Structural Change Within Versus Across Firms: Evidence from the United States

Xiang Ding
Georgetown

Teresa C. Fort
Dartmouth Tuck & CEPR & NBER

Stephen J. Redding
Princeton & CEPR & NBER

Peter K. Schott
Yale SOM & CEPR & NBER

June 2024

Disclaimer

Any views expressed are those of the authors and not those of the U.S. Census Bureau. The Census Bureau's Disclosure Review Board and Disclosure Avoidance Officers have reviewed this information product for unauthorized disclosure of confidential information and have approved the disclosure avoidance practices applied to this release. This research was performed at a Federal Statistical Research Data Center under FSRDC Project Number 1975. (CBDRB-FY22-P1975-R9364, CBDRB-FY22-P1975-R9379, CBDRB-FY22-171)

Motivation

- US manufacturing employment declined from 27% to 9% between 1977 to 2019
- Significant policy attention on this decline and calls for protection and support
- Yet the majority of the decline occurred within continuing firms
  - 75% of decline from 1977 to 2012 occurred in continuing firms (Fort et al. 2018)
  - Real value added of manufacturing relatively stable
- These continuing firms grew their non-manufacturing employment over the period
  - Their non-manufacturing employment more than offset the manuf emp declines

This Paper

- How does structural change occur within firms?
  - Manufacturing firms transition towards related service inputs
  - Firms with in-house knowledge inputs grow and pivot more
- Why does structural change occur within firms?
  - Exploit 'China Shock' to identify relative changes in prices of firms' inputs and outputs
  - Input shock increases non-manuf employment and sales of firms with in-house knowledge
- What are the implications of structural change within firms?
  - In-house knowledge inputs are complementary with physical inputs
  - Cost reductions in physical inputs induce shifts towards knowledge inputs
  - Such reallocation is only evident for firms with in-house knowledge

Literature

- Firm dynamics and manufacturing transitions

  Jovanovic (1982); Dunne, Roberts, and Samuelson (1988); Dunne, Roberts, and Samuelson (1989); **Pakes and Ericson (1990)**; Hopenhayn (1992); Davis and Haltiwanger (1992); Doms, Dunne, and Roberts (1995); **Aw, Roberts, and Xu (2011)**; Dey, Houseman, and Polivka (2012); Berlingieri (2013); Bernard and Fort (2015); Fort, Pierce, and Schott (2018); Bernard, Smeets, and Warzynski (2017); Berlingeri and Pisch (2022)

- Effects of low-wage imports on manufacturing

  Bernard, Jensen, and Schott (2006); Autor, Dorn and Hanson (2013); Bloom, Draca, and Van Reenen (2016); Pierce and Schott (2016); Acemoglu et al. (2016); Magyari (2018); **Breinlich, Soderbury, and Wright (2018)**; **Bloom et al. (2019)**; Autor et al. (2020); **Bernard et al. (2024)** Amiti, Kong, and Weinstein (2022); Greenland et al. (2022)

- Multiproduct firms and intangibles/knowledge

  Teece (1982); Bernard, Redding, Schott (2010, 2011); **Atalay, Hortaçsu, Syverson (2014)**; Neiman and Karabarbounis (2018); Ding (2020); **Boehm, Dhingra, Morrow (2021); Argente et al. (2021)**; Crouzet at al. (2022, 2023)

Outline

- Manufacturing firms are pivoting towards (input) services
- New measure of in-house services that relates to growth and pivoting
- Effects of exogenous changes in prices of firms' inputs and outputs (China)
- Model with complementary knowledge and production inputs (not today)

Outline

- Manufacturing firms are pivoting towards (input) services
- New measure of in-house services that relates to growth and pivoting
- Effects of exogenous changes in prices of firms' inputs and outputs (China)
- Model with complementary knowledge and production inputs (not today)

Data

- Longitudinal Business Database (LBD)
  - All private, employer, non-farm establishments from 1976 to 2019
  - Longitudinal plant identifiers
  - Firm identifiers ("firmids")
  - Employment, payroll, location, industry
  - Fort-Klimek (2018) "FK" NAICS codes with additional fixes

- Economic censuses (EC)
  - All establishments every 5 years, 1977 - 2012 (sales, etc.)
  - Census of manufactures: sales by product, inputs by industry for most plants
  - Census of auxiliaries (1977 - 1997): establishments that primarily serve their firm
  - Census of services (CSR): does plant primarily serve other plants in firm?

- New panel of support establishments
  - Estabs that primarily serve their own firm, i.e., in-house service establishments (‘auxiliaries’)
  - Combined Business Register, EC Aux data, FK NAICS AUX, and CSR information

Defining manufacturing firms and continuing firms

- Census firmid definition (cross-sectional)
  - All estabs that are majority-owned by same entity have the same 'firmid'
  - We fix simple SU-MU breaks in firmid
  - Spurious longitudinal breaks still occur
- HJM firm (Haltiwanger, Jarmin, and Miranda; Business Dynamics Statistics)
  - Firm entry only if all the estabs are births
  - Firm death only if all the estabs exit

Defining manufacturing firms and continuing firms

- Census firmid definition (cross-sectional)
  - All estabs that are majority-owned by same entity have the same 'firmid'
  - We fix simple SU-MU breaks in firmid
  - Spurious longitudinal breaks still occur
- HJM firm (Haltiwanger, Jarmin, and Miranda; Business Dynamics Statistics)
  - Firm entry only if all the estabs are births
  - Firm death only if all the estabs exit
- Census manufacturing firms are those that ever have manuf estabs
  - Today: firm that ever has 1 manuf estab
  - Undisclosed: firm that ever has 50% emp, pay, or sales in manuf estabs
- HJM manufacturing firms are Census firmids that ever have manuf estabs
  - Plants carry knowledge with them from past manufacturing exposure

Employment Changes by Firm Type and Margin

	Manufacturing Employment				Non-Manufacturing Employment			
	1977	2019	Change	Share of Change	1977	2019	Change	Share of Change
Census Firmid	18	12	-6	1.00				

Employment Changes by Firm Type and Margin

	Manufacturing Employment				Non-Manufacturing Employment			
	1977	2019	Change	Share of Change	1977	2019	Change	Share of Change
Census Firmid	18	12	-6	1.00				
Continuers	6	5	-1	0.20				
Net Birth/Death	12	8	-5	0.80				

Employment Changes by Firm Type and Margin

	Manufacturing Employment				Non-Manufacturing Employment			
	1977	2019	Change	Share of Change	1977	2019	Change	Share of Change
Census Firmid	18	12	-6	1.00				
Continuers	6	5	-1	0.20				
Net Birth/Death	12	8	-5	0.80				
HJM Firm	18	12	-6	1.00				

Employment Changes by Firm Type and Margin

	Manufacturing Employment				Non-Manufacturing Employment			
	1977	2019	Change	Share of Change	1977	2019	Change	Share of Change
Census Firmid	18	12	-6	1.00				
Continuers	6	5	-1	0.20				
Net Birth/Death	12	8	-5	0.80				
HJM Firm	18	12	-6	1.00				
Continuers	11	7	-4	0.62				
Net Birth/Death	7	5	-2	0.38				

Employment Changes by Firm Type and Margin

	Manufacturing Employment				Non-Manufacturing Employment			
	1977	2019	Change	Share of Change	1977	2019	Change	Share of Change
Census Firmid	18	12	-6	1.00	13	24	11	0.16
Continuers	6	5	-1	0.20				
Net Birth/Death	12	8	-5	0.80				
HJM Firm	18	12	-6	1.00				
Continuers	11	7	-4	0.62				
Net Birth/Death	7	5	-2	0.38				

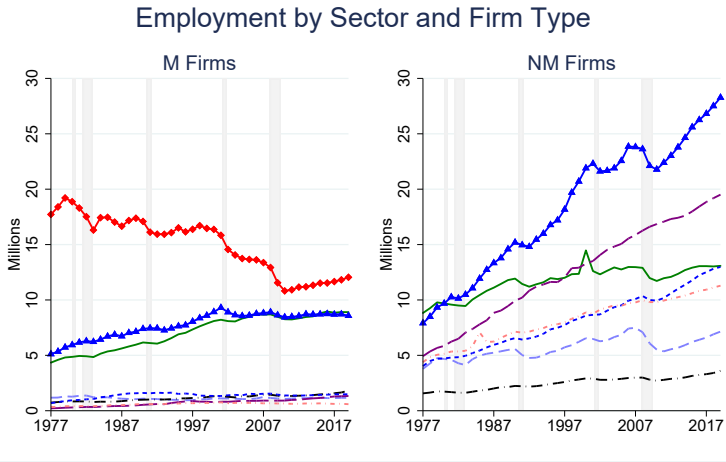
Employment Changes by Firm Type and Margin

