Sectoral vs. Aggregate Shocks: A Structural Factor Analysis of Industrial Production

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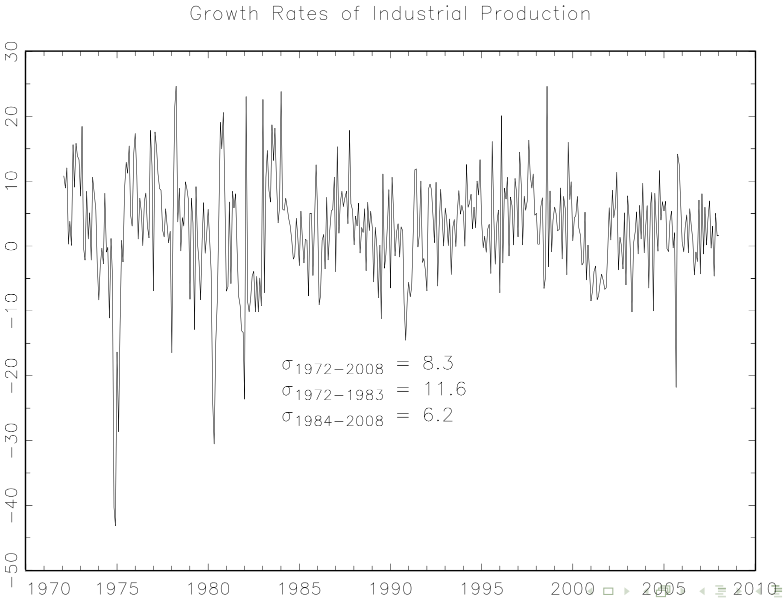
Observations and Motivating Questions

- Month-to-month and quarter-to-quarter variations in Industrial Production (IP) are large
  - std. dev. of monthly growth rates is 8 percent
  - std. dev. of quarterly growth rates is 6 percent
  - noticeably large fall in the volatility of IP after 1984

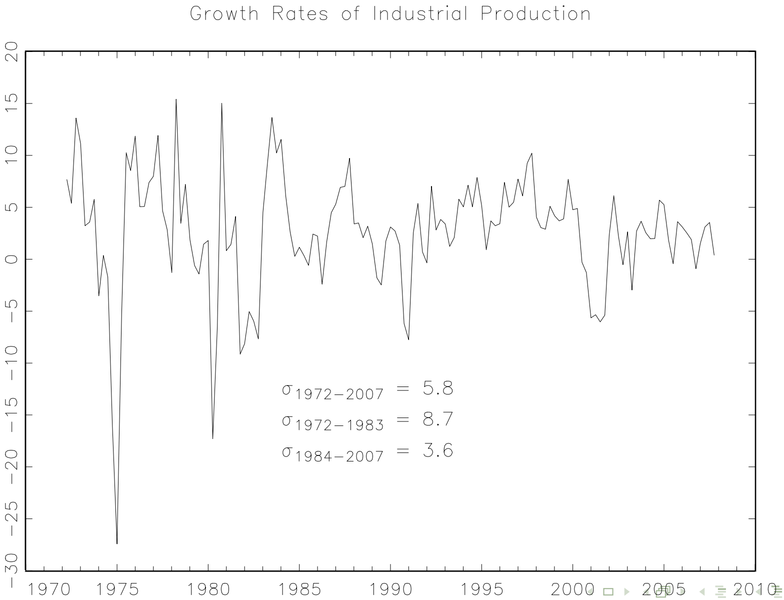
- IP index is constructed as a weighted average of production indices across a large number of sectors...

- ... apparently, much of the variability in individual sectors does not "average out"

An Initial Look at IP Data



An Initial Look at IP Data



Observations and Motivating Questions

- Aggregate Shocks that affect all industrial sectors

- Some sectors have very large weights in the aggregate index, Gabaix (2005)

- Complementarities in production amplify and propagate sector-specific shocks
  - input-output (IO) linkages
  - aggregate activity spillovers
  - local activity spillovers

Approaches to analyzing sources of variations in the business cycle

- Factor Analytic Methods - Long and Plosser (1987), Forni and Reichlin (1998), Shea (2002)
  - broad identifying restrictions
  - Non-trivial contribution of sector-specific shocks to aggregate variability (approximately 50 percent)
- Structural (calibrated) Models - Long and Plosser (1983), Horvath (1998), Dupor (1999), Horvath (1998, 2000)
  - contribution of idiosyncratic shocks to aggregate variability depends on exact structure of IO matrix
- Other: Conley and Dupor (2003), Gabaix (2005), Comin and Philippon (2005)

Overview for this paper

- Bridge factor-analytic and structural approaches to the analysis of idiosyncratic and aggregate shocks
  - Highlight conditions under which multisector growth models (Long and Plosser 1983, Horvath 1998) produce factor models as reduced forms
  - Factors are associated with aggregate productivity shocks
  - "Uniquenesses" are associated with (linear combinations of) sector-specific productivity shocks

