Appendix
Diffusion: Patent Access

Dense Enough To Be Brilliant: Patents, Urbanization, and Transportation in Nineteenth Century America

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Diffusion: Patent Access

One common way of studding technology diffusion is using a distance wighted measure of the "stock" of technology that different countries possess. The cost and distance weights can be used to measure a county's "patent access," if rather than being used to form a weighted sum of the country's population, they are used to create a weighted sum of the stock of patents issued to inventors in a county. Table 1 uses weighted sums of the number of patents issued in a county the last 17 years (the length of a patent grant) as the measure of patenting access in a fixed effects regression (from Equation **??**) . It is not surprising that measures in which a county's own patents are included are strongly related to the number of patents per 10,000 people issued by a county, however this also shows that there is a relationship between nearby counties' past patenting and a county's own patenting. All coefficient remain precisely estimated even after controls are added, the implied effect from changes in cost weighted population and distance weighted population is about the same, but is small as compared to the effect implied by the local transportation access coefficients.

Table 2 uses the instrument described in Section **??**, the point estimate of cost weighted patent access grows, and when controls are added remains well estimated. However, Table 3 suggests that local transportation, nearby patenting, and nearby population, have a stronger relationship to patents per capita than other measures considered. However, this may be caused by attenuation basis, as the distanced weighted measures have many fewer assumptions and estimations involved.

As a measure of nearby information, one would expect patent access and the speed of word arrival to be correlated. Indeed, Table 4 shows that they are. However, Tables 5 and 6 suggest that improved transportation is not playing a strong roll in this relationship. This is further supported by Tables 7 and 8, where the distance weighted measures out preform the cost weighted ones.

References

Atack, J. (2013). On the use of geographic information systems in economic history: The american transportation revolution revisited. *The Journal of Economic History*, 73:313–338. (On pages 3, 4, 5, 6, 7, 8, 9, 10.)

Haines, M. R. (2010). Historical, Demographic, Economic, and Social Data: The United States, 1790-2002 [Computer file]. (On pages 3, 4, 5, 6, 7, 8, 9, 10.)

Hornbeck, R. (2010). Barbed Wire: Property Rights and Agricultural Development. *The Quarterly Journal of Economics*, 125(2):767–810. (On pages 3, 4, 5, 6, 7, 8, 9, 10.)

Patent Access Tables

Table 1: Fixed Effects: Patents per Capita vs. Estimated Patent Access

VARIABLES	(1) Patents per 10K People	(2) Patents per 10K People	(3) Patents per 10K People	(4) Patents per 10K People	(5) Patents per 10K People	(6) Patents per 10K People	(7) Patents per 10K People	(8) Patents per 10K People
log Patent Access with Own Pat ($\theta = 3.8$)	0.464** (0.0337)	0.172** (0.0264)						
log Patent Access ($\theta = 3.8$)			0.426** (0.0442)	0.0529+ (0.0289)				
log CF Patent Access with Own Pat ($\theta = 3.8$)					0.984** (0.0568)	0.674** (0.0472)		
log CF Patent Access ($\theta = 3.8$)							1.347** (0.280)	0.398** (0.112)
Years	1790-1900	1790-1900	1790-1900	1790-1900	1790-1900	1790-1900	1790-1900	1790-1900
County Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Pre-trends	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	No	Yes	No	Yes	No	Yes	No	Yes
Counties	1250	1250	1250	1250	1250	1250	1250	1250
Observations	13,249	13,249	13,249	13,249	13,249	13,249	13,249	13,249
R-squared	0.640	0.792	0.619	0.791	0.674	0.801	0.636	0.792

Robust standard errors in parentheses, standard errors clustered by county.
** $p<0.01$, * $p<0.05$, + $p<0.1$

Sources: Patent data as described in the text, U.S. Census Data is from Haines (2010) (county boundaries harmonized to 1840 as in Hornbeck (2010)), transportation data from Atack (2013).