	Manufacturing Employment				Non-Manufacturing Employment			
	1977	2019	Change	Share of Change	1977	2019	Change	Share of Change
Census Firmid	18	12	-6	1.00	13	24	11	0.16
Continuers	6	5	-1	0.20				
Net Birth/Death	12	8	-5	0.80				
HJM Firm	18	12	-6	1.00	17	40	23	0.32
Continuers	11	7	-4	0.62				
Net Birth/Death	7	5	-2	0.38				

Employment Changes by Firm Type and Margin

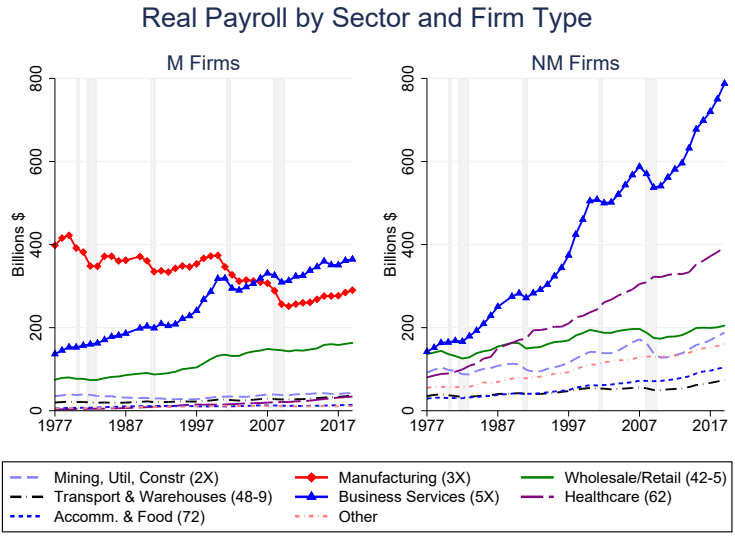
	Manufacturing Employment				Non-Manufacturing Employment			
	1977	2019	Change	Share of Change	1977	2019	Change	Share of Change
Census Firmid	18	12	-6	1.00	13	24	11	0.16
Continuers	6	5	-1	0.20	5	16	11	0.15
Net Birth/Death	12	8	-5	0.80	7	8	1	0.01
HJM Firm	18	12	-6	1.00	17	40	23	0.32
Continuers	11	7	-4	0.62	14	32	19	0.26
Net Birth/Death	7	5	-2	0.38	4	8	4	0.06

Manufacturing firms grow their non-manufacturing employment



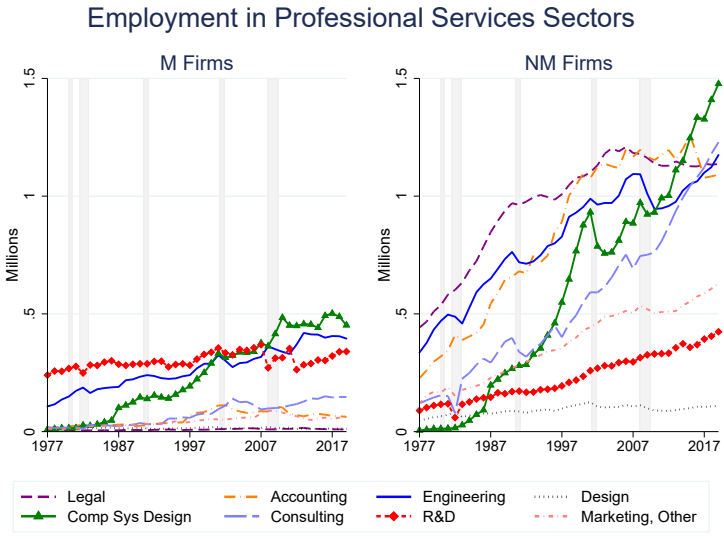
- M firms grow employment in Business Services and Wholesale/Retail

Manufacturing firms grow their non-manufacturing payroll



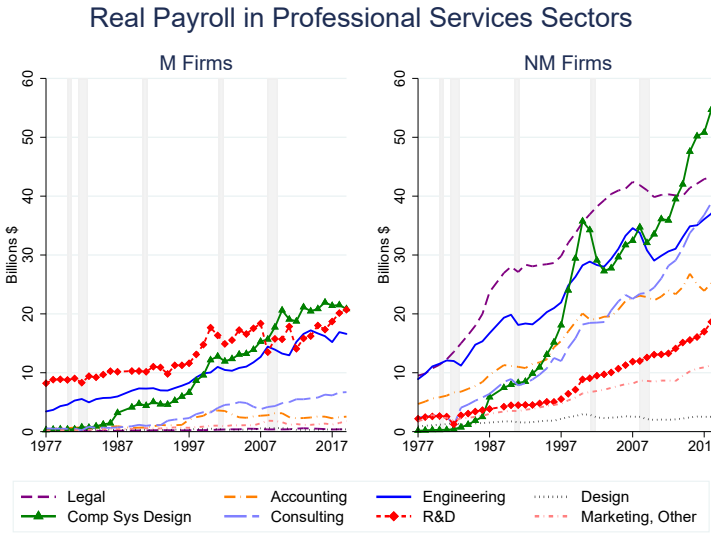
- M firms grow employment in Business Services and Wholesale/Retail

Manufacturing firms grow in a subset of Professional Services sectors



- M firms' growth concentrated in Engineering, Computer Systems Design, and R&D

Manufacturing firms grow in a subset of Professional Services sectors



- M firms' growth concentrated in Engineering, Computer Systems Design, and R&D

Continuing-firm transitions out of manufacturing from 1985 to 2018

- Transition matrix of 2018 employment shares in continuing Compustat firms by sector

Major Historic NAICS in 1985 \ Major NAICS in 2018	20	30	42	44	48	51	52	53	54	56	60	70	81
20	0.97		0.01		0.01							0.01	
30	0.02	0.98	0.07			0.23			0.34			0.02	
42			0.92								0.06		
44				1.00									
48	0.01				0.99			0.02		0.06			
51						0.64			0.01	0.02	0.06		
52		0.01					1.00	0.15					
53								0.54					
54									0.63		0.01		
56									0.03	0.92			
60										0.01	0.87		
70						0.13						0.97	
81								0.29					1.00
Total	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

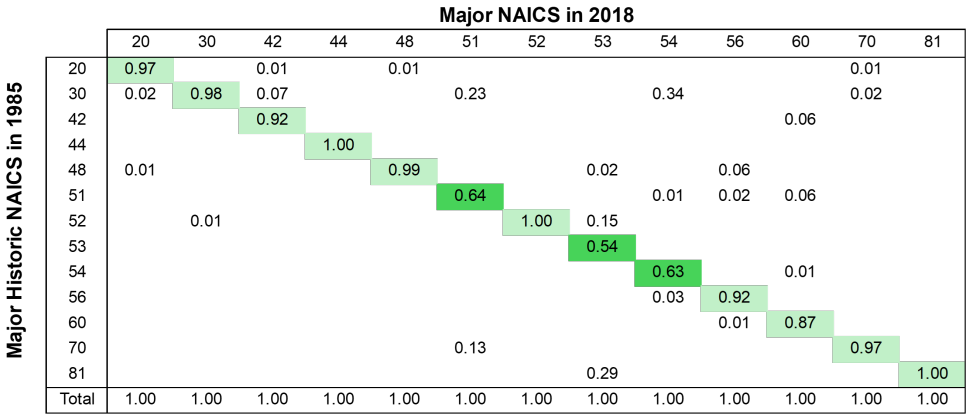
Continuing-firm transitions out of manufacturing from 1985 to 2018

- Transition matrix of 2018 employment shares in continuing Compustat firms by sector