- Sort through leading explanations underlying:
  - both aggregate and sectoral IP volatility
  - the decline in aggregate IP volatility after 1984

Overview for this paper

- Aggregate variability is driven mainly by covariability across sectors, Quah and Sargent (1993), Forni and Reichlin (1998), Shea (2002)

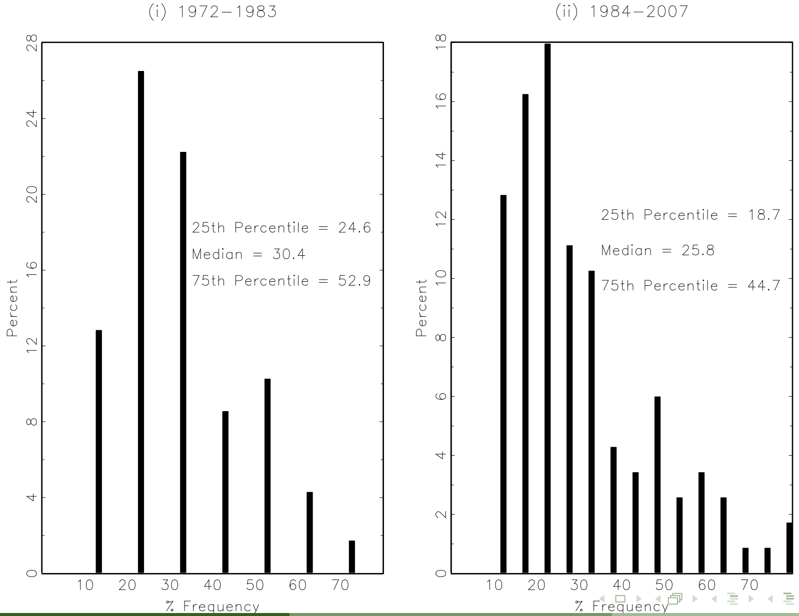
- This covariability resides in a small number of factors
  - factors capture mostly aggregate productivity shocks

- Sectoral productivity shocks play an important role in explaining aggregate IP variability
  - about 50 percent after 1984
  - changes in U.S. IO matrix did not lead to greater propagation of idiosyncratic shocks after 1984
  - increase in relative importance of idiosyncratic productivity shocks stems from decrease in contribution of aggregate productivity shocks

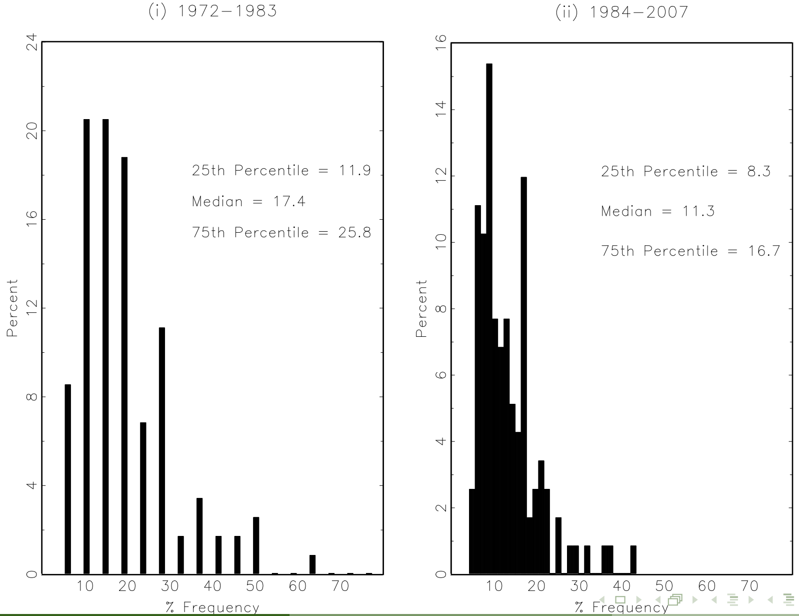
Data

- Sectoral Industrial Production, 1972-2007 from Board of Governors
- Benchmark Input-Output tables from Bureau of Economic Analysis
- Disaggregated according to NAICS
- Consider two benchmark years, 1977 and 1998
  - NAICS cannot be matched to IO tables prior to 1997
  - make use of vintage IP data, 1967-2002, disaggregated according to SIC codes
  - discontinued after 2002

Std. Dev. of Sectoral IP Growth Rates



Std. Dev. of Sectoral IP Growth Rates



Average Pairwise Correlation of Sectoral IP Growth Rates

Monthly Growth Rates			Quarterly Growth Rates		
72-07	72-83	84-07	72-07	72-83	84-07
0.08	0.13	0.05	0.19	0.27	0.11

Standard Deviation of IP Growth Rates
(Percentage points at annual rate)

