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e-companion

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Electronic Companion—"Identifying Formal and Informal Influence in Technology Adoption with Network Externalities" by Catherine Tucker, *Management Science*, DOI 10.1287/mnsc.1080.0897.

Supporting Empirical Evidence

EC.1. Details about the Call Data

Table EC.1 illustrates how calls ended. In my empirical analysis, I exclude calls which were refused or where the call timed out. Table EC.2 illustrates the relative proportion of two-way video-messaging calls and one-way calls where video was broadcast in only one direction. The majority of these one-way calls were television broadcasts. These proportions suggest that the network usage of video-messaging dominated the stand-alone usage of TV, in terms of call volume.

Table EC.1 How the Call Ended by Call Duration

EndEvent	No Call Duration	Positive Call Duration	Total
Allocation Failed	66	0	66
Collapsed	781	30,518	31,299
Error	76,780	110,110	186,890
Forwarded	14,450	64,064	78,514
Hangup	180,229	1,532,876	1,713,105
Redirected	4,129	57,608	61,737
Refused	82,404	144	82,548
Ring Timeout	363,930	2,314	366,244
Total	722,769	1,797,634	2,520,403

All calls with no call duration, that are refused or where the ring times out are dropped from the data

Table EC.2 Number of Two-Way video-messaging Calls and One Way TV calls

Item	Number of Calls	Percent
One Way	752,055	30
Two Way	1,768,348	70
Total	2,520,403	100

EC.2. Details about the Personnel Data

The data do not indicate whether personnel details changed between January 2001 to August 2004. It is more likely that an employee got promoted than changed work group or city, given geographic immobility and group-specific human capital. Accordingly, an employee is described as a manager if she was on an upwards career trajectory which meant she would be a manager by 2004. The personnel records do not include data on employees who left the firm before 2004. Observations of these employees' calling patterns are excluded from the dataset.

The dataset excludes 127 personnel records of employees who joined the firm after January 2001: The unfavorable business climate from 2001-2003 means that the firm made few new appointments. The dataset also excludes 18 employees in Moscow, Bangkok and Athens, since the video-messaging infrastructure did not connect to these cities.

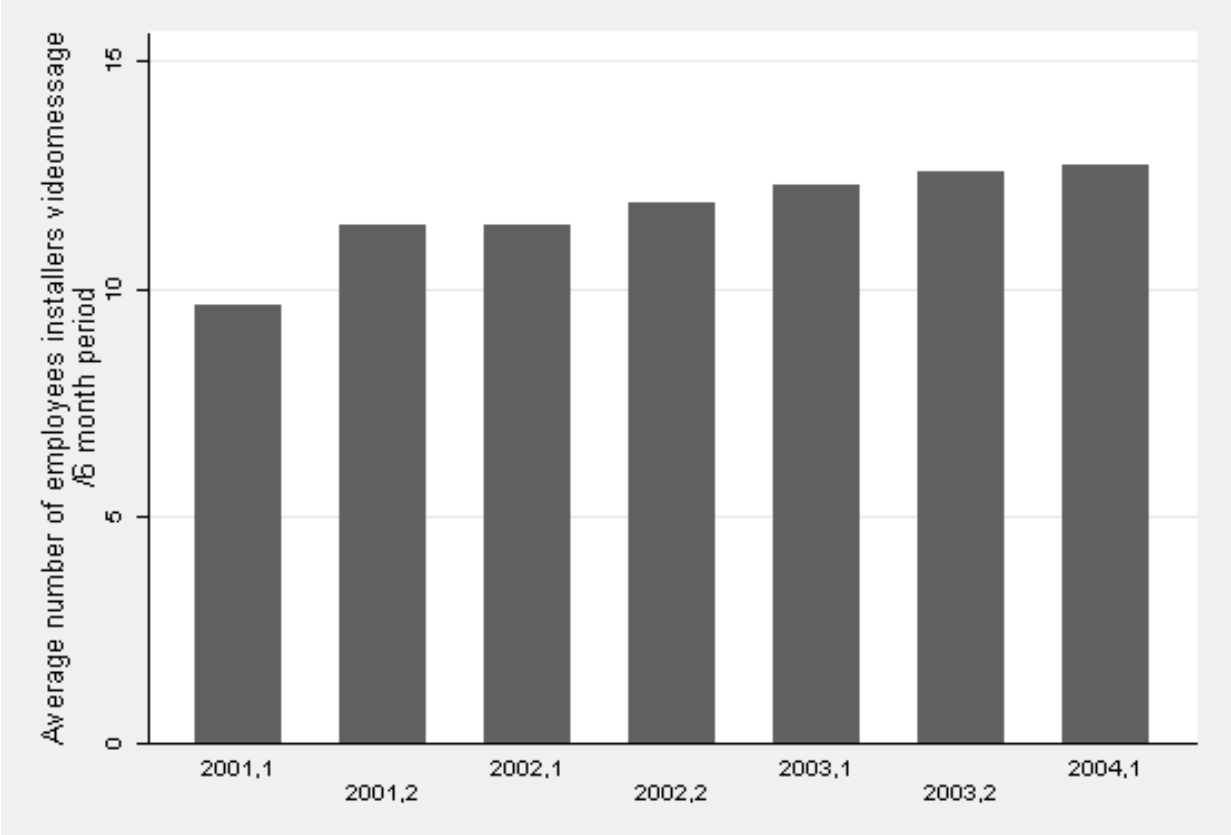
EC.3. Relationship Between Usage Intensity and Adoption

