Is distance from innovation a barrier to the adoption of Artifical Intelligence?

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Question

Do firms at a greater distance from US commuting zones with historical strength in AI scientific publications delay adopting AI?

Geographic units

- U.S. commuting zones (CZ)
  - 741
  - Cover all of U.S.

Measure of innovation

- Number of AI publications in CZ through 2006
  - Academic journal papers
  - Conference proceedings
  - Patents (2.7%)
- Created own geocoded dataset
  - Using Microsoft Academic Graph

Measure of adoption

- Share of CZ's online job advertisements requiring AI skill
  - Especially for use of AI–based applications
  - Especially in industries like finance
- Data from Burning Glass Technologies 2007–2019
  - Scrapes and clean data from online job boards
  - 200 million observations
- Use long differences (show here: 7; also 12 years)

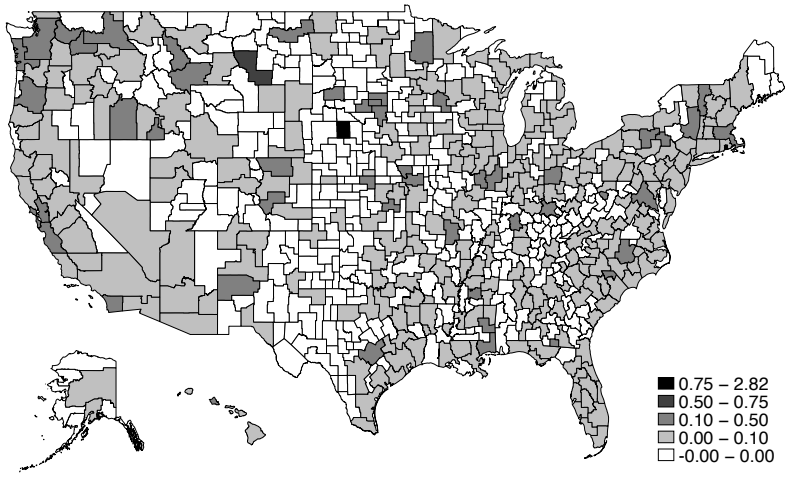
Key distance measure

1. Log km to closest AI publication hotspot CZ
2. Main definition of hotspot
   - Main results: at least 1000 AI publications (32 hotspots)
   - But vary threshold

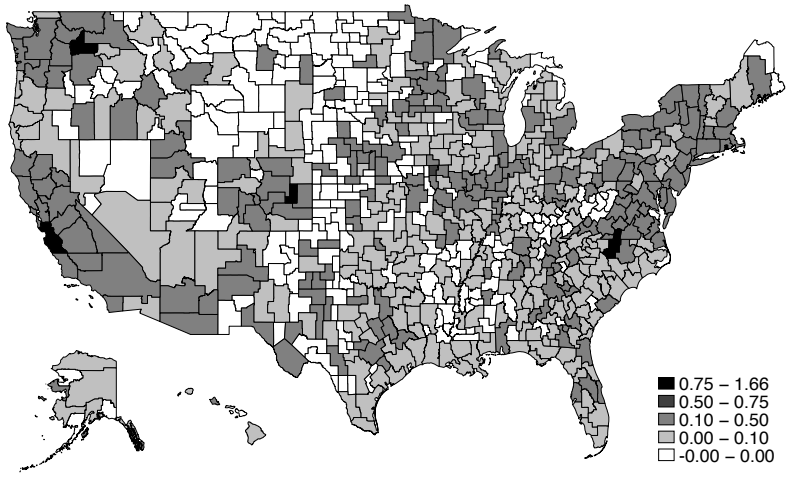
Key other controls

- Help control for unobserved determinants of AI adoption
  - Initial level and change in
    - ★ (Non-AI) IT's share in job ads
    - ★ AI publications
- Distinguish from distance to large city
  - Distance to closest large CZ