Share Weights Used to Aggregate Sectoral IP	Monthly Growth Rates 1972-2007	1972-1983	1984-2007	Quarterly Growth Rates 1972-2007	1972-1983	1984-2007
a. Full Covariance Matrix of Sectoral Growth Rates						
Time Varying (w_{it})	8.3	11.6	6.2	5.8	8.7	3.6
Constant (μ_w)	8.4	11.7	6.2	5.8	8.9	3.6
Equal ($1/N$)	10.4	14.4	7.6	6.9	10.5	4.2
b. Diagonal Covariance Matrix of Sectoral Growth Rates						
Time Varying (w_{it})	4.3	4.9	4.1	1.9	2.6	1.6
Constant (μ_w)	4.2	4.6	4.0	1.9	2.4	1.5
Equal ($1/N$)	4.6	5.6	4.0	1.8	2.5	1.4

Statistical Factor Analysis

- $$X_t = \Lambda F_t + u_t$$
- X_t is an N-dimensional vector of sectoral output growth rates, F_t is a set of r common factors, and u_t is an Nx1 vector of idiosyncratic disturbances that satisfy weak dependence
- Principle components of X_t are consistent estimators of F_t, Stock and Watson (2002)
- $$\Sigma_{XX} = \Lambda \Sigma_{FF} \Lambda' + \Sigma_{uu}$$
- Note: Λ and F_t are not separably identified (because $\Lambda F_t = \widetilde{\Lambda}\widetilde{F}_t$ where $\widetilde{\Lambda} = \Lambda R$ and $\widetilde{F}_t = R^{-1} F_t$ for arbitrary kxk matrices R)

A Digression: Principle Components

- The PC problem represents a way to capture the comovement across these N categories of output changes in a convenient way
- The PC problem transforms the X 's into a new set of variables that...
  - are pairwise uncorrelated,
  - of which the first such variable has the maximum possible variance, the second the maximum possible variance among those uncorrelated with the first, etc...

A Digression: Principle Components

- Let
$$F_1' = X'\lambda_1$$
denote the first variable, where Λ_1 is $Nx1$ and F_1' is $Tx1$

- The sum of squares is
$$F_1 F_1' = \lambda_1{}'\Sigma_{XX}\lambda_1$$
where Σ_{XX} is the variance-covariance (when divided by T) of interest rate changes

- We wish to choose the weights λ_1 to maximize $F_1 F_1'$, but some constraint must evidently be imposed on λ_1

A Digression: Principle Components

- The PC problem is,

$$\max_{\lambda_1} \lambda_1' \Sigma_{XX} \lambda_1 + \mu_1 (1 - \lambda_1' \lambda_1)$$

- The corresponding firs-order condition is,

$$2\Sigma_{xx}\lambda_1 - 2\mu_1\lambda_1 = 0.$$

- or

$$\Sigma_{xx}\lambda_1 = \mu_1\lambda_1.$$

- Note that $\lambda_1' \Sigma_{XX} \lambda_1 = \lambda_1' \mu_1 \lambda_1 = \mu_1$. So choose the eigenvector associated with the largest eigenvalue of Σ_{xx}.

A Digression: Principle Components

- Define the next principle component of X as $F_2' = X'\lambda_2$
- The PC problem is

$$\max_{\lambda_2} \lambda_2'\Sigma_{XX}\lambda_2 + \mu_2(1 - \lambda_2'\lambda_2) + \phi\lambda_2'\lambda_1.$$

- The weights λ_2 satisfy

$$\Sigma_{xx}\lambda_2 = \mu_2\lambda_2,$$

- and, in particular, should be chosen as the eigenvector associated with the second largest eigenvalue of Σ_{XX}.

A Digression: Principle Components

- Proceeding in this way, suppose we find the first k principle components of X. We can arrange the weights λ_1, λ_2,...,λ_k in an $N \times k$ orthogonal matrix

$$\Lambda_k = [\lambda_1, \lambda_2, ..., \lambda_k].$$

- Furthermore, the general PC problem may then be described as finding the $T \times k$ matrix of components, $F' = X'\Lambda_k$, such that Λ_k solves

$$\max_{\Lambda_k} \Lambda_k' \Sigma_{XX} \Lambda_k \text{ subject to } \Lambda_k' \Lambda_k = I_k.$$

A Digression: Principle Components

- Solving the general PC problem is equivalent to solving

$$\min_{\{F_1\}_{t=1}^T,\ldots,\{F_k\}_{t=1}^T,\Lambda_k} T^{-1}\sum_{t=1}^{T}(X_t-\Lambda_k F_t)'(X_t-\Lambda_k F_t) \text{ s. t. } \Lambda_k'\Lambda_k = I_k$$

- To see this, suppose Λ_k is known. Then,

$$F_t(\Lambda_k) = (\Lambda_k'\Lambda_k)^{-1}\Lambda_k X_t$$

- Now concentrate out F_t to get

$$\min_{\Lambda_k} T^{-1}\sum_{t=1}^{T} X_t'[I_k - \Lambda_k(\Lambda_k'\Lambda_k)\Lambda_k]X_t \text{ s. t. } \Lambda_k'\Lambda_k = I_k$$

