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Online Appendix to "Team-Specific Capital and Innovation"

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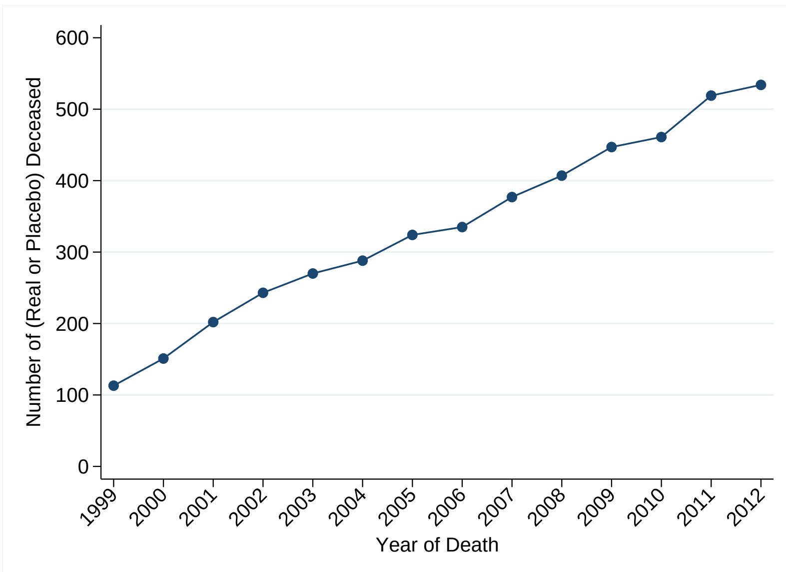
Appendix A

Additional Summary Statistics

A1 Inventor Summary Statistics

Figure A1: Number of Deceased Inventors Per Year



Notes: This figure shows, in each year between 1999 and 2012, the number of inventors who passed away before or at the age of 60 and who had at least one co-inventor. The reason why the number of deceased inventors per year is increasing over time is that, for a deceased inventor to become part of our analysis, they need to have applied for at least one co-invented patent between 1996 and the year of their death (otherwise they have no associated survivor inventor). More and more inventors have applied for co-invented patents as we get closer to 2012, the end of our sample, therefore the number of deceased inventors per year is increasing over time.

Table A1: Detailed Summary Statistics for Real and Placebo Survivor Inventors

Variable	Sample	Mean	SD	10pc	25pc	50pc	75pc	90pc
Total Earnings	Full Sample	144,096	316,636	38,000	58,000	110,000	163,000	241,000
	Real Deceased	139,857	308,000	35,000	59,000	105,000	160,000	237,000
	Placebo Deceased	139,102	320,970	36,000	58,000	104,000	162,000	236,000
	Real Survivors	177,020	355,347	48,000	89,000	125,000	173,000	270,000
	Placebo Survivors	177,247	360,780	47,000	89,000	125,000	173,000	271,000
Labor Earnings	Full Sample	117,559	257,466	25,000	46,000	90,000	142,000	202,000
	Real Deceased	121,691	258,289	29,000	50,000	99,000	147,000	210,000
	Placebo Deceased	124,149	248,546	33,000	52,000	101,000	148,000	210,000
	Real Survivors	152,602	295,832	42,000	78,000	113,000	160,000	239,000
	Placebo Survivors	155,098	290,201	44,000	80,000	116,000	162,000	242,000
Cumulative Applications	Full Sample	2.31	2.51	0	1	1	3	7
	Real Deceased	2.50	2.43	0	1	1	3	7
	Placebo Deceased	2.50	2.43	0	1	1	3	7
	Real Survivors	12.42	28.31	1	2	5	13	28
	Placebo Survivors	11.92	29.52	1	2	5	13	27
Cumulative Citations	Full Sample	6.64	12.2	0	0	1	6.58	23.5
	Real Deceased	8.74	13.09	0	0	3	10	29.13
	Placebo Deceased	8.51	13.20	0	0	2.5	9.95	30
	Real Survivors	42.00	171.03	0.25	1.3	7	28.5	89.53
	Placebo Survivors	40.20	164.20	0.32	1.5	7	29.5	85.32
Age	Full Sample	43.29	9.65	30	36	44	51	56
	Real Deceased	50.85	7.44	40	46	52	57	59
	Placebo Deceased	50.85	7.44	40	46	52	57	59
	Real Survivors	47.53	10.89	35	41	48	55	61
	Placebo Survivors	47.289	11.16	34	41	47	55	60
# Inventors	Full Sample	756,118						
	Real Deceased	4,714						
	Placebo Deceased	4,714						
	Real Survivors	14,150						
	Placebo Survivors	13,350						

Notes: This table reports summary statistics for the various groups of inventors defined in Section II.B. The statistics for the full sample are computed using data from 1999 to 2012. For the deceased and survivor inventors, the statistics are computed using data before the year of death. Dollar amounts are reported in 2012 dollars and are rounded to the nearest $1,000 to preserve taxpayer confidentiality. The balance between real and placebo survivors is qualitatively similar when considering the exact percentile values. For a detailed description of the data sources and sample construction, see Sections II.A and II.B.

Table A2: Detailed Summary Statistics for Real and Placebo Coworkers and Second-Degree Connections

Variable	Sample	Mean	SD	10pc	25pc	50pc	75pc	90pc
Total Earnings	Real Second-degree Connections	175,247	358,347	46,000	81,000	116,000	170,000	267,00
	Placebo Second-degree Connections	174,900	350,102	45,000	82,000	115,000	173,000	266,000
	Real Coworkers	149,861	312,721	39,000	64,000	115,000	169,000	251,000
	Placebo Coworkers	154,627	316,266	40,000	65,000	118,000	174,000	254,000
Labor Earnings	Real Second-degree Connections	144,449	291,697	39,000	70,000	108,000	156,00	239,000
	Placebo Second-degree Connections	146,674	297,697	40,000	72,000	110,000	159,000	241,000
	Real Coworkers	114,559	257,233	22,000	56,000	91,000	142,000	200,000
	Placebo Coworkers	117,691	258,908	25,000	57,000	94,000	146,000	204,000
Cumulative Applications	Real Second-degree Connections	10.42	42.78	1	2	5	11	25
	Placebo Second-degree Connections	9.92	25.21	1	2	5	11	25
	Real Coworkers	2.40	2.58	0	1	1	3	7
	Placebo Coworkers	2.45	2.52	0	1	1	3	7
Cumulative Citations	Real Second-degree Connections	37.76	170.11	0.35	1.2	7	26.5	80.34
	Placebo Second-degree Connections	39.40	173.23	0.22	1.1	7.5	29.5	83
	Real Coworkers	5.74	11.62	0	0	1	8.5	22.5
	Placebo Coworkers	6.05	12.19	0	0	3	9	20.13
Age	Real Second-degree Connections	47.72	19.08	34	40	47	55	63
	Placebo Second-degree Connections	47.93	19.96	35	39	47	55	64
	Real Coworkers	44.28	12.94	30	36	44	52	56
	Placebo Coworkers	44.49	14.13	30	36	43	52	56
# Inventors	Real Second-degree Connections	11,264						
	Placebo Second-degree Connections	12,047						
	Real Coworkers	13,828						
	Placebo Coworkers	14,364						

Notes: This table reports summary statistics for the various groups of inventors defined in Section II.B, using data between 1999 and 2012 before the year of death. The table shows that the real and placebo second-degree connections and the real and placebo coworkers are very similar prior to co-inventor death, although our matching strategy did not use any information on these inventors. Note that the real and placebo second-degree connections are very similar to the survivor inventors, while the distribution of outcomes for real and placebo coworkers is very similar to that of the full sample. Dollar amounts are reported in 2012 dollars and are rounded to the nearest $1,000 to preserve taxpayer confidentiality. The balance between real and placebo coworkers and second-degree connections is qualitatively similar when considering the exact percentile values. For a detailed description of the data sources and sample construction, see Sections II.A and II.B.

Table A3: Balance in Technology Classes For Survivor Co-Inventors

Technology Class	Share of Patents at Co-inventor Death Real	Placebo
1. Chemical	14.37	14.82
2. Computers & Communications	28.60	27.49
3. Drugs & Medical	15.05	14.50
4. Electrical & Electronic	14.99	15.39
5. Mechanical	13.20	13.82
6. Others	13.58	13.61

Notes: This table shows the breakdown by technology class of all patents the real and placebo survivor inventors had invented at the time of their co-inventor death. The table shows very good balance across the two groups, although we did not use this information for the match described in Section II.B.

Table A4: Additional Balance Tests for Survivor Co-Inventors

Variable	Sample	Mean	SD	10pc	25pc	50pc	75pc	90pc
	Real Survivors	9.726	10.85	2	3	6	12	21
Number of Co-inventors	Placebo Survivors	9.583	10.61	2	3	6	12	21
	Real Deceased	3.002	3.873	1	1	2	5	10
	Placebo Deceased	2.83199	3.423	1	1	2	5	9
	Real Survivors	35,191	124,097	44	300	4,400	29,200	69,500
EIN Size	Placebo Survivors	34,942	123,514	43	300	4,300	29,400	69,200
	Real Deceased	37,449	126,254	44	300	4,600	29,900	99,500
	Placebo Deceased	37,691	125,537	43	300	4,500	30,000	98,900
Year of	Real Survivors	2006.629	3.42	2002	2004	2006	2009	2011
Co-inventor Death	Placebo Survivors	2006.723	3.44	2002	2004	2006	2009	2011
	Real Deceased	4,714						
# Inventors	Placebo Deceased	4,714						
	Real Survivors	14,150						
	Placebo Survivors	13,350						

Notes: This table presents summary statistics computed for the real and placebo deceased and survivor inventors. The statistics on number of co-inventors and EIN size are computed in the year of death. The distribution of EIN size is based on all inventors who receive a W2. For both real and placebo survivor inventors, about 10% of inventor-year observations are missing a W2, i.e. the inventors have no labor earnings (either because they are unemployed, self-employed or retired). EIN size is rounded to the nearest one hundred to preserve taxpayer confidentiality.

Table A5: Balance for Number of Real and Placebo Survivor Coworkers per Deceased

Variable	Sample	Mean	SD	10pc	25pc	50pc	75pc	90pc
Number of Inventor Coworkers	Real	52.38	100.61	1	4	19	63	143
In The Year of Death	Placebo	46.75	93.85	1	4	19	65	141
# Real Coworkers	143,646							
# Placebo Coworkers	173,128							

Notes: This table reports the number of real and placebo coworkers per real and placebo deceased inventor. There is good balance except in the tail, which creates an imbalance in the total number of real and placebo survivor coworkers.

Table A6: Team Dynamics for Placebo Survivors

Variable	Mean	SD	Mean	SD	Mean	SD
Distinct Co-inventors before Co-inventor Death	3.43	3.73	3.12	3.31	3.65	3.97
Distinct New Co-inventors after Co-inventor Death	0.63	1.80	0.8925	2.145	0.45	1.49
Share of Patents with New Co-inventors after Co-inventor Death	25.8	35.5	28.91	33.05	22.71	37.58
Sample	All Placebo Survivors		Placebo Survivors Below 44 at Co-Inventor Death		Placebo Survivors Above 45 at Co-Inventor Death	

Notes: This table reports summary statistics on team dynamics at the inventor level for placebo survivors. See Appendix Table A7 for related evidence on EIN switching behavior. For a detailed description of the data sources and sample construction, see Sections II.A and II.B.

Table A7: Summary Statistics on Switching EINs for Placebo Survivors

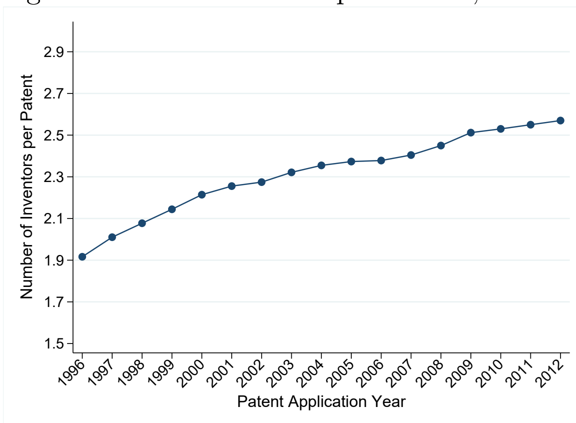
Variable	Mean	Mean	Mean
Probability of Changing EINs before Co-inventor Death	15.49	17.73	13.20
Probability of Changing EINs after Co-inventor Death	14.72	16.58	11.90
Sample	All Placebo Survivors	Placebo Survivors Below 44 at Co-Inventor Death	Placebo Survivors Above 45 at Co-Inventor Death

Notes: This table reports summary statistics at the inventor level for the placebo survivors. Younger inventors tend to switch EINs more often. For a detailed description of the data sources and sample construction, see Sections II.A and II.B.

