

The Internet and Local Wages? Convergence or Divergence?



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Core question

- ▶ Did the diffusion of the internet contribute to convergence or divergence of wages across locations in the United States?
 - Either convergence or divergence possible.
 - Convergence: Places with lower wage levels experience higher rates of growth.
 - Divergence: Places with high wage levels experience higher rates of growth.
 - Examples to support either view, but no statistics about general trends.

Our Experiment

- Assemble data on advanced internet in business as of 2000. Associated with local outcomes?
 - Most comprehensive data of its kind.
 - Compare/contrast w/establishment data about IT, such as PC use and basic Internet use at home.
 - We expect diffusion developed enough to observe short run effect.
- Compare wage growth b/w 1995 and 2000.
 - Identify the relationship between the extent of investment in advanced internet technologies and local economic outcomes, particularly wages.

How to measure localization?

Two step procedure

- Step 1: Measure average relationship b/w internet use & wage growth across all counties.
 - Establish link between internet and growth.
 - Worry about omitted variables & reverse causality.
- Step 2: Examine whether advanced internet investment led to faster growth in high or low income areas.
 - Then explore characteristics of areas where link is strongest to provide evidence about convergence/divergence.

Using growth equation (1995–2000):

$$\log(\bar{Y}_i) = \alpha_1 X_i + \alpha_2 \bar{Z}_i + \beta Internet_i + \varepsilon_i$$

Where

- i =county
- X & Z are controls & other potential omitted variables.
 - X are fixed features of regions
 - Z are things that change over time.
- Endogenous variable is wage growth.
- Internet is the percent adopters as of 2000
 - Adoption was effectively zero in 1995

Step 2: Framework for estimation

$$\log(\bar{Y}_i) = \alpha_1 X_i + \alpha_2 \bar{Z}_i + \beta Internet_i + \phi(Internet_i \times HighIncome_i) + \varepsilon_i$$

- ϕ measures relationship between wages and advanced internet & income.

$$\log(\bar{Y}_i) = \alpha_1 X_i + \alpha_2 \bar{Z}_i + \beta Internet_i + \varphi_1(Internet_i \times HighIncome_i) + \varphi_2(Internet_i \times HighEducation_i) + \varphi_3(Internet_i \times HighPopulation_i) + \varphi_4(Internet_i \times HighITIntensity_i) + \varphi_5(Internet_i \times HighAllFactors_i) + \varepsilon_i$$

- ϕ measures key relationship. Divide counties by income, skills, population, and the IT intensity of firms. Call the high counties “high all factors.”