Table 2: Instrumental Variables: Patents per Capita vs. Estimated Patent Access, 1840-1870

VARIABLES	(1) OLS Patents per 10K People	(2) First Stage Percent Trans 5.0 Miles	(3) IV Patents per 10K People	(4) OLS Patents per 10K People	(5) First Stage Percent Trans 5.0 Miles	(6) IV Patents per 10K People
Line Instrument		0.352** (0.0644)			0.196** (0.0592)	
log Patent Access ($\theta = 3.8$)	0.393** (0.0611)		0.730 (0.476)	0.0526+ (0.0286)		1.249+ (0.705)
log Total Pop				-0.0103 (0.0492)	-0.370** (0.0691)	-0.444 (0.749)
T-Squared		29.96			10.95	
Wald Stat.			40.02			14.73
Years	1840-1870	1840-1870	1840-1870	1840-1870	1840-1870	1840-1870
County Dummies	Yes	Yes	Yes	Yes	Yes	Yes
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes
Pre-trends	Yes	Yes	Yes	Yes	Yes	Yes
County Controls	No	No	No	Yes	Yes	Yes
Counties	1250	1250	1250	1250	1250	1250
Observations	4,995	4,995	4,995	13,249	4,995	4,995
R-squared	0.623	0.892	0.373	0.791	0.918	-0.179

Robust standard errors in parentheses, standard errors clustered by county.
** $p<0.01$, * $p<0.05$, + $p<0.1$

Sources: Patent data as described in the text, U.S. Census Data is from Haines (2010) (county boundaries harmonized to 1840 as in Hornbeck (2010)), transportation data from Atack (2013).

Table 3: Fixed Effects: Patents per Capita vs. Local Transportation Access, Estimated Market Access, and Estimated Patent Access

VARIABLES	(1) Patents per 10K People	(2) Patents per 10K People	(3) Patents per 10K People	(4) Patents per 10K People	(5) Patents per 10K People	(6) Patents per 10K People	(7) Patents per 10K People	(8) Patents per 10K People	(9) Patents per 10K People
log Patent Access ($\theta = 3.8$)	0.225** (0.0529)	0.315** (0.0495)	0.0528+ (0.0303)				0.147* (0.0591)	0.194** (0.0597)	0.0247 (0.0323)
log CF Patent Access ($\theta = 3.8$)				0.471* (0.188)	0.456* (0.190)	0.371** (0.118)	0.724** (0.183)	0.941** (0.185)	0.524** (0.109)
log Market Access with Own Pop ($\theta = 3.8$)	0.171* (0.0820)	-0.258** (0.0964)	0.0226 (0.0602)				-0.423** (0.122)	-0.392** (0.125)	-0.136* (0.0642)
log CF Market Access with Own Pop ($\theta = 3.8$)				0.394** (0.0531)	1.090* (0.471)	0.558+ (0.329)	0.626** (0.0935)	1.310* (0.538)	0.662+ (0.345)
% within 5 miles of transport	0.488** (0.180)	0.623** (0.181)	0.248 (0.170)	0.314+ (0.172)	0.305+ (0.170)	0.340* (0.159)	0.500** (0.174)	0.521** (0.172)	0.398* (0.178)
log Total Pop		0.484** (0.116)	-0.0946 (0.0824)		-0.648 (0.450)	-0.507 (0.325)		-0.665 (0.459)	-0.510 (0.323)
Years	1790-1900	1790-1900	1790-1900	1790-1900	1790-1900	1790-1900	1790-1900	1790-1900	1790-1900
County Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Pre-trends	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
County Controls	No	No	Yes	No	No	Yes	No	No	Yes
Counties	1250	1250	1250	1250	1250	1250	1250	1250	1250
Observations	13,249	13,249	13,249	13,249	13,249	13,249	13,249	13,249	13,249
R-squared	0.664	0.666	0.797	0.700	0.701	0.799	0.714	0.709	0.801

Robust standard errors in parentheses, standard errors clustered by county.

** p<0.01, * p<0.05, + p<0.1

Sources: Patent data as described in the text, U.S. Census Data is from Haines (2010) (county boundaries harmonized to 1840 as in Hornbeck (2010)), transportation data from Atack (2013).