Table EC.3 illustrates the relationship between adoption in each month and the subsequent intensity of usage. It is clear there is no monotonic relationship between how early someone adopted and how much they ultimately used the technology. One interpretation is that this reflects the lack of video-messaging use by groups of early adopters who adopted the technology to watch television. The measure of what proportion of how many days each month an employee spent using the technology is somewhat distorted upwards by a few extreme values. A few Scandinavian employees left their video-message screen open for days on end. Figure EC.1 provides evidence that the number of different people that an adopter calls on average remains relatively stable over time. Figures EC.2 explores the relationship between the number of calls and the timing of adoption, and it is clear that again this is not monotonic. Figure EC.3 explores the relationship between the number of contacts and number of calls, and shows that in general employees who have more contacts are making more calls to these contacts.

Table EC.3 Relationship between Adoption timing and Usage intensity

Year-Month of Adoption	Average total calls in last 12 months	Average time spent video-messaging each month (one unit is one day
200102	287.11	1.03
200103	136.75	0.57
200104	101.89	0.40
200105	242.19	0.82
200106	168.32	0.88
200107	87.27	0.24
200108	194.78	0.60
200109	260.59	0.96
200110	144.32	0.44
200111	57.48	0.19
200112	114.93	0.30
200201	77.94	0.26
200202	113.09	0.33
200203	52.94	0.19
200204	277.73	0.86
200205	96.74	0.38
200206	197.17	0.95
200207	186.55	0.56
200208	118.59	0.49
200209	166.07	0.67
200210	273.86	1.88
200211	376.43	1.48
200212	167.14	2.44
200301	147.50	0.71
200302	91.00	0.32
200303	252.13	1.24
200304	158.70	0.55
200305	239.44	1.02
200306	96.00	0.52
200307	254.59	0.97