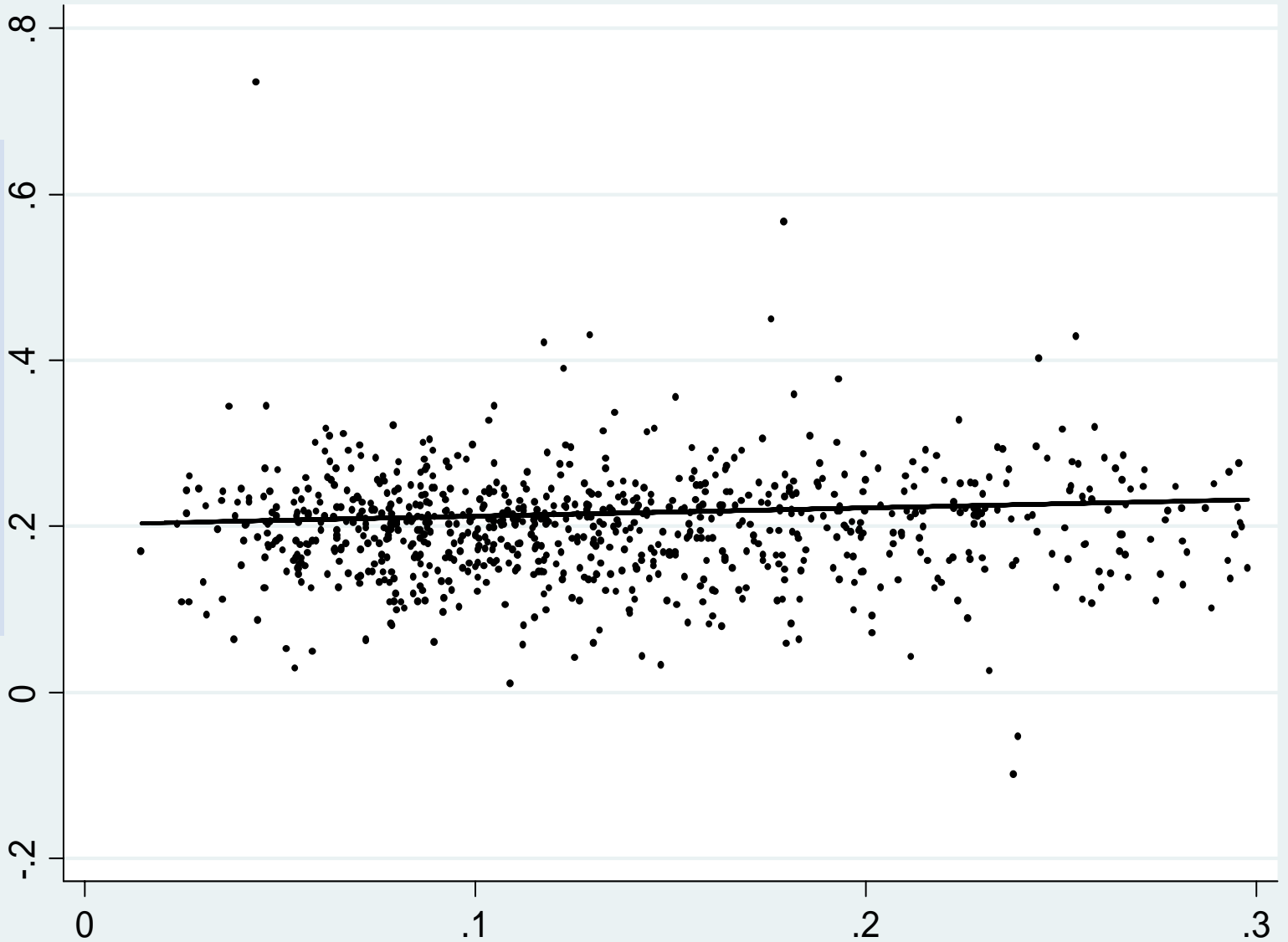
Internet data

- ▶ Harte Hanks Market Intelligence Computer Intelligence Technology database
 - CI database. As of December 2000
- ▶ Good news: Best establishment-level data about the use of IT in the US
 - Data on PCs, internet, basic enterprise stats.
 - Includes half of all establishments with 100 or more employees in the US
 - 86,879 establishments
 - Aggregate to 2743 counties. Dropped over 300 which lack internet investment data (generally very low density).