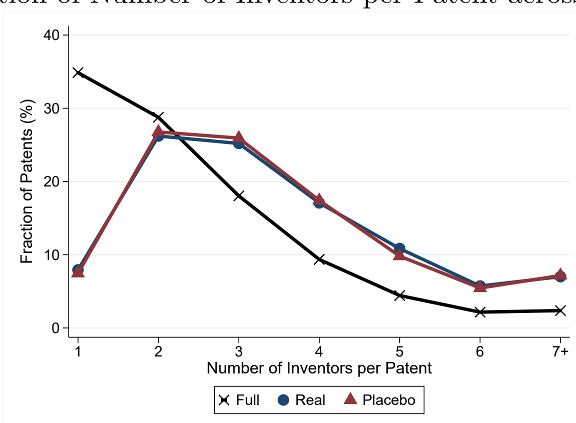
A2 Team Summary Statistics

Figure A2: Number of Inventors per Patent over Time and across Samples

Panel A: Average Number of Inventors per Patent, Full Inventor Sample



Panel B: Distribution of Number of Inventors per Patent across Inventor Samples



Notes: Panel A shows the average number of inventors per patent over time, in our full sample of inventors. Panel B shows the distribution of the number of inventors per patent across three samples of inventors: the full sample, the real survivors sample, and the placebo survivors sample. See Appendix Table A8 for a similar exercise across technology classes. For a detailed description of the data sources and sample construction, see Sections II.A and II.B.

Table A8: Distribution of Number of Inventors per Patent across Technology Classes, Full Sample of Inventors

Technology Class	Mean	p10	p25	p50	p75	p90
1. Chemical	2.61	1	1	2	3	5
2. Computers & Communications	2.52	1	1	2	3	4
3. Drugs & Medical	2.74	1	1	2	3	5
4. Electrical & Electronic	2.39	1	1	2	3	4
5. Mechanical	2.10	1	1	2	3	4
6. Others	1.93	1	1	1	2	4

Notes: This table shows the number of inventors per patent across technology classes, for the full sample of inventors. The distributions are broadly similar across technology classes. For a detailed description of the data sources and sample construction, see Sections II.A and II.B.

Table A9: Geographic Dispersion of Teams

Panel A: Distribution of Number of CZs by Team Size, Full Sample

Team Size	Mean Number	p10	p25	p50	p75	p90
2	1.376	1	1	1	2	2
3	1.623	1	1	2	2	3
4	1.848	1	1	2	2	3
5	2.064	1	1	2	3	3
6	2.262	1	1	2	3	4

Panel B: Distribution of Number of States by Team Size, Full Sample

Team Size	Mean Number	p10	p25	p50	p75	p90
2	1.270	1	1	1	2	2
3	1.435	1	1	1	2	2
4	1.592	1	1	1	2	3
5	1.752	1	1	2	2	3
6	1.891	1	1	2	2	3

Panel C: Distribution of Number of States by Team Size, Real and Placebo Survivors

Team Size	Mean Number	p10	p25	p50	p75	p90
2	1.315	1	1	1	2	2
3	1.414	1	1	1	2	2
4	1.634	1	1	1	2	3
5	1.689	1	1	2	2	3
6	1.945	1	1	2	2	3

Notes: The various panels of this table characterize geographic dispersion of teams, by team size, for the various groups of inventors defined in Section II.B. A team is defined as a unique combination of more than two inventors listed on a patent. Bigger teams are more dispersed geographically, but there is always a large percentage of fully co-located teams regardless of team size. For a detailed description of the data sources and sample construction, see Sections II.A and II.B.

Table A10: Characterizing Heterogeneity within Teams for Real and Placebo Inventors, Distribution of Coefficients of Variation

Variable	Team Size	Mean	p10	p25	p50	p75	p90
	2	.399	.057	.144	.306	.561	.997
	3	.406	.055	.139	.301	.577	1.01
Wages	4	.413	.075	.167	.316	.576	.932
	5	.422	.082	.183	.345	.583	.900
	6	.465	.104	.221	.383	.629	.976
	2	.516	.061	.202	.471	.792	1.037
	3	.491	.058	.184	.474	.761	1.010
Cumulative Applications	4	.542	.067	.266	.505	.781	1.040
	5	.565	.128	.290	.538	.794	1.044
	6	.579	.115	.326	.544	.816	1.060
	2	.725	.080	.313	.742	1.141	1.351
Cumulative	3	.727	.044	.305	.738	1.162	1.384
Forward Citations	4	.818	.123	.420	.831	1.219	1.418
	5	.876	.171	.491	.878	1.245	1.517
	6	.907	.218	.533	.899	1.245	1.540
	2	.1498	.019	.055	.122	.220	.317
	3	.158	.021	.061	.133	.225	.331
Age	4	.160	.033	.076	.145	.226	.308
	5	.164	.039	.082	.148	.230	.304
	6	.168	.045	.097	.164	.225	.291

Notes: This table characterizes the degree of within-team heterogeneity for the real and placebo survivors, using a variety of outcomes and the within-team coefficient of variation as a measure of heterogeneity. A team is defined as a unique combination of more than two inventors listed on a patent. Team heterogeneity tends to increase with team size, but relatively little, while there is wide variation in the degree of within-team heterogeneity holding team size constant. For a detailed description of the data sources and sample construction, see Sections II.A and II.B.

Table A11: Characterizing Heterogeneity within Teams for Full Sample of Inventors, Distribution of Coefficients of Variation

Variable	Team Size	Mean	p10	p25	p50	p75	p90
	2	.462	.050	.158	.368	.704	1.007
	3	.596	.152	.261	.434	.680	1.003
Adjusted Gross Income	4	.560	.202	.304	.454	.690	1.015
	5	.575	.238	.332	.479	.711	1.070
	6	.388	.261	.349	.492	.723	1.114
	2	.465	.057	.153	.351	.749	1.015
	3	.486	.130	.229	.402	.656	.957
Wages	4	.506	.171	.264	.418	.661	.956
	5	.533	.199	.291	.443	.673	.983
	6	.553	.220	.307	.460	.678	1.017
	2	.525	.059	.108	.471	.848	1.131
	3	.653	.133	.410	.654	.887	1.170
Cumulative Applications	4	.720	.285	.461	.690	.947	1.209
	5	.761	.344	.514	.724	.977	1.249
	6	.787	.365	.545	.742	.991	1.268
	2	.759	.156	.232	.831	1.283	1.414
Cumulative	3	.969	.228	.626	.958	1.398	1.672
Forward Citations	4	1.097	.436	.741	1.087	1.477	1.843
	5	1.193	.537	.826	1.165	1.555	1.978
	6	1.266	.609	.885	1.222	1.614	2.061
	2	.1734	.021	.061	.136	.246	.368
	3	.189	.062	.106	.172	.251	.334
Age	4	.194	.084	.126	.183	.249	.317
	5	.198	.100	.137	.188	.247	.306
	6	.198	.107	.143	.189	.242	.298

Notes: This table characterizes the degree of within-team heterogeneity for the full sample of inventors, using a variety of outcomes and the within-team coefficient of variation as a measure of heterogeneity. A team is defined as a unique combination of two or more inventors listed on a patent. Within-team heterogeneity tends to increase with team size, but relatively little, while there is wide variation in the degree of within-team heterogeneity holding team size constant. For a detailed description of the data sources and sample construction, see Sections II.A and II.B.

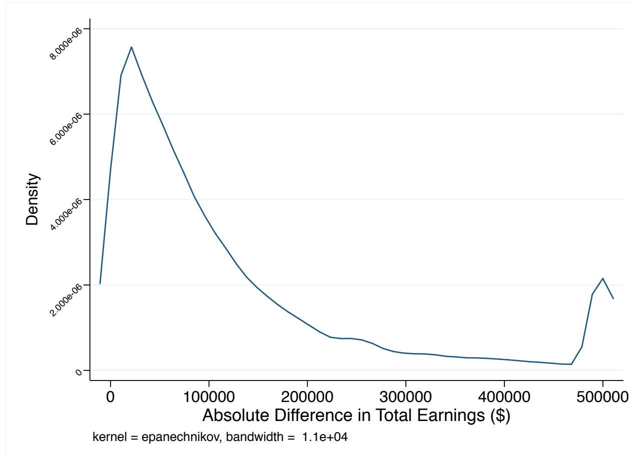
Table A12: Characterizing Heterogeneity within Teams for Real and Placebo Survivors, Distribution of Standard Deviations

Variable	Team Size	Mean	p10	p25	p50	p75	p90
	2	263892.4	8824.692	23918.59	57277.06	132258.3	309400.2
	3	206702.1	9434.219	24277.8	57285.55	120200.4	268307.4
Adjusted Gross Income	4	217135.7	13190.37	31465.94	63923.3	127760.8	282168.8
	5	224742.1	15987.31	34948.75	67761.39	127987	296003.4
	6	297479.1	18865.61	38365.59	71981.13	144830.2	399298.3
	2	116869	5625.123	16619.89	41574.08	81594.55	175599.1
	3	97752.13	5483.79	16068.03	37803.48	76578.63	162250.2
Wages	4	96811.71	8437.463	19945.29	41166.41	78653.08	161463.9
	5	99563.44	9532.86	22096.29	43702.45	81222.41	164561.8
	6	120620	13605.75	27253.44	49179.26	94817.32	202527.7
	2	9.344	.706	1.414	4.242	9.899	21.921
	3	7.456	.465	.707	3.535	8.485	17.677
Cumulative Applications	4	8.710	.577	1.413	4.242	9.849	21.213
	5	9.979	.706	1.788	4.949	10.692	24.041
	6	9.849	.709	2.12	4.961	11.313	22.201
	2	76.640	.707	4.547	18.510	59.539	155.174
Cumulative	3	52.404	.335	2.070	11.634	44.195	119.265
Forward Citations	4	55.319	.318	3.240	14.487	51.399	139.495
	5	63.811	.742	4.458	16.702	57.786	147.347
	6	75.911	1.106	5.292	18.430	65.112	162.090
	2	6.537	.706	2.121	4.949	8.142	14.142
	3	6.909	.707	2.828	5.656	7.329	14.849
Age	4	6.927	1.414	3.214	6.110	9.899	13.435
	5	7.102	1.632	3.535	6.363	9.923	13.391
	6	7.291	2.121	4.112	6.826	9.789	13.245

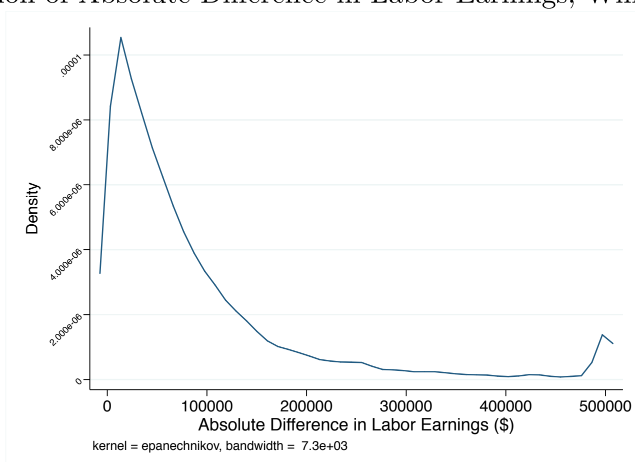
Notes: This table characterizes the degree of within-team heterogeneity for the real and placebo survivor, using a variety of outcomes and the within-team standard deviation as a measure of heterogeneity. A team is defined as a unique combination of two or more inventors listed on a patent. Within-team heterogeneity tends to increase with team size, but relatively little, while there is wide variation in the degree of within-team heterogeneity holding team size constant. Similar results, available from the authors, hold when the Herfindahl index is used as a measure of heterogeneity instead of the standard deviation. For a detailed description of the data sources and sample construction, see Sections II.A and II.B.

