

# Colocation of Production and Innovation: Evidence from the United States

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## Motivation

- In the US, manufacturers traditionally have performed the majority of innovation
- Declining US manufacturing employment has raised concerns that innovation will decline
  - Less resources available for innovation
  - Innovation will follow physical production
- Other research (Bloom et al. 2020) finds that ideas seem to be getting harder to find

## Main questions

- How has US innovation evolved over time?
- Does innovation depend on the co-location of R&D and physical production?
- If so, which form of colocation matters most?
  - Within geographic borders?
  - Within firm boundaries?
  - Within both?

## Why shocks to manufacturing may affect innovation

- Complementarities between production and R&D?
  - Face-to-face interactions about feasibility, prototypes, etc?
- Gains from reallocation?
  - Lower production costs, e.g., from offshoring, allow reallocation towards R&D?
  - Agglomeration benefits from knowledge spillovers and labor pooling of R&D in cities?

## Main findings

- Shift in US patenting to non-manufacturing firms (*NMFs*) over time
- Former manufacturers firms (*FMFs*) continue innovating
- Firms containing manufacturing (*M*) and innovation (*P*) plants patent more
- Within *MP* firms, patenting is ( $\approx 12\%$ ) greater if they are within 5 miles
- *MP* firms' *M* and *P* plants are spreading out over time
- *Future plans*
  - *Does patenting occur within co-located plants?*
  - *Why is the distance between co-located plants changing?*

## Related literature

- Economic geography of innovation and production
  - Jaffe et al. (1993); Audretsch and Feldman (1996); Duranton and Puga (2001); Ellison, Glaeser, Kerr (2010); Pisano and Shih (2012); Buzard and Carlino (2013); Tecu (2013); Alcacer and Delgado (2016); Buzard et al. (2017); Lan (2019); Davis and Dingel (2019); Delgado (2020); Berkes et al. (2020)
- Evolution of manufacturers and innovators
  - Bloom et al. (2015); Bernard and Fort (2015); Bernard et al. (2017); Fort (2017); Kamal (2018); Fort et al. (2018); Ding et al. (2019); Autor et al. (*forthcoming*);
- Innovation and offshoring
  - Naghavi and Ottaviano (2009); Rodriguez-Clare (2010); Fuchs and Kirchain (2010); Fuchs (2014); Bøler et al. (2015); Arkolakis et al. (2018); Bilir and Morales (2020) ; Bernard et al. (2020)

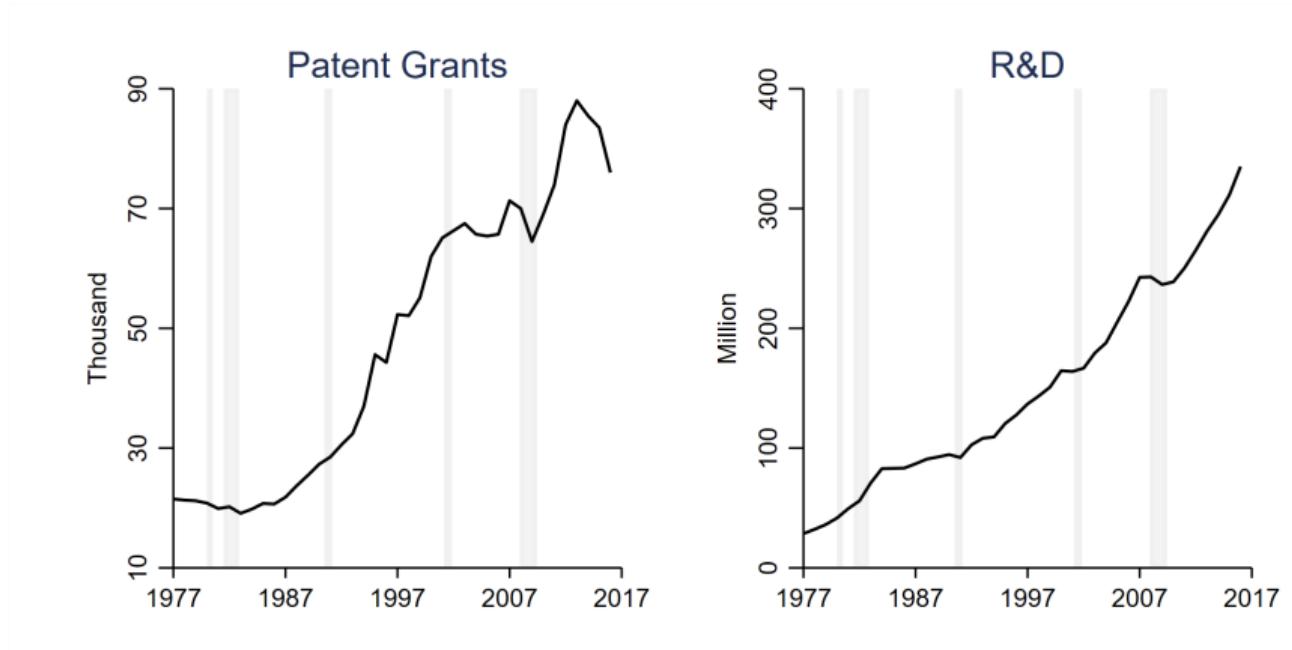
# Outline of Talk

- Portrait of US innovation
- Do firms with both manufacturing and innovation plants patent differently?
- Within firms with both types of plants, does spatial proximity matter?
- *Future plans*

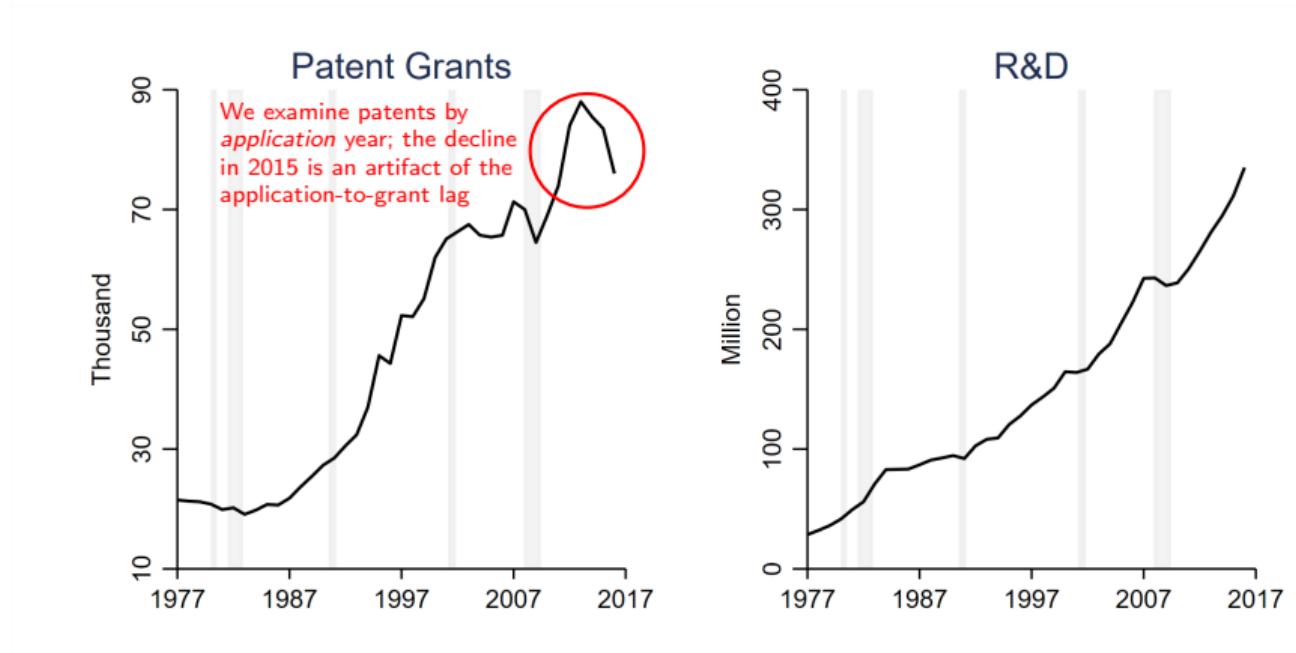
## New dataset on US innovation from 1977 to 2016

- Longitudinal Business Database, 1977-2016
  - Every private, non-farm employer establishment
  - Consistent establishment-level NAICS classification (Fort and Klimek 2018)
- Business Register, 1977-2016
  - Geocodes (addresses, latitude and longitude)
- Economic Censuses, 1977(5)2012
  - Establishment-level sales, inputs, etc. for manuf, wholesale, retail, and services
- Longitudinal foreign trade transactions database, 1992-2016
  - Firm-level import and export transactions
- USPTO PatentView database, 1973-2018
  - Name and address matching to firms and firm-city-states in LBD
  - Identify manufacturing and processing patents
- SIRD and BRDIS R&D surveys, 1977-2016

# US innovation grows over the last 40 years



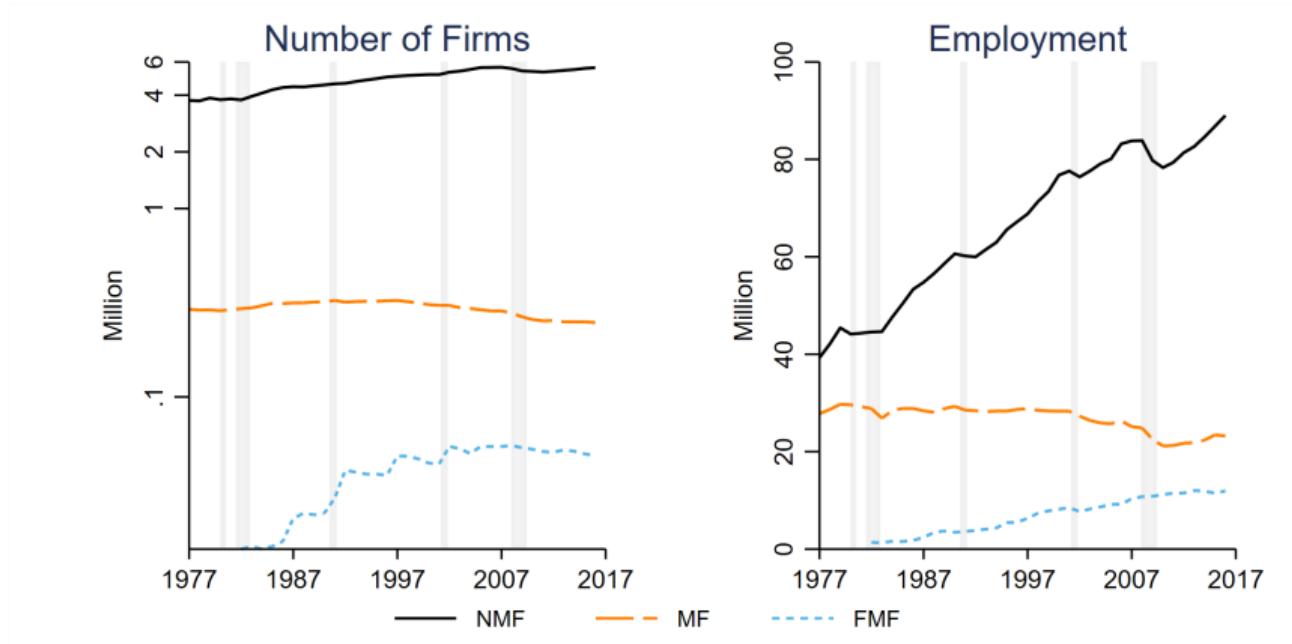
# US innovation grows over the last 40 years