Other variables

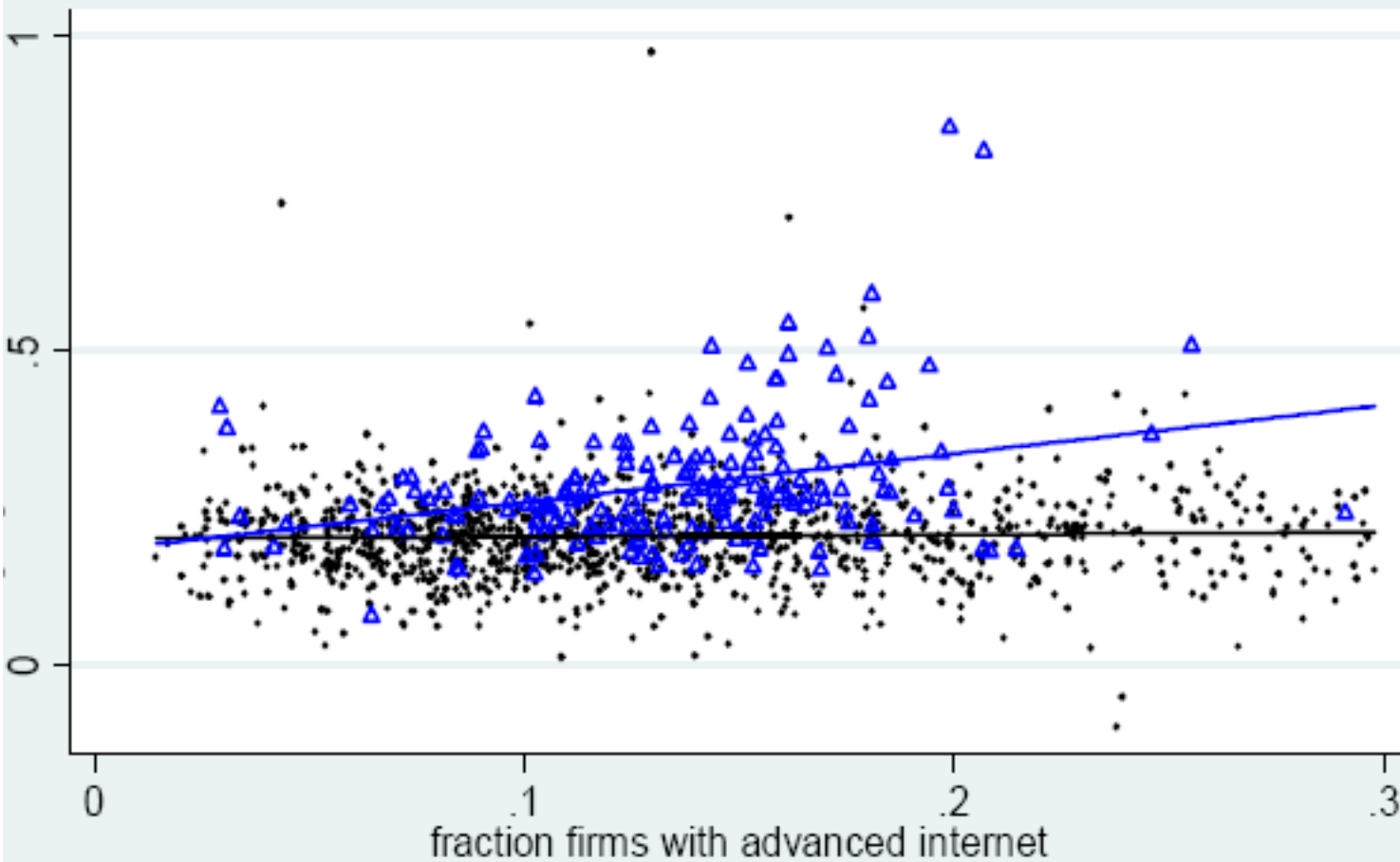
- ▶ County average weekly wages, total employment, and total establishments
 - Quarterly Census of Employment and Wages
 - Population, education, and income from 1990 Census. Lots of other controls.
 - Demographics, patents, etc.
 - IT-using & IT producing industries as of 1995 from the US Census County Business Patterns data, using definition from Jorgensen, Ho, and Stiroh (2005).

Wage growth 1995-2000



% firms with advanced internet as of 2000

Wage growth 1995-2000



- Not top county in income, education, population, and IT-intensity in 1990
- ▲ Top county in income, education, population, and IT-intensity in 1990

Outline of results.

- ▶ Step 1: We initially establish a link between investment in advanced internet and wages.
- ▶ Step 2: Advanced internet is primarily associated with growth in counties that were already well off.

Table 2, Step 1.