Figure A3: Team Composition for Two-Inventor Teams in 2002

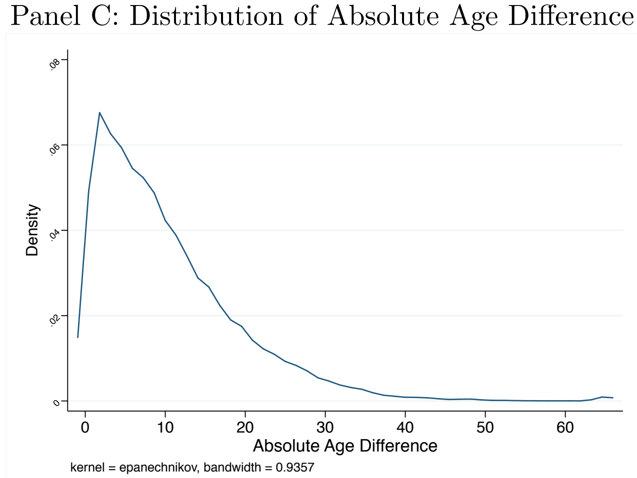
Panel A: Distribution of Absolute Difference in Total Earnings, Winsorized at $500,000



Panel B: Distribution of Absolute Difference in Labor Earnings, Winsorized at $500,000



Panel C: Distribution of Absolute Age Difference



Notes: This figure shows the Epanechnikov kernel density of the absolute differences in total earnings, labor earnings and age between the inventors listed on a two-inventor patent. The sample is the population of inventors residing in the US who invented a patent with exactly one co-inventor in 2002. There are 23,210 such patents. The earnings differences are winsorized at $500,000, hence the point mass at the right of the distributions.

Table A13: Assortative Matching in Teams of Two Inventors (In Percentiles of the Distribution of the Full Sample of Inventors)

Panel A: Full Sample of Inventors

Differenced Variable	Mean	SD	p10	p20	p50	p75	p90
Total Earnings	24.039	20.0386	3	8	19	35	53
Labor Earnings	27.458	22.88877	3	9	21	42	62
Cumulative Applications	20.131	23.81058	0	1	10	33	58
Cumulative Citations	20.543	25.03466	0	1	10	31	59
Age	10.117	21.12023	1	4	8	14	21

Panel B: Real and Placebo Survivors

Differenced Variable	Mean	Age	p10	p20	p50	p75	p90
Total Earnings	21.369	18.035	2	7	17	31	48
Labor Earnings	26.196	22.798	3	8	19	39	62
Cumulative Applications	20.962	23.325	0	1	10	31	55
Cumulative Citations	21.261	28.702	0	2	10	32	58
Age	9.121	7.304	1	3	7	13	19

Notes: This table characterizes the degree of assortative matching for teams of two inventors, for the inventor samples described in Section II.B. The various outcome variables are transformed into percentiles of the distribution of outcomes in the full sample of inventors. The absolute difference gives the distance between the two inventors. For a detailed description of the data sources and sample construction, see Sections II.A and II.B.

Table A14: Frequency of Collaborations Across EINs

Team Size	N	Share w/ 1 EINs	Share w/ 2 EINs	Share w/ 3 EINs	Share w/ 4 EINs	Share w/ 5 EINs
2	262,198	0.73	0.27	-	-	-
3	148,100	0.65	0.26	0.08	-	-
4	73,636	0.59	0.27	0.10	0.04	-
5	33,496	0.53	0.28	0.12	0.05	0.02

Notes: This table shows the percentage of teams of various sizes collaborating across one or more EINs. For instance, the table reports that in 27% of two-inventor teams, the inventors are in two EINs, and that in 5% of five-inventor teams, the inventors are scattered across four EINs. Therefore, collaborations across EINs are quite frequent.

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Appendix B

Additional Results on The Causal Effect of Co-Inventor's Premature Death

B1 On the Long-Lasting and Gradual Nature of the Effect

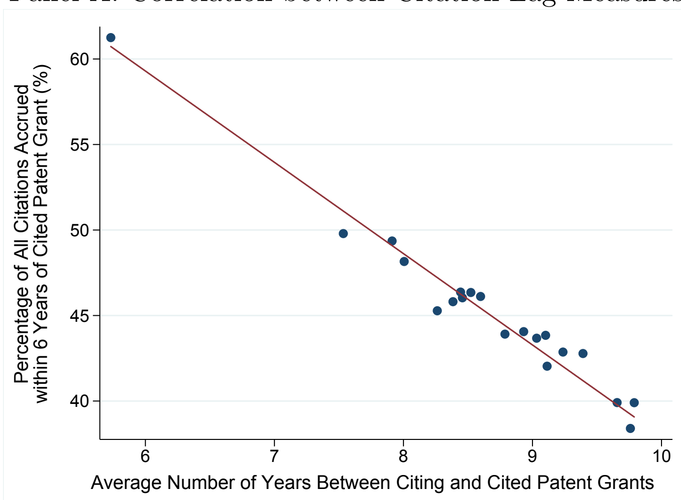
Explaining Why the Effect Appears Gradually

Intuitively, when an inventor loses a co-inventor, their probability of successful innovation decreases because the loss of a co-inventor makes them less productive. As they find new co-inventors, their probability of successful innovation starts increasing, and could potentially go back to its original level or trend. In other words, the probability of successful innovation should exhibit a sharp decrease and a mean-reversion pattern after the time of co-inventor death. But our outcomes do not exhibit such mean-reversion, which we find is due to two forces. First, innovation is a long-term and highly stochastic process, therefore the effect of decreased propensity to innovate takes time to show up in the data — we show the relevance of this channel below. Second, we show in Section V that the "experience" component of team-specific capital is a key driver of the overall effect. This means that it will take a long time for the survivor inventor to build a new collaborative relationship of equally good quality as the one they had with the deceased.

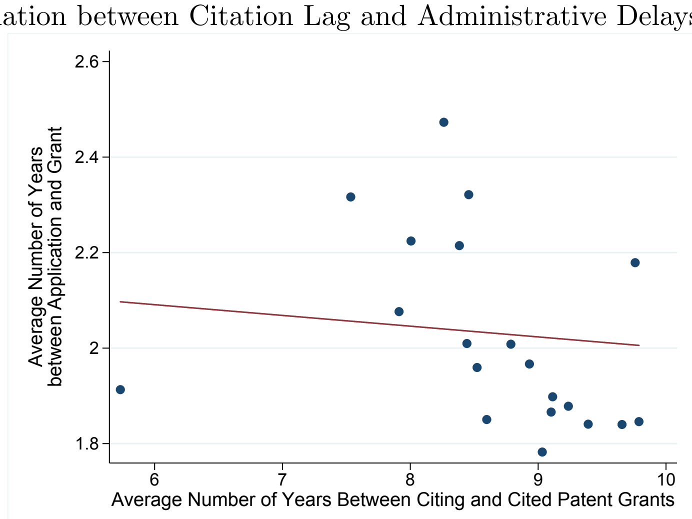
We use citation lags measures to proxy for the "speed of patenting", or "time to build", across the 37 secondary technology categories defined in the NBER patent database (Hall et al., 2001). The variety of citation lag measures we have considered are all very strongly correlated across technology categories. For instance, the patent-level binned scatter plot in Panel A of Appendix Figure B1 illustrates that the average number of years between the grant dates of citing and cited patents is very strongly correlated with the percentage of all citations that occur within six years of cited patent grant (R^2 of 0.95). We use the average number of years between the grant dates of citing and cited patents as our preferred measure of the speed of patenting in the tables below, but the results are similar with other metrics: we have checked the robustness of the results using the application dates of citing and cited patents, based on the percentage of all citations that accrue within a fixed time window (around grant or application), as well as measures using external citations (in patents applied for by other assigned) and examiner-added citations. Panel B of Appendix Figure B1 shows that our preferred citation lag measure is not strongly correlated with administrative delays at the USPTO, which are proxied for by the average number of years between patent application and grant (conditional on grant). This is a desirable property, given that we measure successful innovation in the data based on the application year, which should not be affected by administrative delays.*

Figure B1: Measuring the Speed of the Patent Cycle

Panel A: Correlation between Citation Lag Measures



Panel B: Correlation between Citation Lag and Administrative Delays at the USPTO



Notes: The binned scatter plot in Panel A shows the relationship between the average number of years between the application dates of citing and cited patents, at the patent level. The binned scatter plot in Panel B shows the relationship between the average number of year between the application dates of citing and cited patents and the average number of years between application and grant, at the patent level. The results are similar when the regressions are at the level of the 37 secondary technology classes. The sample is the full sample of inventors: for a detailed description of the data sources and sample construction, see Sections II.A and II.B.

*We have checked that the results are similar when using priority date instead of application year.

Next, we identify the main technology category of each real and placebo inventor, defined as their technology category with the highest number of patents at the time of co-inventor death. We then merge in information on average citation lags, our proxy for the speed of patenting, for each technology category. We then run an analysis of heterogeneity in the treatment effect by creating an indicator capturing the magnitude of the long-term effect, relative to the short-term effect, and we interact this indicator for the technology category being below median by speed of patenting (as measured by the rank of citation lags). We then run robustness checks.

Our main specification is as follows, using similar notation to Section III.B.:

$$Y_{it} = \begin{array}{c} \beta^{Real} AfterDeath_{it}^{Real} + \beta^{All} AfterDeath_{it}^{All} \\ +\lambda^{Real} AfterDeath_{it}^{Real} \cdot SlowInnovation_i + \lambda^{All} AfterDeath_{it}^{All} \cdot SlowInnovation_i \\ +\widetilde{\beta^{Real}} LongRunAfterDeath_{it}^{Real} + \widetilde{\beta^{All}} LongRunAfterDeath_{it}^{All} \\ +\widetilde{\lambda^{Real}} LongRunAfterDeath_{it}^{Real} \cdot SlowInnovation_i + \widetilde{\lambda^{All}} LongRunAfterDeath_{it}^{All} \cdot SlowInnovation_i \\ +\sum_{j=25}^{70} \lambda_j 1_{\{age_{it}=j\}} + \sum_{m=1999}^{2012} \gamma_m 1_{\{t=m\}} + \alpha_i + \epsilon_{it} \end{array}$$

where $LongRunAfterDeath_{it}^{All/Real}$ is an indicator turning to one 5 years after the death of the deceased and $SlowInnovation_i$ is an indicator equal to one if the main technology subclass of inventor i is above the median of the citation lag distribution. The coefficient of interest is $\widetilde{\lambda^{Real}}$, which measures the extent to which the long-term path of the outcome changes depending on the speed of innovation (relative to the short-term path).[†] To facilitate the interpretation, in the regression table below we report the following magnitude: $\frac{\widetilde{\lambda^{Real}}}{\widetilde{\beta^{Real}}} \cdot 100$, which measures the percentage of the "long-run effect" (relative to the short-run effect) which is predicted by our indicator for the speed of innovation. This quantity is equal to zero if the speed of patenting does not predict heterogeneity in the long-run path of the effect, to +50% if technology classes in which innovation is slow have a 50% steeper slope of the effect, and to -50% if these technology classes have a 50% smaller slope.

The results are reported in the table below. We find that our proxy for the speed of innovation is strongly predictive of the path of the causal effect of co-inventor death on all of our outcomes. When an inventor is active in a technology class where innovation is "slow" (above median of the citation lag distribution), then the slope of the effect is 55% more negative for total earnings, i.e. it looks more like the inventor is doing worse over time. Likewise, the slope is 41% more negative for labor earnings, 63% for non-labor earnings, 38% for patents and 66% for citations. For completeness, the table also reports $\widetilde{\lambda^{Real}}$ (which is negative, like $\widetilde{\beta^{Real}}$). Overall, these results show that the gradual nature of the effect of co-inventor death is largely explained by the fact that it takes time for inventors to innovate and receive the rewards from innovation.

[†]Note that we interacted the baseline $AfterDeath_{it}^{All/Real}$ indicators with $SlowInnovation_i$ in order to make sure that our coefficient only picks up on the differential effect over time.