Statistical Factor Analysis

- Bai and Ng (2002) ICP1 and ICP2 yield 2 factors in full and first sample,(1972-2007) and (1972-1983), and 1 factor in second sample (1984-2007)

- $$g_t = \mathbf{w}' X_t = \mathbf{w}' \Lambda F_t + \mathbf{w}' u_t$$

- $$R^2(F) = \mathbf{w}' \Lambda \Sigma_{FF} \Lambda' \mathbf{w} / \sigma_g^2$$

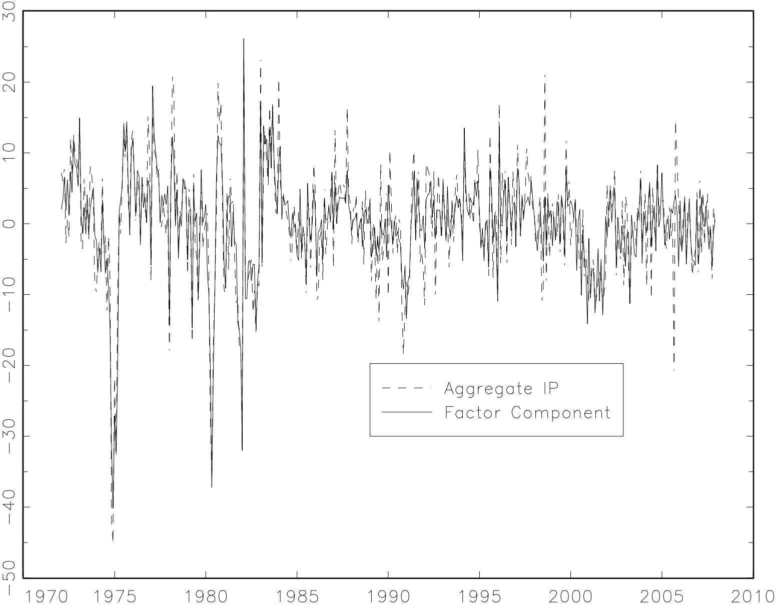
- Distribution of $R_i^2(F)$

Statistical Factor Analysis

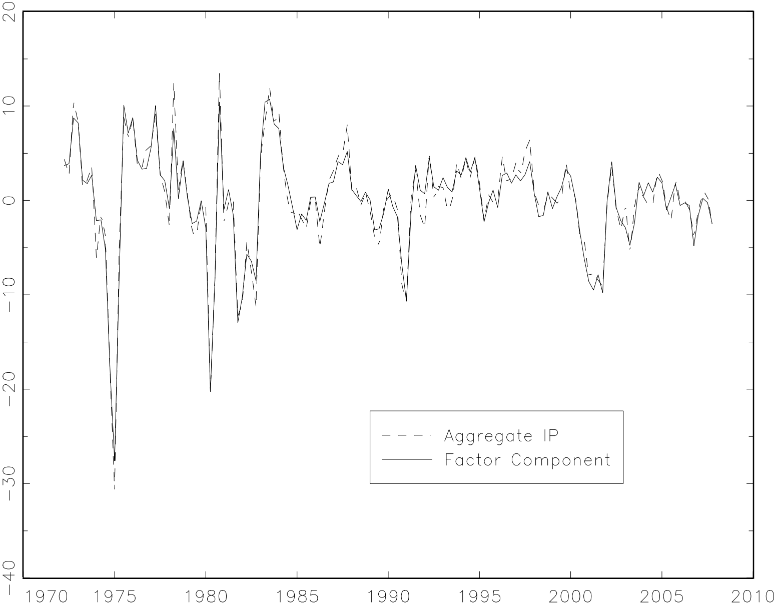
Decomposition of Variance from Statistical 2-Factor Model

	Monthly Rates		Quarterly Rates	
	72-83	84-07	72-83	84-07
Std. Deviation of IP Growth Rates Implied by Factor Model (with Constant Share Weights)	11.7	6.2	8.9	3.6
$R^2(F)$	0.86	0.49	0.89	0.87

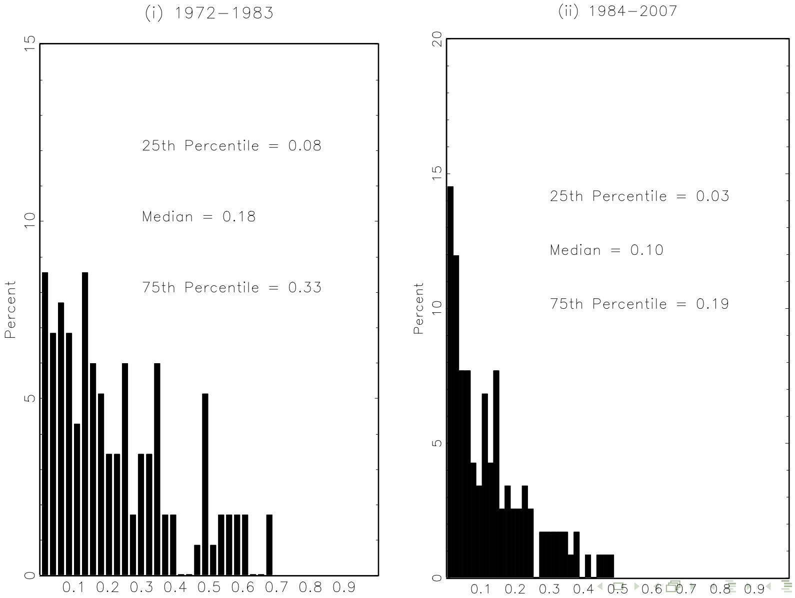
Factor Decomposition of Industrial Production (Monthly)