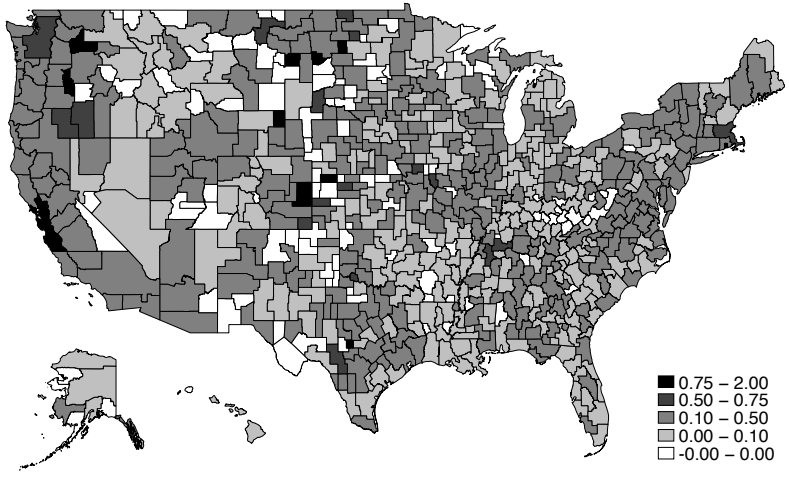
AI job ads as share of all job ads (%)