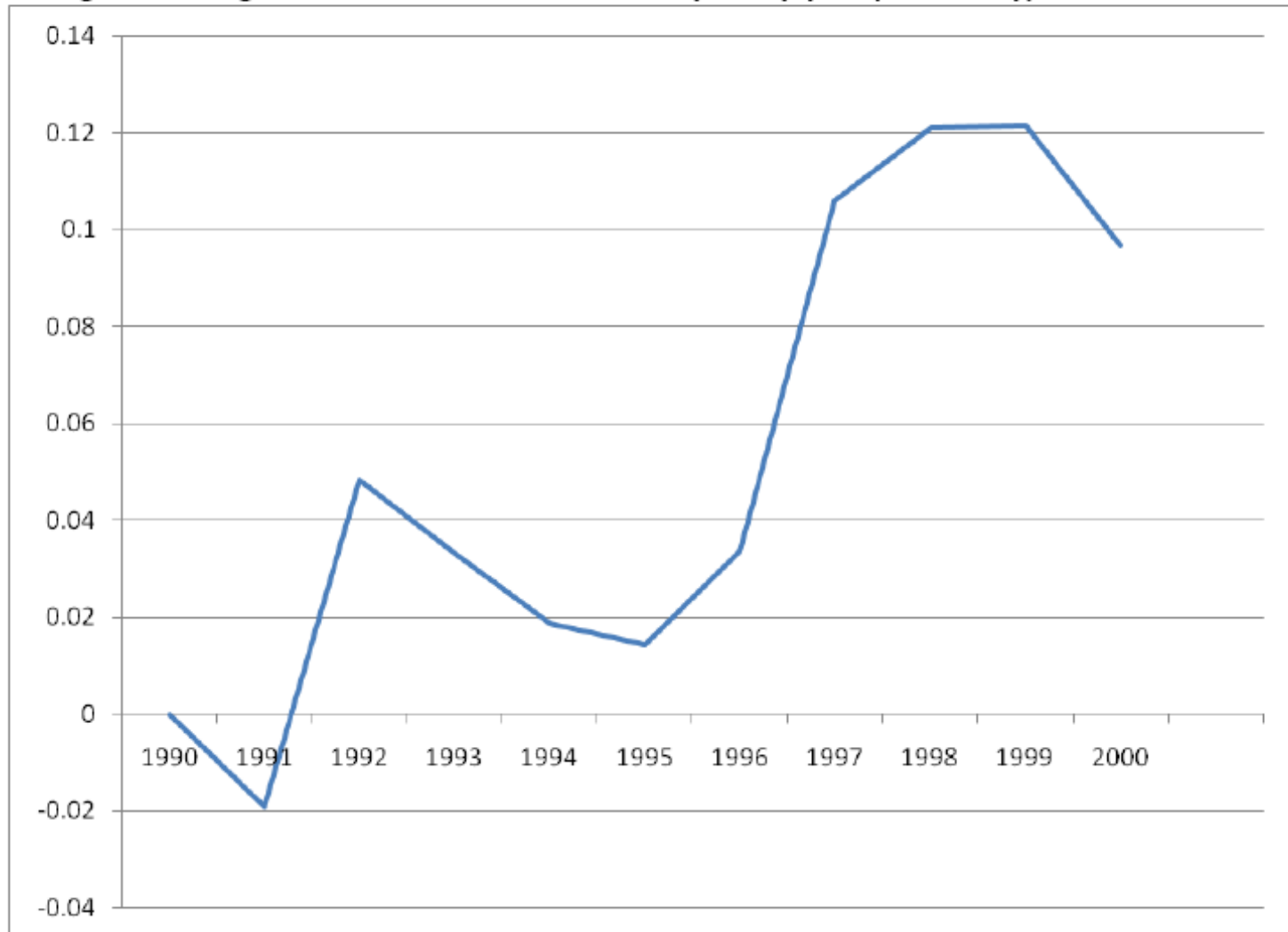
- ▶ Coefficient on use of advanced internet technologies is 0.0252.
 - An average level of internet use → 0.24% wage growth above regions with no internet use.
 - A one standard deviation increase in the use of the internet is associated with 0.335% increase in wage growth.
 - Top decile is 0.216. That leads to a 0.32% increase in wage growth above the mean.
- ▶ Effects are statistically significant, but not economically large.
 - Average wage growth is 20%. Internet explains little.

Table 2: Wages increase with Internet use

	(1)	(2)	(3)
	No covarates	Main specification	MSAs only
Advanced Internet	0.0370 (0.0132)**	0.0252 (0.0128)*	0.0672 (0.0364)+
Observations	2743	2742	843

Falsification test

Figure 1: Marginal effect of advanced internet year-by-year (MSAs only)



Instrumental Variables

	(1)	(2)	(3)	(4)	(5)	(6)
	Instrument: Number of programmers residing in other establishment locations	Instrument: ARPANET connections	Instrument: BITNET connections	Instrument: Year when state adopted a telecom price cap or freeze	Instrument: Average cost per phone line by state	All five instruments combined
Advanced Internet	0.1592 (0.1673)	3.193 (9.068)	2.653 (5.823)	1.105 (1.088)	3.533 (22.71)	0.3167 (0.1705)+
Observations	2743	2743	2743	2743	2743	2743
F-Test	17.62	0.59	0.84	4.07	0.48	14.77
Hausman test chi-sq	2.39	0.12	0.20	0.99	0.02	3.53
Hausman test p-value ($H_0: IV=OLS$)	1.00	1.00	1.00	1.00	1.00	0.999