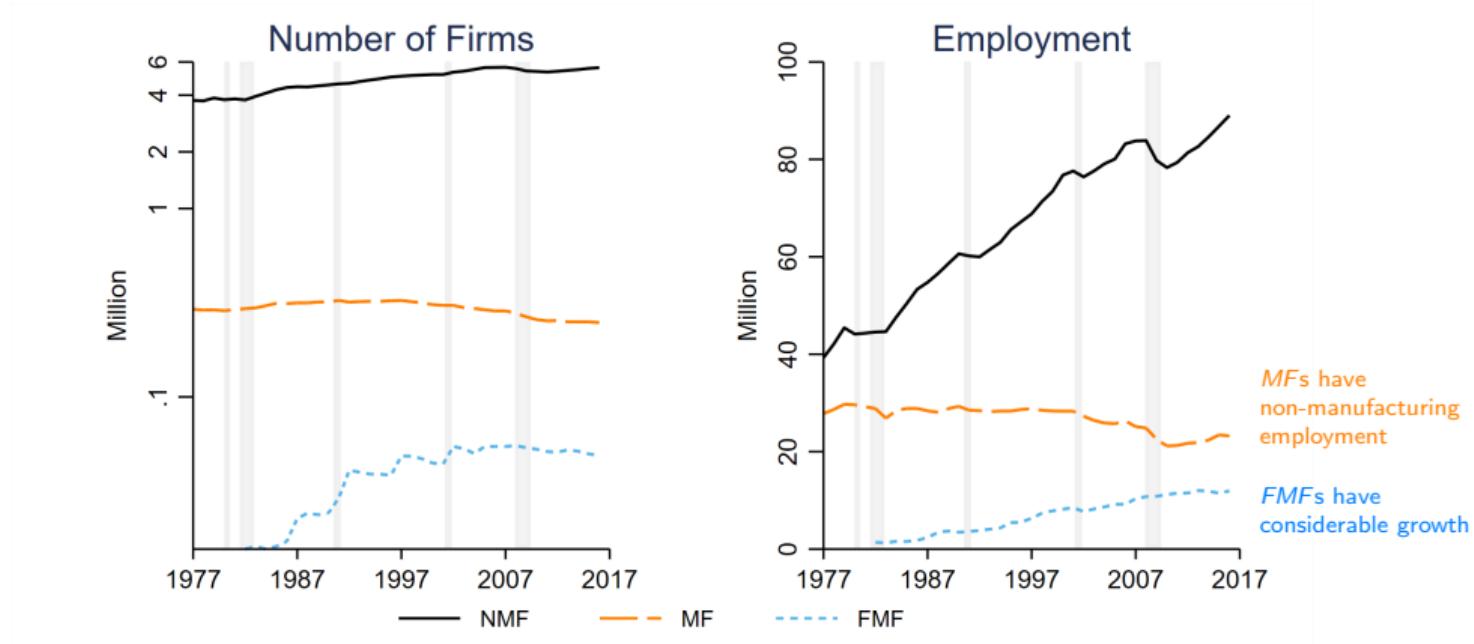
## We decompose patents by firm *type*

- Classify firms into 3 mutually-exclusive types for each year  $t$ 
  - $MF$ : manufacturing firm ( $\geq 1$  manufacturing plant in year  $t$ )
  - $NMF$ : non-manufacturing firm (0 manufacturing plants up to  $t$ )
  - $FMF$ : former manufacturing firm ( $\geq 1$  manufacturing plant prior to  $t$ ; 0 in  $t$ )
- Note
  - By definition,  $NMF$  can later switch into  $MF$  but not back (rare)
  - We later focus on a subset of  $MFs$ ,  $MP$  firms, which have both manufacturing ( $M$ ) and innovation ( $P$ ) plants within their boundaries

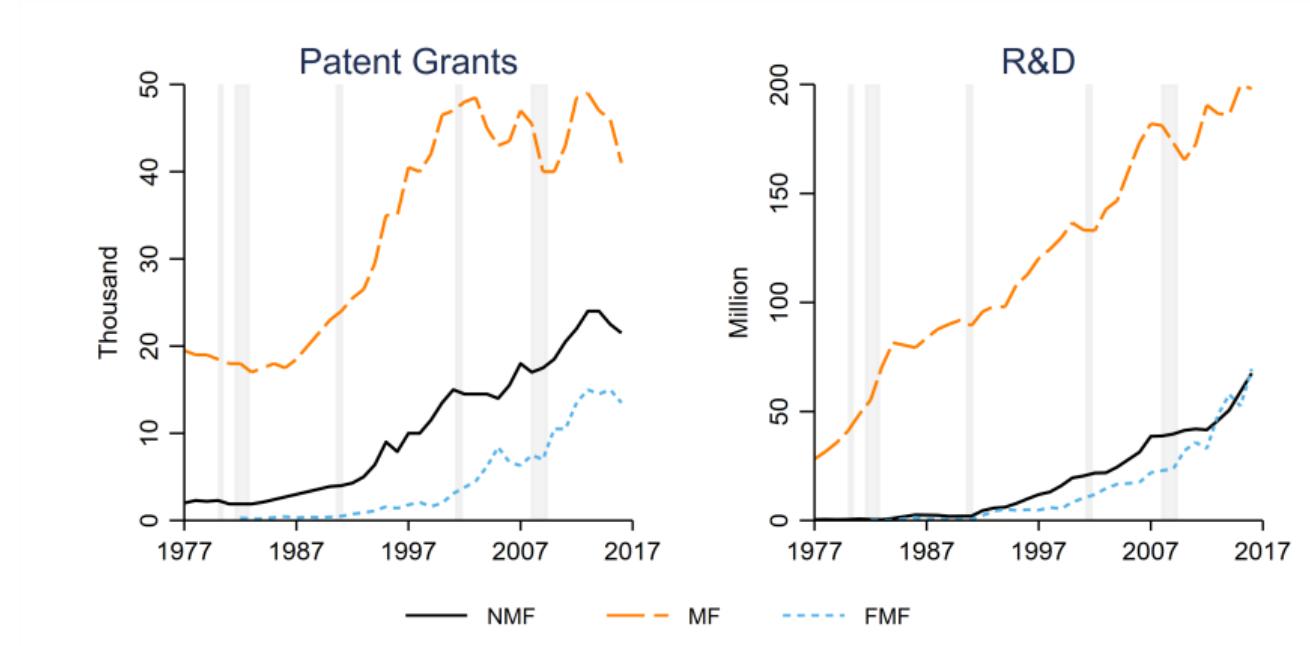
## *NMFs* and *FMFs* dominate firms and employment



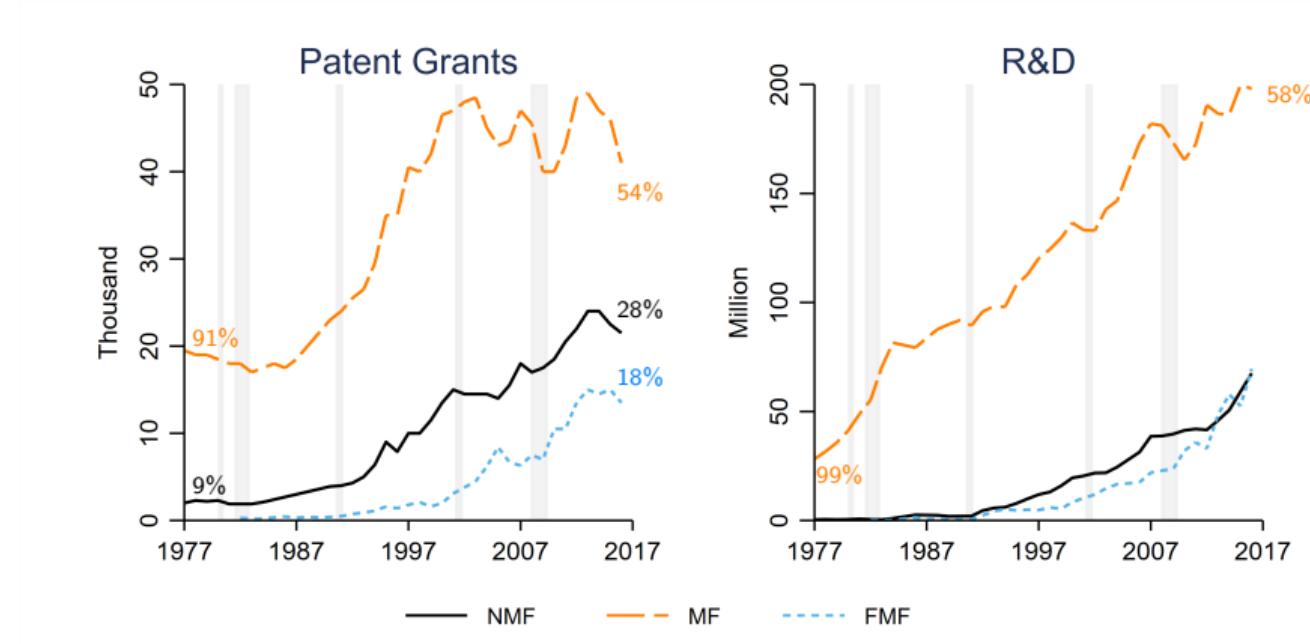
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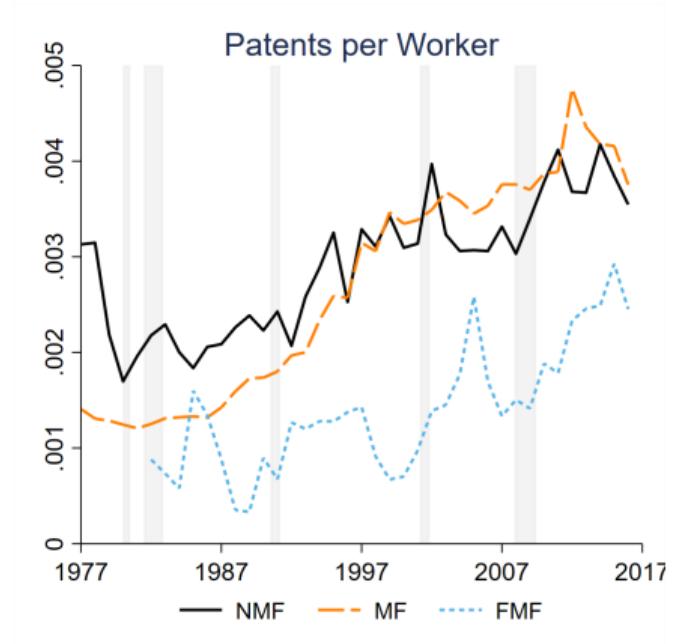
# MFs dominate US innovation