Major Historic NAICS in 1985 \ Major NAICS in 2018	20	30	42	44	48	51	52	53	54	56	60	70	81
20	0.97		0.01		0.01							0.01	
30	0.02	0.98	0.07			0.23			0.34			0.02	
42			0.92								0.06		
44				1.00									
48	0.01				0.99			0.02		0.06			
51						0.64			0.01	0.02	0.06		
52		0.01					1.00	0.15					
53								0.54					
54									0.63		0.01		
56									0.03	0.92			
60										0.01	0.87		
70						0.13						0.97	
81								0.29					1.00
Total	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Continuing-firm transitions out of manufacturing from 1985 to 2018

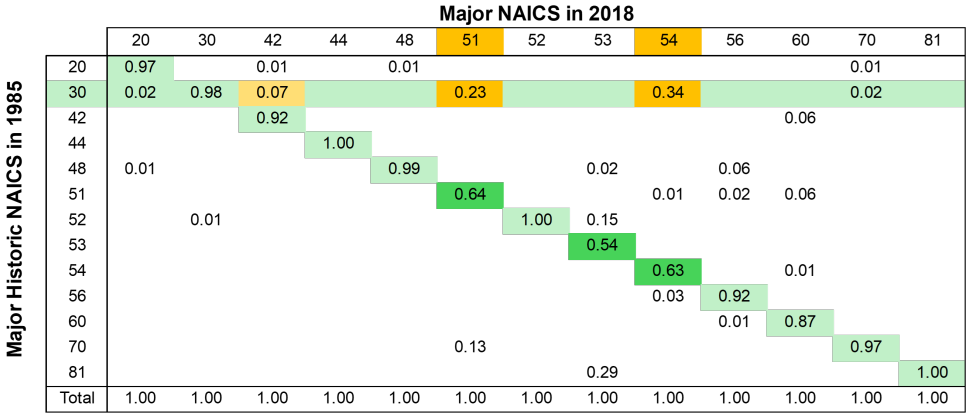
- Transition matrix of 2018 employment shares in continuing Compustat firms by sector



Major Historic NAICS in 1985	20	30	42	44	48	51	52	53	54	56	60	70	81
20	0.97		0.01		0.01							0.01	
30	0.02	0.98	0.07			0.23			0.34			0.02	
42			0.92								0.06		
44				1.00									
48	0.01				0.99			0.02		0.06			
51						0.64			0.01	0.02	0.06		
52		0.01					1.00	0.15					
53								0.54					
54									0.63		0.01		
56									0.03	0.92			
60										0.01	0.87		
70						0.13						0.97	
81								0.29					1.00
Total	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Continuing-firm transitions out of manufacturing from 1985 to 2018

- Transition matrix of 2018 employment shares in continuing Compustat firms by sector



Major Historic NAICS in 1985 \ Major NAICS in 2018	20	30	42	44	48	51	52	53	54	56	60	70	81
20	0.97		0.01		0.01							0.01	
30	0.02	0.98	0.07			0.23			0.34			0.02	
42			0.92								0.06		
44				1.00									
48	0.01				0.99			0.02		0.06			
51						0.64			0.01	0.02	0.06		
52		0.01					1.00	0.15					
53								0.54					
54									0.63		0.01		
56									0.03	0.92			
60										0.01	0.87		
70						0.13						0.97	
81								0.29					1.00
Total	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

- High 2018 employment shares in Information and Professional Services from past M firms

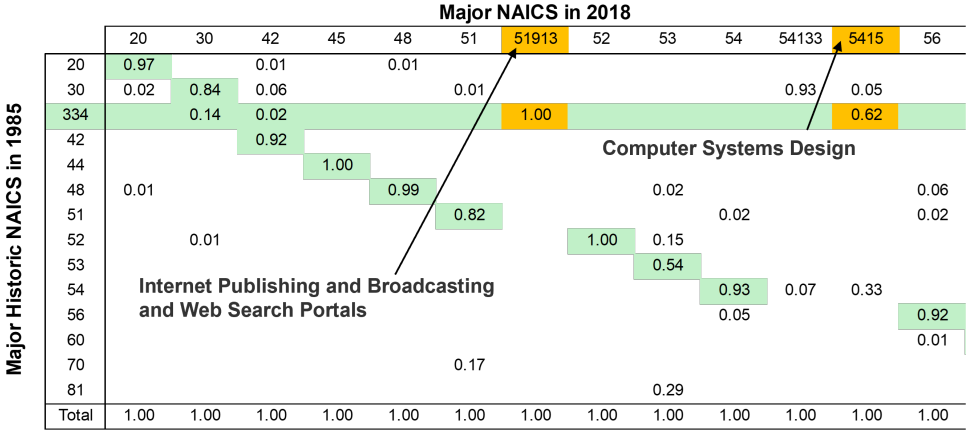
Continuing-firm transitions out of manufacturing from 1985 to 2018

- Transition matrix of 2018 employment shares in continuing Compustat firms by sector

Major Historic NAICS in 1985 \ Major NAICS in 2018	20	30	42	45	48	51	51913	52	53	54	54133	5415	56
20	0.97		0.01		0.01								
30	0.02	0.84	0.06			0.01					0.93	0.05	
334		0.14	0.02				1.00					0.62	
42			0.92										
44				1.00									
48	0.01				0.99				0.02				0.06
51						0.82				0.02			0.02
52		0.01						1.00	0.15				
53									0.54				
54										0.93	0.07	0.33	
56										0.05			0.92
60													0.01
70						0.17							
81									0.29				
Total	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Continuing-firm transitions out of manufacturing from 1985 to 2018

- Transition matrix of 2018 employment shares in continuing Compustat firms by sector

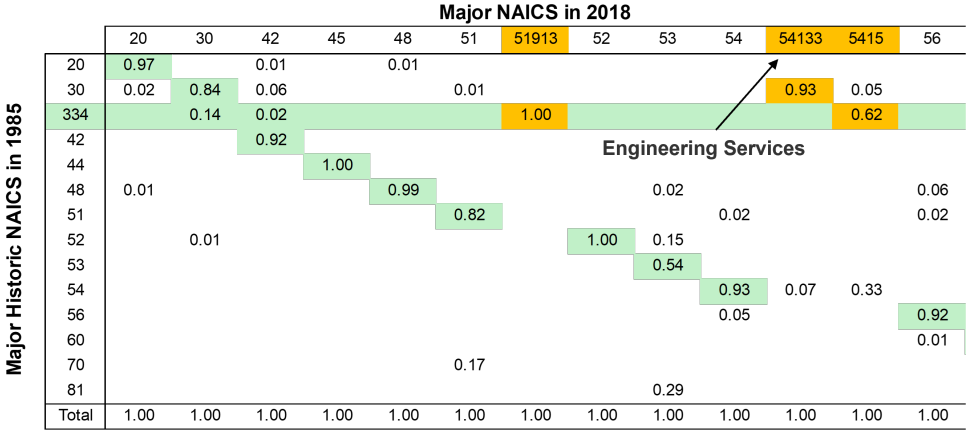


Major Historic NAICS in 1985	20	30	42	45	48	51	51913	52	53	54	54133	5415	56
20	0.97		0.01		0.01								
30	0.02	0.84	0.06			0.01					0.93	0.05	
334		0.14	0.02				1.00					0.62	
42			0.92										
44				1.00									
48	0.01				0.99				0.02				0.06
51						0.82				0.02			0.02
52		0.01						1.00	0.15				
53									0.54				
54										0.93	0.07	0.33	
56										0.05			0.92
60													0.01
70						0.17							
81									0.29				
Total	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

- Transitions suggest knowledge redeployment (IBM, Unisys)

Continuing-firm transitions out of manufacturing from 1985 to 2018

- Transition matrix of 2018 employment shares in continuing Compustat firms by sector