Advanced internet is associated with wage growth in high income counties

	(1)	(2)	(3)	(4)
Advanced internet	0.0150 (0.0138)	0.0099 (0.0127)	0.0063 (0.0128)	0.0194 (0.0135)
Advanced internet and High income county	0.0891 (0.0368)*		0.0532 (0.0481)	
Advanced internet * High education county		0.1064 (0.0447)*	0.0887 (0.0529)+	
Advanced internet * High income and education county				0.1008 (0.0462)*

...and high education counties

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...but especially “high all factors” counties

	(6)	(7)	(8) ^a
Advanced Internet	0.0225 (0.0130)+	0.0029 (0.0152)	0.1979 (0.1622)
Advanced Internet and High income county		0.0378 (0.0502)	
Advanced Internet and High education county		0.0796 (0.0557)	
Advanced Internet and High population county		0.0298 (0.0774)	
Advanced Internet and High IT-intensity county		0.0155 (0.0241)	
Advanced Internet and High income, education, IT-intensity, and population county	0.1785 (0.0530)**	0.1232 (0.0582)*	0.1767 (0.0736)*

1

Column (8) is IV estimate

How much can we explain?

- ▶ 180 counties had higher wage growth than other 2563 counties in the sample (29.2% vs. 20.5%).
 - For the “High All Factors” group, advanced internet is related to 8.2% (2.4 percentage points) of total wage growth
 - For other counties, advanced internet explains just 1.1% (0.2 percentage points) of wage growth
 - Suggests advanced internet explains one quarter of 8.7 percentage point difference between the 180 and the other 2563

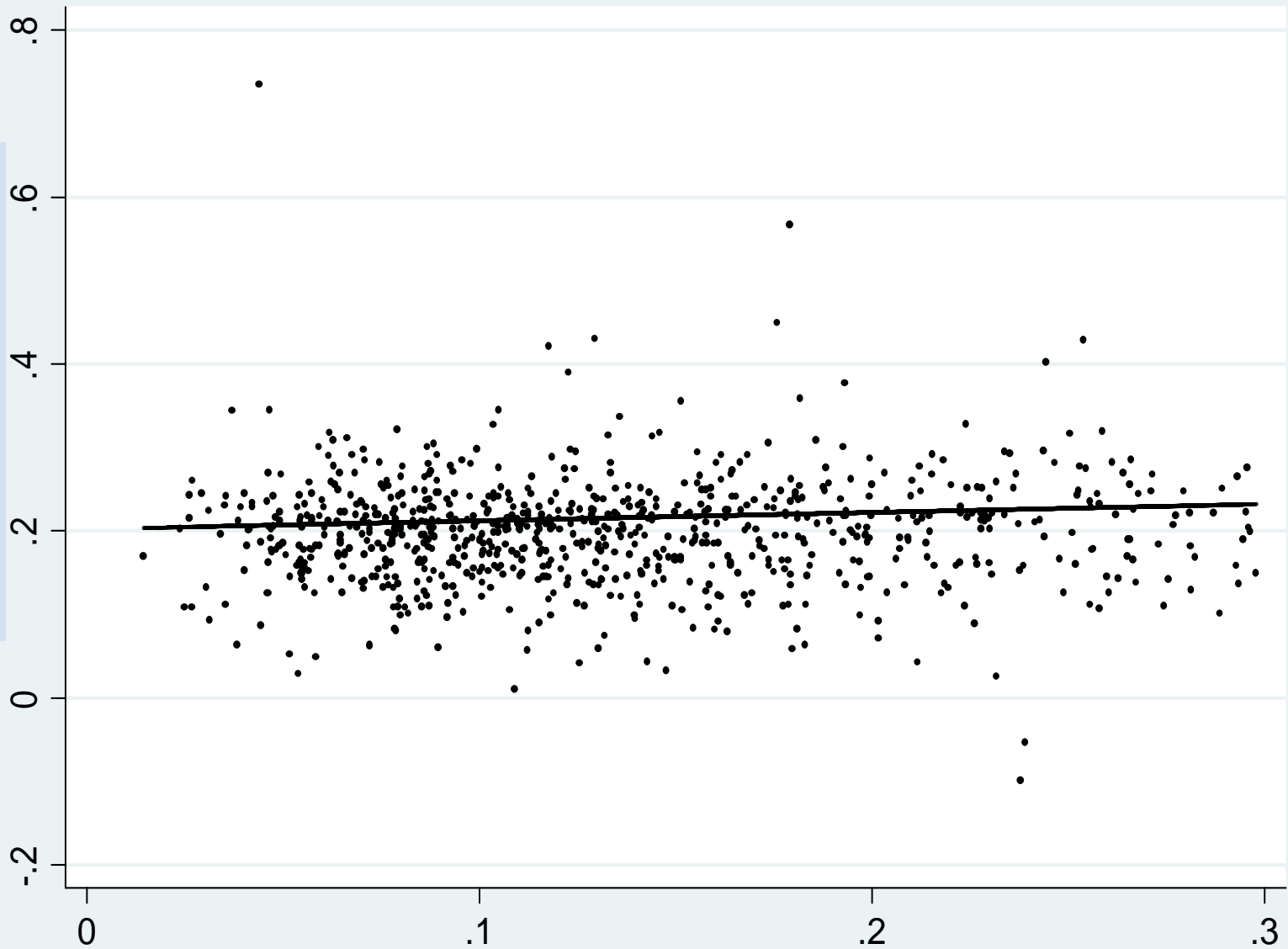
Summary of core observations about convergence/divergence