# MFs dominate US innovation



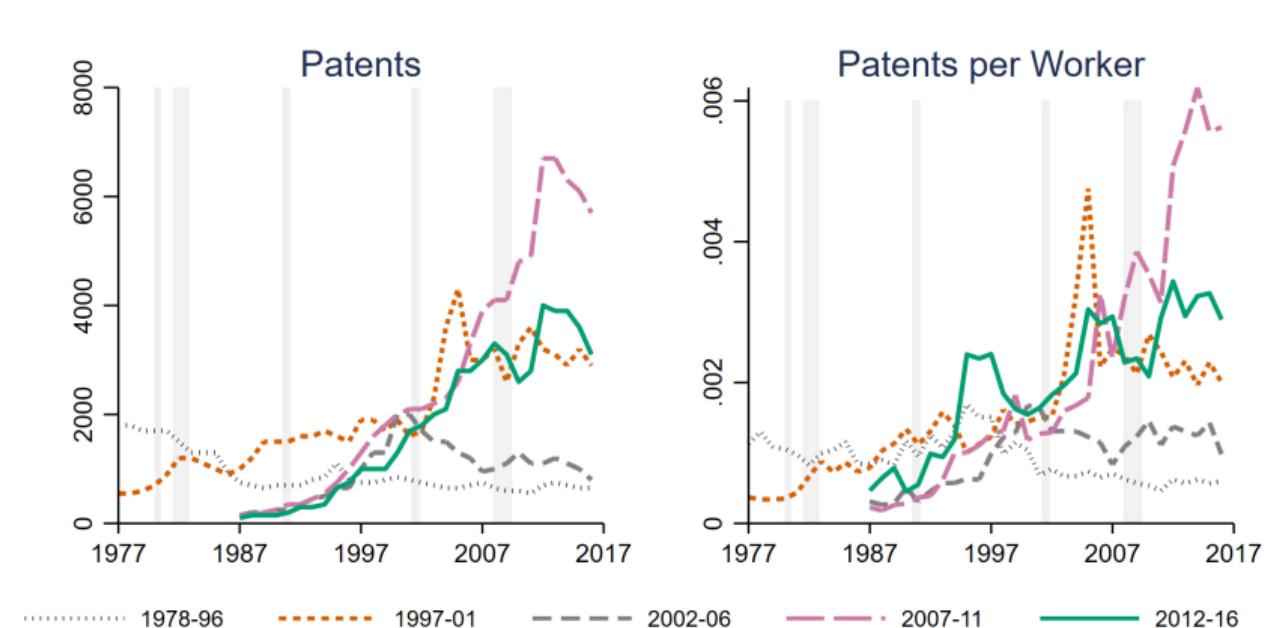
## Patent efficiency by firm type (vs Bloom et al. 2020)



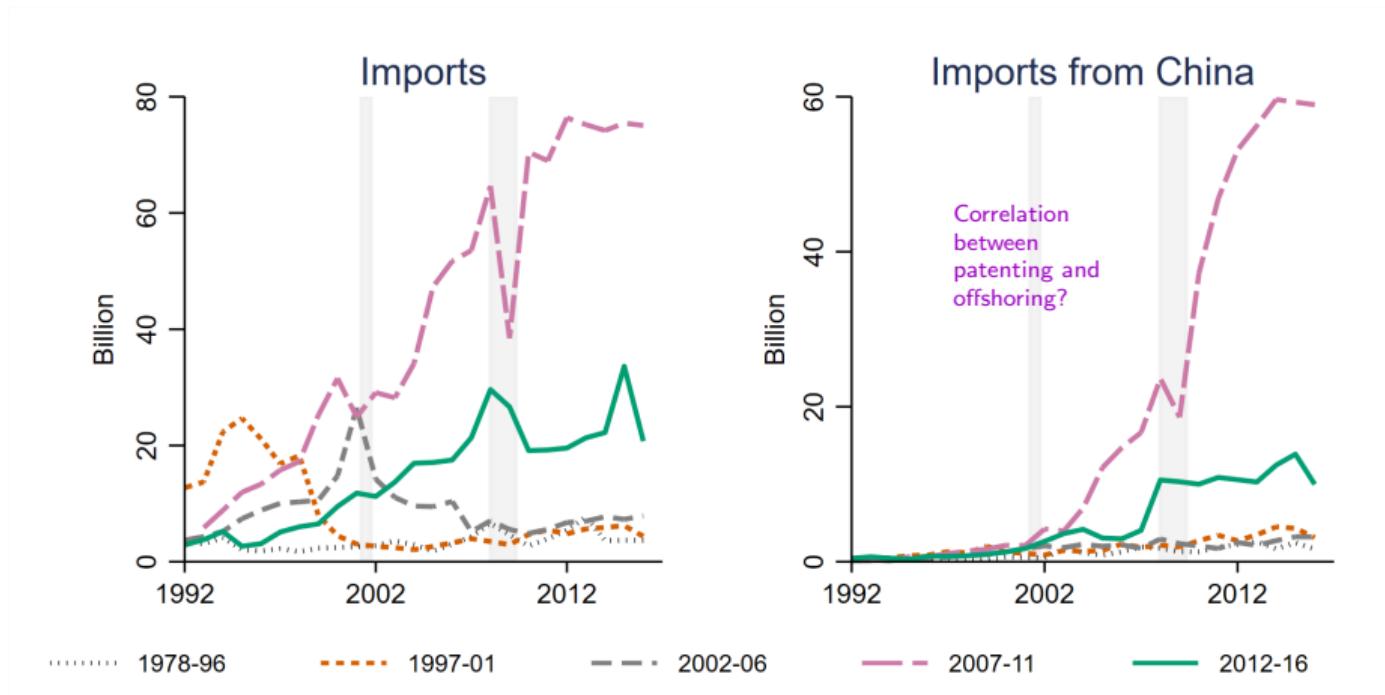
## *Permanent* former manufacturing firms

- A *permanent FMF* in year  $t$  is one that does not have a  $M$  plant after  $t$
- We group permanent *FMFs* by the year in which they leave
  - 1978-1996
  - 1997-2001
  - 2002-2011
  - 2007-2011
  - 2012-2016

## *Permanent* FMFs' patents differ by cohort



## *Permanent* FMFs' import growth driven by post-2007 cohorts



## Summary of new facts

- Manufacturing firms' dominance of innovation has declined substantially
- Some recent cohorts of former manufacturing firms continue patenting intensively
- Imports by patenting firms suggestive of offshoring

# Outline of Talk

- Portrait of US innovation
- Do firms with both manufacturing and innovation plants patent differently?
- Within firms with both types of plants, does spatial proximity matter?
- *Future plans*

## Example: Bristol Meyers Squibb, North America



Source: Google Maps and author's calculations. Locations of BMS North American facilities are publicly available at <https://www.bms.com/about-us/our-company/worldwide-facilities.html>.

## Identifying innovation (*P*) establishments

- How to identify *P* establishments?
- We classify establishments with the following activities as *P* plants
  - NAICS 5417: Scientific Research and Development Services (i.e., R&D labs)
  - NAICS 551114: Corporate, Subsidiary, and Regional Managing Offices (i.e., HQs)
  - NAICS 5413-5416: Professional Scientific and Technical Services
  - NAICS 5112, 517, 518: Information and Telecommunications
- Descriptive regressions
  - (1) How does firm patenting vary with the presence of *both M* and *P* plants within the firm?
  - (2) Within *MP* firms, how does patenting vary with the spatial proximity of *M* and *P* plants?
  - (3) Does *MP* firm patenting occur in their spatially located *M-P* plants?

► NAICS

## Firm patenting and the presence of both $M$ and $P$ plants within the firm

$$\ln(\tilde{y}_{ft}) = \gamma_1 M_{ft} + \gamma_2 P_{ft} + \gamma_3 M_{ft} \times P_{ft} + \\ \gamma_4 FMF_{ft} + \gamma_5 FMF_{ft} \times P_{ft} + \\ \beta X_{ft} + \alpha_t + \alpha_c + \varepsilon_{fct}$$

- $\ln(\tilde{y}_{ft})$ : log number of patents granted to firm  $f$  applied for in years  $t:t+4$  ( $\sinh^{-1}$  transform)
- $M_{ft}, P_{ft}$ : indicators that firm  $f$  has a  $M$  or  $P$  plant in year  $t$
- $FMF_{ft}$ : indicator that firm  $f$  is a former manufacturing firm in  $t$
- $X_{ft}$ : time-varying firm size and age controls
- $\alpha_t, \alpha_c$ : year and county fixed effects
- **Omitted category**: firms with no  $M$  or  $P$  estabs in year  $t$
- **Sample**:  $MP$  firms, Census years ending in "2" and "5" from 1977 to 2012

# Patenting is highest for firms with both *M* and *P* plants

Dependent variable is  $\ln(\text{Patents}_{f,t:t+4})$ : firm  $f$ 's total patent grants applied for in years  $t:t+4$

	(1)	(2)	(3)	(4)	(5)	(6)
$M_{ft}$	0.0374*** (0.0003)			0.0149*** (0.0009)		
$P_{ft}$	0.0172*** (0.0004)			0.0047*** (0.0006)		
$M_{ft} \times P_{ft}$	0.665*** (0.0132)			0.147*** (0.0082)		
$FMF_{ft}$						
$FMF_{ft} \times P_{ft}$						
$Emp_{ft}, Age_{ft}$	Yes			Yes		
FIPS FEs	Yes			Yes		
Year FEs	Yes			Yes		
Firm FEs	No			Yes		
R-squared	0.152			0.742		
N (millions)	27			27		

Notes: Dependent variables is the  $\sinh^{-1}$  transform of firm's patents of the sum of subsequently granted patents applied for by firm  $f$  in years  $t$  to  $t+4$ , with mean and standard deviation of 0.0074 and 0.1360. Standard errors clustered by firm. \*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ .