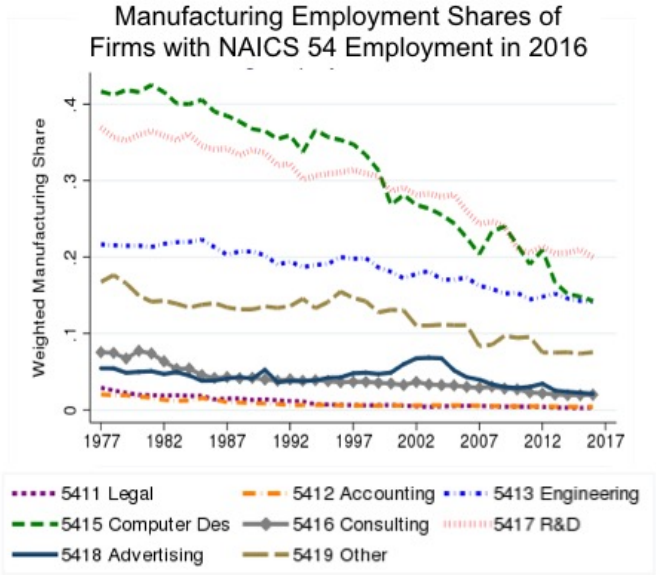
Major Historic NAICS in 1985	20	30	42	45	48	51	51913	52	53	54	54133	5415	56
20	0.97		0.01		0.01								
30	0.02	0.84	0.06			0.01					0.93	0.05	
334		0.14	0.02				1.00					0.62	
42			0.92										
44				1.00									
48	0.01				0.99				0.02				0.06
51						0.82				0.02			0.02
52		0.01						1.00	0.15				
53									0.54				
54										0.93	0.07	0.33	
56										0.05			0.92
60													0.01
70						0.17							
81									0.29				
Total	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

- Engineering Services transition from Aircraft manufacturing (McDermott)

Assess extent of transformation *within* the same firm using Census data

- Focus on *all* continuing firms with Professional Services employment in 2016
  - Calculate these firms' manufacturing employment shares in each year
  - Plot the weighted average of these shares by sector
  - Use firms' Professional Services employment in 2016 as weights

Continuing firms in Professional Services pivoted from Manufacturing



Sample is continuing firms with Prof & Tech (N54) employment in 2016

R&D and Computer Systems Design firms pivoted most from manufacturing

Think Apple, IBM

Apple: *functional* structural change

1977

2016

IBM: *sectoral* structural change

Outline

- Manufacturing firms are pivoting towards (input) services
- New measure of in-house services that relates to growth and pivoting
- Effects of exogenous changes in prices of firms' inputs and outputs (China)
- Model with complementary knowledge and production inputs (not today)

A new measure of firm intangibles: support estabs as knowledge plants

- Firm transitions from manufacturing to services suggest mutable knowledge
- In-house service estabs are a potential source/receptacle of firm knowledge
  - In-house service estabs primarily serve other establishments of their firm (e.g., an R&D lab)
  - Key idea: within-firm knowledge is excludable from other firms

A new measure of firm intangibles: support estabs as knowledge plants

- Firm transitions from manufacturing to services suggest mutable knowledge
- In-house service estabs are a potential source/receptacle of firm knowledge
  - In-house service estabs primarily serve other establishments of their firm (e.g., an R&D lab)
  - Key idea: within-firm knowledge is excludable from other firms

Target's Chief Information Officer, Mike McNamara as reported in Fierce Retail 2019:

> *By keeping the intellectual property generated by the inhouse software engineers, the company can preserve competitive advantage, McNamara told WSJ's CIO Journal. ... "If you can get advantage through shorter lead times, you don't want a third-party provider sending it to Retailer B down the road."*

A new measure of firm intangibles: support estabs as knowledge plants

- Firm transitions from manufacturing to services suggest mutable knowledge
- In-house service estabs are a potential source/receptacle of firm knowledge
  - In-house service estabs primarily serve other establishments of their firm (e.g., an R&D lab)
  - Key idea: within-firm knowledge is excludable from other firms

Firm-level Employment Shares by Sector at In-House Estabs

	All	By two-digit NAICS						
	In-House Services	48	49	51	54	55	56	81
Mean	0.173	0.001	0.012	0.001	0.012	0.138	0.007	0.002
Standard Deviation	0.191	0.022	0.063	0.025	0.072	0.173	0.058	0.034

Sample is continuing firms in each decade from 1977 to 2007 with in-house service estabs. 48 - Trucking, 49 - Warehousing, 51 - Information, 54 - Professional Services, 55 - Management, 56 - Admin, 81 - Repair

A new measure of firm intangibles: support estabs as knowledge plants

- Firm transitions from manufacturing to services suggest mutable knowledge
- In-house service estabs are a potential source/receptacle of firm knowledge
  - In-house service estabs primarily serve other establishments of their firm (e.g., an R&D lab)
  - Key idea: within-firm knowledge is excludable from other firms
- Assess role of support estabs as 'knowledge' plants that relate to growth and pivoting
  - In-house service estabs are smaller but pay higher wages within their sector
  - Firms with in-house service estabs are much larger
  - Avg firm with in-house service estabs grows 3.4 ppt in emp, 4.2 in sales, and pivots 1.6 pts more
  - In-house estabs in Warehousing, Professional Services, and Management most relevant

Summary of new facts

- A small set of continuing manufacturing firms shift into related input services
- In-house service estabs pay higher wages than other plants within the same industry
- Firm growth and pivoting are increasing in the share of in-house services employment

Outline

- Manufacturing firms are pivoting towards (input) services
- New measure of in-house services that we relate to growth and pivoting
- Effects of exogenous changes in prices of firms' inputs and outputs (China)
- Model with complementary knowledge and production inputs (not today)

How does influx of low-wage labor affect US manufacturers' activity?

- Literature has focused on decreased employment due to increased competition
- Potential for firms to restructure and reorganize
  - Lower-cost inputs may benefit US manufacturers
  - Firm organizational capital may influence these responses

Measure China's impact on US manufactures' inputs and outputs

- Exploit China's growth in world markets as an exogenous change to competition
  - Trade policy changes and Chinese productivity growth
  - Focus on 1997 to 2007 period

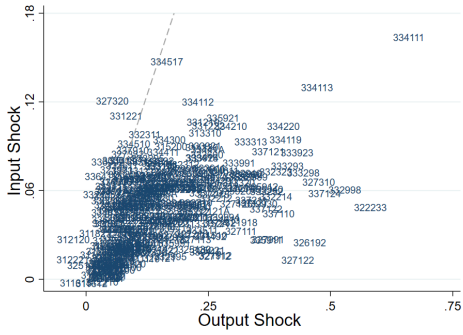
- Construct measures of output and input exposure to Chinese import competition

$$OutputShock_f = \sum_j \frac{Sales_{fj1997}}{Sales_{f1997}} \Delta ChineseMktSh_j^{EU}$$

$$InputShock_f = \sum_j \frac{Inputs_{fj1997}}{Inputs_{f1997}} \Delta ChineseMktSh_j^{EU}$$

  - $ChineseMktSh_j^{EU}$ is China's import share in Europe in industry j
  - $Inputs_{fj1997}$ is the firm's expenditure on inputs from industry j in 1997

Industry variation in Output versus Input shocks



- Output shock is positive in 91% of industries with median of 0.09
- Input shock is positive in 99% of industries with median of 0.05

Estimate reduced-form specifications of US firms' responses to exposure

- We consider long-differences for the 1997 to 2007 period

$$\Delta Outcome_f = \alpha + \beta_1 OutputShock_f + \beta_2 OutputShock_f \times \text{In-house}_f^{1997} + \beta_3 InputShock_f + \beta_4 InputShock_f \times \text{In-house}_f^{1997} + Controls_f^{1997} + \varepsilon_f$$

- Details
  - Balanced panel of firms that manufacture in 1997
  - In-house_f^{1997} is an indicator for whether the firm has in-house service estabs in 1997
  - Examine firms' total, manufacturing, and non-manufacturing employment and sales
  - Control for firm age, size ($ln(emp)$), size interacted with shocks
  - Control for manufacturing sales and cost shares, and interactions with In-house_f^{1997}
  - Use 4-digit NAICS FEs
  - Two-way cluster by main output and input industries

Reduced-form estimates of exit probabilities

Dependent variable is an indicator equal to one if firm exits between 1997 and 2007

	Census Firm Definition Exit			HJM Definition of Firm Exit		
	(1)	(2)	(3)	(4)	(5)	(6)
Output Shock	0.096	0.091	0.038	0.053	0.049	-0.074
	(0.088)	(0.088)	(0.126)	(0.068)	(0.069)	(0.099)
Output Shock × In-house$_f^{1997}$		0.244**	0.131		0.183*	0.036
		(0.113)	(0.128)		(0.102)	(0.094)
Output Shock × $ln(Emp_f^{1997})$			0.019			0.043**
			(0.027)			(0.020)
Input Shock	0.063	0.057	-0.764**	-0.046	-0.047	-0.503*
	(0.124)	(0.131)	(0.381)	(0.109)	(0.115)	(0.288)
Input Shock × In-house$_f^{1997}$		0.038	-0.499**		-0.048	-0.369*
		(0.195)	(0.218)		(0.174)	(0.193)
Input Shock × $ln(Emp_f^{1997})$			0.240**			0.134**
			(0.093)			(0.066)
R-squared	0.117	0.117	0.118	0.105	0.105	0.106
Observations	168,000	168,000	168,000	168,000	168,000	168,000

Regressions include firm-level controls for age, log number of estabs, share of sales in manufacturing, share of materials in manufacturing costs, and 4-digit NAICS fixed effects. SEs 2-way clustered by main input and output industries.