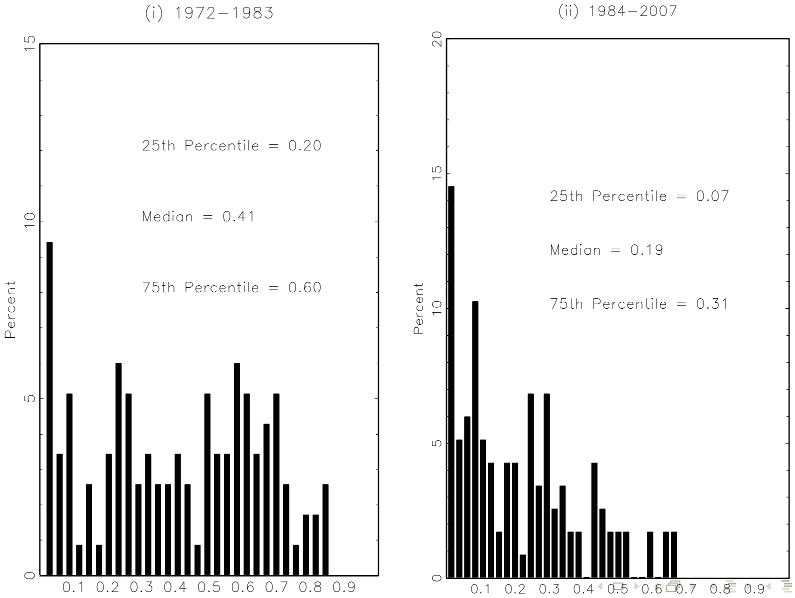
Factor Decomposition of Industrial Production (Quarterly)



Distribution of $R_i^2(F)$ of Sectoral Growth Rates



Distribution of $R_i^2(F)$ of Sectoral Growth Rates



Fraction of Variability in Sectoral Growth Rates Explained by Common Factors (Quarterly Data Growth Rates)

1972-1983	
Sector	$R_i^2(F)$
Other Fabricated Metal Products	0.86
Fabricated Metals: Forging and Stamping	0.85
Machine Shops: Turned Products and Screws	0.83
Commercial and Service Industry Machinery/Other General Purpose	0.83
Foundries	0.80
Other Electrical Equipment	0.79
Metal Working Machinery	0.78
Fabricated Metals: Cutlery and Handtools	0.76
Electrical Equipment	0.73
Architectural and Structural Metal Products	0.72

Fraction of Variability in Sectoral Growth Rates Explained by Common Factors (Quarterly Data Growth Rates)

1984-2007	
Sector	$R_i^2(F)$
Coating, Engraving, Heat Treating, and Allied Activities	0.68
Plastic Products	0.67
Commercial and Service Industry Machinery/Other General Purpose	0.65
Fabricated Metals: Forging and Stamping	0.65
Household and Institutional Furniture and Kitchen Cabinets	0.59
Veneer, Plywood, and Engineered Wood Products	0.59
Metal Working Machinery	0.52
Foundries	0.52
Millwork	0.51
Other Fabricated Metal Products	0.50

Statistical Factor Analysis

- Tracking real time movements in IP using only a subset M of the IP sectors
- $\widetilde{X}_t = \mathbf{s}X_t$, where $\mathbf{s}$ is an M x N selection matrix
- Weights, ψ, determined by projection of g_t onto $\widetilde{X}_t$

$$\psi = (\mathbf{s}\Sigma_{XX}\mathbf{s}')^{-1}\mathbf{s}\Sigma_{XX}\mathbf{w}$$

- Bulk of variation in IP explained by a small number of sectors

Information Content of IP Contained in Individual Sectors

Selected Sectors Ranked by $R_i^2(F)$	1972-1983 Fraction of Explained IP	1984-2000 Fraction of Explained IP
Top 5 Sectors	85.0	75.4
Top 10 Sectors	90.3	80.4
Top 20 Sectors	97.9	86.4
Top 30 Sectors	98.8	90.3

Structural Factor Analysis

- Consistent estimation of factors relies on weak cross-sectional dependence of “uniquenesses”, u_t ...
- ... but IO linkages can transform sector-specific shocks into common shocks
- Require a model that incorporates linkages across sectors - Long and Plosser (1983), Horvath (1998)
- Key feature is that production in each sector uses materials produced in other sectors
- Statistical Factor Model can be interpreted as the reduced form of the Structural Model. We can filter out the effects of IO linkages.