Table B1: The Speed of Patenting Predicts How Gradually the Effect of Co-Inventor Death Appears

	Total Earnings	Labor Earnings	Non-Labor Earnings	Patent Count	Citation Count
$\frac{\widetilde{\lambda^{Real}}}{\widetilde{\beta^{Real}}} \cdot 100$	55.173**	41.221**	63.013*	38.483**	65.811**
s.e.	(25.731)	(18.541)	(37.039)	(16.417)	(33.204)
$\widetilde{\lambda^{Real}}$	-1,038.459**	-583.649**	-370.034*	-0.0142**	-0.0203**
s.e.	(480.096)	(267.433)	(216.489)	(0.00605)	(0.0103)
Age and Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
Individual Fixed Effects	Yes	Yes	Yes	No	No
# Observations	325,726	325,726	325,726	325,726	325,726
# Survivors	27,500	27,500	27,500	27,500	27,500
# Deceased	9,428	9,428	9,428	9,428	9,428
Estimator	OLS	OLS	OLS	Poisson	Poisson

Notes: This table investigates heterogeneity in the gradual nature of the effect by the speed of patenting across technology classes. The specification with the corresponding point estimates is explained in detail in the text above. For a detailed description of the data sources and sample construction, see Sections II.A and II.B. Standard errors are clustered around the deceased inventors. *$p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table B2: The Speed of Patenting Predicts How Gradually the Effect of Co-Inventor Death Appears, Robustness

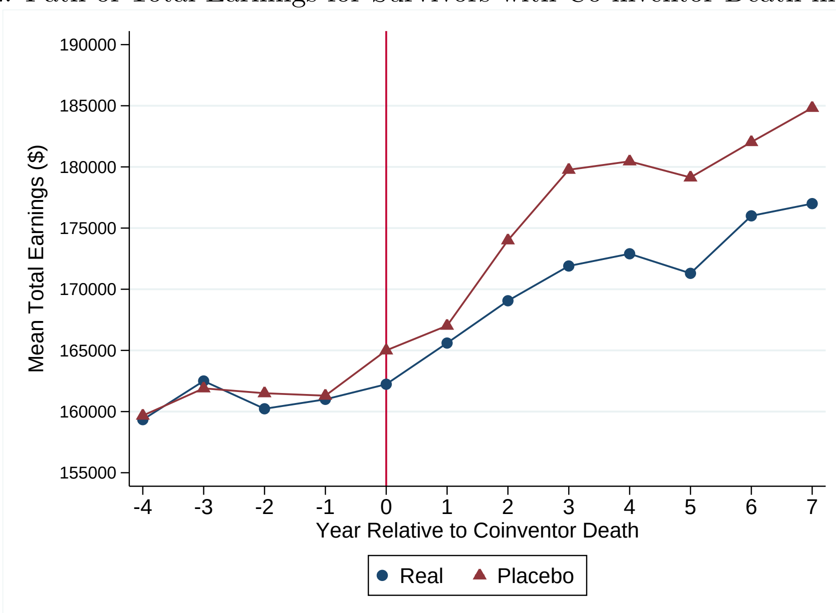
	Total Earnings	Labor Earnings	Non-Labor Earnings	Patent Count	Citation Count
$\frac{\widetilde{\lambda^{Real}}}{\widetilde{\beta^{Real}}} \cdot 100$	45.855**	47.802**	56.123*	35.53**	59.598**
s.e.	(23.001)	(22.778)	(31.997)	(16.021)	(28.245)
$\widetilde{\lambda^{Real}}$	-925.649**	-658.486**	-321.022*	-0.0140**	-0.0183**
s.e.	(457.513)	(320.494)	(187.394)	(0.00599)	(0.0088)
Age and Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
Individual Fixed Effects	Yes	Yes	Yes	No	No
Six High-Level Technology Class F.E. as Interacted Controls	Yes	Yes	Yes	Yes	Yes
# Observations	325,726	325,726	325,726	325,726	325,726
# Survivors	27,500	27,500	27,500	27,500	27,500
# Deceased	9,428	9,428	9,428	9,428	9,428
Estimator	OLS	OLS	OLS	Poisson	Poisson

Notes: This table investigates heterogeneity in the gradual nature of the effect by the speed of patenting across technology classes, adding higher-level technology class fixed effects as interacted controls to the specification documented in the text above. For a detailed description of the data sources and sample construction, see Sections II.A and II.B. Standard errors are clustered around the deceased inventors. *$p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

We have run a series of additional checks ensuring the robustness of these results. First, we have introduced the six higher-level technology classes defined in the NBER patent database as interacted controls, and we used residual variation in the speed of patenting only within these classes. This exercise delivers similar results, shown in Appendix Table B2. Second, we have checked that we obtain similar results when using other definitions of "long-run" (six or seven years), other proxies for the speed of patenting (discussed above), and interactions with a linear term instead of an indicator around the median to capture the speed of patenting.

Dynamic Effects

Figure B2: Path of Total Earnings for Survivors with Co-inventor Death in 2003-2005



Notes: This figure shows the path of mean total earnings for real and placebo survivor inventors around the year of co-inventor death. The sample is restricted to the 4,812 co-inventors of the 1,764 real and placebo deceased with a year of death between 2003 and 2005. Inventor-year observations are dropped if the lag relative to co-inventor death is greater than seven years or if the lead relative to death is greater than four years. The panel is balanced: we observe the same inventors over a period of twelve years. Appendix Table B4 reports the results of the regression analysis in this sample. Note that total earnings are trending up for the real survivors, while in Figure **??** in the main text total earnings were relatively flat for the seven years following co-inventor death. This is due to the fact that we are considering a different time period (for instance, the dot-com bubble is excluded from our analysis here, but not in Figure **??**). We have checked that the full dynamic specification, with year, age and individual fixed effects, gives similar results in both samples.

Table B3: Dynamic Causal Effect of Co-inventor Death, Full Sample

	Total Earnings	Labor Earnings	Labor Earnings >0	Patent Count	Citation Count
$AfterDeath^{Real}$	-2,081**	-1,735**	-0.00658**	-0.0743***	-0.0939**
s.e.	(853)	(683)	(0.002712)	(0.0258)	(0.0375)
$AfterDeath^{Real} \cdot LongRun$	-2,949**	-1,990**	-0.00576**	-0.0504	-0.0507**
s.e.	(1,253)	(903)	(0.0026166)	0.0321	(0.0231)
Age and Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
Individual Fixed Effects	Yes	Yes	Yes	No	No
# Observations	325,726	325,726	325,726	325,726	325,726
# Survivors	27,500	27,500	27,500	27,500	27,500
# Deceased	9,428	9,428	9,428	9,428	9,428
Estimator	OLS	OLS	OLS	Poisson	Poisson

Notes: This panel reports the estimated coefficients β^{Real} and $\widetilde{\beta^{Real}}$ from the following specification:

$$Y_{it=} \quad \beta^{Real} AfterDeath_{it}^{Real} + \beta^{All} AfterDeath_{it}^{All} + \widetilde{\beta^{Real}} AfterDeath_{it}^{Real} \cdot LongRun + \widetilde{\beta^{All}} AfterDeath_{it}^{All} \cdot LongRun + \sum_{j=25}^{70} \lambda_j 1_{\{age_{it}=j\}} + \sum_{m=1999}^{2012} \gamma_m 1_{\{t=m\}} + \alpha_i + \epsilon_{it}$$

using similar notation to Section III.B and where $LongRun$ is an indicator equal to one for observations more than four years after death. The columns report the results for total earnings, labor earnings, employment, the count of patents and the count of citations. For all outcome variables, we find that the effect in the long run is significantly larger than in the short run following death events. For more details on the sample see Table **??** and the main text. Standard errors are clustered around the deceased inventors. *$p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table B4: Dynamic Causal Effect of Co-inventor Death, Sample Restricted to Deaths from 2003 to 2005

	Total Earnings	Labor Earnings	Labor Earnings >0	Patent Count	Citation Count
$AfterDeath^{Real}$	-1,980**	-1,635**	-0.00558*	-0.0843***	-0.0839**
s.e.	(990)	(823)	(0.003112)	(0.0311)	(0.0412)
$AfterDeath^{Real} \cdot LongRun$	-2,743**	-2,001*	-0.00549**	-0.0404*	-0.0443*
s.e.	(1,365)	(1,103)	(0.002724)	(0.02421)	(0.02634)
Age and Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
Individual Fixed Effects	Yes	Yes	Yes	No	No
# Observations	67,368	67,368	67,368	67,368	67,368
# Survivors	4,812	4,812	4,812	4,812	4,812
# Deceased	1,764	1,764	1,764	1,764	1,764
Estimator	OLS	OLS	OLS	Poisson	Poisson

Notes: This panel reports the estimated coefficients β^{Real} and $\widetilde{\beta^{Real}}$ from the following specification:

$$Y_{it=} \quad \beta^{Real} AfterDeath_{it}^{Real} + \beta^{All} AfterDeath_{it}^{All} + \widetilde{\beta^{Real}} AfterDeath_{it}^{Real} \cdot LongRun + \widetilde{\beta^{All}} AfterDeath_{it}^{All} \cdot LongRun + \sum_{j=25}^{70} \lambda_j 1_{\{age_{it}=j\}} + \sum_{m=1999}^{2012} \gamma_m 1_{\{t=m\}} + \alpha_i + \epsilon_{it}$$

using similar notation to Section III.B and where $LongRun$ is an indicator equal to one for observations more than four years after death. The sample is restricted to the 4,812 co-inventors of the 1,764 real and placebo deceased with a year of death between 2003 and 2005. Inventor-year observations are dropped if the lag relative to co-inventor death is above seven years or if the lead relative to death is below four years. The various columns of the panel report the results for total earnings, labor earnings, employment, the count of patents and the count of citations. For all outcome variables, we find that the effect in the long run is significantly larger than in the short run following death events. The magnitude of the effects is similar to Figure **??** and Appendix Table B4, indicating that the dynamics of the effect are not driven by changes in the composition of the sample. Standard errors are clustered around the deceased inventors. *$p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

B2 Robustness Checks

Summary of Results

Anticipation. Another potential concern with our design is that co-inventor death may result from a lingering health condition. To investigate this hypothesis, we study tax deductions for high medical expenditures claimed by the deceased on their personal income tax return.[‡] As shown in Appendix Figure B3, we find that seventy-five percent of deceased inventors do not claim any such deduction, but twenty-five percent claim a deduction in the year preceding death as well as in the year of death, and a small number claim deductions starting several years before death. As a robustness check, we repeat our analysis by excluding survivors whose associated deceased had a positive amount of tax deductions for high medical expenses in any year before death. We find that our results strengthen, as shown in Appendix Table B7. The point estimates for the various outcomes increase by about 10% (in absolute value). Intuitively, when the co-inventor is impaired before the time of death, our estimate of the causal effect on the survivors is biased downward because part of the effect starts before the time of death. This robustness check confirms that anticipation effects result in a downward bias and shows that the magnitude of the bias is relatively small.

Matching Strategy. We have investigated an alternative matching strategy, identifying a control group of placebo survivor inventors using propensity score reweighting, after estimating the propensity score on total earnings, labor earnings, year of birth and patent applications of the deceased inventors in the years preceding death. The results with this empirical strategy are reported in Appendix Figure B4 and Appendix Table B8 and are similar to the results using the real and placebo deceased exact match strategy.

Citations. Appendix Table B9 reports the causal effect of co-inventor death on a series of alternative measures of citations. Specifically, we consider in turns measures of citations that count only citations received in 3-year or 5-year citation windows after the time of grant or application (in order to address censoring), and that take into account only applicant-added or examiner-added citations. We find large and statistically-significant effects, with magnitudes similar to Table **??**. Appendix Table B10 shows the robustness of the citation results using a negative binomial estimator with individual fixed effects instead of a Poisson estimator.

[‡] This information is available on IRS form 1040.

Technology Classes. We check that our results are consistent across technology classes. Appendix Table B11 shows that, for the various outcome variables of interest, the effect of co-inventor death is not significantly different across technology classes. Our results are therefore not driven by a particular technology class.

Inference Taking into Account the Match Step. We implement the coupled bootstrap procedure presented in Abadie and Spiess (2015) so that our standard errors reflect the matching step. The results are robust, with slightly smaller standard errors as shown in Appendix Table B12.