Table 4: Fixed Effects: Speed vs. Estimated Patent Access, 1850-1890

VARIABLES	(1) Speed 10 Years Patenters	(2) Speed 10 Years All Counties	(3) Speed All Years Patenters	(4) Speed All Years All Counties	(5) Speed 10 Years Patenters	(6) Speed 10 Years All Counties	(7) Speed All Years Patenters	(8) Speed All Years All Counties
				Without Controls				
log Patent Access	0.00277*	0.000617	0.00771**	0.00521**				
($\theta = 3.8$)	(0.00127)	(0.000483)	(0.00214)	(0.00100)				
log CF Patent Access					0.0219**	0.0140**	0.0347*	0.0222**
($\theta = 3.8$)					(0.00604)	(0.00322)	(0.0139)	(0.00728)
County Controls	No	No	No	No	No	No	No	No
R-squared	0.745	0.744	0.732	0.728	0.751	0.749	0.737	0.734
				With Controls				
log Patent Access	0.00356**	0.00138*	0.00485**	0.00205*				
($\theta = 3.8$)	(0.00136)	(0.000545)	(0.00181)	(0.000833)				
log CF Patent Access					0.0172**	0.0107**	0.0210*	0.0147**
($\theta = 3.8$)					(0.00643)	(0.00310)	(0.00874)	(0.00399)
County Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.825	0.815	0.817	0.812	0.827	0.818	0.819	0.813
Years	1850-1890	1850-1890	1850-1890	1850-1890	1850-1890	1850-1890	1850-1890	1850-1890
County Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Pre-trends	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Counties	1173	1250	1173	1250	1173	1250	1173	1250
Observations	4,100	6,245	4,100	6,245	4,100	6,245	4,100	6,245

Robust standard errors in parentheses, standard errors clustered by county.

** p<0.01, * p<0.05, + p<0.1

Sources: Patent data as described in the text, U.S. Census Data is from Haines (2010) (county boundaries harmonized to 1840 as in Hornbeck (2010)), transportation data from Atack (2013).

Table 5: Instrumental Variables: Speed of Word Arrival vs. Estimated Patent Access, 1850-1870

VARIABLES	(1) OLS Speed 10 Years All Counties	(2) First Stage Patent Access	(3) IV Speed 10 Years All Counties	(4) OLS Speed 10 Years All Counties	(5) First Stage Patent Access	(6) IV Speed 10 Years All Counties
Line Instrument		0.144* (0.0719)			0.141* (0.0644)	
log Patent Access ($\theta = 3.8$)	0.000532 (0.000663)		-0.0143 (0.0125)	0.00128+ (0.000697)		-0.0130 (0.0113)
log Total Pop				0.00540 (0.00366)	-0.218+ (0.123)	0.00227 (0.00386)
T-Squared		4.021			4.774	
Wald Stat.			6.051			7.251
Years	1850-1870	1850-1870	1850-1870	1850-1870	1850-1870	1850-1870
County Dummies	Yes	Yes	Yes	Yes	Yes	Yes
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes
Pre-trends	Yes	Yes	Yes	Yes	Yes	Yes
County Controls	No	No	No	Yes	Yes	Yes
Counties	1250	1250	1250	1250	1250	1250
Observations	3,745	3,745	3,745	3,745	3,745	3,745
R-squared	0.808	0.915	-0.133	0.866	0.939	-0.173

Robust standard errors in parentheses, standard errors clustered by county.
** p<0.01, * p<0.05, + p<0.1

Sources: Patent data as described in the text, U.S. Census Data is from Haines (2010) (county boundaries harmonized to 1840 as in Hornbeck (2010)), transportation data from Atack (2013).

Table 6: Instrumental Variables: Speed of Word Arrival vs. Estimated Patent Access, 1850-1870

VARIABLES	(1) OLS Speed All Years All Counties	(2) First Stage Patent Access	(3) IV Speed All Years All Counties	(4) OLS Speed All Years All Counties	(5) First Stage Patent Access	(6) IV Speed All Years All Counties
Line Instrument		0.144* (0.0717)			0.141* (0.0644)	
log Patent Access ($\theta = 3.8$)	0.00683** (0.00139)		-0.0112 (0.0185)	0.00212* (0.000822)		-0.00714 (0.0146)
log Total Pop				0.0271** (0.00538)	-0.218+ (0.123)	0.0131* (0.00610)
T-Squared		4.032			4.774	
Wald Stat.			6.063			7.251
Years	1850-1870	1850-1870	1850-1870	1850-1870	1850-1870	1850-1870
County Dummies	Yes	Yes	Yes	Yes	Yes	Yes
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes
Pre-trends	Yes	Yes	Yes	Yes	Yes	Yes
County Controls	No	No	No	Yes	Yes	Yes
Counties	1250	1250	1250	1250	1250	1250
Observations	3,750	3,750	3,750	6,245	3,745	3,745
R-squared	0.818	0.915	0.118	0.813	0.939	-0.025

Robust standard errors in parentheses, standard errors clustered by county.
** $p<0.01$, * $p<0.05$, + $p<0.1$

Sources: Patent data as described in the text, U.S. Census Data is from Haines (2010) (county boundaries harmonized to 1840 as in Hornbeck (2010)), transportation data from Atack (2013).