Figure EC.1 Stability in Video-messaging Behavior over Time



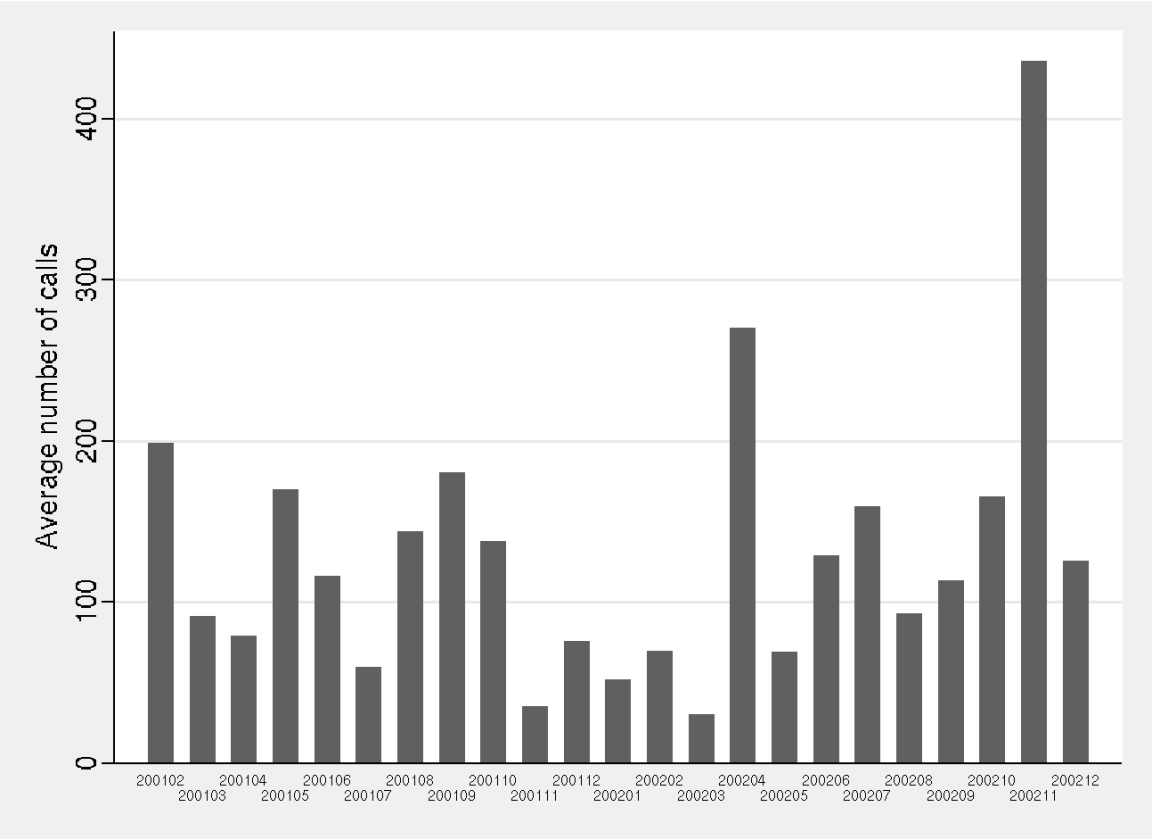


Figure EC.2 Relationship between Number of Calls and Timing of Adoption

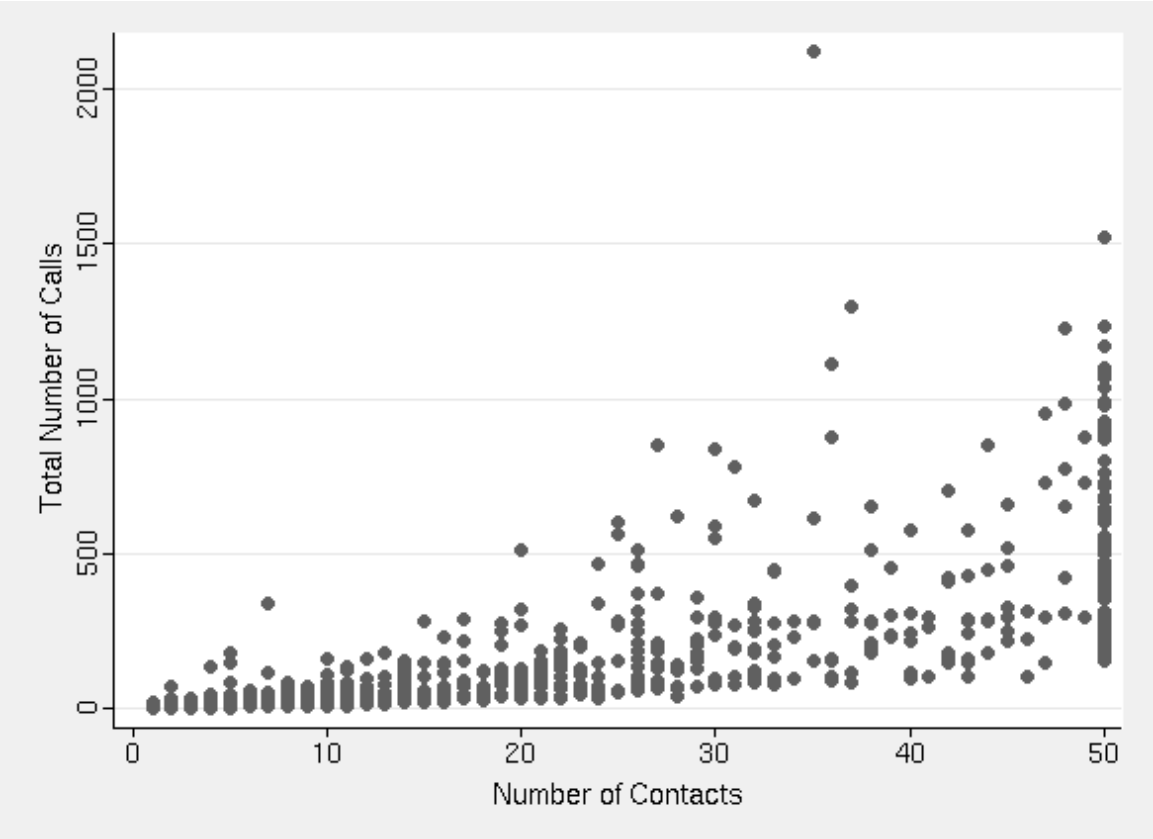


Figure EC.3 Relationship between Number of Calls and Number of Contacts

EC.4. Calculations of Social Network Centrality Measures

All measures of centrality were calculated using the software package UCinet written by Borgatti et al. (2002). Though these measures are very familiar to sociologists, they are unfamiliar to economists. Table EC.4 provides a description of the basic concepts behind the calculation of social network measures. Table **??** provides a technical description of how Borgatti et al. (2002) calculates each of the different measures of centrality.

Table EC.4 Social Network Analysis Terminology

Name	Description
Vertex	A node in a network (in my case, the position the contact occupies in the video-messaging network)
Geodesic	Shortest path between two vertices
Adjacency matrix	A n by n matrix that summarizes whether is a link between any of the n vertices in a network

Table EC.5 How centrality measures are calculated

Name	Description
	Formal Influence
Managerial Status	Indicator variable for whether a contact has a title of Director or higher
	Informal Influence
Betweenness	Proportion of all geodesics linking vertex j and vertex k which pass through vertex i. Formula given by Freeman (1977)
Closeness	The reciprocal of a contact's length of geodesic to every other vertex.
Degrees	The number of vertices adjacent to the given vertex (the contact)
Bonacich Power	$\sum A_{ij}(\alpha+\beta c_j)$, where A is the adjacency, c_j is the centrality of vertex j, and α is a normalization factor. In my specification β=1.
Distance	Distance in km between the employee's city and the contact's city calculated using air travel distances

EC.5. Robustness Checks for Network Measures

As a robustness check I also estimated a linear probability model specification to verify my results. This allowed me (unlike in the Newey two-step methodology) to implement different specifications of the error term such as allowing for robustness. Reassuringly, the results suggest that little changed even when errors were clustered at the regional level.