Reduced-form estimates of exit probabilities

Dependent variable is an indicator equal to one if firm exits between 1997 and 2007

	Census Firm Definition Exit			HJM Definition of Firm Exit		
	(1)	(2)	(3)	(4)	(5)	(6)
Output Shock	0.096	0.091	0.038	0.053	0.049	-0.074
	(0.088)	(0.088)	(0.126)	(0.068)	(0.069)	(0.099)
Output Shock × In-house$_f^{1997}$		0.244**	0.131		0.183*	0.036
		(0.113)	(0.128)		(0.102)	(0.094)
Output Shock × $ln(Emp_f^{1997})$			0.019			0.043**
			(0.027)			(0.020)
Input Shock	0.063	0.057	-0.764**	-0.046	-0.047	-0.503*
	(0.124)	(0.131)	(0.381)	(0.109)	(0.115)	(0.288)
Input Shock × In-house$_f^{1997}$		0.038	-0.499**		-0.048	-0.369*
		(0.195)	(0.218)		(0.174)	(0.193)
Input Shock × $ln(Emp_f^{1997})$			0.240**			0.134**
			(0.093)			(0.066)
R-squared	0.117	0.117	0.118	0.105	0.105	0.106
Observations	168,000	168,000	168,000	168,000	168,000	168,000

Regressions include firm-level controls for age, log number of estabs, share of sales in manufacturing, share of materials in manufacturing costs, and 4-digit NAICS fixed effects. SEs 2-way clustered by main input and output industries.

Reduced-form estimates of exit probabilities

Dependent variable is an indicator equal to one if firm exits between 1997 and 2007

	Census Firm Definition Exit			HJM Definition of Firm Exit		
	(1)	(2)	(3)	(4)	(5)	(6)
Output Shock	0.096	0.091	0.038	0.053	0.049	-0.074
	(0.088)	(0.088)	(0.126)	(0.068)	(0.069)	(0.099)
Output Shock × In-house$_f^{1997}$		0.244**	0.131		0.183*	0.036
		(0.113)	(0.128)		(0.102)	(0.094)
Output Shock × $ln(Emp_f^{1997})$			0.019			0.043**
			(0.027)			(0.020)
Input Shock	0.063	0.057	-0.764**	-0.046	-0.047	-0.503*
	(0.124)	(0.131)	(0.381)	(0.109)	(0.115)	(0.288)
Input Shock × In-house$_f^{1997}$		0.038	-0.499**		-0.048	-0.369*
		(0.195)	(0.218)		(0.174)	(0.193)
Input Shock × $ln(Emp_f^{1997})$			0.240**			0.134**
			(0.093)			(0.066)
R-squared	0.117	0.117	0.118	0.105	0.105	0.106
Observations	168,000	168,000	168,000	168,000	168,000	168,000

Regressions include firm-level controls for age, log number of estabs, share of sales in manufacturing, share of materials in manufacturing costs, and 4-digit NAICS fixed effects. SEs 2-way clustered by main input and output industries.

Reduced-form estimates of employment and sales changes

Dependent variable is the 1997 - 2007 DHS growth rate of the firm outcome indicated in column header

	Employment			Sales		
	Total	Manuf	Non-Manuf	Total	Manuf	Non-Manuf
Output Shock	0.324*	0.465*	0.132			
	(0.196)	(0.271)	(0.211)			
Output Shock × In-house$_f^{1997}$	-0.433**	-0.709**	-0.579**			
	(0.210)	(0.312)	(0.256)			
Output Shock × $ln(Emp_f^{1997})$	-0.115**	-0.164**	-0.018			
	(0.049)	(0.067)	(0.059)			
Input Shock	-0.067	-0.238	-0.224			
	(0.450)	(0.440)	(0.543)			
Input Shock × In-house$_f^{1997}$	0.457	0.135	1.537***			
	(0.533)	(0.510)	(0.551)			
Input Shock × $ln(Emp_f^{1997})$	0.018	0.034	0.091			
	(0.130)	(0.138)	(0.140)			
R^2	0.116	0.084	0.059			
Observations	73,500	73,500	73,500			

Regressions include firm-level controls for age, log number of estabs, share of sales in manufacturing, share of materials in manufacturing costs, and 4-digit NAICS fixed effects. SEs 2-way clustered by main input and output industries.

Reduced-form estimates of employment and sales changes

Dependent variable is the 1997 - 2007 DHS growth rate of the firm outcome indicated in column header

	Employment			Sales		
	Total	Manuf	Non-Manuf	Total	Manuf	Non-Manuf
Output Shock	0.324*	0.465*	0.132			
	(0.196)	(0.271)	(0.211)			
Output Shock × In-house$_f^{1997}$	-0.433**	-0.709**	-0.579**			
	(0.210)	(0.312)	(0.256)			
Output Shock × $ln(Emp_f^{1997})$	-0.115**	-0.164**	-0.018			
	(0.049)	(0.067)	(0.059)			
Input Shock	-0.067	-0.238	-0.224			
	(0.450)	(0.440)	(0.543)			
Input Shock × In-house$_f^{1997}$	0.457	0.135	1.537***			
	(0.533)	(0.510)	(0.551)			
Input Shock × $ln(Emp_f^{1997})$	0.018	0.034	0.091			
	(0.130)	(0.138)	(0.140)			
R^2	0.116	0.084	0.059			
Observations	73,500	73,500	73,500			

Regressions include firm-level controls for age, log number of estabs, share of sales in manufacturing, share of materials in manufacturing costs, and 4-digit NAICS fixed effects. SEs 2-way clustered by main input and output industries.

Reduced-form estimates of employment and sales changes

Dependent variable is the 1997 - 2007 DHS growth rate of the firm outcome indicated in column header

	Employment			Sales		
	Total	Manuf	Non-Manuf	Total	Manuf	Non-Manuf
Output Shock	0.324*	0.465*	0.132	0.615**	0.875***	0.075
	(0.196)	(0.271)	(0.211)	(0.237)	(0.318)	(0.195)
Output Shock × In-house$_f^{1997}$	-0.433**	-0.709**	-0.579**	-0.192	-0.591*	-0.250
	(0.210)	(0.312)	(0.256)	(0.210)	(0.338)	(0.391)
Output Shock × $ln(Emp_f^{1997})$	-0.115**	-0.164**	-0.018	-0.201***	-0.283***	0.009
	(0.049)	(0.067)	(0.059)	(0.060)	(0.077)	(0.054)
Input Shock	-0.067	-0.238	-0.224	-0.163	-0.322	0.229
	(0.450)	(0.440)	(0.543)	(0.569)	(0.662)	(0.438)
Input Shock × In-house$_f^{1997}$	0.457	0.135	1.537***	0.031	-0.128	1.619***
	(0.533)	(0.510)	(0.551)	(0.481)	(0.502)	(0.598)
Input Shock × $ln(Emp_f^{1997})$	0.018	0.034	0.091	0.020	0.045	-0.026
	(0.130)	(0.138)	(0.140)	(0.169)	(0.194)	(0.111)
R^2	0.116	0.084	0.059	0.077	0.069	0.067
Observations	73,500	73,500	73,500	73,500	73,500	73,500

Regressions include firm-level controls for age, log number of estabs, share of sales in manufacturing, share of materials in manufacturing costs, and 4-digit NAICS fixed effects. SEs 2-way clustered by main input and output industries.