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Table 7: Fixed Effects: Speed 1850-1890, Local Transportation, Market Access and Patent Access, with Controls

VARIABLES	(1) Speed 10 Years	(2) Speed 10 Years	(3) Speed 10 Years	(4) Speed 10 Years	(5) Speed 10 Years	(6) Speed 10 Years	(7) Speed 10 Years	(8) Speed 10 Years	(9) Speed 10 Years
				Only Patenters					
log Patent Access ($\theta = 3.8$)	-0.00550+ (0.00285)	0.000735 (0.00218)	0.00133 (0.00214)				-0.000159 (0.00244)	-0.00227 (0.00216)	-0.000348 (0.00209)
log CF Patent Access ($\theta = 3.8$)				0.0114 (0.00835)	0.0106 (0.00835)	0.0131+ (0.00701)	0.0106 (0.0101)	0.00910 (0.00600)	0.0115+ (0.00595)
log Market Access with Own Pop ($\theta = 3.8$)	0.0192* (0.00877)	0.000620 (0.00607)	0.00337 (0.00517)				-0.00103 (0.00642)	0.00560 (0.00604)	0.00406 (0.00530)
log CF Market Access with Own Pop ($\theta = 3.8$)				0.0429** (0.0149)	-0.0229 (0.0277)	-0.00298 (0.0322)	0.0435** (0.0138)	-0.0246 (0.0258)	-0.000864 (0.0323)
% within 5 miles of transport	-0.0146+ (0.00764)	-0.0169* (0.00790)	-0.0126 (0.00807)	-0.0173* (0.00810)	-0.0169* (0.00813)	-0.00745 (0.00669)	-0.0158+ (0.00887)	-0.0166* (0.00830)	-0.00947 (0.00809)
log Total Pop		0.0487** (0.0131)	0.0251* (0.0127)		0.0605** (0.0206)	0.0290 (0.0314)		0.0579** (0.0216)	0.0224 (0.0309)
Counties	1173	1173	1173	1173	1173	1173	1173	1173	1173
Observations	4,104	4,100	4,100	4,104	4,100	4,100	4,104	4,100	4,100
R-squared	0.770	0.777	0.835	0.782	0.783	0.835	0.788	0.785	0.838
				All Counties					
log Patent Access ($\theta = 3.8$)	-0.00138 (0.000854)	9.36e-05 (0.000765)	0.00101 (0.000832)				0.000555 (0.000962)	-0.00106 (0.000799)	1.75e-05 (0.000819)
log CF Patent Access ($\theta = 3.8$)				0.00941** (0.00356)	0.00887* (0.00347)	0.00708* (0.00318)	0.00929* (0.00398)	0.00537* (0.00242)	0.00683* (0.00270)
log Market Access with Own Pop ($\theta = 3.8$)	0.00708* (0.00287)	0.000559 (0.00198)	0.000263 (0.00163)				-0.00114 (0.00220)	0.00285 (0.00190)	0.00141 (0.00166)
log CF Market Access with Own Pop ($\theta = 3.8$)				0.0165* (0.00669)	-0.0246 (0.0166)	-0.00981 (0.0124)	0.0176* (0.00684)	-0.0282 (0.0178)	-0.0122 (0.0121)
% within 5 miles of transport	-0.00943* (0.00417)	-0.00741+ (0.00384)	-0.00479 (0.00338)	-0.00756+ (0.00386)	-0.00745+ (0.00384)	-0.00270 (0.00281)	-0.00704 (0.00436)	-0.00789+ (0.00421)	-0.00353 (0.00348)
log Total Pop		0.0218** (0.00582)	0.0112* (0.00492)		0.0378* (0.0148)	0.0175 (0.0111)		0.0385* (0.0165)	0.0180+ (0.0105)
Counties	1250	1250	1250	1250	1250	1250	1250	1250	1250
Observations	6,250	6,245	6,245	6,250	6,245	6,245	6,250	6,245	6,245
R-squared	0.762	0.766	0.823	0.771	0.772	0.824	0.774	0.772	0.824
County Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Pre-trends	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	No	No	Yes	No	No	Yes	No	No	Yes