Table EC.6 Linear Probability Robustness Checks for Base Specification

	Managers			Workers		
	Standard	**Robust**	**Clust.Region**	**Standard**	**Robust**	**Clust.Region**
Installed Worker	0.0003	0.0003	0.0003	0.0022***	0.0022***	0.0022*
	(0.0008)	(0.0009)	(0.0009)	(0.0004)	(0.0005)	(0.0007)
Installed Manager	0.0174***	0.0174***	0.0174*	0.0073***	0.0073**	0.0073**
	(0.0042)	(0.0046)	(0.0063)	(0.0027)	(0.0034)	(0.0015)
TV in employee's region	0.0280*	0.0280*	0.0280**	0.0387***	0.0387***	0.0387*
	(0.0146)	(0.0154)	(0.0086)	(0.0073)	(0.0084)	(0.0151)
Observations	4635	4635	4635	8088	8088	8088

Dependent Variable: Indicator for when an employee first makes an outward video-messaging call

Sample: Adopters who have not yet made a video-messaging call

Dummies for month, region, title, product included in all regressions

Instruments for the heterogeneity-weighted installed base are the heterogeneity-weighted TV valuation of each employee's manager and worker contacts. TV valuation is measured by the % of prior adopters who watch local TV in that contact's region in the next month.

* p<0.10, ** p<0.05, *** p<0.01

Table EC.7 Linear Probability Model: Reflecting different effects of Centrality

	Managers					
	Regular	**Betweenness**	**Closeness**	**Degrees**	**Power**	**Distance**
Installed Worker	0.0003	0.0014***	0.0074**	0.0010*	-0.0048	-0.0024*
	(0.0009)	(0.0005)	(0.0031)	(0.0005)	(0.0036)	(0.0012)
Installed Manager	0.0174***	0.0030	0.0272**	0.0030	-0.0043	0.0077
	(0.0046)	(0.0024)	(0.0109)	(0.0026)	(0.0053)	(0.0047)
TV in employee's region	0.0280*	0.0299*	0.0287*	0.0317**	0.0530***	0.0436***
	(0.0154)	(0.0154)	(0.0154)	(0.0153)	(0.0152)	(0.0153)
Observations	4635	4635	4635	4635	4635	4635
	Workers					
	Regular	**Betweenness**	**Closeness**	**Degrees**	**Power**	**Distance**
Installed Worker	0.0022***	0.0015***	0.0084***	0.0012***	-0.0016	-0.0024***
	(0.0005)	(0.0004)	(0.0021)	(0.0003)	(0.0025)	(0.0008)
Installed Manager	0.0073**	0.0036*	0.0401**	0.0053**	-0.0039	0.0011
	(0.0034)	(0.0021)	(0.0159)	(0.0023)	(0.0035)	(0.0045)
TV in employee's region	0.0387***	0.0394***	0.0394***	0.0376***	0.0504***	0.0433***
	(0.0084)	(0.0084)	(0.0083)	(0.0084)	(0.0084)	(0.0083)
Observations	8088	8088	8088	8088	8088	8088

Dependent Variable: Indicator for when an employee first makes an outward video-messaging call

Sample: Adopters who have not yet made a video-messaging call

Dummies for month, region, title, product included in all regressions

Instruments for the heterogeneity-weighted installed base are the heterogeneity-weighted TV valuation of each employee's manager and worker contacts. TV valuation is measured by the % of prior adopters who watch local TV in that contact's region in the next month.

Robust Standard Errors: * p<0.10, ** p<0.05, *** p<0.01

EC.6. Prediction of Networks

I use a linear probability model to obtain estimates of what characteristics affect an adopter's decision to video-message another employee. Table EC.8 summarizes and provides a precise description of the dependent variable and the RHS variables. I use a linear probability model because I have nearly 10,000 right-hand-side variables, and because probit specifications are notoriously bad at handling large numbers of dummy variables. Reassuringly, when I compare the results for a probit specification with a linear probability model for a more restricted number of right-hand-side variables, they produce similar predictions.