# Patenting is highest for firms with both *M* and *P* plants

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$M_{ft} \times P_{ft}$	0.665*** (0.0132)			0.147*** (0.0082)		
$FMF_{ft}$						→ Firms patent 15% more when they have both <i>M</i> and <i>P</i> plants versus when they don't
$FMF_{ft} \times P_{ft}$						
$Emp_{ft}, Age_{ft}$	Yes			Yes		
FIPS FEes	Yes			Yes		
Year FEes	Yes			Yes		
Firm FEes	No			Yes		
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	(1)	(2)	(3)	(4)	(5)	(6)
$M_{ft}$	0.0374*** (0.0003)	0.0376*** (0.0004)		0.0149*** (0.0009)	0.0179*** (0.001)	
$P_{ft}$	0.0172*** (0.0004)	0.0172*** (0.0004)		0.0047*** (0.0006)	0.0047*** (0.0006)	
$M_{ft} \times P_{ft}$	0.665*** (0.0132)	0.665*** (0.0133)		0.147*** (0.0082)	0.147*** (0.0082)	
$FMF_{ft}$		0.0046* (0.0024)			0.0081*** (0.0019)	→ <i>FMFs</i> patent more than <i>non-FMFs</i>
$FMF_{ft} \times P_{ft}$						
$Emp_{ft}, Age_{ft}$	Yes	Yes		Yes	Yes	
FIPS FEes	Yes	Yes		Yes	Yes	
Year FEes	Yes	Yes		Yes	Yes	
Firm FEes	No	No		Yes	Yes	
R-squared	0.152	0.152		0.742	0.742	
N (millions)	27	27		27	27	

Notes: Dependent variables is the  $\sinh^{-1}$  transform of firm's patents of the sum of subsequently granted patents applied for by firm  $f$  in years  $t$  to  $t+4$ , with mean and standard deviation of 0.0074 and 0.1360. Standard errors clustered by firm. \*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ .

# Patenting is highest for firms with both *M* and *P* plants

Dependent variable is  $\ln(\text{Patents}_{f,t:t+4})$ : firm  $f$ 's total patent grants applied for in years  $t:t + 4$

	(1)	(2)	(3)	(4)	(5)	(6)
$M_{ft}$	0.0374*** (0.0003)	0.0376*** (0.0004)	0.0365*** (0.0003)	0.0149*** (0.0009)	0.0179*** (0.001)	0.0174*** (0.001)
$P_{ft}$	0.0172*** (0.0004)	0.0172*** (0.0004)	-0.213*** (0.0206)	0.0047*** (0.0006)	0.0047*** (0.0006)	-0.0199 (0.0126)
$M_{ft} \times P_{ft}$	0.665*** (0.0132)	0.665*** (0.0133)	0.707*** (0.0149)	0.147*** (0.0082)	0.147*** (0.0082)	0.154*** (0.0090)
$FMF_{ft}$		0.0046* (0.0024)	-0.016*** (0.0015)		0.0081*** (0.0019)	0.0061*** (0.0016)
$FMF_{ft} \times P_{ft}$			0.231*** (0.0206)			0.0247* (0.0127)
<i>Emp<sub>ft</sub>, Age<sub>ft</sub></i>	Yes	Yes	Yes	Yes	Yes	Yes
FIPS FE <sub>s</sub>	Yes	Yes	Yes	Yes	Yes	Yes
Year FE <sub>s</sub>	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE <sub>s</sub>	No	No	No	Yes	Yes	Yes
R-squared	0.152	0.152	0.153	0.742	0.742	0.742
N (millions)	27	27	27	27	27	27

→ The *FMF* result  
is driven by their  
having *P* plants

Notes: Dependent variables is the  $\sinh^{-1}$  transform of firm's patents of the sum of subsequently granted patents applied for by firm  $f$  in years  $t$  to  $t + 4$ , with mean and standard deviation of 0.0074 and 0.1360. Standard errors clustered by firm. \*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ .

# Patenting is highest for firms with both *M* and *P* plants

Dependent variable is  $\ln(\text{Patents}_{f,t:t+4})$ : firm  $f$ 's total patent grants applied for in years  $t:t+4$

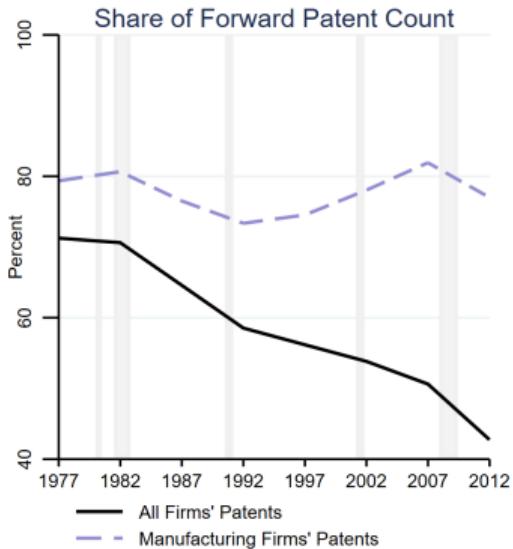
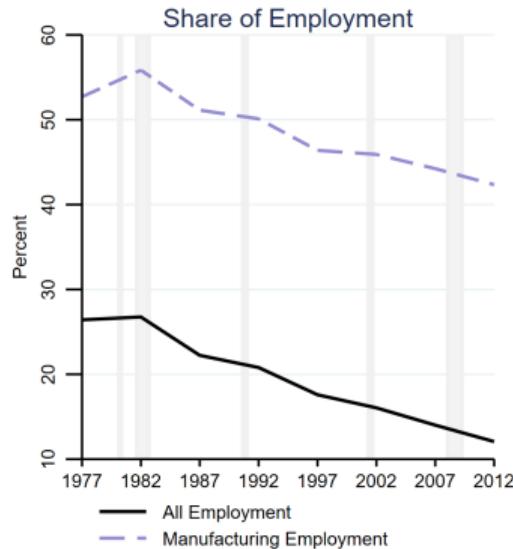
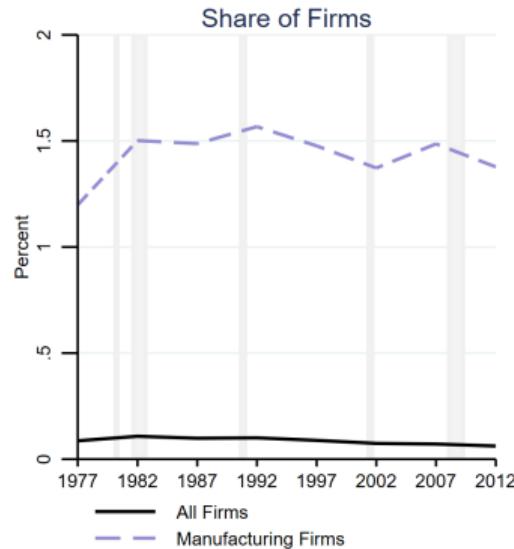
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$M_{ft}$	0.0374*** (0.0003)	0.0376*** (0.0004)	0.0365*** (0.0003)	0.0149*** (0.0009)	0.0179*** (0.001)	0.0174*** (0.001)
$P_{ft}$	0.0172*** (0.0004)	0.0172*** (0.0004)	-0.213*** (0.0206)	0.0047*** (0.0006)	0.0047*** (0.0006)	-0.0199 (0.0126)
$.8M_{ft} \times P_{ft}$	0.665*** (0.0132)	0.665*** (0.0133)	0.707*** (0.0149)	0.147*** (0.0082)	0.147*** (0.0082)	0.154*** (0.0090)
$FMF_{ft}$		0.0046* (0.0024)	-0.016*** (0.0015)		0.0081*** (0.0019)	0.0061*** (0.0016)
$FMF_{ft} \times P_{ft}$			0.231*** (0.0206)			0.0247* (0.0127)
$Emp_{ft}, Age_{ft}$	Yes	Yes	Yes	Yes	Yes	Yes
FIPS FEes	Yes	Yes	Yes	Yes	Yes	Yes
Year FEes	Yes	Yes	Yes	Yes	Yes	Yes
Firm FEes	No	No	No	Yes	Yes	Yes
R-squared	0.152	0.152	0.153	0.742	0.742	0.742
N (millions)	27	27	27	27	27	27

Notes: Dependent variables is the  $\sinh^{-1}$  transform of firm's patents of the sum of subsequently granted patents applied for by firm  $f$  in years  $t$  to  $t+4$ s, with mean and standard deviation of 0.0074 and 0.1360. Standard errors clustered by firm. \*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ .

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- Portrait of US innovation
- Do firms with both  $M$  and  $P$  plants patent differently?
- Within  $MP$  firms, does spatial proximity matter?
- *Future plans*

## MP firms are a minority but dominate patenting



## Measuring the spatial proximity of $M$ and $P$ *within* firms

- Use geocodes (latitude and longitude) to measure
  - $dist_{ft}^{avg}$ : average distance between plants within firms, in miles
  - $dist_{ft}^{min}$ : minimum distance between plants within firms, in miles
  - Examine the median and average of these firm-level measures
- In a future draft we hope to examine
  - Colocation within plants
  - Colocation across firms

## Colocation of *MP* firms' *M* and *P* plants

	$dist_{ft}^{min}$	
	Mean	Median
1977	95	3
1982	115	4
1987	120	5
1992	141	6
1997	153	6
2002	139	5
2007	142	5
2012	137	6

*Note:* Distances are in miles.

## Colocation of *MP* firms' *M* and *P* plants

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	Mean	Median
1977	95	3
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2007	142	5
2012	137	6

The median firm has at least one pair of very close *M* and *P* establishments

*Note:* Distances are in miles.

## Colocation of *MP* firms' *M* and *P* plants

	$dist_{ft}^{min}$		$dist_{ft}^{avg}$	
	Mean	Median	Mean	Median
1977	95	3	445	301
1982	115	4	457	322
1987	120	5	470	336
1992	141	6	487	359
1997	153	6	502	381
2002	139	5	501	387
2007	142	5	498	383
2012	137	6	517	416

*Note:* Distances are in miles.

