})^{1/1-\zeta} \\
RER &= P^F/P^H
\end{aligned}
$$

Backus-Smith Puzzle

	Data	One Sector	Two-Sector		
Basline Experiment			Complete Mkt	Bond Economy	
				CRRA	GHH
Corr($RER, \frac{C^H}{C^F}$)	-0.71	0.88	0.95	-0.86	-0.88

	Two-Sector Bond Economy (CRRA)				
Sensitivity					
	$\theta = 0.5$	$\theta = 1.5$	High Persistence	$b = 0$	$\alpha_1 = \alpha_2$
Corr($RER, \frac{C^H}{C^F}$)	-0.86	-0.86	-0.85	-0.30	0.88

- Corsetti et al (2008): Two sector + complete specialization (Armington), require very low θ or high θ and high ρ.

- Our model: Two sector + endogenous production and trade composition
    - Robust
    - **Key**: strong composition effect

Compositional changes across countries are *unsynchronized*

Country	$\rho(l_K^j/l^j, l_K^{US}/l^{US})$
Canada	0.198
France	-0.110
Germany	-0.328
Italy	-0.490
Japan	-0.453
UK	0.269
average	**-0.152**

Sectoral Heterogeneity – Capital Intensive Sectors

Sector	NAICS	Labor Share
Real estate	531	0.056
Rental and leasing services and lessors of intangible assets	532, 533	0.188
Farms	111, 112	0.195
Petroleum and coal products	324	0.238
Oil and gas extraction	211	0.268
Utilities	22	0.309
Broadcasting and telecommunications	515, 517	0.407
Federal Reserve banks, credit intermediation, and related activities	521, 522	0.429
Chemical products	325	0.463
Pipeline transportation	486	0.483
Forestry, fishing, and related activities	113, 114, 115	0.494
Motion picture and sound recording industries	512	0.514
Food and beverage and tobacco products	311, 312	0.520
Water transportation	483	0.522
Mining, except oil and gas	212	0.534
Funds, trusts, and other financial vehicles	525	0.549
Performing arts, spectator sports, museums, and related activities	711, 712	0.570
Legal services	5411	0.571
Paper products	322	0.586
Information and data processing services	518, 519	0.586
Insurance carriers and related activities	524	0.601
Waste management and remediation services	562	0.602
Publishing industries (includes software)	511, 516	0.611
Miscellaneous manufacturing	339	0.623
Transit and ground passenger transportation	485	0.632
Miscellaneous professional, scientific, and technical services	5412-5414, 5416-5419	0.632
Electrical equipment, appliances, and components	335	0.634
Truck transportation	484	0.643
Plastics and rubber products	326	0.649
Nonmetallic mineral products	327	0.660

Sectoral Heterogeneity – Labor Intensive Sectors

Accommodation	721	0.666
Other services, except government	81	0.667
Amusements, gambling, and recreation industries	713	0.669
Construction	23	0.676
Support activities for mining	213	0.685
Wholesale trade	42	0.690
Fabricated metal products	332	0.699
Other transportation and support activities	487, 488, 492	0.707
Rail transportation	482	0.713
Primary metals	331	0.718
Machinery	333	0.723
Retail trade	44, 45	0.727
Motor vehicles, bodies and trailers, and parts	3361, 3362, 3363	0.746
Textile mills and textile product mills	313, 314	0.747
Food services and drinking places	722	0.748
Furniture and related products	337	0.749
Ambulatory health care services	621	0.753
Apparel and leather and allied products	315, 316	0.754
Wood products	321	0.756
Administrative and support services	561	0.764
Computer and electronic products	334	0.769
Other transportation equipment	3364, 3365, 3366, 3369	0.773
Air transportation	481	0.780
Warehousing and storage	493	0.804
Social assistance	624	0.825
Securities, commodity contracts, and investments	523	0.853
Printing and related support activities	323	0.876
Computer systems design and related services	5415	0.902
Management of companies and enterprises	55	0.903
Hospitals and nursing and residential care facilities	622, 623	0.915
Educational services	61	0.919

Production Structure over the Business Cycle
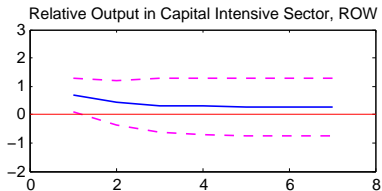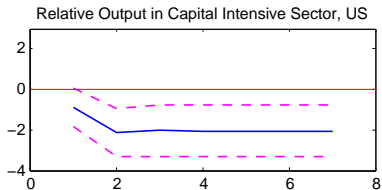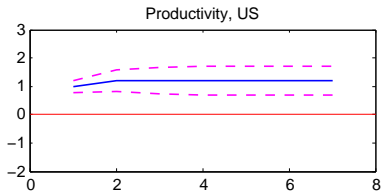## (Tradables)
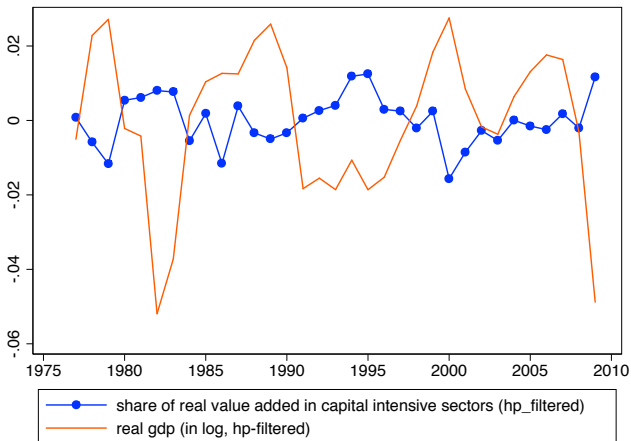
Source: U.S. BEA;

Robust to alternative aggregation and across other OECD countries.

Structural VAR analysis

$$
\left[\begin{array}{c} \Delta x_t \\ \Delta y_t \end{array} \right] = \left[\begin{array}{cc} C^{11}(L) & C^{12}(L) \\ C^{21}(L) & C^{22}(L) \end{array} \right] \left[\begin{array}{c} \Delta \varepsilon_t^a \\ \Delta \varepsilon_t^m \end{array} \right]
$$

- $C^{12}(L) = 0$.
- x_t – (log) labor productivity in the U.S. economy
- y_t – $\log(Y_k^{US}/Y_l^{US})$, $\log(Y_k^{ROW}/Y_l^{ROW})$

Impulse Responses to a U.S. Productivity Shock

What Drives the Strength of Composition Effects?

Note: regression line using a five-sector model