Structural Factor Analysis

- N distinct sectors, indexed $j = 1, ..., N$
- Technology, Final Goods:

$$Y_{jt} = A_{jt} K_{jt}^{\alpha_j} \prod_{i=1}^{N} M_{ij}^{\gamma_{ij}} L_{jt}^{1-\alpha_j-\sum_{i=1}^{N}\gamma_{ij}},$$

- M_{ij} - quantity of sector i material used in sector j. An input-output matrix for this economy is an N x N matrix, Γ, with typical element γ_{ij}
- $N + 1$ disturbances

$$\Delta lnA_{jt} = \epsilon_{jt}$$

- $\epsilon_t = (\epsilon_{1t}, \epsilon_{2t}, ..., \epsilon_{Nt})'$ has covariance matrix $\Sigma_{\epsilon\epsilon}$

Structural Factor Analysis

- Technology: Investment Goods

$$Z_{jt} = \prod_{i=1}^{N} Q_{ijt}^{\theta_{ij}}, \quad \sum_{i=1}^{N} \theta_{ij} = 1$$

- $$K_{jt+1} = Z_{jt} + (1 - \delta) K_{jt}$$

- Q_{ij} - quantity of sector i output used in sector j. A capital flow matrix for this economy is an N x N matrix, Θ, with typical element θ_{ij}

Structural Factor Analysis

- preferences:

$$E\sum_{t=0}^{\infty}\beta^t\sum_{j=1}^{N}(\frac{C_{jt}^{1-\sigma}}{1-\sigma}-\psi L_{jt})$$

- resource constraints:

$$C_{jt}+\sum_{i=1}^{N}M_{jit}+\sum_{i=1}^{N}Q_{jit}=Y_{jt},\quad j=1,...,N$$

- Planner's solution for sectoral output allocations,

$$X_t=\Phi X_{t-1}+\Pi\epsilon_t+\Xi\epsilon_{t-1},$$

where $X_t=(\Delta\ln(Y_{1t}),\Delta\ln(Y_{2t}),...,\Delta\ln(Y_{Nt}))'$

- Φ, Π, and Ξ are $N\times N$ matrices that depend only on the model parameters, α_d, Γ, β, σ, ψ, and δ

Structural Factor Analysis

- $$\epsilon_t = \Lambda_s S_t + v_t,$$

  where v_t has a diagonal variance-covariance matrix

- then

  $$X_t = \Lambda F_t + u_t,$$

  where $\Lambda(\mathbf{L}) = (I - \Phi\mathbf{L})^{-1}(\Pi + \Xi\mathbf{L})\Lambda_s$, $F_t = S_t$, and $u_t = (I - \Phi\mathbf{L})^{-1}(\Pi + \Xi\mathbf{L})v_t$

Structural Factor Analysis

- The structural model produces a an approximate factor model as a reduced form. Common factors are associated with aggregate shocks to sectoral productivity. “Uniquenesses” are linear combinations of the sector-specific shocks.

- To eliminate the propagation of sector-specifc shocks induced by IO linkages, filter the vector of sectoral output growth

$$\epsilon_t = (\Pi + \Xi \mathbf{L})^{-1}(I - \Phi \mathbf{L})X_t$$

Benchmark Calibration

- $\beta = 0.99$, $\delta = 0.025$, $\sigma = 1$ and $\psi = 1$
- γ_{ij}, θ_{ij}, and α_j obtained from IO and Capital Flow tables published by the BEA.
- We consider two benchmark years for the IO tables, 1977 and 1998
- We choose two calibrations for $\Sigma_{\epsilon\epsilon}$, i) $\Sigma_{\epsilon\epsilon}$ is diagonal, and ii) $\Sigma_{\epsilon\epsilon}$ is represented by a factor model,

$$\Sigma_{\epsilon\epsilon} = \Lambda_s \Sigma_{SS} \Lambda_s' + \Sigma_{vv}$$

Sectoral Correlations and Volatility of IP Growth Rates Implied by Structural Model

	Data		Model with Uncorrelated Shocks		Model with 2 Factors		
Sample Period	$\bar{\rho}_{ij}$	σ_g	$\bar{\rho}_{ij}$	σ_g	$\bar{\rho}_{ij}$	σ_g	$R^2(S)$
1972-1983	0.27	8.8	0.05	5.1	0.26	9.5	0.81
1984-2007	0.11	3.6	0.04	3.1	0.10	4.1	0.50

Deconstructing the Empirical Results

- Long and Plosser (1983): Log preferences over consumption and leisure, materials delivered with a one period lag, no capital: $\Phi = \Gamma'$, $\Pi = I$, $\Xi = 0$
$$X_t = \Gamma' X_{t-1} + \varepsilon_t$$

- Carvalho (2007): Same preferences, no capital: $\Phi = 0, \Pi = (I - \Gamma')^{-1}$, $\Xi = 0$
$$X_t = (I - \Gamma')^{-1} \varepsilon_t$$