Additional Robustness Checks. We show in Appendix Table B13 that the earnings results are similar when using log transformations. In Appendix Table B14, we find that the earnings results are also similar when considering non-winsorized variables.

F-Test for Pretrending

We can formally test the hypotheses that the point estimates obtained by running specification (1) and shown in Figure **??** are all the same before and after co-inventor death, considering an equal number of periods before and after co-inventor death:

$$H_0^{Before\ Death}:\ \beta_{-9}^{Real} = \beta_{-8}^{Real} = ... = \beta_{-2}^{Real}$$

$$H_0^{After\ Death}:\ \beta_{0}^{Real} = \beta_{2}^{Real} = ... = \beta_{7}^{Real}$$

The results of the F-tests, shown in Appendix Table B5, confirms that there is no pretrending while there is an effect after death. We can reject at the 10% confidence level that all coefficients are similar after death for adjusted gross income and labor earnings, but we cannot do so for non-labor earnings and citations, which are more noisily estimated (although the point estimates reported in Figure **??** appear very stable). We can never reject that the point estimates are all similar before death.

Table B5: Testing For Dynamic Effects, P-Values of F-Tests

	Total Earnings	Labor Earnings	Non-Labor Earnings	Citation Count
For $H_0^{Before\ Death}$	0.671	0.875	0.690	0.764
For $H_0^{After\ Death}$	0.079	0.084	0.268	0.382

Notes: This panel reports the p-values of F-tests for equality of the β_k^{Real} coefficients from specification (1) before and after death, as specified by the hypotheses $H_0^{Before\ Death}$ and $H_0^{After\ Death}$ described in the text above the table. For more details on the outcome variables and the sample, see Table **??** and the main text. P-values are adjusted for the clustering of standard errors around the deceased inventors. *$p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Balanced Panel

Table B6: Regressions Results on Balanced Panel of Survivors Experiencing Co-inventor Death between 2003 and 2008

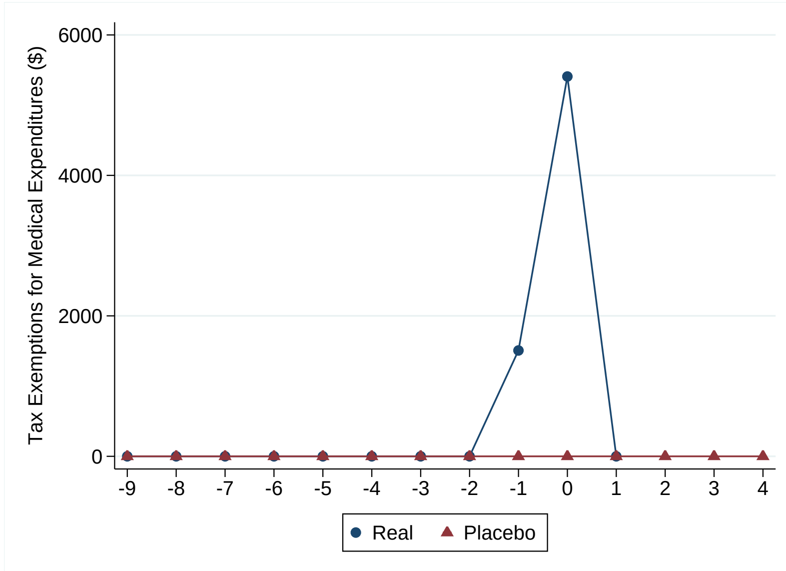
	Total Earnings	Labor Earnings	Labor Earnings >0	Patents Count	Citation Count
$AfterDeath^{Real}$	-2905.73**	-1907.36**	-0.0049*	-0.08090***	-0.0945***
s.e.	1345.88	806.25	0.00289	0.02957	0.0299
$AfterDeath^{All}$	199.025	-168.25	-0.00306**	-0.00622	-0.0293
s.e.	854.76	526.32	0.0021	0.02154	0.032
Age and Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
Individual Fixed Effects	Yes	Yes	Yes	No	No
# Observations	99,108	99,108	99,108	99,108	99,108
# Survivors	11,012	11,012	11,012	11,012	11,012
# Deceased	4,148	4,148	4,148	4,148	4,148
Estimator	OLS	OLS	OLS	Poisson	Poisson

Notes: This table reports the estimated coefficients β^{Real} and β^{All} from specification (2) on a balanced panel, keeping four years before and after death for each inventor in the sample. Specifically, we restrict the sample to survivor inventors whose associated deceased co-inventors passed away between 2003 and 2008 and we drop inventor-year observations when the lead or lag relative to co-inventor death is more than 4 years. Patent count is the number of patents the survivor inventor applied for in a given year, and citation count is the number of adjusted forward citations received on patents that the survivor applied for in a given year. Under the identification assumption described in Section III.B, β^{Real} gives the causal effect of co-inventor death on the various outcomes. The table shows that, for all outcome variables, we find a large and statistically significant effect. This indicates that the effect documented in Table **??** is not driven by the changing composition of the panel. The point estimates reported in this table are smaller than those reported in Table **??**, because the balanced panel includes fewer inventor-year observations many years after death and Figure **??** shows that the negative effect on the survivors amplifies over time. Standard errors are clustered around the deceased inventors. $*p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

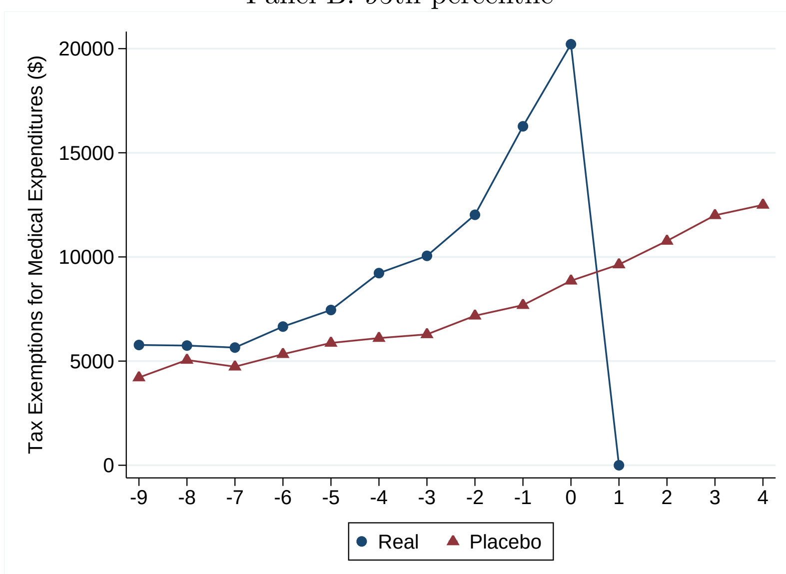
Anticipation

Figure B3: Tax Deductions for High Medical Expenditures Claimed by the Deceased

Panel A: 75th percentile



Panel B: 95th percentile



Notes: This figure shows the path of tax exemptions for medical expenditures claimed by the real and placebo deceased around the time of (real or placebo) death. For details on the sample, refer to Section II.B. Panel A shows that 75 percent of the real deceased inventors never claim any tax exemption for medical expenditures, except in the years just before death as well as during the year of death, suggesting that death is unanticipated for most survivors. Panel B shows that the 95th percentile of the distribution of tax deductions claimed for medical expenditures is very similar for real and placebo deceased until a few years before death, showing that some deaths result from lingering conditions and may therefore be anticipated. Note that the distribution of medical expenditures is truncated. We observe positive medical expenditures only if they are greater than 10% of Adjusted Gross Income (or 7.5% depending on the age).

Table B7: Results for Main Outcomes, Excluding Deceased who Claimed Any Tax Deduction for High Medical Expenditures

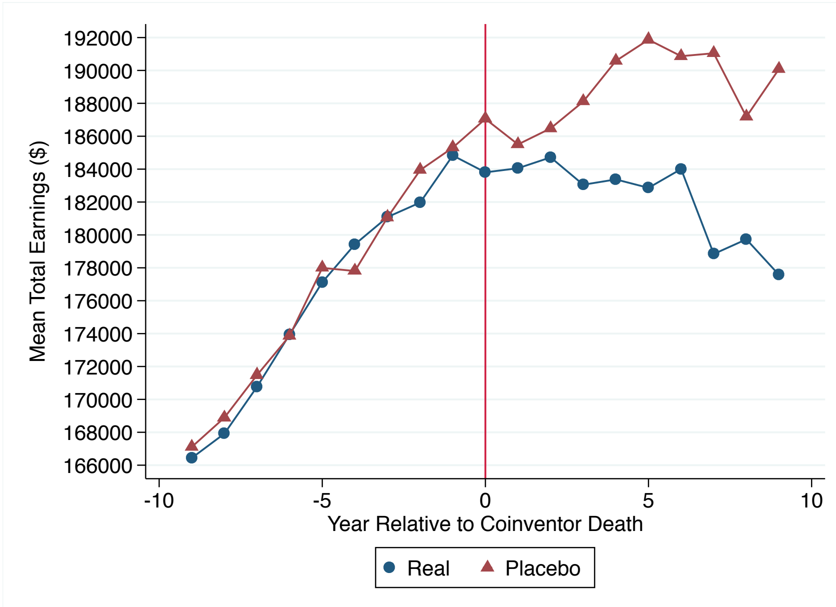
	Total Earnings	Labor Earnings	Labor Earnings >0	Patent Count	Citation Count
$AfterDeath^{Real}$	-4301.1562***	-3022.1***	-0.01047**	-0.1258***	-0.1017**
s.e.	1217.367	925.37	0.00417	0.0361	0.0442
$AfterDeath^{All}$	- 141.17	53.06	-0.00634**	-0.0020	0.0089
s.e.	576.10	595.30	0.0028	0.0231	0.00668
Age and Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
Individual Fixed Effects	Yes	Yes	Yes	No	No
# Observations	250,809	250,809	250,809	250,809	250,809
# Survivors	21,147	21,147	21,147	21,147	21,147
# Deceased	7,062	7,062	7,062	7,062	7,062
Estimator	OLS	OLS	OLS	Poisson	Poisson

Notes: This table reports the estimated coefficients β^{Real} and β^{All} from specification (2) in a sample that excludes all survivors whose associated deceased ever claimed tax deductions for medical expenditures. The table shows that the estimated causal effect of co-inventor death on the various outcomes is negative, statistically significant and large in magnitude. The point estimates are not very different but slightly larger than in Table **??**. This result is not surprising, because our difference-in-differences estimator is biased downward if the causal effect of co-inventor impairment manifests itself before death. It bolsters the validity of the research design by showing that, if anything, we might be slightly underestimating the effect of co-inventor death due to lingering health conditions affecting some deceased inventors. Standard errors are clustered around the deceased inventors. $*p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Alternative Matching Strategy

Figure B4: Path of Outcomes for Real and Placebo Survivor, Propensity Score Reweighting