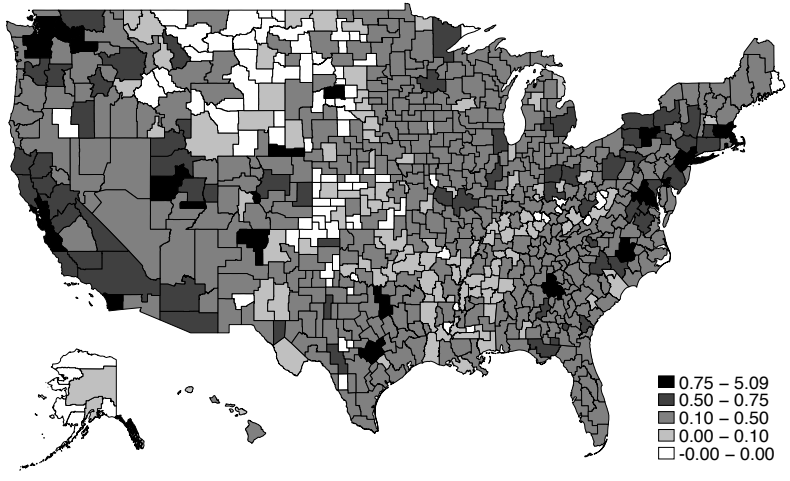
(a) 2007



(b) 2010

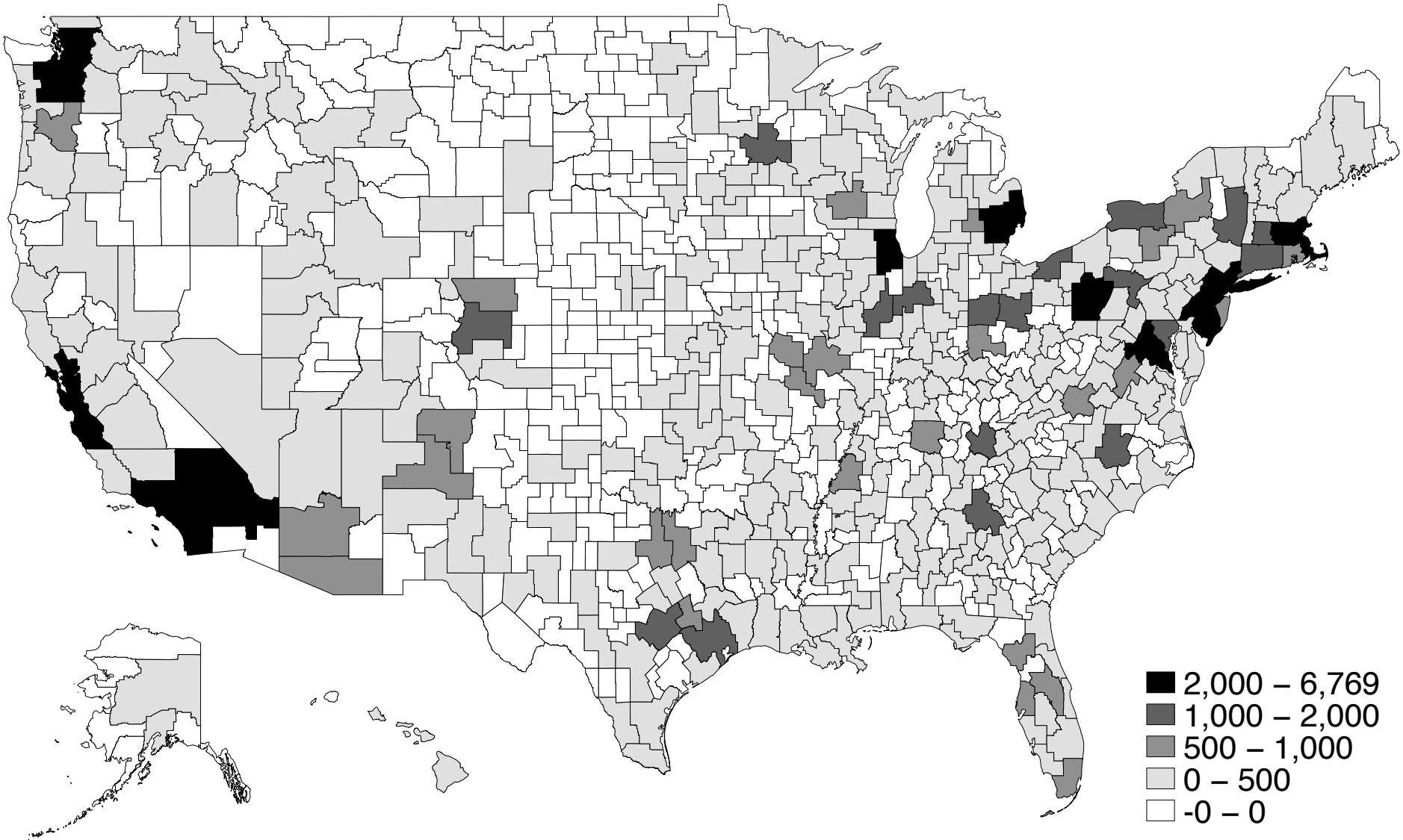


(c) 2014



(d) 2018

Geographic distribution of AI publications through 2006



Main equation

$$
\begin{aligned}
\Delta^k AI^s_{ct} = & \alpha + \sigma log(D^{Hot}_c) \\
& + \beta_1 AI\ Pub > 0_{c,t^*} + \beta_2 AI\ Pubs_{c,t^*} + \beta_3 (AI\ Pubs_{c,t^*})^2 \\
& + \gamma_1 log(All\ job\ ads_{c,t^*}) + \gamma_2 log(Pop_{c,t^*}) \\
& + \nu IT^s_{c,t^*} \\
& + \phi_1 log(\bar{D}_c) + \phi_2 log(D^{Pop}_c) + \phi_3 log(D^{min}_c) \\
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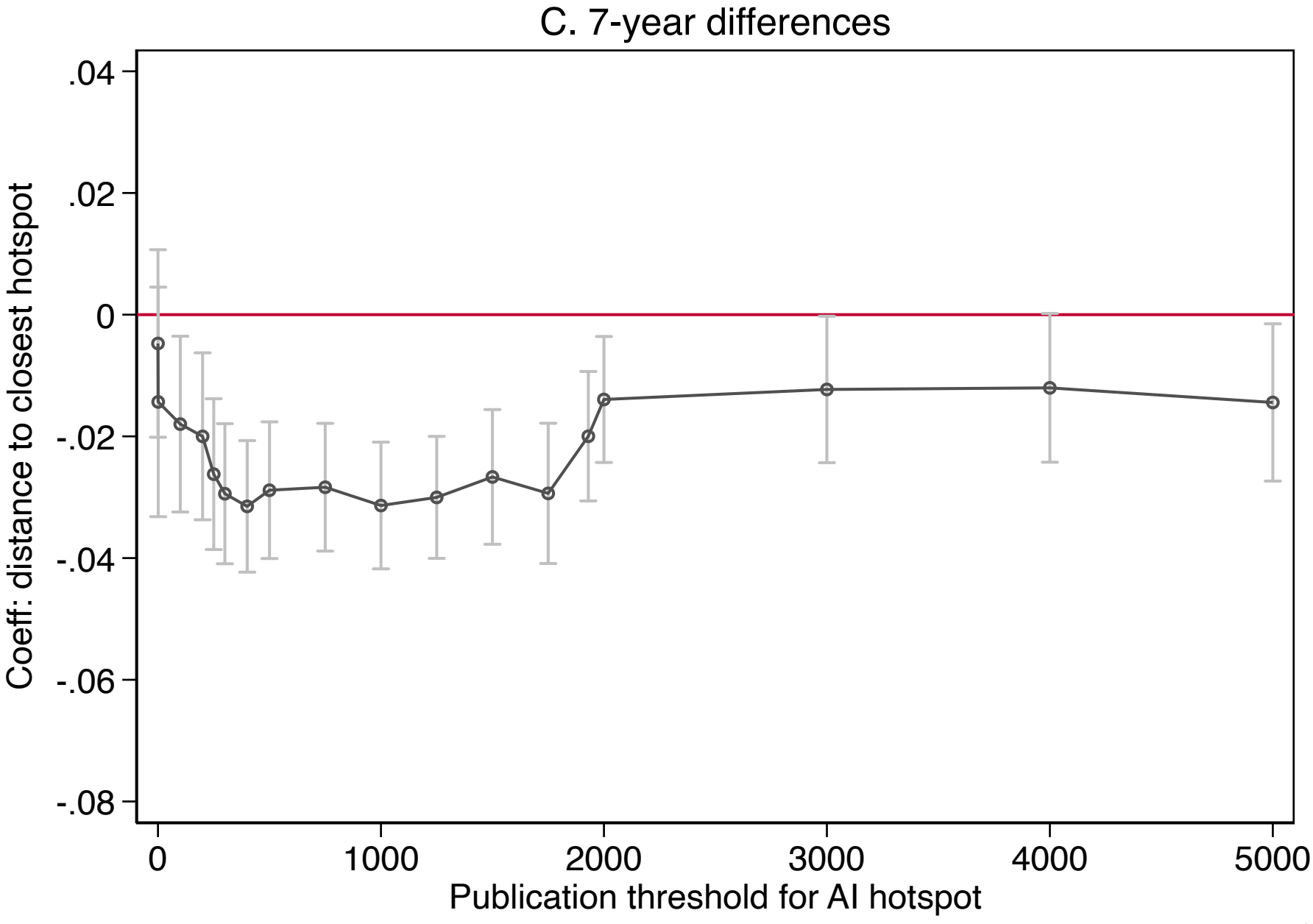
Effect of distance to closest hotspot on AI jobs' share in job ads

	Median regression				OLS
Ln distance hotspot	-0.029***	-0.031***	-0.031***	-0.024***	-0.049***
	(0.005)	(0.006)	(0.005)	(0.007)	(0.008)
X's	--	Y	Y	Y	Y
ΔX's	--	--	Y	Y	Y
Ln distance large CZ	--	--	--	Y	--

2964 obs; year dummies, controls for AI publications thru 2006 included

Coefficients on distance to closest AI hotspot, median regressions



Magnitudes of effect on median growth in AI job ad share

- Std dev of distance to closest hotspot is $\approx$10% mean (8.9%)
- 1 standard deviation reduces growth by 2-3% of median

Types of AI required (microdata, ads with valid occ)

	All AI	AI App	Unspecified AI only	AI Tool	AI R&D	Image Processing
% AI type	100%	19.2%	37.1%	9.1%	34.4%	12.5%
% Comp sci	62.6%	52.2%	68.3%	80.2%	66.5%	49.9%

Effect of distance to hotspot on AI jobs' share, by AI type

	Median regression					OLS
	All	App	Unspec only	Tool	R&D	Image Process
Ln distance hotspot	-0.031***	-0.0013	-0.017***	-0.0025***	-0.0069***	0.0030*
	(0.005)	(0.0010)	(0.002)	(0.0004)	(0.0016)	(0.0017)
Median dep var (pp)	0.093	0.004	0.033	0.000	0.017	0.000
Dist ↑ 10% (% of med)	-3.3%	-3.3%	-5.2%	--	-4.1%	--