Reduced-form estimates of employment and sales changes

Dependent variable is the 1997 - 2007 DHS growth rate of the firm outcome indicated in column header

	Employment			Sales		
	Total	Manuf	Non-Manuf	Total	Manuf	Non-Manuf
Output Shock	0.324*	0.465*	0.132	0.615**	0.875***	0.075
	(0.196)	(0.271)	(0.211)	(0.237)	(0.318)	(0.195)
Output Shock × In-house$_f^{1997}$	-0.433**	-0.709**	-0.579**	-0.192	-0.591*	-0.250
	(0.210)	(0.312)	(0.256)	(0.210)	(0.338)	(0.391)
Output Shock × $ln(Emp_f^{1997})$	-0.115**	-0.164**	-0.018	-0.201***	-0.283***	0.009
	(0.049)	(0.067)	(0.059)	(0.060)	(0.077)	(0.054)
Input Shock	-0.067	-0.238	-0.224	-0.163	-0.322	0.229
	(0.450)	(0.440)	(0.543)	(0.569)	(0.662)	(0.438)
Input Shock × In-house$_f^{1997}$	0.457	0.135	1.537***	0.031	-0.128	1.619***
	(0.533)	(0.510)	(0.551)	(0.481)	(0.502)	(0.598)
Input Shock × $ln(Emp_f^{1997})$	0.018	0.034	0.091	0.020	0.045	-0.026
	(0.130)	(0.138)	(0.140)	(0.169)	(0.194)	(0.111)
R^2	0.116	0.084	0.059	0.077	0.069	0.067
Observations	73,500	73,500	73,500	73,500	73,500	73,500

Regressions include firm-level controls for age, log number of estabs, share of sales in manufacturing, share of materials in manufacturing costs, and 4-digit NAICS fixed effects. SEs 2-way clustered by main input and output industries.

Reduced-form estimates of employment and sales changes

Dependent variable is the 1997 - 2007 DHS growth rate of the firm outcome indicated in column header

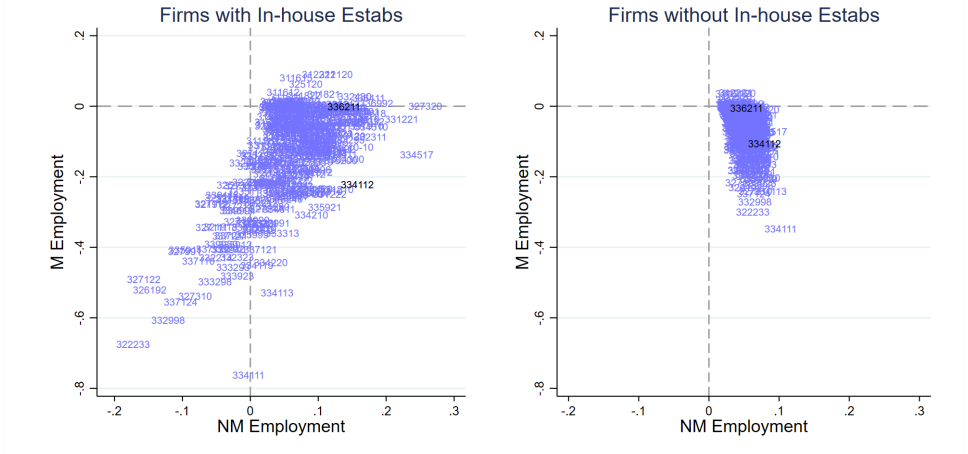
	Employment			Sales		
	Total	Manuf	Non-Manuf	Total	Manuf	Non-Manuf
Output Shock	0.324*	0.465*	0.132	0.615**	0.875***	0.075
	(0.196)	(0.271)	(0.211)	(0.237)	(0.318)	(0.195)
Output Shock × In-house$_f^{1997}$	-0.433**	-0.709**	-0.579**	-0.192	-0.591*	-0.250
	(0.210)	(0.312)	(0.256)	(0.210)	(0.338)	(0.391)
Output Shock × $ln(Emp_f^{1997})$	-0.115**	-0.164**	-0.018	-0.201***	-0.283***	0.009
	(0.049)	(0.067)	(0.059)	(0.060)	(0.077)	(0.054)
Input Shock	-0.067	-0.238	-0.224	-0.163	-0.322	0.229
	(0.450)	(0.440)	(0.543)	(0.569)	(0.662)	(0.438)
Input Shock × In-house$_f^{1997}$	0.457	0.135	1.537***	0.031	-0.128	1.619***
	(0.533)	(0.510)	(0.551)	(0.481)	(0.502)	(0.598)
Input Shock × $ln(Emp_f^{1997})$	0.018	0.034	0.091	0.020	0.045	-0.026
	(0.130)	(0.138)	(0.140)	(0.169)	(0.194)	(0.111)
R^2	0.116	0.084	0.059	0.077	0.069	0.067
Observations	73,500	73,500	73,500	73,500	73,500	73,500

Regressions include firm-level controls for age, log number of estabs, share of sales in manufacturing, share of materials in manufacturing costs, and 4-digit NAICS fixed effects. SEs 2-way clustered by main input and output industries.

Predicted effects on M vs NM differ by industry

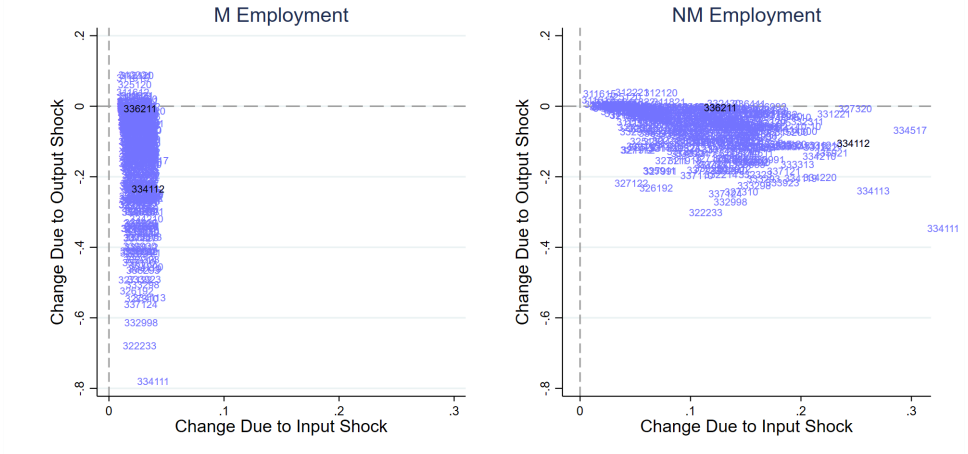
- Use coefficients for a firm with 500 workers and in-house services employment
- Construct input shock for representative firm using IO tables (not actual firm's input use)
- Example 1: Computer Storage Device Manufacturing Firm
  - Output shock of 0.18, input shock of 0.12
  - M emp decrease of 23 log points from output shock
  - NM emp decrease of 10 pts from output shock, 23 log point increase from input shock
- Example 2: Motor Vehicle Body Manufacturing Firm
  - Output shock of 0.005, input shock of 0.056
  - M employment flat
  - NM emp increases by 10 log points from input shock
- Firms in both industries pivot from M to NM

Predicted log changes in M versus NM employment



- Estimates for a ‘representative’ firm with 500 workers
- Estimates imply M declines, while NM mostly rises (especially for firms w/in-house)

Predicted log employment changes for firms with in-house services



- Estimates for a ‘representative’ firm with 500 workers
- Output shocks generally reduce M, while input shocks increase NM

Reduced-form estimates of imports and pivoting

Dependent variable is the 1997 - 2007 in firm's:

	Import	Pivoting	
	Growth	Sales	Emp
Output Shock	-0.108	-0.152	-0.138
	-0.327	-0.220	-0.219
Output Shock × In-house$_f^{1997}$	-1.521***	0.209**	0.212**
	(0.289)	(0.098)	(0.103)
Output Shock × $ln(Emp_f^{1997})$	0.076	0.055	0.051
	(0.077)	(0.036)	(0.037)
Input Shock	1.42	0.409	0.380
	(1.443)	(0.451)	(0.459)
Input Shock × In-house$_f^{1997}$	1.473***	0.098	0.181
	(0.515)	(0.175)	(0.178)
Input Shock × $ln(Emp_f^{1997})$	-0.399	-0.101	-0.092
	(0.302)	(0.103)	(0.106)
R^2	0.1	0.087	0.081
Observations	73,500	73,500	73,500

Regressions include firm-level controls for age, log number of estabs, share of sales in manufacturing, share of materials in manufacturing costs, and 4-digit NAICS fixed effects. SEs 2-way clustered by main input and output industries.