- ▶ Use of advanced internet technology was associated with local wage growth.
- ▶ Relationship isolated to particular locations: high population counties in which IT production and use were concentrated, and where income and skills were high.
 - Advanced internet use explains a quarter of the difference in wage growth between these counties and the average county in the US.
 - Little growth from Internet outside urban areas.
- ▶ Little evidence that use of advanced internet was associated with growth in either employment or establishments.

Thank you!

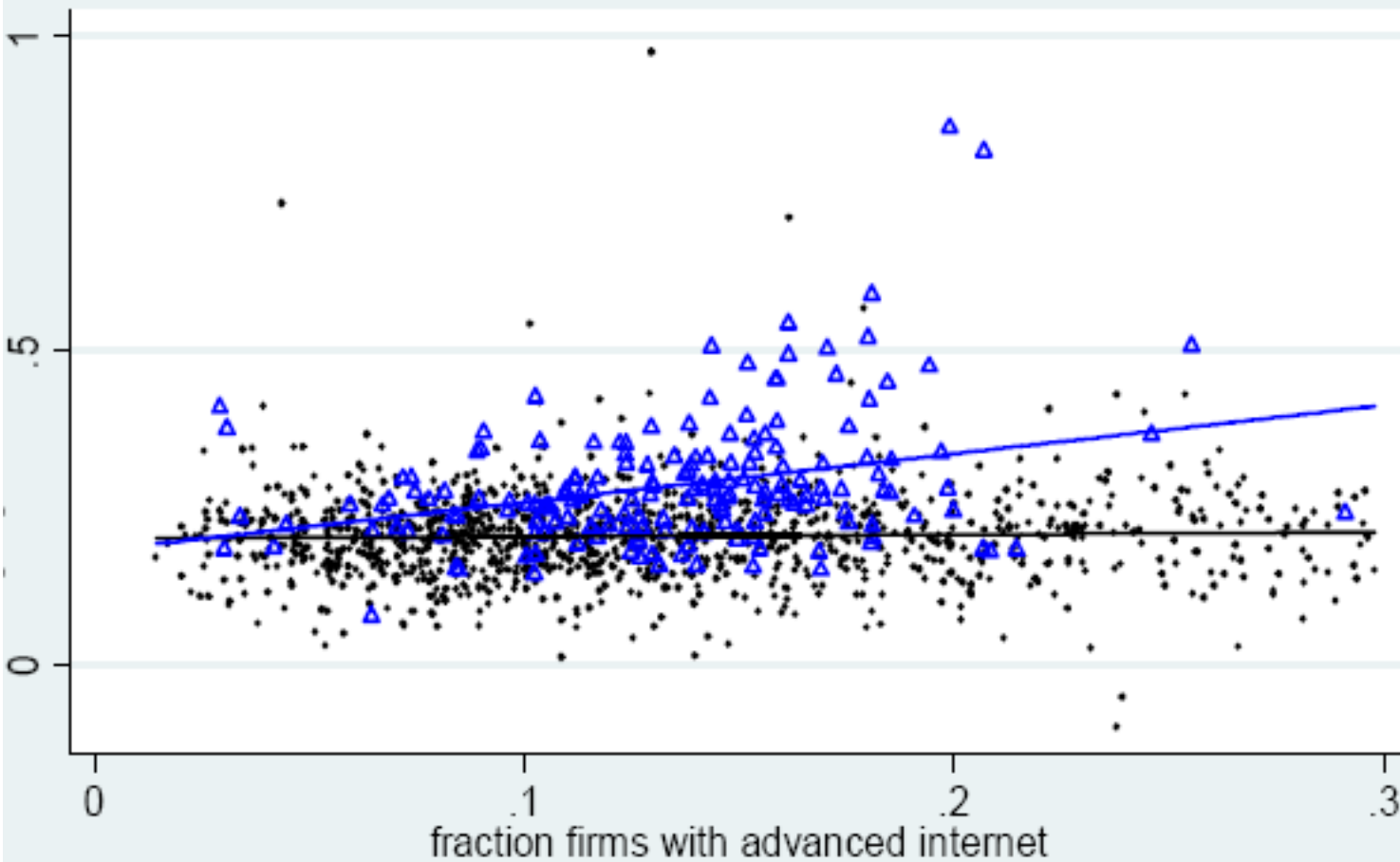
Backup Slides

Wage growth 1995-2000



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Outline of results.