Robust standard errors in parentheses, standard errors clustered by county.
** p<0.01, * p<0.05, + p<0.1

Table 8: Fixed Effects: Speed 1850-1890, Local Transportation, Market Access and Patent Access, with Controls

VARIABLES	(1) Speed All Years	(2) Speed All Years	(3) Speed All Years	(4) Speed All Years	(5) Speed All Years	(6) Speed All Years	(7) Speed All Years	(8) Speed All Years	(9) Speed All Years
				Only Patenters					
log Patent Access	-0.00733*	0.00456	0.00254				0.00853*	0.00554	0.00207
($\theta = 3.8$)	(0.00364)	(0.00363)	(0.00328)				(0.00407)	(0.00362)	(0.00330)
log CF Patent Access				0.00423	0.00328	0.0124	-0.000385	0.00184	0.00925
($\theta = 3.8$)				(0.0124)	(0.0126)	(0.00940)	(0.0125)	(0.00966)	(0.00729)
log Market Access with	0.0305**	-0.00487	0.00288				-0.0176+	-0.00721	0.000989
Own Pop ($\theta = 3.8$)	(0.00873)	(0.00834)	(0.00746)				(0.00900)	(0.00785)	(0.00745)
log CF Market Access				0.0890**	0.0557	0.0662+	0.0990**	0.0564	0.0653+
with Own Pop ($\theta = 3.8$)				(0.0183)	(0.0562)	(0.0360)	(0.0184)	(0.0605)	(0.0356)
% within 5 miles	-0.00469	-0.00944	-0.0154	-0.00143	-0.00143	-0.00640	-0.00312	-0.00338	-0.0114
of transport	(0.0111)	(0.0113)	(0.0120)	(0.0111)	(0.0111)	(0.0107)	(0.0123)	(0.0113)	(0.0119)
log Total Pop		0.0931**	0.0507**		0.0335	-0.00379		0.0342	-0.00287
		(0.0144)	(0.0135)		(0.0534)	(0.0325)		(0.0541)	(0.0318)
Counties	1173	1173	1173	1173	1173	1173	1173	1173	1173
Observations	4,104	4,100	4,100	4,104	4,100	4,100	4,104	4,100	4,100
R-squared	0.760	0.772	0.827	0.783	0.783	0.830	0.789	0.784	0.832
				All Counties					
log Patent Access	-0.00215	0.00142	0.00158				0.00486**	0.00337*	0.00188
($\theta = 3.8$)	(0.00163)	(0.00147)	(0.00128)				(0.00159)	(0.00146)	(0.00127)
log CF Patent Access				0.00628	0.00579	0.00848*	0.00623	0.00538	0.00815*
($\theta = 3.8$)				(0.00570)	(0.00569)	(0.00408)	(0.00573)	(0.00412)	(0.00324)
log Market Access with	0.0170**	0.00122	0.000216				-0.0114**	-0.00588+	-0.00200
Own Pop ($\theta = 3.8$)	(0.00369)	(0.00322)	(0.00262)				(0.00359)	(0.00308)	(0.00263)
log CF Market Access				0.0618**	0.0215	0.0358*	0.0674**	0.0266	0.0333+
with Own Pop ($\theta = 3.8$)				(0.00884)	(0.0296)	(0.0167)	(0.00921)	(0.0306)	(0.0172)
% within 5 miles of transport	-0.00338	0.00126	-0.00686	-0.00203	-0.00189	-0.00231	-8.88e-05	-0.000566	-0.00450
of transport	(0.00593)	(0.00586)	(0.00592)	(0.00532)	(0.00530)	(0.00508)	(0.00604)	(0.00581)	(0.00591)
log Total Pop		0.0537**	0.0322**		0.0382	0.000181		0.0337	0.00250
		(0.00636)	(0.00536)		(0.0272)	(0.0147)		(0.0272)	(0.0152)
Counties	1250	1250	1250	1250	1250	1250	1250	1250	1250
Observations	6,250	6,245	6,245	6,250	6,245	6,245	6,250	6,245	6,245
R-squared	0.751	0.761	0.820	0.780	0.780	0.824	0.783	0.780	0.825
County Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Pre-trends	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	No	No	Yes	No	No	Yes	No	No	Yes

Robust standard errors in parentheses, standard errors clustered by county.

** p<0.01, * p<0.05, + p<0.1