Conclusion

- New link between globalization and US shift towards knowledge-input services
- Coefficient estimates on inputs imply that NM and M inputs are complementary
  - But only for firms with in-house support estabs
  - Broader implications for studies on productivity and firm dynamics
- Firm transitions suggest that firm boundaries serve to accumulate knowledge
  - Firms with inhouse estabs are more exposed to output shocks
  - Firms with inhouse estabs are able to transform in response to input shocks

Appendix

Non-Manufacturing Employment Changes of NM Firms by Firm Margin

Employment in non-manufacturing estabs (millions)

		1977	2019	Change	Share of All NM Change	Share of NM Firms' Change
NM Census Firms		35	96	60	0.84	1.00
Census Firmid	Continuers	6	18	13	0.18	0.21
	Net Birth/Death	30	78	48	0.67	0.79
NM HJM Firms		31	80	49	0.68	1.00
HJM Firm	Continuers	7	19	11	0.16	0.23
	Net Birth/Death	24	61	38	0.52	0.77

- NM firms are those that never have an M plant
- Census versus HJM firm margins are comparable

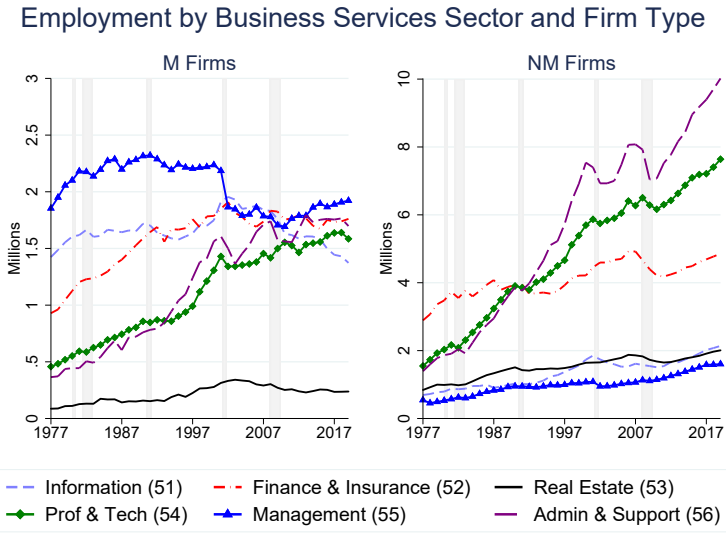
Manufacturing Payroll Changes by Firm Type

Payroll in manufacturing estabs (billions of 1982$)

		1977	2019	Change	Share of Change
M Firms		398	290	-108	1.00
Census Firmid	Continuers	147	121	-26	0.24
	Net Birth/Death	251	169	-81	0.76
HJM Firm	Continuers	270	188	-82	0.76
	Net Birth/Death	128	103	-26	0.24

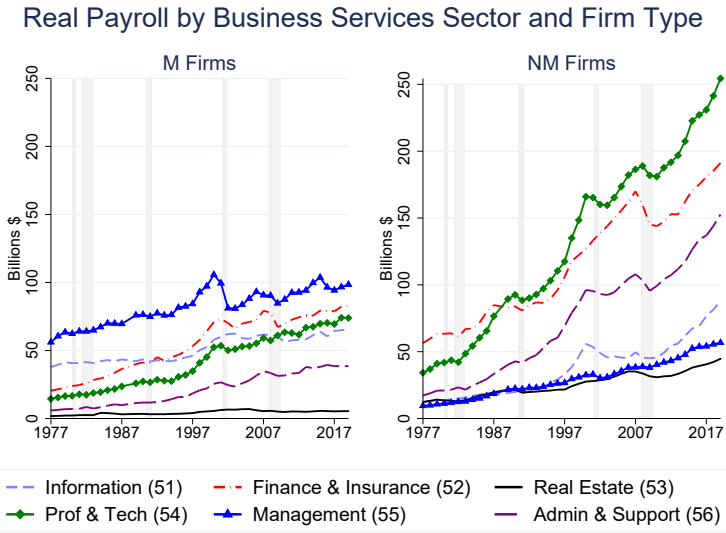
- M firms are those that ever have an M plant

Manufacturing firms' employment across Business Services sectors



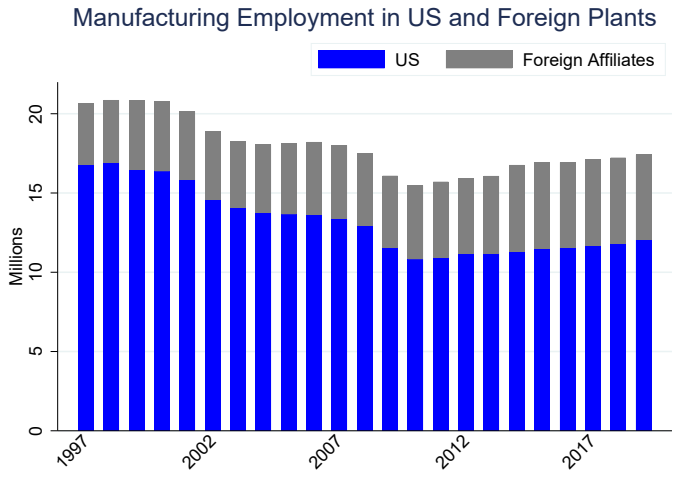
- Professional Services (N54) and Management (N55) are key sectors

Manufacturing firms' payroll across Business Services sectors



- Professional Services (N54) and Management (N55) are key sectors

Total manufacturing employment in US plants and foreign affiliates



- Including foreign affiliate manufacturing employment does not change aggregate pattern

Employment in Regression Sample Relative to Economy Totals

	M Employment				NM Employment			
	1997		Δ 1997-2007		1997		Δ 1997-2007	
	Level	Share	Level	Share	Level	Share	Level	Share
Firms in Regression Sample	10.00	0.61	-0.77	0.26	8.75	0.10	3.90	0.20
Firms without Auxiliaries in 1997	3.85	0.24	0.26	-0.09	0.29	0.00	0.41	0.02
Firms with Auxiliaries in 1997	6.15	0.38	-1.03	0.34	8.45	0.10	3.49	0.18
Firms Outside Regression Sample	6.38	0.39	-2.24	0.74	78.04	0.90	15.59	0.80
Economy Total	16.38	1.00	-3.01	1.00	86.79	1.00	19.49	1.00

Regression sample contains 73,500 continuing firms with *M* employment in 1997, of which 3,600 have an auxiliary establishment. Administrative Records from the Census of Manufactures are excluded from the regression sample since all their sales and input purchases are imputed. Employment is in millions.

Sample summary statistics

	Mean	Standard Deviation
Output Shock	0.1438	0.0904
Output Shock $\times Aux_f^{1997}$	0.0037	0.0242
Output Shock $\times ln(Emp_f^{1997})$	0.4699	0.3476
Input Shock	0.0614	0.0425
Input Shock $\times Aux_f^{1997}$	0.0024	0.0152
Input Shock $\times ln(Emp_f^{1997})$	0.2102	0.1780
Aux_f^{1997}	0.0487	0.2151
$ln(Emp_f^{1997})$	3.4340	1.3480
Output Share, η_f	0.9623	0.1547
Input Share, λ_f^*	0.5162	0.2138

Additional regression outcomes

	Import	Pivoting	
	Growth	Sales	Emp
Output Shock	-0.108	-0.152	-0.138
	-0.327	-0.220	-0.219
Output Shock $\times Aux_f^{1997}$	-1.521***	0.209**	0.212**
	(0.289)	(0.098)	(0.103)
Output Shock $\times ln(Emp_f^{1997})$	0.076	0.055	0.051
	(0.077)	(0.036)	(0.037)
Input Shock	1.42	0.409	0.380
	(1.443)	(0.451)	(0.459)
Input Shock $\times Aux_f^{1997}$	1.473***	0.098	0.181
	(0.515)	(0.175)	(0.178)
Input Shock $\times ln(Emp_f^{1997})$	-0.399	-0.101	-0.092
	(0.302)	(0.103)	(0.106)
R^2	0.1	0.087	0.081
Observations	73,500	73,500	73,500