- ▶ Step 1: We initially establish a link between investment in advanced internet and wages.
 - No such link exists between advanced internet and employment.
 - There is something different about advanced internet compared to basic internet applications and personal computer use.
- ▶ Step 2: Advanced internet is primarily associated with growth in counties that were already well off.

Table 2, Step 1.

- ▶ Coefficient on use of advanced internet technologies is 0.0252.
 - An average level of internet use → 0.24% wage growth above regions with no internet use.
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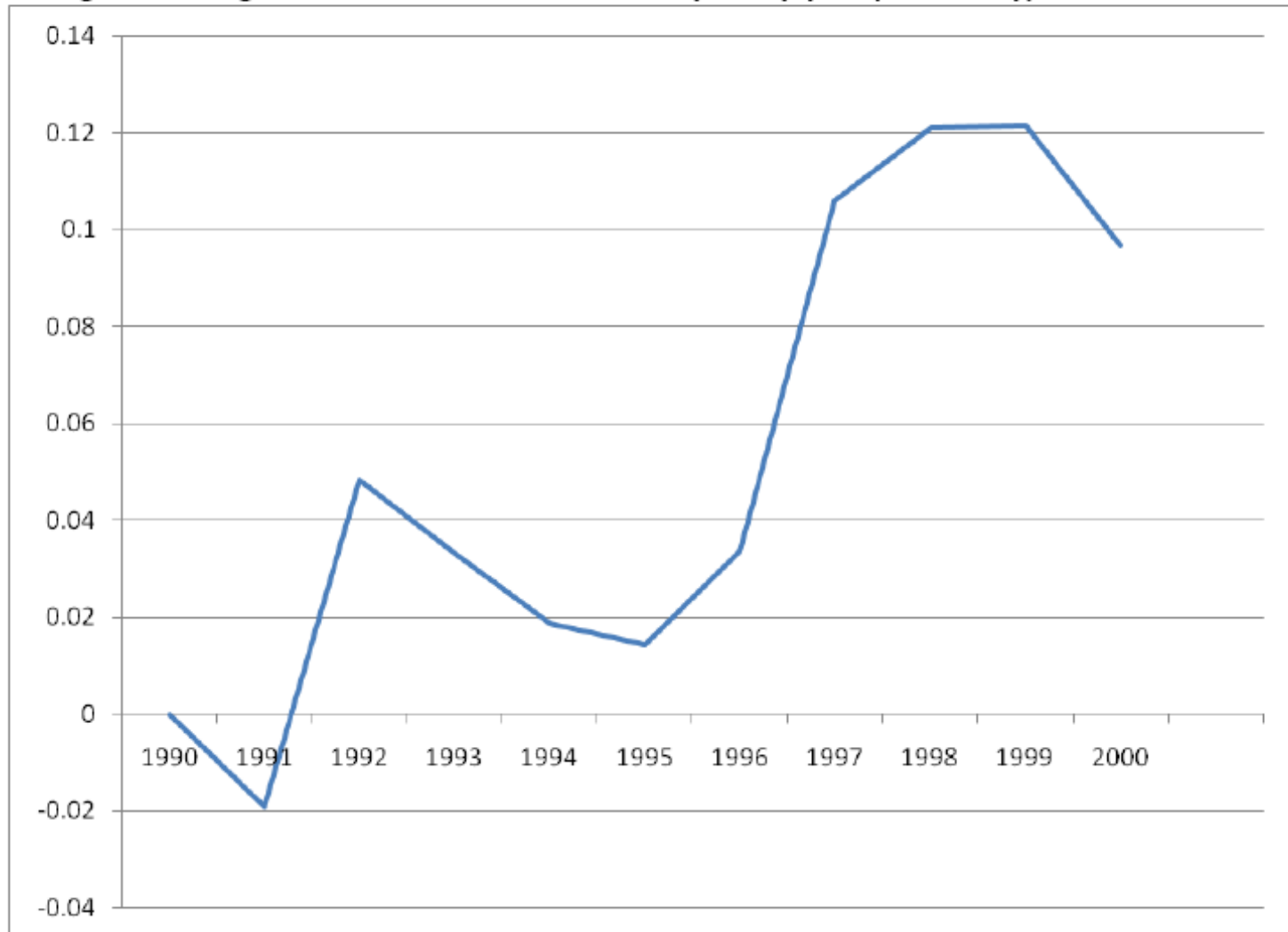
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Various robustness tests