2964 observations; year dummies, full controls included

Effect of distance to hotspot on AI jobs' share, by industry

	Share	Mean dep var	OLS
All	100.0%	0.14	-0.049***
			(0.007)
Ag, Utilities, Mining, Construction, Manuf	9.0%	0.08	0.002
			(0.014)
Wholesale trade, Retail trade, Warehousing, Transport	12.3%	0.02	0.004
			(0.008)
Information	3.0%	0.21	-0.079*
			(0.042)
Finance, Insurance	7.6%	0.28	-0.061**
			(0.027)
Real Estate, Prof-scientific services, Administration	17.9%	0.24	-0.090**
			(0.030)
Missing industry	16.0%	0.25	-0.136***
			(0.013)

2964 observations; year dummies, full controls included

Missing industry or firm name

- Most ads with missing industry have missing employer name
- BGT says employer name missing = employment agency

Effect of distance to hotspot on AI jobs' share, by micro sample

Job ads included	All	Valid industry	Missing industry	Valid employer	Missing employer
Log distance hotspot	-0.031***	-0.012***	-0.094***	-0.005	-0.067***
	(0.005)	(0.004)	(0.011)	(0.003)	(0.008)
Median dep var (pp)	0.093	0.060	0.144	0.047	0.103
Distance ↑ 10% (% of med)	-3.3%	-2.0%	-6.5%	-1.1%	-6.5%

2964 observations; year dummies, full controls included

Focusing on adoption (or adaptation)

- Effects driven by employment agency ads (1/3 ads)
  - So for sorts of firms using agencies, distance barrier 3x as large
- Distance barrier for finance industry
- Distance barrier for AI tools and applications

Determinants of missing employer name, micro data

	All	Finance, ins	AI apps
College educated share	-0.727***	-0.666***	-1.596***
of 2000 labor force	(0.067)	(0.082)	(0.233)
Log av distance other CZs	0.064***	0.048*	0.051
	(0.015)	(0.019)	(0.054)
AI publications <2007	0.004**	0.002	0.005
(/1000)	(0.002)	(0.003)	(0.009)
# skills required	-0.0122***	-0.0061***	-0.0019***
	(0.0003)	(0.0003)	(0.0004)
Management	-0.130***	-0.011**	-0.157***
	(0.008)	(0.005)	(0.016)
Business and finance	-0.051***	0.095***	-0092***
	(0.007)	(0.007)	(0.019)
Computer science-math	--	--	--
Architecture-engineering	-0.037***	0.010*	0.002
	(0.008)	(0.006)	(0.017)
IT skill required	0.053***	0.051***	--
	(0.005)	(0.005)	

Conclusions

- Distance from AI innovation is barrier to adoption
  - As long as CZ not itself a hotspot
- For types of firms using employment agencies
  - Firms without suitable local workers
- So distance deters AI innovation workers from moving to locations that do not have workers suitable for AI adoption

Effect of pre-2007 AI publications

Job ads sample:	Employer name is: Valid	Missing
Ln distance hotspot	-0.003	-0.087***
	(0.003)	(0.011)
Pre-2007 AI pubs	p=0.00	p=0.00
Interactions pre-2007, distance	p=0.01	p=0.01
Distance evaluated at		
1 AI pub pre-2007	-0.009	-0.063**
	(0.006)	(0.013)
500 AI pubs pre-2007	-0.001	-0.040***
	(0.013)	(0.010)
1000 AI pubs pre-2007	0.002	-0.021
	(0.022)	(0.016)

2964 observations; year dummies, full controls included

Effect of pre-2007 AI publications

Micro sub-sample	Employer name		Industry	Skills
	Valid	Missing	Finance, ins	AI app
Ln distance hotspot	-0.005	-0.067***	-0.061**	-0.0013
	(0.003)	(0.008)	(0.027)	(0.0010)
Change in AI pubs (x1000)	0.380***	0.187**	0.299***	0.024**
	(0.006)	(0.082)	(0.045)	(0.009)
Pre-2007 AI pub controls	p=0.00	p=0.10	p=0.60	p=0.00
Effect of pre-2007 AI pubs at				
Change 0 to 1 AI pub	0.093***	-0.044**	-0.049	0.007*
	(0.020)	(0.021)	(0.080)	(0.004)
100 AI pubs/1000	0.098***	-0.033	0.016	0.008*
	(0.022)	(0.020)	(0.065)	(0.004)
1000 AI pubs/1000	0.065***	-0.033	0.006	0.005
	(0.015)	(0.016)	(0.047)	(0.004)

2964 observations; year dummies, full controls included