- Horvath (1998), Dupor (1999): Log preferences over consumption, no labor, sector-specific capital, full depreciation within the period $\Phi = (I - \Gamma')^{-1} \alpha_d$, $\Pi = (I - \Gamma')^{-1}$, $\Xi = 0$
$$X_t = (I - \Gamma')^{-1} \alpha_d X_{t-1} + (I - \Gamma')^{-1} \varepsilon_t$$

Deconstructing the Empirical Results

- Long and Plosser (1983):

$$\Sigma_{XX} = \sum_{j=0}^{\infty} (\Gamma')^j \Sigma_{\varepsilon\varepsilon} \Gamma^j$$

- Carvalho (2007):

$$\Sigma_{XX} = (I - \Gamma')^{-1} \Sigma_{\varepsilon\varepsilon} (I - \Gamma)^{-1}$$

- Horvath (1998), Dupor (1999):

$$\Sigma_{XX} = \sum_{j=0}^{\infty} \left[(I - \Gamma')^{-1} \alpha_d \right]^j (I - \Gamma')^{-1} \Sigma_{\varepsilon\varepsilon} (I - \Gamma)^{-1} \left[\alpha_d (I - \Gamma)^{-1} \right]^j$$

Deconstructing the Empirical Results

- Dupor (1999) imposes 2 key restrictions on Horvath(1998)
  - Γ has a unit eigenvector, so that $\Gamma I = \kappa I$, where I is the unit vector and κ is a scalar
  - all capital shares are equal, so that $\alpha_d = \alpha I$, where α is a scalar
- It is possible to derive simple expressions for the variance of the equally weighted aggregate growth rate,

$$g_t^{ew} = N^{-1} \sum_{i=1}^{N} x_{it}$$

Deconstructing the Empirical Results

- $$\sigma_g^2(Long - Plosser) = (1 - \kappa^2)^{-1}\overline{\sigma}_{ij}$$

  $$\sigma_g^2(Carvalho) = (1 - \kappa)^{-2}\overline{\sigma}_{ij}$$

  $$\sigma_g^2(Horvath - Dupor) = [(1 - \kappa - \alpha)(1 - \kappa + \alpha)]^{-1}\overline{\sigma}_{ij}$$

- where $\overline{\sigma}_{ij}$ is the average element of $\Sigma_{\varepsilon\varepsilon}$

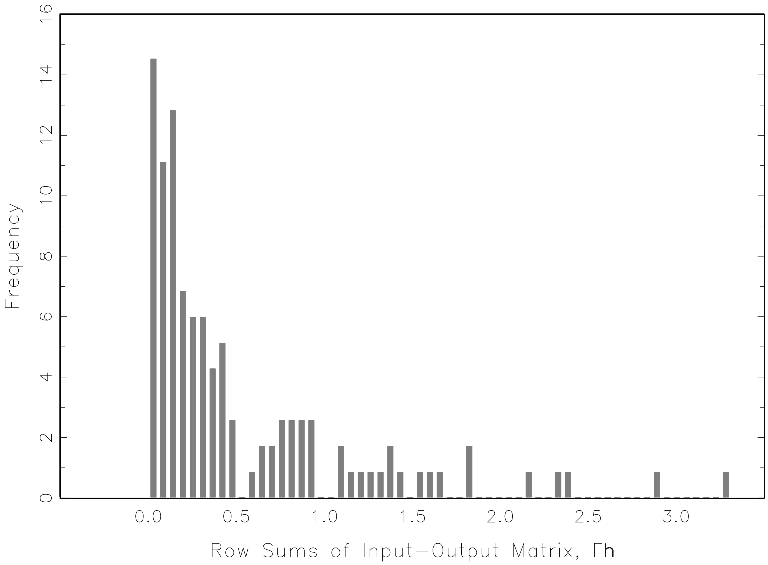
Deconstructing the Empirical Results

- The variance of aggregate growth is proportional to $\overline{\sigma}_{ij}$ not only in Horvath-Dupor, but in all models
- If sectoral shocks are uncorrelated, $\overline{\sigma}_{ij}$ is their average variance divided by N
- In this case,

$$\lim_{N\to\infty} \overline{\sigma}_{ij} = 0 \text{ so that } \lim_{N\to\infty} \sigma_g^2 = 0$$

- If a handful of sectors are subject to particularly large shocks,this will only affect aggregate variability through the average element of $\Sigma_{\varepsilon\varepsilon}$

Distribution of Row Sums of Input−Output Matrix



Selected Summary Statistics for Data and Various Models with Uncorrelated Shocks (1972-2007 Sample Period)