Employment growth in M and NM by firm type

	"Census Firms" (Lower Bound)							
	Manufacturing Emp				Non-Manufacturing Emp			
	1977	2019	Change	Share of Change	1977	2019	Change	Share of Change
M Firms	17.7	12.1	-5.7	1.00				
NM Firms								
Total	17.7	12.1	-5.7	1.00				

- M firms are those that ever have an M plant

Employment growth in M and NM by firm type

	"Census Firms" (Lower Bound)							
	Manufacturing Emp				Non-Manufacturing Emp			
	1977	2019	Change	Share of Change	1977	2019	Change	Share of Change
M Firms	17.7	12.1	-5.7	1.00	12.6	23.9	11.3	0.16
NM Firms					35.4	95.9	60.5	0.84
Total	17.7	12.1	-5.7	1.00	48.0	119.8	71.7	1.00

- M firms are those that ever have an M plant
- M firms account for 16% of US NM employment growth (25% in payroll)

Employment growth in M and NM by firm type

	"Census Firms" (Lower Bound)							
	Manufacturing Emp				Non-Manufacturing Emp			
	1977	2019	Change	Share of Change	1977	2019	Change	Share of Change
M Firms	17.7	12.1	-5.7	1.00	12.6	23.9	11.3	0.16
Continuers	5.6	4.5	-1.1	0.20	5.3	15.9	10.6	0.15
Net Birth/Death	12.1	7.5	-4.6	0.80	7.3	7.9	0.7	0.01
NM Firms					35.4	95.9	60.5	0.84
Total	17.7	12.1	-5.7	1.00	48.0	119.8	71.7	1.00

- M firms are those that ever have an M plant
- Continuing M firms are $< 1\%$ of firms and account for 15% of NM growth

Employment growth in M and NM by firm type

	"Census Firms" (Lower Bound)							
	Manufacturing Emp				Non-Manufacturing Emp			
	1977	2019	Change	Share of Change	1977	2019	Change	Share of Change
M Firms	17.7	12.1	-5.7	1.00	12.6	23.9	11.3	0.16
Continuers	5.6	4.5	-1.1	0.20	5.3	15.9	10.6	0.15
Net Birth/Death	12.1	7.5	-4.6	0.80	7.3	7.9	0.7	0.01
NM Firms					35.4	95.9	60.5	0.84
Continuers					5.6	18.2	12.6	0.18
Net Birth/Death					29.8	77.7	47.9	0.67
Total	17.7	12.1	-5.7	1.00	48.0	119.8	71.7	1.00

- M firms are those that ever have an M plant
- NM firms' growth driven by net births

Plant-year-level premia regressions for support estabs

	$ln(emp_{ijt})$		$ln(sales_{ijt})$		$ln(wage_{ijt})$	
In-house$_{ijt}$	0.764***	-0.078***	0.970***	-0.158***	0.383***	0.064***
	(0.027)	(0.021)	(0.025)	(0.021)	(0.016)	(0.011)
Adj. R-Squared	0.22	0.84	0.24	0.86	0.35	0.95
Observations (000s)	4,389	4,389	4,389	4,389	4,389	4,389
Firm Age & Size	No	Yes	No	Yes	No	Yes

Regressions include plant age, industry, year, and FIPS fixed effects.
Sample is all estabs in support industries, for Economic Census years from 1977 - 2012.

- In-house estabs pay higher wages relative to other plants in the same 6-digit NAICS
  - Consistent with support estabs employing higher skill workers

Firm-level in-house estab growth premia regressions, decades 1977 - 2007

	$\Delta ln(emp_{ft})$		$\Delta ln(sales_{ft})$		$Pivot_{ft}$	
In-house$_{ft}$	0.00	-0.048***	-0.011	-0.086***	0.002	-0.013***
	(0.007)	(0.009)	(0.009)	(0.010)	(0.003)	(0.003)
In-house Emp Share$_{ft}$		0.472***		0.738***		0.149***
		(0.045)		(0.059)		(0.016)
Implied Average Effect		3.4 ppt		4.2 ppt		1.6 ppt
Adj. R-Squared	0.09	0.09	0.06	0.06	0.11	0.11
Observations (M)	3.9	3.9	3.9	3.9	3.9	3.9

Regressions control for firm size, age, number of estabs, and N2 employment shares.
Regressions include industry and year FEs.
Sample is all firms in each decade from 1977 to 2007.

- Define pivoting as $Pivot_{it} = -\sum_{j \in i} min\left(\frac{e_{itj}}{\sum_j e_{itj}}, \frac{e_{it'j}}{\sum_j e_{it'j}}\right)$, where e represents employment
- Driven by in-house estabs in Warehousing, Professional Services, and Management

Outline

- Manufacturing firms are pivoting towards (input) services
- New measure of in-house services that we relate to growth and pivoting
- Effects of exogenous changes in prices of firms' inputs and outputs (China)
- Model with complementary knowledge and production inputs

Simple model of structural transformation within firms

- Goal: model that captures within-firm structural change in response to shocks
- Setting
  - Discrete number of final-good sectors indexed by j
  - Continuum of firms each pay fixed cost for $\mathcal{J}$ productivity draws φ_{fj} (Bernard et al. 2011)
  - Constant marginal costs that depend on knowledge and manufacturing inputs:

$$\frac{1}{\theta_f}\gamma_{fj} = \frac{1}{\theta_f}\left[\left(w^S\right)^{1-\mu_j} + \left(\frac{\left(w^P\right)^{\beta_j}\left(Q_j\right)^{1-\beta_j}}{\varphi_{fj}}\right)^{1-\mu_j}\right]^{\frac{1}{1-\mu_j}}$$

Simple model of structural transformation within firms

- Goal: model that captures within-firm structural change in response to shocks
- Setting
  - Discrete number of final-good sectors indexed by j
  - Continuum of firms each pay fixed cost for $\mathcal{J}$ productivity draws φ_{fj} (Bernard et al. 2011)
  - Constant marginal costs that depend on knowledge and manufacturing inputs:

$$\frac{1}{\theta_f}\gamma_{fj} = \frac{1}{\theta_f}\left[\left(w^S\right)^{1-\mu_j} + \left(\frac{\left(w^P\right)^{\beta_j}\left(Q_j\right)^{1-\beta_j}}{\varphi_{fj}}\right)^{1-\mu_j}\right]^{\frac{1}{1-\mu_j}}$$

- Knowledge and manufacturing are complementary inputs ($0 < \mu_j < 1$)
  - w^S and w^P are service (i.e., knowledge) and production worker wages
  - Firms can produce knowledge in-house or purchase on the market
  - Q_j is the cost of intermediate inputs

Simple model of structural transformation within firms

- Goal: model that captures within-firm structural change in response to shocks
- Setting
  - Discrete number of final-good sectors indexed by j
  - Continuum of firms each pay fixed cost for $\mathcal{J}$ productivity draws φ_{fj} (Bernard et al. 2011)
  - Constant marginal costs that depend on knowledge and manufacturing inputs:

$$\frac{1}{\theta_f}\gamma_{fj} = \frac{1}{\theta_f}\left[\left(w^S\right)^{1-\mu_j} + \left(\frac{\left(w^P\right)^{\beta_j}\left(Q_j\right)^{1-\beta_j}}{\varphi_{fj}}\right)^{1-\mu_j}\right]^{\frac{1}{1-\mu_j}}$$

- Knowledge and manufacturing are complementary inputs ($0 < \mu_j < 1$)
  - w^S and w^P are service (i.e., knowledge) and production worker wages
  - Firms can produce knowledge in-house or purchase on the market
  - Q_j is the cost of intermediate inputs
- θ_f is firm's intangible knowledge capital that depends on in-house knowledge workers

Firm choice on in-house knowledge production

- Firms can outsource knowledge or produce it in-house
  - In-house knowledge confers a sector-neutral productivity advantage $\theta_f > 1$
  - In-house knowledge requires endogenous fixed cost paid by employing $F_s + \psi \left(\theta_f^{\xi} - 1\right)$ knowledge workers, else $\theta_f = 1$
- In-house knowledge workers therefore represent both fixed and variable costs
  - Fixed-cost portion is non-rival across sectors
  - Marginal-cost portion is complementary with manufacturing production

Takeaways from model

- Self-selection of more productive firms into in-house knowledge services
- Sectoral structural change occurs within and across firms in response to demand shocks
- Shocks to input costs induce functional structural change for firms with in-house knowledge