# Colocation of *MP* firms' *M* and *P* plants

	$dist_{ft}^{min}$		$dist_{ft}^{avg}$	
	Mean	Median	Mean	Median
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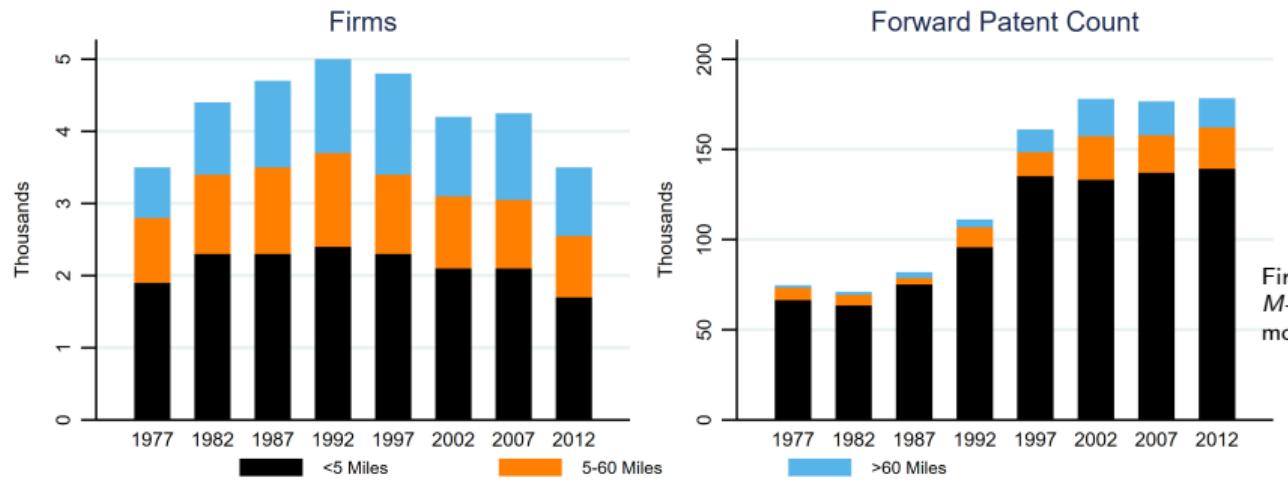
*Note:* Distances are in miles.

Average distances are much larger than minimums.

Distances grow over time, but the minimum distance stays small

We create three  $dist_{ft}^{min}$  bins for our regressions:  
<5 miles  
5-60 miles  
>60 miles

# Distribution of *MP* firms and their patents by $dist_{ft}^{min}$ bins



Firms with closest  
*M-P* plants patent  
most

## *MP* firm patenting and *M-P* plant distance

$$\ln(\tilde{y}_{ft}) = \delta_1 [dist_{ft}^{min} \in (0, 5)] + \delta_2 [dist_{ft}^{min} \in (5, 60)] + \gamma \ln(PatentStock_{f,t-1}^{dep}) + \beta X_{ft} + \alpha_t + \alpha_c + \varepsilon_{fct}$$

- $\ln(\tilde{y}_{ft})$ : log number of patents granted to firm  $f$  applied for in years  $t:t+4$  ( $\sinh^{-1}$  transform)
- $\ln(\tilde{y}_{ft})$ :  $\sinh^{-1}$  transform of firm's granted patents applied for in  $t:t+4$
- $dist_{ft}^{min}$ : indicators for the minimum distance between firm's  $M$  and  $P$  plants
- $\ln(PatentStock_{f,t-1}^{dep})$ : firm's depreciated and 1-year lagged patent stock
- $X_{ft}$ : time-varying firm size and age controls
- $\alpha_t, \alpha_c$ : year and county fixed effects
- **Omitted category**:  $MP$  firms with  $M$  and  $P$  plants over 60 miles apart
- **Sample**:  $MP$  firms, Census years ending in "2" and "5" from 1977 to 2012

## *MP* firm patenting is higher when *M* and *P* estabs are closer

Dependent variable is: $\ln(\text{Patents}_{f,t:t+4})$				
	(1)	(2)	(3)	(4)
$dist_{ft}^{\min} \in (0, 5)$	0.131*** (0.0284)	0.149*** (0.0300)	0.0201 (0.0131)	0.116*** (0.0279)
$dist_{ft}^{\min} \in (5, 60)$	-0.0230 (0.0303)	0.0984*** (0.0298)	0.00690 (0.0148)	0.0764*** (0.0281)
$\ln(\text{Patent Stock}_{f,t-1}^{\text{dep}})$			0.833*** (0.00526)	0.278*** (0.0148)
$Emp_{ft}, Age_{ft}$	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
FIPS Fixed Effects	Yes	Yes	Yes	Yes
Firm Fixed Effects	No	Yes	No	Yes
R-Squared	0.401	0.875	0.787	0.881
Observations	34,500	34,500	34,500	34,500

Notes: Dependent variables is the  $\sinh^{-1}$  transform of firm's patents of the sum of subsequently granted patents applied for by firm  $f$  in years  $t$  to  $t + 4$ , with mean and std deviation of 1.114 and 1.768. Standard errors clustered by firm. \*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$

# *MP* firm patenting is higher when *M* and *P* estabs are closer

Dependent variable is: $\ln(\text{Patents}_{f,t:t+4})$					
	(1)	(2)	(3)	(4)	
$dist_{ft}^{\min} \in (0, 5)$	0.131*** (0.0284)	0.149*** (0.0300)	0.0201 (0.0131)	0.116*** (0.0279)	→ Firms patent 12% more when $dist_{ft}^{\min}$ is very small
$dist_{ft}^{\min} \in (5, 60)$	-0.0230 (0.0303)	0.0984*** (0.0298)	0.00690 (0.0148)	0.0764*** (0.0281)	→ A bit less when it is a bit larger
$\ln(\text{Patent Stock}_{f,t-1}^{\text{dep}})$			0.833*** (0.00526)	0.278*** (0.0148)	
<i>Emp<sub>ft</sub>, Age<sub>ft</sub></i>	Yes	Yes	Yes	Yes	
Year Fixed Effects	Yes	Yes	Yes	Yes	
FIPS Fixed Effects	Yes	Yes	Yes	Yes	
Firm Fixed Effects	No	Yes	No	Yes	
R-Squared	0.401	0.875	0.787	0.881	
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Notes: Dependent variables is the  $\sinh^{-1}$  transform of firm's patents of the sum of subsequently granted patents applied for by firm *f* in years *t* to *t* + 4, with mean and std deviation of 1.114 and 1.768. Standard errors clustered by firm. \*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$

# Estimated impacts are similar for citations as well as manufacturing and process patents

Dependent Variable:	$\ln(Citations_{f,t:t+4})$		$\ln(ManufPats_{f,t:t+4})$		$\ln(ProcessingPats_{f,t:t+4})$	
	(1)	(2)	(3)	(4)	(5)	(6)
$dist_{ft}^{min} \in (0, 5)$	0.015 (0.026)	0.243*** (0.051)	0.038*** (0.013)	0.115*** (0.026)	0.044*** (0.012)	0.068*** (0.020)
$dist_{ft}^{min} \in (5, 60)$	-0.005 (0.030)	0.133** (0.052)	0.012 (0.015)	0.072*** (0.027)	0.004 (0.013)	0.042** (0.021)
$\ln(Patent Stock_{f,t-1}^{dep})$	1.201*** (0.008)	0.126*** (0.023)	0.795*** (0.006)	0.264*** (0.015)	0.563*** (0.008)	0.278*** (0.014)
$Emp_{ft}$ , $Age_{ft}$	Yes	Yes	Yes	Yes	Yes	Yes
Year FEs	Yes	Yes	Yes	Yes	Yes	Yes
FIPS FEs	Yes	Yes	Yes	Yes	Yes	Yes
Firm FEs	No	Yes	No	Yes	No	Yes
R-squared	0.695	0.835	0.780	0.883	0.708	0.872
N (rounded)	34,500	34,500	34,500	34,500	34,500	34,500

Notes: Dependent variables is the  $\sinh^{-1}$  transform of firm's patents of the sum of subsequently granted patents applied for by firm  $f$  in years  $t$  to  $t + 4$ , with mean and std deviation of 1.114 and 1.768. Standard errors clustered by firm. \*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$

## Outline of Talk

- Portrait of US innovation
- Do firms with both  $M$  and  $P$  patent differently?
- Within  $MP$  firms, does spatial proximity matter?
- *Future plans*
  - Exploit geography of inventors

# Bristol Meyers Squibb: patent 10167343

(12) **United States Patent**  
**Lonberg et al.**

(10) **Patent No.:** US 10,167,343 B2  
(45) **Date of Patent:** Jan. 1, 2019

(54) **ANTIBODIES AGAINST CD73**

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(73) **Assignee:** **BRISTOL-MYERS SQUIBB COMPANY**, Princeton, NJ (US)

(2013.01); **C07K 16/3069** (2013.01); **G01N 33/573** (2013.01); **A61K 2039/505** (2013.01); **C07K 2317/21** (2013.01); **C07K 2317/31** (2013.01); **C07K 2317/34** (2013.01); **C07K 2317/52** (2013.01); **C07K 2317/522** (2013.01); **C07K 2317/524** (2013.01); **C07K 2317/526** (2013.01); **C07K 2317/53** (2013.01);  
(Continued)

(58) **Field of Classification Search**

CPC ..... **C07K 2317/92**; **C07K 2317/76**; **C07K 2317/56**; **C07K 2317/21**; **C07K 2317/34**; **C07K 16/40**; **C07K 2317/31**; **C07K 2317/565**; **C07K 2317/71**; **C07K 2317/77**; **C07K 16/30**; **C07K 2317/521**; **C07K 2317/522**; **C07K 2317/524**; **C07K 2317/526**; **C07K 16/3015**; **C07K 2317/54**; **C07K 2317/55**; **A61K 2039/505**; **A61K 45/06**; **A61K 49/49558**

See application file for complete search history.