		$\bar{\rho}_{ij}$	σ_g	σ_g (diag)	σ_g (scaled)	$\frac{\sigma_g^2}{\sigma_{g,Benchmark}^2}$
1	Data	0.19	5.80	1.85	5.80	
2	Benchmark Model	0.04	3.87	1.88	3.82	1.00
3	Long-Plosser	0.01	2.66	2.07	2.38	0.39
4	Carvalho	0.04	3.15	1.64	3.56	0.87
5	Horvath-Dupor	0.06	3.76	1.81	3.84	1.01
6	Benchmark, $\Theta = I$	0.02	3.86	2.43	2.94	0.59
7	Benchmark, $\delta = I$	0.06	3.74	1.72	4.04	1.12
8	Long-Plosser, Γ average	0.01	1.61	1.39	2.15	0.32
9	Carvalho, Γ average	0.04	2.60	1.53	3.15	0.68
10	Horvath-Dupor, Γ average, $\alpha_d = \alpha I$	0.05	2.89	1.58	3.40	0.79
11	Benchmark, Γ average, $\alpha_d = \alpha I$	0.05	3.30	1.71	3.57	0.87
12	Benchmark, $\Sigma_{\varepsilon\varepsilon} = \sigma^2 I$	0.04	5.72	2.99	3.55	0.86

Selected Summary Statistics with Different Levels of Sectoral Aggregation

	1972-1983			1984-2007		
	$\bar{\rho}_{ij}$		$R^2(S)$	$\bar{\rho}_{ij}$		$R^2(S)$
	Data	Model with Diagonal $\Sigma_{\varepsilon\varepsilon}$		Data	Model with Diagonal $\Sigma_{\varepsilon\varepsilon}$	
2-Digit Level (26 Sectors)	0.38	0.09	0.76	0.22	0.07	0.53
3-Digit Level (88 Sectors)	0.29	0.05	0.85	0.13	0.05	0.53
4-Digit Level (117 Sectors)	0.27	0.05	0.81	0.11	0.04	0.50

Comparing Results (Model with $\Theta = I$) Sectoral Correlations and Volatility of IP Growth Rates Implied by Structural Model

Sample Period	Γ	Data		Model with Uncorrelated Shocks		Structural Model with 2 Factors	Reduced Form Model with 2 Factors
		$\bar{\rho}_{ij}$	σ_g	$\bar{\rho}_{ij}$	σ_g	$R^2(S)$	$R^2(S)$
1972-1983	Γ^{1997}	0.27	8.8	0.02	3.7	0.88	0.89
1984-2007	Γ^{1997}	0.11	3.6	0.02	2.2	0.69	0.87
1967-1983	Γ^{1977}	0.21	8.5	0.03	4.0	0.83	0.85
1984-2002	Γ^{1977}	0.10	3.9	0.02	2.4	0.73	0.94

Fraction of Variability of IP Explained by SectorSpecific Shocks

Rank	Sector	Fraction
	A. 1972-1983 SIC ($\Theta = I$)	
1	Basic Steel and Mill Products	0.064
2	Coal Mining	0.034
3	Motor Vehicles, Trucks, and Buses	0.008
4	Utilities	0.007
5	Oil and Gas Extraction	0.005
6	Copper Ores	0.004
7	Iron and Other Ores	0.003
8	Petroleum Refining and Miscellaneous	0.003
9	Motor Vehicle Parts	0.004
10	Eelctronic Components	0.002

Fraction of Variability of IP Explained by SectorSpecific Shocks

	B. 1984-2007 NAICS ($\Theta = I$)	
1	Iron and Steel Products	0.042
2	Electric Power Generation, Transmission and Distribution	0.036
3	Semiconductors and Other electronic Components	0.026
4	Oil and Gas Extraction	0.017
5	Automobiles and Light Duty Motor Vehicles	0.017
6	Organic Chemicles	0.017
7	Aerospace Products and Parts	0.015
8	Motor Vehicle Parts	0.013
9	Natural Gas Distribution	0.012
10	Support Activities for Mining	0.011

Fraction of Variability of IP Explained by SectorSpecific Shocks

	C. 1984-2007 NAICS ($\Theta = \Theta^{1997}$)	
1	Iron and Steel Products	0.078
2	Semiconductors and Other Electronic Components	0.076
3	Electric Power Generation, Transmission and Distribution	0.046
4	Oil and Gas Extraction	0.031
5	Organic Chemicals	0.026
6	Automobiles adn Light Duty Motor Vehicles	0.024
7	Natural Gas Distribution	0.020
8	Motor Vehicle Parts	0.018
9	Support Activities for Mining	0.014
10	Other Basic Inorganic Chemicals	0.013

Conclusions

- Neither time variation in sectoral shares of IP, nor their distribution, are important factors in explaining aggregate IP variability
- Aggregate shocks largely explain variations in IP prior to 1984, and a decrease in the volatility of these shocks explain the decline in IP volatility after 1984
- Relative importance of sector-specific shocks has more than doubled over the “Great Moderation” period, from 20 percent to fully 50 percent
- Changes in the structure of the input-output matrix between 1977 and 1998 do not suggest a greater propagation of sectoral shocks
- Analysis highlights the conditions under which multisector growth models first studied by Long and Plosser (1983) admit an approximate factor representation as a reduced form