Panel A: Survivor Inventors' Total Earnings



Panel B: Survivor Inventors' Labor Earnings

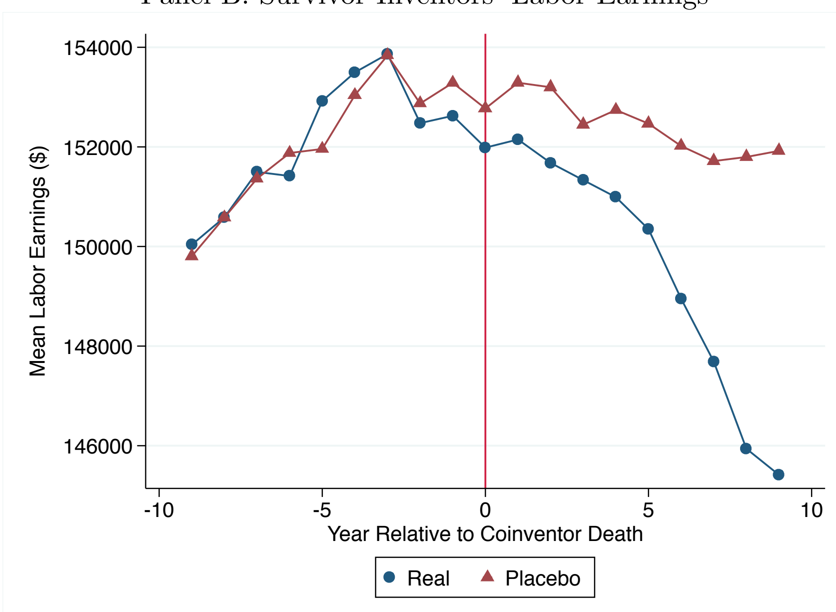
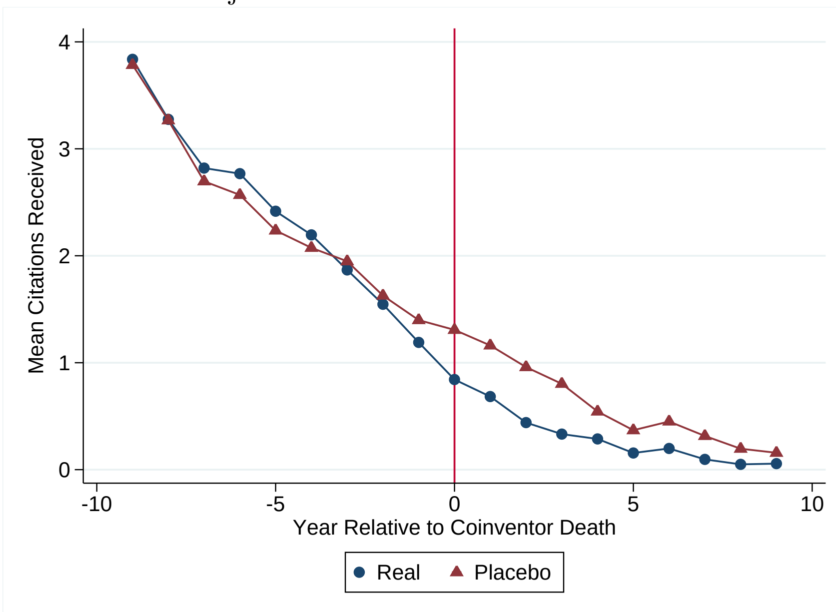


Figure B4: Path of Outcomes for Real and Placebo Survivor, Propensity Score Reweighting

(continued)

Panel C: Survivor Inventor's Adjusted Forward Citations Received for Patents Applied in Year



Notes: Panels A to C of this figure show the path of mean total earnings, labor earnings and citations for real and placebo survivor inventors around the year of co-inventor death, where the placebo survivor inventors are reweighted on the propensity score, following the methodology described in the notes of Appendix Table B8. For all three outcomes, there is no pretrending and the real survivor inventors start performing worse relative to the placebo survivor inventors after the year of co-inventor death. The effect is large, gradual and sustained and is very similar to the results presented in Figure 2, indicating that the choice of matching strategy is not driving the results. The sample includes all real and placebo survivor inventors in a 9-year window around the year of co-inventor death, i.e. inventor-year observations are dropped when the lead or lag relative to co-inventor death is above 9 years. The unbalanced nature of this panel is the same for real and placebo inventors. Dollar amounts are reported in 2012 dollars. Refer to Section II.B for more details on the sample and to Section II.C for more details on the outcome variables.

Table B8: The Causal Effect of Co-Inventor Death, Reweighting on the Propensity Score

	Total Earnings	Labor Earnings	Labor Earnings >0	Non-Labor Earnings	Patent Count	Citation Count
$AfterDeath^{Real}$	-3,624***	-2,621***	-0.00945***	-1,032**	-0.0989***	-0.1103***
s.e.	(890)	(687)	(0.00289)	(472)	(0.0236)	(0.0266)
$AfterDeath^{All}$	- 322	-51	-0.0071**	552	-0.00081	0.07213
s.e.	(437)	(390)	(0.0036)	(378)	(0.01452)	(0.12341)
Age and Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Individual Fixed Effects	Yes	Yes	Yes	Yes	No	No
# Observations	734,742	734,742	734,742	734,742	734,742	734,742
# Deceased	24,929	24,929	24,929	24,929	24,929	24,929
Estimator	OLS	OLS	OLS	OLS	Poisson	Poisson

Notes: This panel reports the estimated coefficients β^{Real} and β^{All} from specification (2) in a sample of real and placebo survivors constructed following an alternative matching strategy, different from the one presented in the main text. Specifically, the matching strategy is as follows: (1) we identify all inventors who passed away before or at the age of 60 in our sample and we keep a random sample of 20,000 inventors who did not pass away during our sample ; (2) for each of the 20,000 inventors who did not pass away, we keep at random only one year of the sample, which will serve as our counterfactual year of death for these inventors in the following steps ; (3) we estimate the propensity score (which gives the probability of "treatment", i.e. the probability of passing away before of at the age of 60 between 1999 and 2012) by regressing an indicator for real deceased on age fixed effects, year of (real or placebo) death fixed effects, a fifth-order polynomial of wages in 1999, a fifth-order polynomial of total earnings in 1999, a fifth-order polynomial for cumulative patent applications at the time of death and a fifth-order polynomial for cumulative adjusted forward citations at the time of (real or placebo) death ; (4) we construct the co-inventor networks of all 24,929 real and placebo deceased in our sample for whom we have overlap in the propensity score ; (5) we run specification (2), which is described in the main text, in the sample of real and survivor inventors built in step (5) and using the propensity score estimated in step (2) as regression weights. The results reported in this table are very similar to the results reported in Table **??**, showing that our results are robust to the choice of matching strategy. Note that the propensity-score reweighting strategy we employ here does not use any variables on the survivors, yet we find no pre-trending effects in Appendix Figure B4. Therefore, the details of the matching strategy do not matter for the substance of the results. It is important to use a matching strategy, however, because the real survivor inventors are in general older and of a higher level of achievement than the full sample of inventors, due to a selection effect (having a larger network of co-inventors increases the probability of experiencing the premature death of a co-inventor). For details about the outcome variables, refer to Table **??**. Dollar amounts are reported in 2012 dollars. Standard errors are clustered around the deceased inventors. *$p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Citations

Table B9: Other Citation Metrics

	3-Year Citation Count Around Grant Year	5-Year Citation Count Around Grant Year	5-Year Examiner-Added Citation Count Around Grant Year	5-Year Applicant-Added Citation Count Around Grant Year
$AfterDeath^{Real}$	-0.095***	-0.1242***	-0.0943***	-0.1448***
s.e.	(0.0245)	(0.0256)	(0.0342)	(0.0402)
$AfterDeath^{All}$	0.135	-0.0739	0.086	0.1528
s.e.	(0.1304)	(0.1345)	(0.1023)	(0.1032)
Age and Year Fixed Effects	Yes	Yes	Yes	Yes
Individual Fixed Effects	No	No	No	No
# Observations	325,726	325,726	325,726	325,726
# Survivors	27,500	27,500	27,500	27,500
# Deceased	9,428	9,428	9,428	9,428
Estimator	Poisson	Poisson	Poisson	Poisson

Notes: This table reports the estimated coefficients β^{Real} and β^{All} from specification (2), except that it does not include individual fixed effects because the Poisson estimator with individual fixed effects did not converge for several outcome variables. Appendix Table B10 shows that the results are similar with individual fixed effects, using a negative binomial estimator. The four outcome variables are as follows: (1) "3-year citation count around grant year" is the number of patents the survivor inventor applied for in a given year, weighted by the number of citations these patents received within three years of their respective year of grant; (2) "5-year citation count around grant year" is the number of patents the survivor inventor applied for in a given year, weighted by the number of citations these patents received within five years of their respective years of grant; (3) "5-year examiner-added citation count around grant year" is similar to the outcome variable in the second column, but taking into account only citations from patent examiners; (4) "5-year applicant-added citation count around grant year" is similar to the outcome variable in the second column, but taking into account only citations from applicants. For all outcome variables, we find a large and statistically significant effect. The magnitudes of these effects are similar to the effects reported in Table **??**, Panel C, which shows the robustness of our result to the choice of the citation measure. For more details on the sample, see Table **??**. Standard errors are clustered around the deceased inventors. *$p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table B10: Citation Results with Negative Binomial Estimator and Individual Fixed Effects

	3-Year Citation Count Around Grant Year	5-Year Citation Count Around Grant Year	5-Year Examiner-Added Citation Count Around Grant Year	5-Year Applicant-Added Citation Count Around Grant Year	Citation Count
$AfterDeath^{Real}$	-0.09508***	-0.1291***	-0.1122***	-0.09636***	-0.1299***
s.e.	0.0215	0.0312	0.03172	0.0297	0.0299
$AfterDeath^{All}$	-0.1489***	-0.1691***	-0.161***	-0.1594***	-0.0445**
s.e.	0.04621	0.04221	0.05231	0.04267	0.0187
Age and Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
Individual Fixed Effects	Yes	Yes	Yes	Yes	Yes
# Observations	325,726	325,726	325,726	325,726	325,726
# Survivors	27,500	27,500	27,500	27,500	27,500
# Deceased	9,428	9,428	9,428	9,428	9,428
Estimator	Negative Binomial	Negative Binomial	Negative Binomial	Negative Binomial	Negative Binomial

Notes: This table reports the estimated coefficients β^{Real} and β^{All} from specification (2), using a negative binomial estimator. The five outcome variables are as follows: (1) "3-year citation count around grant year" is the number of patents the survivor inventor applied for in a given year, weighted by the number of citations these patents received within three years of their respective year of grant; (2) "5-year citation count around grant year" is the number of patents the survivor inventor applied for in a given year, weighted by the number of citations these patents received within five years of their respective years of grant; (3) "5-year examiner-added citation count around grant year" is similar to the outcome variable in the second column, but taking into account only citations added by patent examiners; (4) "5-year examiner-added citation count around grant year" is similar to the outcome variable in the second column, but taking into account only citations added by applicants; (5) citation count is the number of forward citations received on patents that the survivor applied for in a given year. For all outcome variables, we find a large and statistically significant effect. The magnitudes of these effects are similar to the effects reported in Table **??**, Panel C, which shows the robustness of our results to the choice of estimator and the inclusion of individual fixed effects. For more details on the sample, see Table **??**. Standard errors are clustered around the deceased inventors and computed by bootstrap with 100 draws. *$p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Technology Classes

Table B11: Testing For Differences Across Technology Classes

	Total Earnings	Labor Earnings	Labor Earnings >0	Patents	Citations
$AfterDeath_{it}^{Real} \cdot Tech1$	-3,883*	-2,200*	-0.0075*	-0.0701**	-0.1065**
s.e.	(2,273)	(1,135)	(0.0044)	(0.0305)	(0.04875)
$AfterDeath_{it}^{Real} \cdot Tech2$	-4,208**	-2,710**	-0.0096*	-0.1406 ***	-0.1234***
s.e.	(2,054)	(1,319)	(0.0049)	(0.0440)	(0.0395)
$AfterDeath_{it}^{Real} \cdot Tech3$	-4,505*	-3,462***	-0.0063*	-0.092***	-0.1180***
s.e.	(2,364)	(1,333)	(0.0038)	(0.0341)	(0.0413)
$AfterDeath_{it}^{Real} \cdot Tech4$	-3,498**	-2,507*	-0.0117**	-0.1021*	-0.0954*
s.e.	(1,613)	(1,331)	(0.00518)	(0.0556)	(0.05096)
$AfterDeath_{it}^{Real} \cdot Tech5$	-3,080*	-2,075*	-0.0086*	-0.0692**	-0.0743*
s.e.	(1,740)	(1,102)	(0.0047)	(0.0343)	(0.0389)
$AfterDeath_{it}^{Real} \cdot Tech6$	-4,402*	-3,233**	-0.0048*	-0.064**	-0.072**
s.e.	(2,476)	(1,314)	(0.0028)	(0.0292)	(0.0312)
Age and Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
Individual Fixed Effects	Yes	Yes	Yes	No	No
F-Test on Equality of All β_{TechT}^{Real}	0.62	0.45	0.42	0.38	0.51
# Observations	325,726	325,726	325,726	325,726	325,726
# Survivors	27,500	27,500	27,500	27,500	27,500
# Deceased	9,428	9,428	9,428	9,428	9,428
Estimator	OLS	OLS	OLS	Poisson	Poisson