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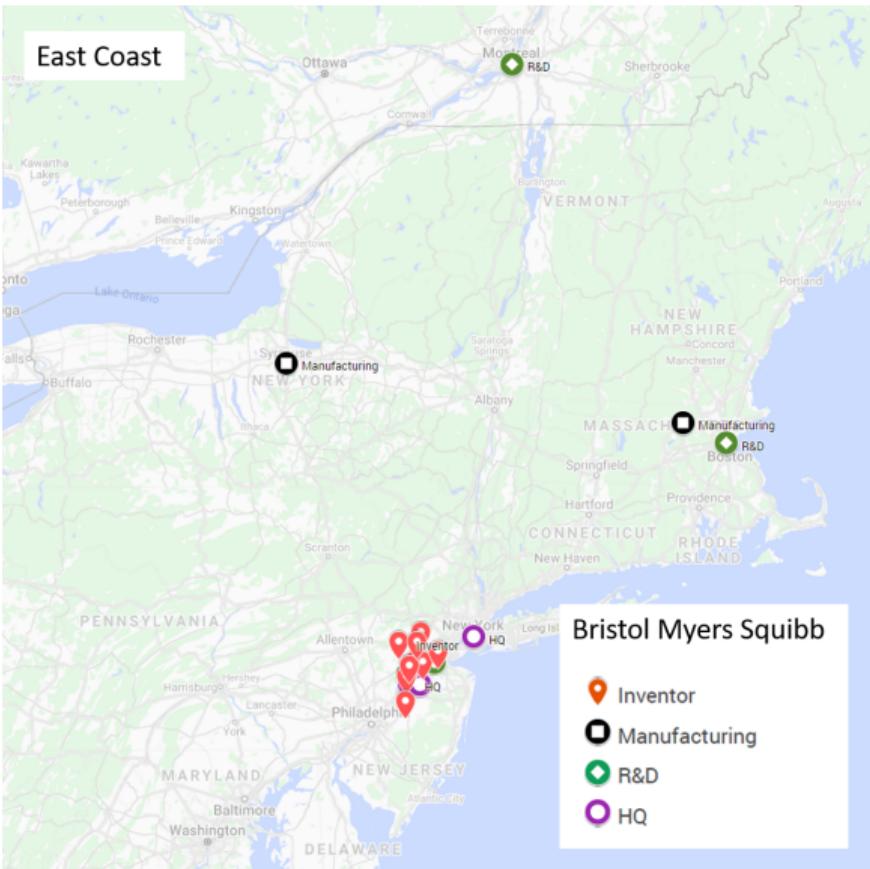
# Bristol Meyers Squibb: patent 10167343



5 plants and 10 inventors

New Brunswick facility  
recently transitioned from  
manufacturing to R&D

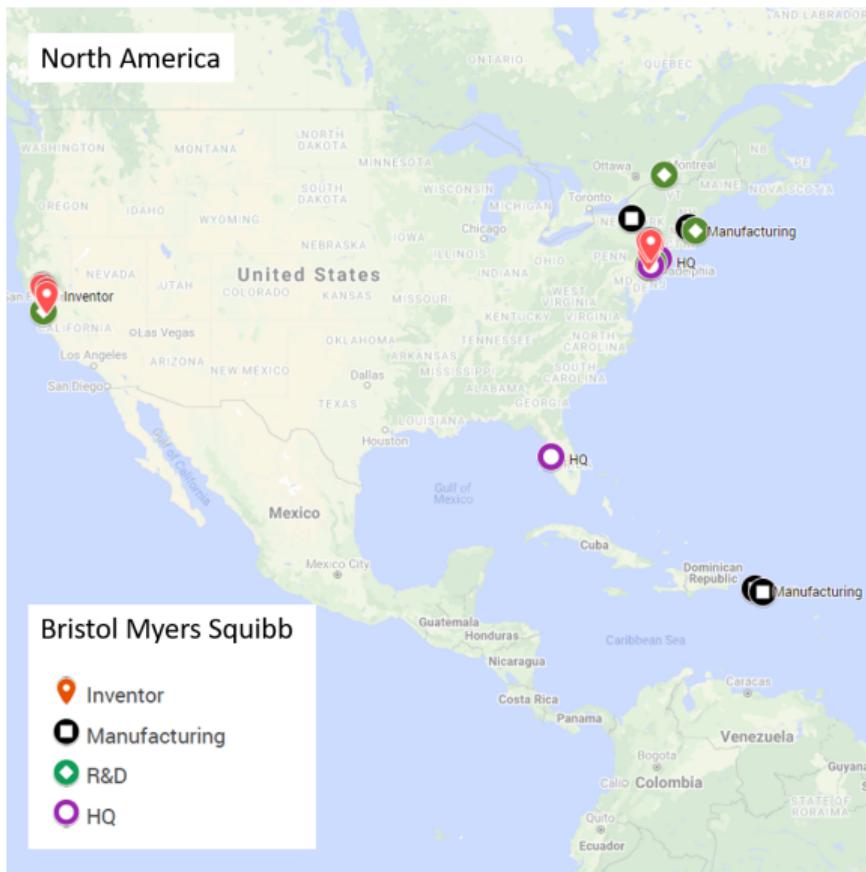
# Bristol Meyers Squibb: patent 10167343



2 R&D labs in Cambridge

Manufacturing and R&D  
are colocated in MA

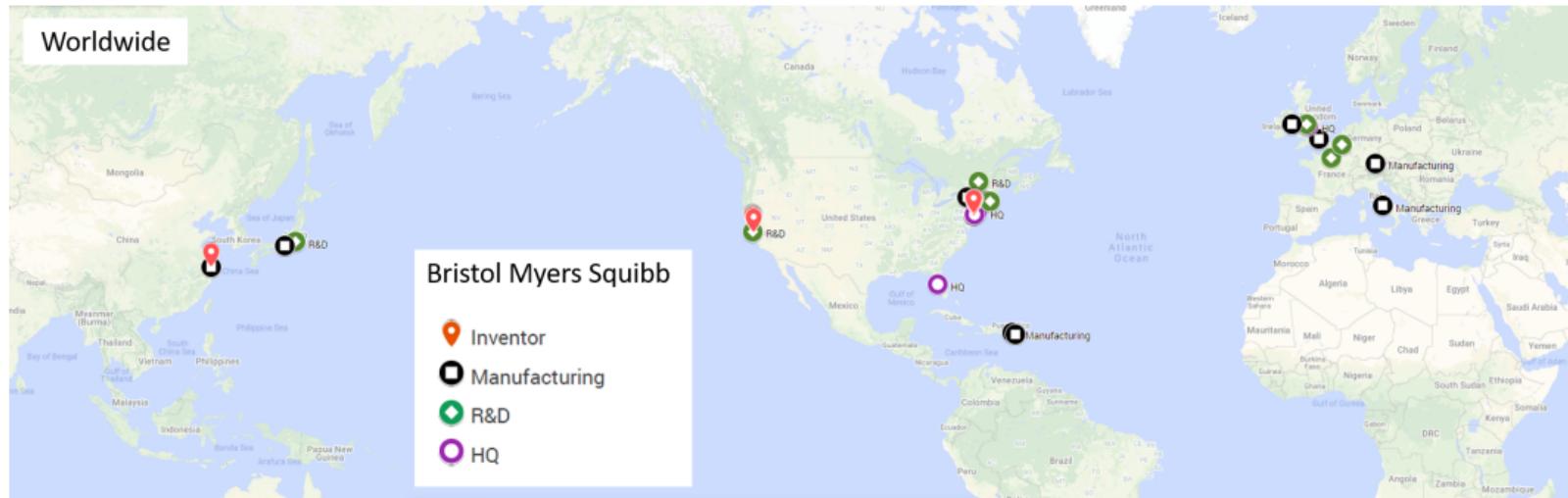
# Bristol Meyers Squibb: patent 10167343



Additional R&D lab in Redwood City, CA and many inventors in area

Additional manufacturing plants in Puerto Rico

# Bristol Meyers Squibb: patent 10167343



Additional manufacturing  
plant and inventor in  
Shanghai

## Future work

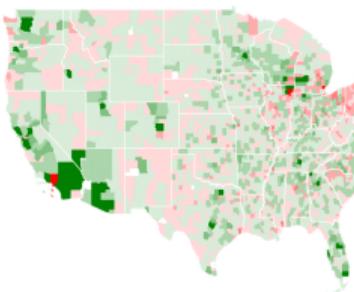
- Where does patenting occur within colocated firms?
- Is across-firm within region colocation important?
- What are the margins of colocation adjustment?

# Change in US *M* and *P* employment before and after 1997

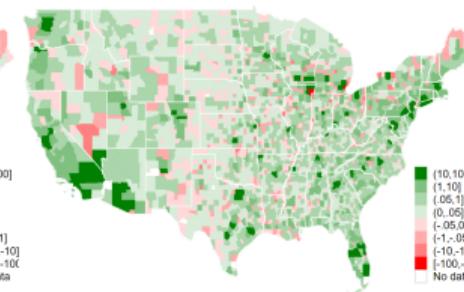
Change in Manufacturing Employment

Change in NAICS 54/55 Employment

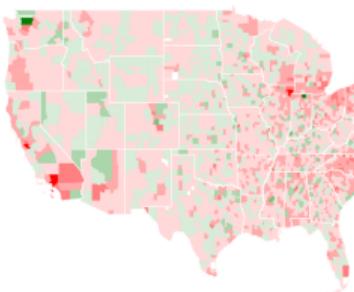
1977 to 1997



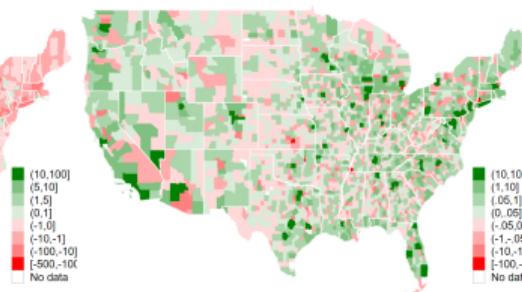
1977 to 1997



1997 to 2016



1997 to 2016

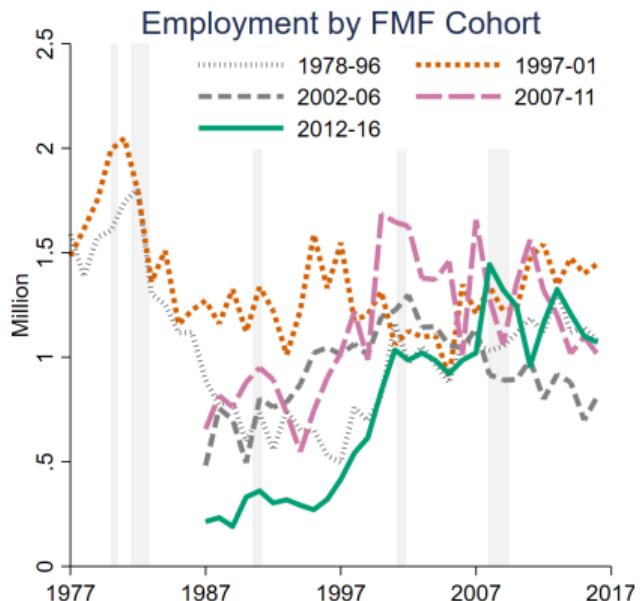


## Conclusion

- Non-manufacturers' share of patents grows from 9% to 46% between 1977 and 2016
- Firms with  $M$  and  $P$  establishments innovate most throughout period
- $MP$  firms patent more the closer  $M-P$  plant pairs
- *Lots more work to be done*