Table EC.8 Description of variables used in prediction of contacts

Variable	Description	Mean	Std. Dev.
	LHS Variable		
Link	Indicator Variable for whether employee i and employee j make a video-messaging call from August 2003 to August 2004	0.0045	0.067
	RHS Variables		
26x26 Interaction Dummies between i and j's city location			
64x64 Interaction Dummies between i and j's field of specialization			
4x4 Interaction Dummies between i and j's title			
2x2 Interaction Dummies between i and j's product			
7x7 Interaction Dummies between i and j's geographical product market			
Total Observations:4,541,161			

EC.7. Robustness Checks for Predicted Measures

Table EC.9 Linear Probability Model: Reflecting effects of centrality for predicted behavior of non-adopters

	Managers					
	Regular	**Betweenness**	**Closeness**	**Degrees**	**Power**	**Distance**
Installed Worker	0.0009	0.0039***	0.0023***	0.0014***	0.0031	-0.0026***
	(0.0013)	(0.0015)	(0.0005)	(0.0003)	(0.0024)	(0.0008)
Installed Manager	0.0027***	-0.0062	-0.0025	-0.0016	0.0019	0.0076***
	(0.0006)	(0.0045)	(0.0016)	(0.0010)	(0.0039)	(0.0016)
TV in employee's region	0.0349***	0.0425***	0.0422***	0.0402***	0.0502***	0.0459***
	(0.0092)	(0.0092)	(0.0091)	(0.0091)	(0.0094)	(0.0092)
Observations	8186	8186	8186	8186	8186	8186

	Workers					
	Regular	**Betweenness**	**Closeness**	**Degrees**	**Power**	**Distance**
Installed Worker	0.0003	0.0009	0.0017***	0.0009***	0.0018	-0.0016***
	(0.0012)	(0.0007)	(0.0003)	(0.0002)	(0.0014)	(0.0004)
Installed Manager	0.0023***	-0.0026	-0.0006	-0.0000	-0.0003	0.0034***
	(0.0003)	(0.0032)	(0.0010)	(0.0006)	(0.0019)	(0.0012)
TV in employee's region	0.0261***	0.0304***	0.0285***	0.0280***	0.0312***	0.0299***
	(0.0034)	(0.0034)	(0.0034)	(0.0034)	(0.0035)	(0.0035)
Observations	23603	23603	23603	23603	23603	23603

Dependent Variable: Indicator for when an employee first makes an outward video-messaging call

Sample: All employees who have not yet made a video-messaging call

Dummies for month, region, title, product included in all regressions

Instruments for the heterogeneity-weighted installed base are the heterogeneity-weighted TV valuation of each employee's manager and worker contacts. TV valuation is measured by the % of prior adopters who watch local TV in that contact's region in the next month.

* p<0.10, ** p<0.05, *** p<0.01

Robust Standard Errors

EC.8. Influence of Direct and Indirect Contacts

In my regressions, I focus only on the influence of the adoption decisions of direct contacts. However, theoretically, indirect contacts may matter too if employees place an option value on their being in the network. To test this, I estimated another specification that included both the installed base of direct contacts and the installed base of indirect contacts. The results in Table EC.10 provide empirical evidence that suggests that only direct contacts have a significant impact on adoption decisions.

Table EC.10 Only Direct Contacts Matter

	Managers		Workers	
	Probit	**Probit IV**	**Probit**	**Probit IV**
Installed Worker	0.0044	0.0007	0.0230***	0.0151**
	(0.0064)	(0.0099)	(0.0054)	(0.0065)
Installed Manager	0.1514***	0.0997***	0.0688***	0.0597**
	(0.0196)	(0.0286)	(0.0201)	(0.0276)
Installed Worker 2	0.0015	0.0024	-0.0013	-0.0000
	(0.0021)	(0.0031)	(0.0017)	(0.0025)
Installed Manager 2	-0.0022	-0.0014	0.0005	0.0003
	(0.0024)	(0.0019)	(0.0012)	(0.0017)
TV in employee's region	0.1693*	0.1815*	0.3758***	0.3892***
	(0.0962)	(0.0979)	(0.0790)	(0.0826)
Observations	4520	4520	7933	7933

Dependent Variable: Indicator for when an employee first makes an outward video-messaging call

Sample: Employees who have not yet made a video-messaging call

Dummies for month, region, title, product included in all regressions

Instruments for the different installed base measures are the TV valuation of each employee's direct and indirect manager and worker contacts. TV valuation is measured by the % of prior adopters who watch local TV in that contact's region in the next month. * $p<0.10$, ** $p<0.05$, *** $p<0.01$