Notes: This panel reports the estimated coefficients $\beta_{Tech\ T}^{Real}$ from the following specification:

$$Y_{it} = \begin{array}{c} \beta^{Real} AfterDeath_{it}^{Real} + \beta^{All} AfterDeath_{it}^{All} \\ + \sum_{T=1}^{6} \widetilde{\beta_{TechT}^{Real}} AfterDeath_{it}^{Real} \cdot TechT + \sum_{T=1}^{6} \widetilde{\beta_{TechT}^{All}} AfterDeath_{it}^{All} \cdot TechT \\ + \sum_{j=25}^{70} \lambda_j 1_{\{age_{it}=j\}} + \sum_{m=1999}^{2012} \gamma_m 1_{\{t=m\}} + \alpha_i + \epsilon_{it} \end{array}$$

using similar notation to Section III.B and where $TechT$ is an indicator equal to one when a survivor inventor has invented most of his patent prior to the year of co-inventor death in technology class T (we aggregate USPC classes into six main technology classes, as in Hall *et al.*, 2001). The distribution of real and placebo survivor inventors across the six main technology classes we consider is presented in Appendix Table A3. Technology class #1 is Chemical, #2 is Computers and Communications, #3 is Drugs and Medical, #4 is Electrical & Electronic, #5 is Mechanical and #6 is Others. The point estimates show significant effects for all outcomes in all technology classes, indicating that our results are not driven by a particular technology class. Formally, for each outcome we report the p-value of a F-test for the hypothesis:

$$H_0: \ \beta_{Tech1}^{Real} = \beta_{Tech2}^{Real} = ... = \beta_{Tech6}^{Real}$$

We fail to reject that the effect is the same across all technology classes. We have investigated the robustness of these results by running regressions in subsamples, considering in turns populations of survivor inventors specializing in each of the six technology classes before the year of co-inventor death. The results are qualitatively similar. For details on the sample, see Table **??**. Standard errors are clustered around the deceased inventors and the p-values of F tests are adjusted accordingly. *$p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Inference Accounting for the Matching Step

Table B12: Inference on The Causal Effect of Co-Inventor Death Accounting For the Matching Step

	Total Earnings	Labor Earnings	Labor Earnings >0	Non-Labor Earnings	Patents	Citations
$AfterDeath^{Real}$	-3,875***	-2,720***	-0.00914***	-1,199**	-0.0916***	-0.092***
s.e.	(839)	(659)	(0.00288)	(473)	(0.0178)	(0.0214)
$AfterDeath^{All}$	-215	-38	-0.0049**	652*	0.0006	0.0508
s.e.	(529)	(451)	(0.0021)	(357)	0.0182	0.1161
Age and Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Individual Fixed Effects	Yes	Yes	Yes	Yes	Yes	No
# Observations	325,726	325,726	325,726	325,726	325,726	325,726
# Survivors	27,500	27,500	27,500	27,500	27,500	27,500
# Matched Pairs	4,714	4,714	4,714	4,714	4,714	4,714
Estimator	OLS	OLS	OLS	OLS	Poisson	Poisson

Notes: This table reports the estimated coefficients β^{Real} and β^{All} from specification (2). For details about the outcome variables and the sample, refer to Table **??**. The difference between this table and Table **??** is that, here, standard errors are computed using the "coupled bootstrap" procedure presented in Abadie and Spiess (2015). We use one hundred bootstrap replications for each of the six outcome variables and we have checked that the results are similar when bootstrapping one thousand times for total earnings. The coupled bootstrap method applied to our setting works as follows: one redraws with replacement *pairs* of matched real-placebo deceased and all of their associated survivors (i.e. the full panel of observations for all of these survivors). The coupled bootstrap is effectively just a block bootstrap, but we re-sample together treated and matched control units, which reflects the dependency between treated and matched control units through the matched covariates (in our setting, the treated and matched control units are the real and placebo deceased). In contrast, in the standard bootstrap, treated and control units are treated as independent and are not resampled together. Note that the validity of the coupled bootstrap follows from a general result that applies to smooth functions of the marginal outcome distributions, therefore it should be valid for inference on the difference-in-differences specification we run in our sample of real and placebo survivor inventors. The standard errors we obtain through this procedure are slightly smaller than the clustered standard errors reported in Table **??**, which shows the robustness of our results. These smaller standard errors may result from a high positive correlation between the potential outcomes conditional on covariates, which is reasonable in our setting. Refer to Abadie and Spiess (2015) for more details.

Logarithmic Transformations of Earnings Outcomes

Table B13: Regression Results for Earnings Outcomes with Log Transformations

	Total Earnings	Labor Earnings	Total Earnings	Labor Earnings
$AfterDeath^{Real}$	-0.02015***	-0.01878***	-0.02161***	-0.0198***
s.e.	(0.007345)	(0.00671)	(0.0079355)	(0.007246)
Age and Year Fixed Effects	Yes	Yes	Yes	Yes
Individual Fixed Effects	Yes	Yes	Yes	Yes
Transformation of Outcome Variable Y	$Log(Y)$		$Log(1+Y)$	
Sample	$Y > 0$		Full	
# Observations	296,410	296,410	325,726	325,726
# Survivors	26,675	26,675	27,500	27,500
# Deceased	9,334	9,334	9,428	9,428
Estimator	OLS	OLS	OLS	OLS

Notes: This table shows the results from running regressions with specification (2) on earnings outcomes transformed by either the $log(.)$ function or by the $log(1+.)$ function. The results are similar to Table **??** in the main text. Standard errors are clustered around the deceased inventor. *$p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Non-Winsorized Earnings Outcomes

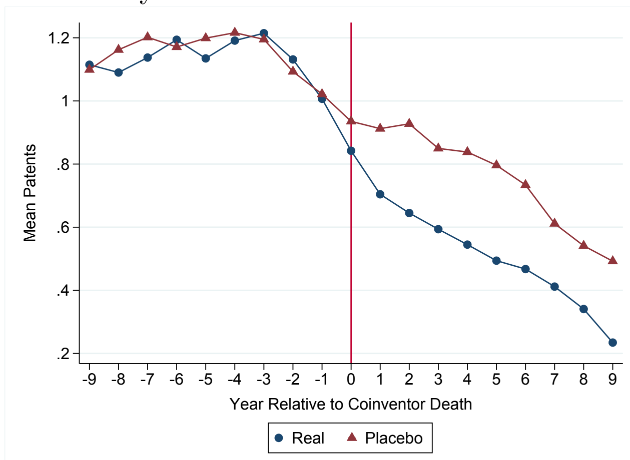
Table B14: Regression Results for Non-Winsorized Earnings Outcomes

	Total Earnings	Labor Earnings	Non-Labor Earnings
$AfterDeath^{Real}$	-4,210**	-2,850***	-1320
s.e.	(1,674)	(1,045)	(890)
Age and Year Fixed Effects	Yes	Yes	Yes
Individual Fixed Effects	Yes	Yes	Yes
# Observations	325,726	325,726	325,726
# Survivors	27,500	27,500	27,500
# Deceased	9,428	9,428	9,428
Estimator	OLS	OLS	OLS

Notes: This table shows the results from running regressions with specification (2) on non-winsorized earnings variables. The results are similar to Table **??** in the main text, except that we lose significance for non-labor earnings due to noise (however, the magnitude of the point estimate is similar). Standard errors are clustered around the deceased inventor. *$p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

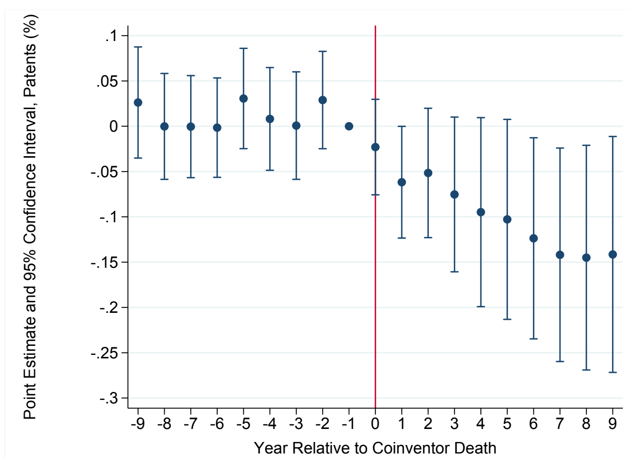
Path of Patent Outcomes around Co-Inventor Death

Figure B5: Event Study for Number of Patents around Co-inventor Death



Notes: This figure shows the path of mean patents for real and placebo survivor inventors around the year of co-inventor death. The sample includes all real and placebo survivor inventors in a 9-year window around the year of co-inventor death, i.e. inventor-year observations are dropped when the lead or lag relative to co-inventor death is above 9 years. The unbalanced nature of this panel is the same for real and placebo inventors. Refer to Section II.B for more details on the sample and to Section II.C for more details on the outcome variables.

Figure B6: Dynamic Causal Effects for Patents around Co-inventor Death



Notes: This figure shows the estimated β_k^{Real} coefficients from specification (1) with the count of patents as the outcome variable. Standard errors are clustered around the deceased inventors. Under the identification assumption described in Section III.B, β_k^{Real} gives the causal effect of co-inventor death in year k relative to co-inventor death. The sample includes all real and placebo survivor inventors in a 9-year window around the year of co-inventor death, i.e. inventor-year observations are dropped when the lead or lag relative to co-inventor death is above 9 years. The unbalanced nature of this panel is the same for real and placebo inventors. For more details on the outcome variables, refer to Section II.C.

For Online Publication

Appendix C

Additional Results On Mechanisms

C1 Discussion of Additional Mechanisms

Loss of person-specific capital. To rule out that the effect is driven by "person-specific capital" - the idea that a given inventor may be irreplaceable to anyone who ever collaborated with them, regardless of team dynamics -, we exploit the fact that many deceased inventors were active in multiple teams. We repeat our previous exercises on heterogeneity in the effect by intensity of collaboration and by relative ability level by including a high-dimensional set of interacted deceased fixed effects in our specifications. The coefficients of interest are now identified from residual variation across multiple inventors collaborating with the same deceased. These within-deceased estimates are reported in Appendix Tables C10 and C11 and are very similar to what we found without interacted deceased fixed effects. Consistent with the team-specific capital interpretation, specific collaboration dynamics drive the effect, rather than generic person effects.

Other mechanisms. A number of mechanisms in which team-specific capital plays no role may be able to explain our results but appear unlikely. First, the loss of a co-inventor may result in emotional distress - however, for this mechanism to be consistent with the patterns we have documented, emotional distress would need to be long-lasting, it should be larger when losing a high-achieving peer and it should cause labor earnings to fall only for inventors who work in the same EIN. Second, the effect of co-inventor death might be driven by disruption of current work - however, we find the effect to be long-lasting and we also find an effect on the survivor inventor's patents beyond co-inventions with the deceased. Third, the effect could be driven by a change in physical inputs available to survivor inventors. For example, after the death of a prominent inventor, the R&D lab might close down, or the start up may fail - however, we find that the effect exists for inventors working in different EINs, as well as for co-inventors of average ability, and we find no negative spillover effect on coworkers in the same EIN as the deceased. Fourth, the effect may be driven by a lower ability inventor exploiting a rent from their collaboration with a higher ability deceased - however, the effect persists for co-inventors of equal ability levels and there is an effect beyond joint production, on the survivor's patents beyond co-inventions with the deceased. Fifth, the effect could result from the fact that after the death of an inventor, the firm decides to promote other teams that did not lose any member - we reject this channel in Appendix Table C16 by showing that inventors suffer even when they are part of the only inventor team in the EIN.

C2 Coworkers and Second-Degree Connections

Regression Results for Coworkers and Second-degree Connections

Table C1 reports the regression results discussed in the main text in Section IV.A. Please refer to this section for an interpretation of the coefficients for $AfterDeath^{Real}$, which are the main coefficients of interest. For $AfterDeath^{All}$, we find negative and significant coefficients in several instances for both coworkers and second-degree connections. Our interpretation is that this results from a "mechanical" effect induced by the construction of the sample. Indeed, the sample of placebo coworkers and second-degree connections is built by imposing that they should have been either employed in the same firm as the deceased or be part of his or her extended network of co-inventors. In both cases, they must necessarily have invented something before the deceased passed away. Therefore, even conditional on year, age and individual fixed effects, it is intuitive that the number of years *relative to the death event* conveys some information about the path of employment and/or patents for these placebo inventors. There is residual information in the year relative to the year of treatment, even conditional on the high-dimensional set of fixed effects. In our econometrics appendix, Appendix E, we discuss related issues (namely, in some circumstances, the point estimate on $AfterDeath^{All}$ may not be a convex combination of the dynamic treatment effects after the death event - but this issue does not affect $AfterDeath^{Real}$).