## Appendix

## Former manufacturing firms' employment by cohort



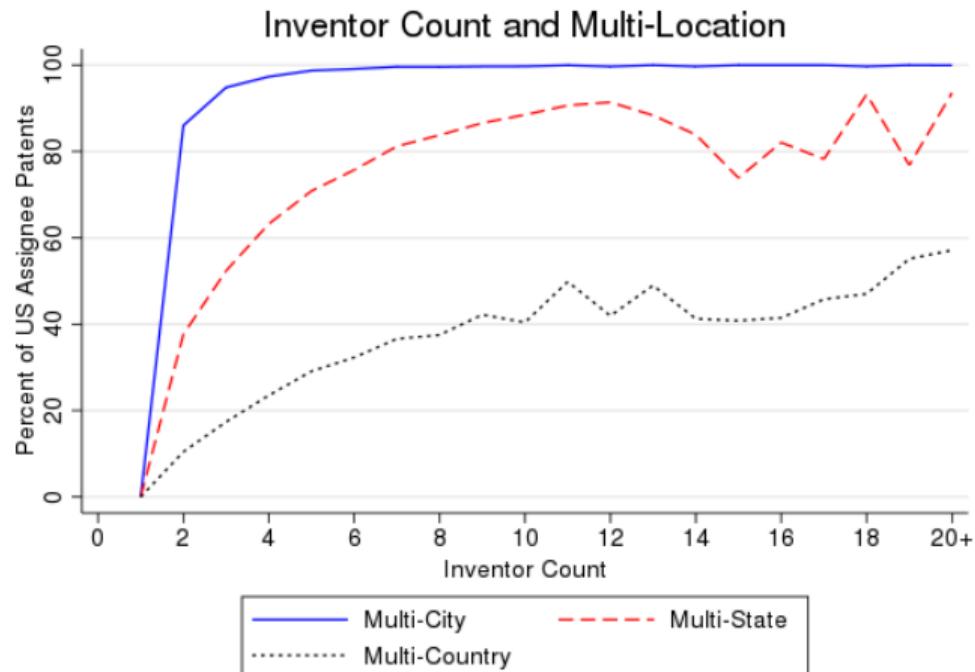
- Employment dynamics are similar in 2000s
- Cohort that exits in 2002-06 least resilient

## NAICS 5413-5416 and 5112, 517, 518

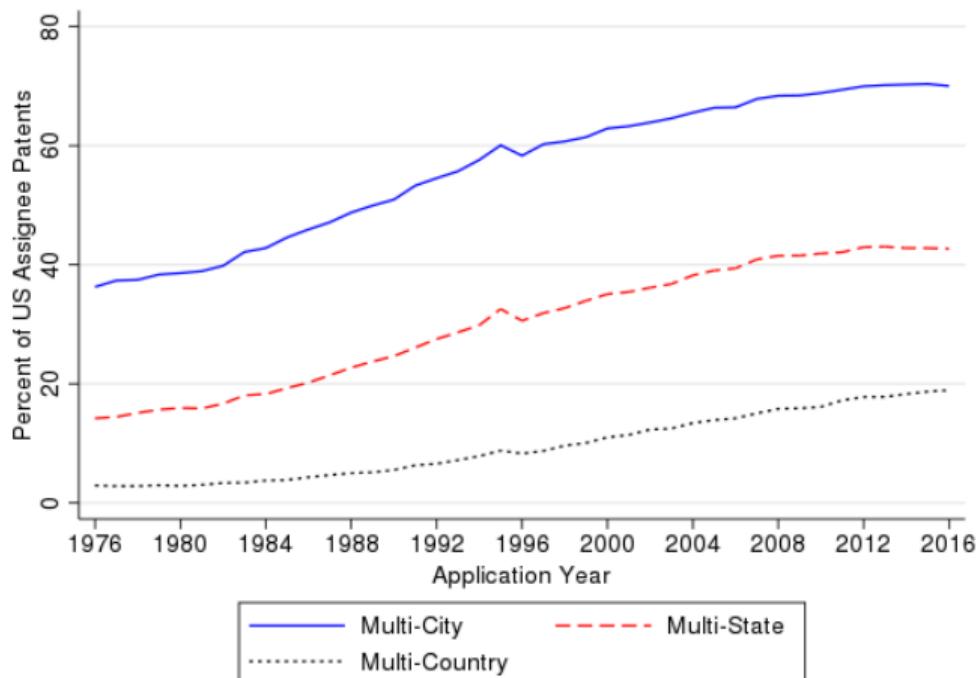
- Professional, Scientific, and Technical Services
  - 5413: Architectural, Engineering, and Related Services
  - 5414: Specialized Design Services
  - 5415: Computer Systems Design and Related Services
  - 5416: Management, Scientific, and Technical Consulting Services
- Information
  - 5112: Software Publishers
  - 517: Telecommunications
  - 518: Data Processing, Hosting, and Related Services

▶ Back

## Inventors tend to span cities and states



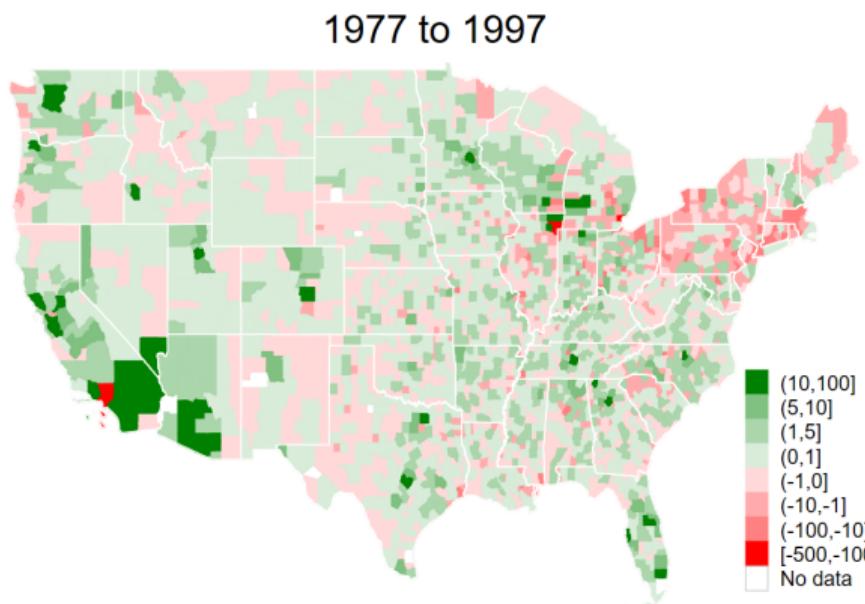
## Inventor dispersion has grown over time



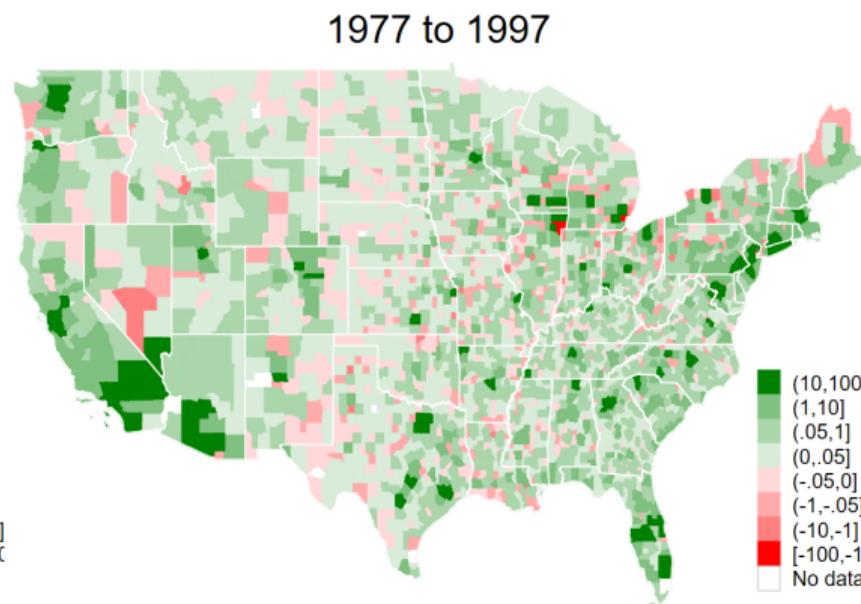
▶ Back

# Spatial distribution of all US M and P

Change in Manufacturing Employment



Change in NAICS 54/55 Employment



## Differences between colocated and distant man plants

- Document characteristics of colocated man plants
  - ▶ Premia regressions on emp, sales, non-prod worker shares, number of products, age
  - ▶ Estab design good?
- Document characteristics of colocated P plants (in new project)

## Analyze changes in firm colocation patterns

- What drives the changes in colocation?
- Are firms less likely to close the colocated plants?
- Are firms more likely to switch the industry of the colocated plants?

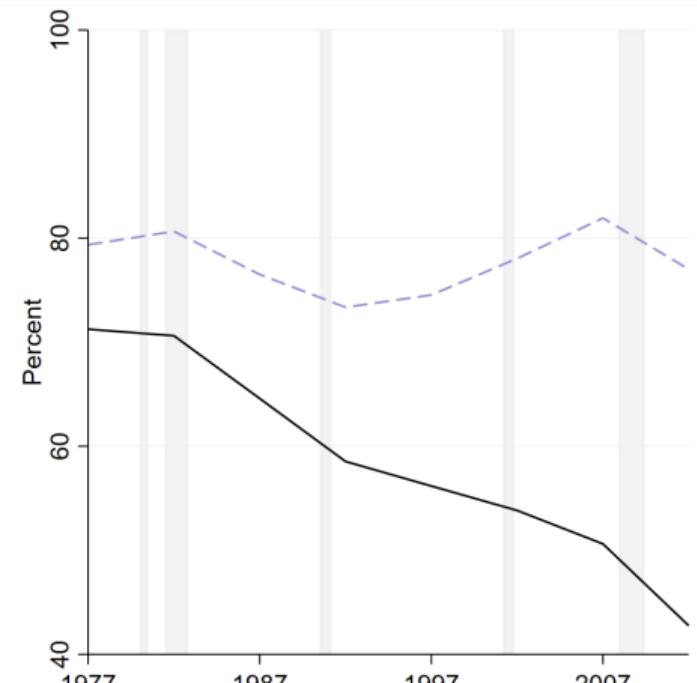
## Interpreting firm-region-patent results

- If patenting does not occur in colocated plants, is CL still important?
- If inventors are near manufacturing estabs, is that colocation?
- If inventor teams are more disperse, does that negate colocation? ► Dispersion ► Over time
- If a growing share of inventors are overseas, is this bad for the US?
- Does the presence of some domestic manufacturing matter?