1. We have included many controls for the initial conditions of the county in order to partially address omitted variables bias. Control for changes in population, racial, education, age, internet use at home.
2. Look for false positives:
 - Does the internet effect show up when it should?
3. Instrumental variables

Falsification test

Figure 1: Marginal effect of advanced internet year-by-year (MSAs only)



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Instrumental Variables (1st Stage)

	(1)	(2)	(3)	(4)	(5)	(6)
Number of programmers residing in other establishment locations	0.000136 (0.0000387)**					0.000138 (0.000039)**
ARPANET connections		0.00473 (0.0133)				0.00328 (0.0137)
BITNET connections			0.00246 (0.00532)			0.00248 (0.00549)
Year when state adopted a telecom price cap or freeze				0.000963 (0.000857)		0.00102 (0.000856)
Average cost per phone line by state					-0.000114 (0.000730)	-0.000210 (0.000730)
Observations	2743	2743	2743	2743	2743	2743
R ²	0.33	0.32	0.32	0.32	0.32	0.33

Table 3: nothing other than wages

Table 3: Employment and Establishments show no clear pattern of correlation with Internet use

<i>Dependent Variable</i> →	<i>EMPLOYMENT</i>		<i>NUMBER OF ESTABLISHMENTS</i>	
	<i>(1)</i>	<i>(2)</i>	<i>(3)</i>	<i>(4)</i>
	No Controls	Main specification with several further controls	No Controls	Main specification with several further controls
Advanced Internet	-0.0023 (0.0201)	-0.0181 (0.0173)	-0.0026 (0.0147)	-0.0031 (0.0135)
Observations	2743	2743	2743	2743
R ²	0.27	0.44	0.42	0.58

Controls are the same as in Table 2. Heteroskedasticity-robust standard errors in parentheses.

+ significant at 10%; * significant at 5%; ** significant at 1%

- ▶ For the rest of the study we focus on our wage results.

Table 4, compared to other IT

Table 4: Is Advanced Internet different from other measures of IT use?

	(1)	(2)	(3)
	Compare all three measures of IT use	Compare Advanced Internet and Basic Internet	Compare Advanced Internet and PCs per employee
Advanced Internet	0.0232 (0.0136)+	0.0229 (0.0134)+	0.0244 (0.0133)+
Basic Internet	0.0127 (0.0108)	0.0119 (0.0103)	
PCs per employee	-0.0014 (0.0078)		0.0022 (0.0074)
Observations	2743	2743	2743

- PC per employee matters, but does not eliminate effect of advanced Internet. (Despite high correlation of .5 at the county level).
- “Internet Participation” not sig. Uninteresting margin by 2000, since near saturation.