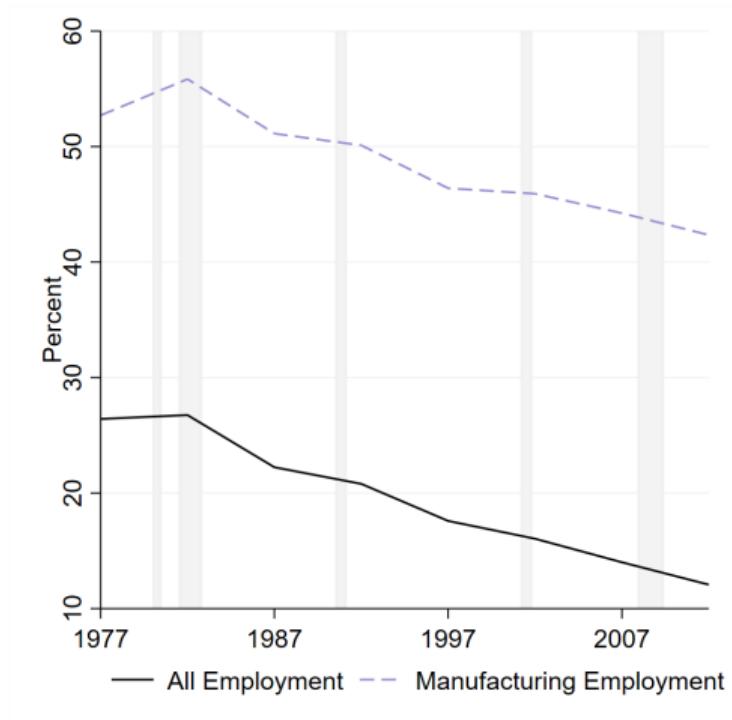
## Conclusion: ordering the to do list

- ① Spatial analysis of where innovation occurs within firms
- ② Decomposition of the margins that drive colocation changes
- ③ Identification of the colocation changes (e.g., import competition vs offshoring)
- ④ Characteristics of the colocated and innovating plants
- ⑤ Importance of across firm colocation
- ⑥ Possibility of colocation within a  $M$  (or  $P$ ) plant
- ⑦ Justification of  $P$  plants

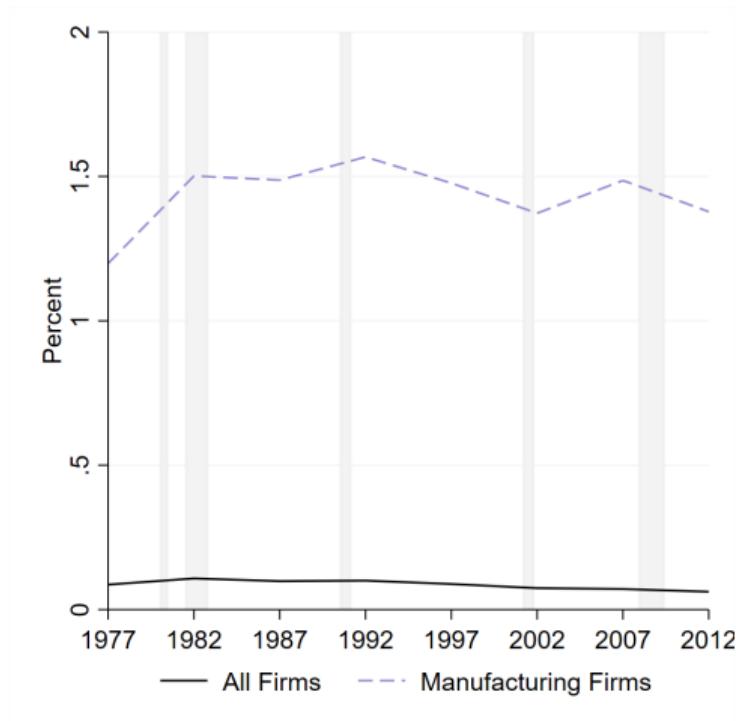
## MP firms share of total forward patent counts



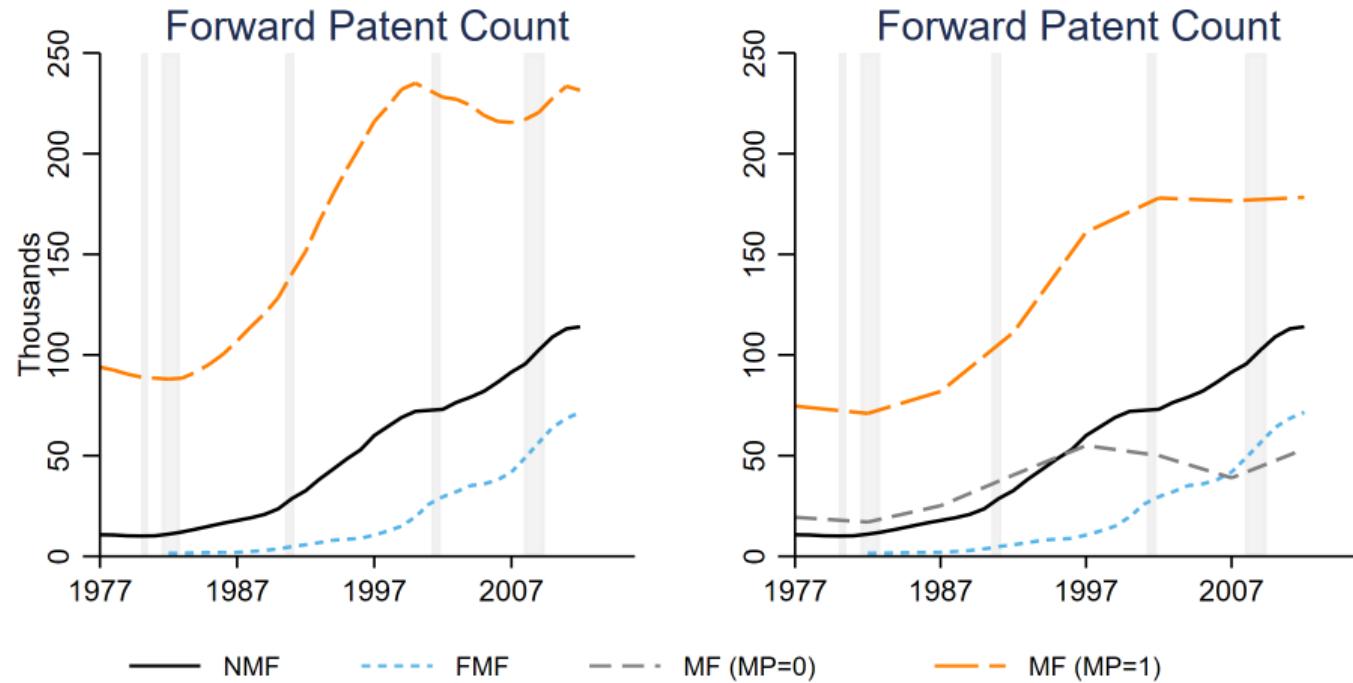
## MP firms share of employment



## MP firms share of firms

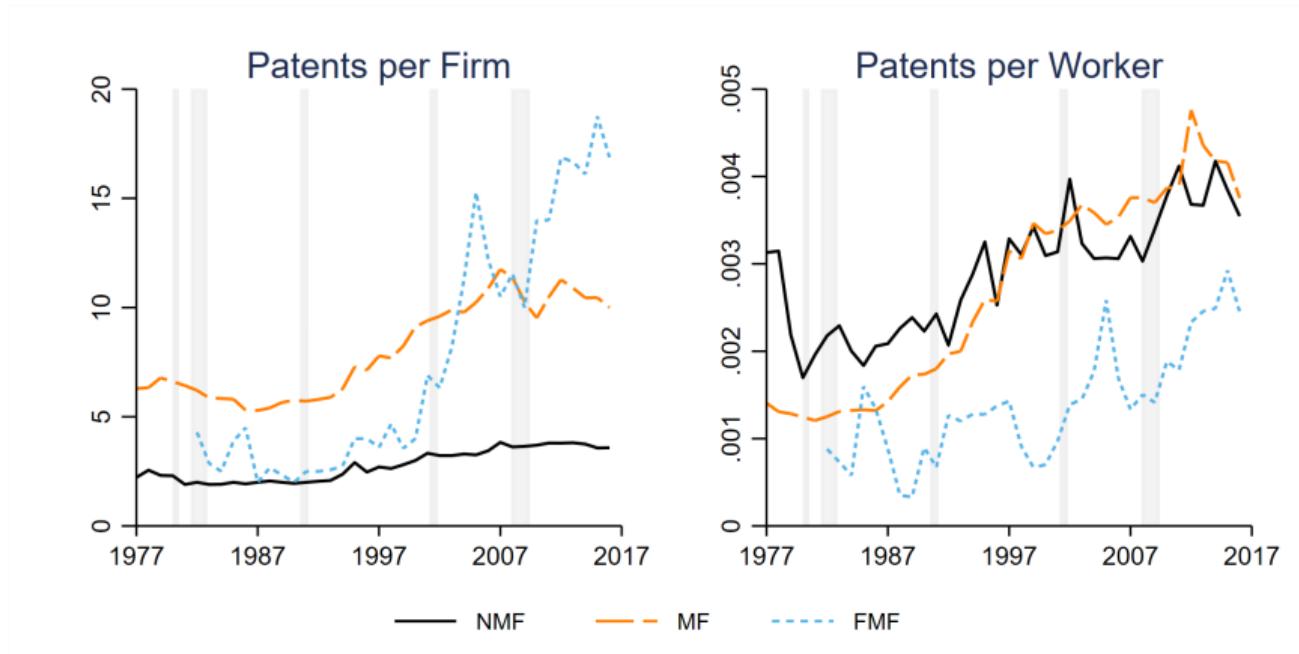


## Forward patent count by firm type



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# Patenting efficiency of patenting firms



- Patenting efficiency does not seem to decline
- Interesting to analyze by worker type