Table C1: Causal Effects of Inventor Death on Coworkers and Second-degree Connections

Panel A: Effect on Coworkers

	Total Earnings	Labor Earnings	Labor Earnings >0	Patent Count	Citation Count
$AfterDeath^{Real}$	207	236	0.00639**	0.0249*	0.0148**
s.e.	(571)	(582)	(0.00296)	(0.0131)	(0.00713)
$AfterDeath^{All}$	-745	-682	-0.00536**	-0.0366**	-0.00976**
s.e.	(818)	(853)	(0.00215)	(0.01664)	(0.00416)
Age and Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
Individual Fixed Effects	Yes	Yes	Yes	No	No
# Observations	335,708	335,708	335,708	335,708	335,708
# Coworkers	28,192	28,192	28,192	28,192	28,192
# Deceased	3,988	3,988	3,988	3,988	3,988
Estimator	OLS	OLS	OLS	Poisson	Poisson

Notes: This panel reports the estimated coefficients β^{Real} and β^{All} from specification (2) in the sample of coworkers. The five outcome variables are as follows: (1) total earnings; (2) labor earnings; (3) an indicator equal to one when the inventor receives a W-2, i.e. has positive labor earnings; (4) the number of patents the coworker applied for in a given year; (5) the number of forward citations received on patents that the coworker applied for in a given year (therefore, this variable reflects the timing and quality of patent applications by the survivor, not the timing of citations). Under the identification assumption described in Section III.B, β^{Real} gives the causal effect of coworker death on these various outcomes. Inventor-year observations are dropped when the lead or lag relative to co-inventor death is above 9 years. The unbalanced nature of this panel is the same for real and placebo inventors. Appendix Table C2 shows that the results are similar on coworker sample keeping firms of all sizes. Dollar amounts are reported in 2012 dollars. Standard errors are clustered around the deceased inventors. *$p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Panel B: Effect on Second-degree Connections

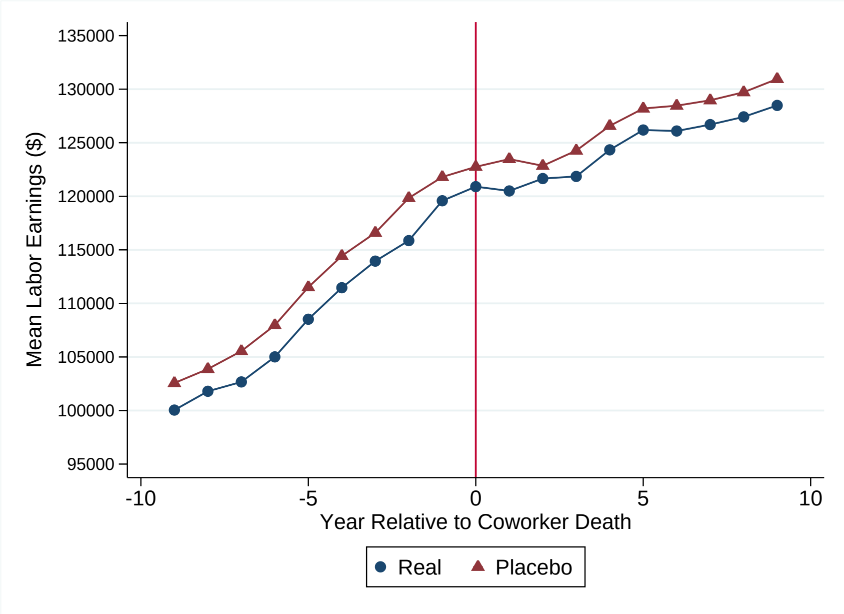
	Total Earnings	Labor Earnings	Labor Earnings >0	Patent Count	Citation Count
$AfterDeath^{Real}$	-159	-9	0.0027	-0.00258	-0.02346
s.e.	(548)	(506)	(0.00325)	(0.02115)	(0.0210)
$AfterDeath^{All}$	-618	-684	-0.00618*	-0.08121**	-0.0208
s.e.	(749)	(565)	(0.00367)	(0.0363)	(0.02625)
Age and Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
Individual Fixed Effects	Yes	Yes	Yes	No	No
# Observations	265,421	265,421	265,421	265,421	265,421
# Second-degree Connections	23,331	23,331	23,331	23,331	23,331
# Deceased	4,183	4,183	4,183	4,183	4,183

Notes: This panel reports the estimated coefficients β^{Real} and β^{All} from specification (2) in the sample of second-degree connections. The five outcome variables are as in Panel A. Inventor-year observations are dropped when the lead or lag relative to co-inventor death is above 9 years. Dollar amounts are reported in 2012 dollars. Standard errors are clustered around the deceased inventors. *$p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Event Studies

Figure C1: Path of Outcomes for Coworkers and Second-Degree Connection around Co-Inventor Death

Panel A: Coworkers' Labor Earnings



Panel B: Coworkers' Adjusted Forward Citations Received for Patents Applied in Year

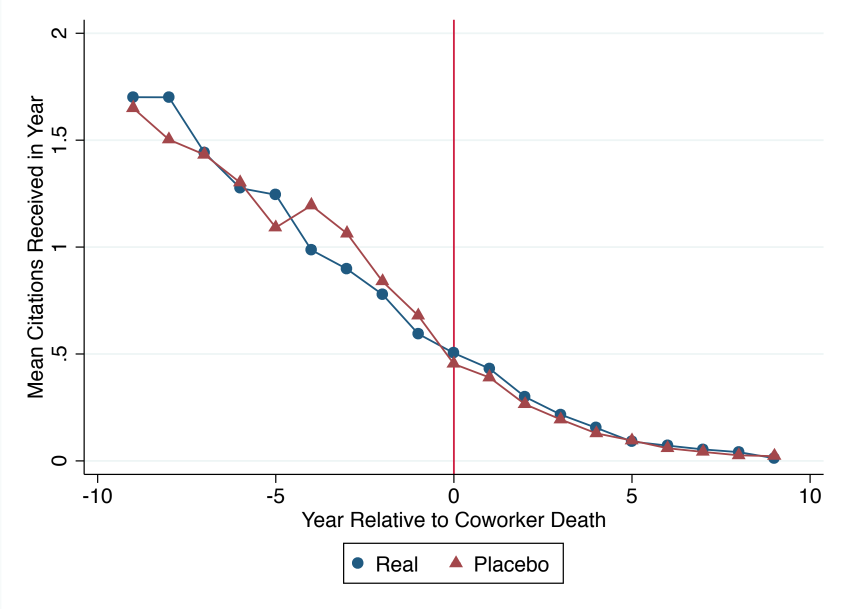
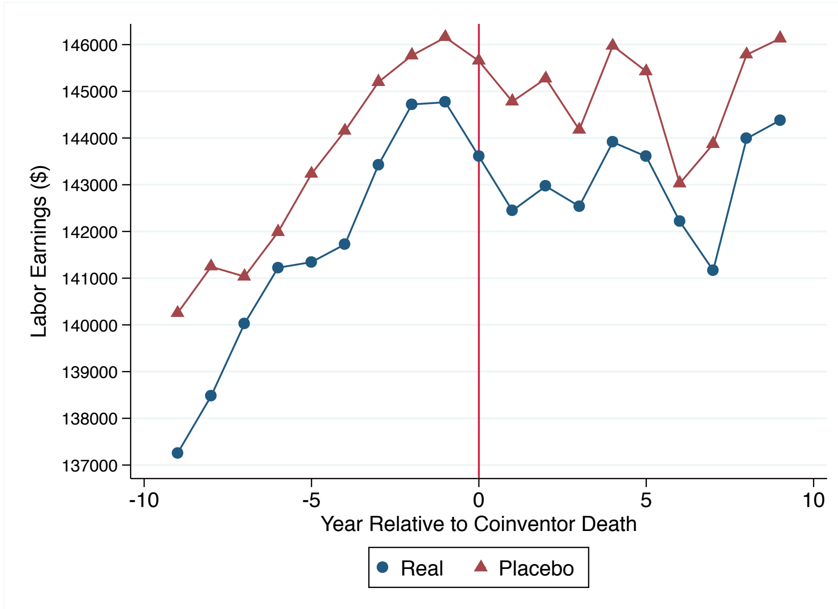
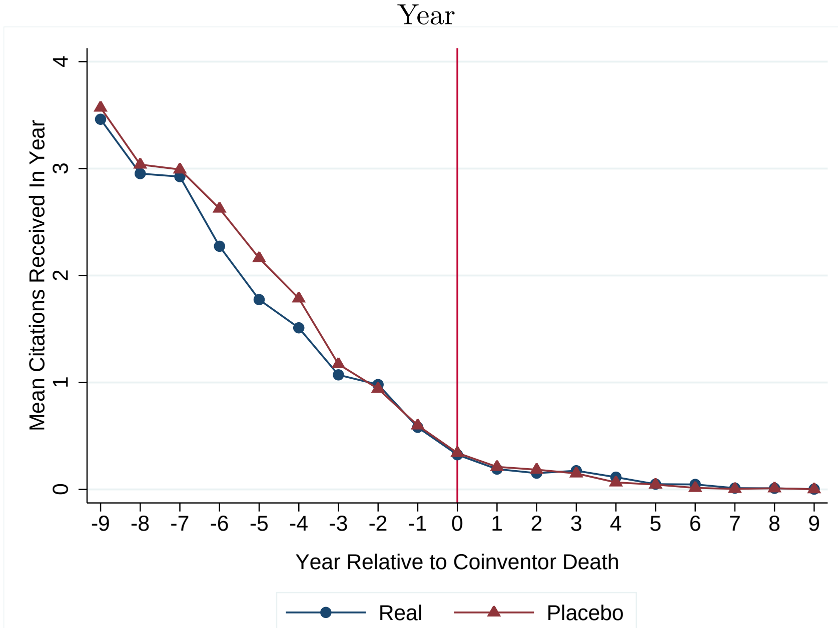


Figure C1: Path of Outcomes for Coworkers and Second-Degree Connections around Co-Inventor Death *(continued)*

Panel C: Second-degree Connections' Labor Earnings



Panel D: Second-degree Connections' Adjusted Forward Citations Received for Patents Applied in Year



Notes: Panels A to D of this figure show the path of mean labor earnings and citations for real and placebo coworkers as well as for real and placebo second-degree connections around the year of death of their associated deceased. For all outcomes, there is no pretrending and there is no visible difference in the relative performance of real and placebo inventors after the year of death. Therefore, the death of an inventor has no strong negative effect on this inventor's coworkers or second-degree connections, in contrast with the large negative effects on the co-inventors documented in Section 3. This finding rules out the theory that the large effects documented in section 3 are driven by the disruption of the firm, because there is no effect on coworkers. The fact that there is no significant effect on second-degree connections shows that network effects are small and that the initial shock does not propagate widely through the co-inventor network. The sample includes all real and placebo inventors in a 9-year window around the year of co-inventor death, i.e. inventor-year observations are dropped when the lead or lag relative to co-inventor death is above 9 years. The unbalanced nature of this panel is the same for real and placebo inventors. Dollar amounts are reported in 2012 dollars. Refer to section II.B for more details on the sample and to section II.C for more details on the outcome variables.

Causal Effect of Coworker Death in the Full Sample

Table C2: Causal Effect of Coworker Death, Including Coworkers in EINs of Any Size

	Total Earnings	Labor Earnings	Labor Earnings >0	Patent Count	Citation Count
β^{Real}	105.21	336.05	0.0034	0.0149	0.0048
s.e.	(461.22)	(312.59)	(0.0048)	(0.0110)	(0.0041)
β^{All}	-521	-702.5	-0.004357*	-0.0366**	-0.00623*
s.e.	(518)	(653)	(0.00241)	(0.01462)	(0.00355)
Age and Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
Individual Fixed Effects	Yes	Yes	Yes	No	No
# Observations	3,642,901	3,642,901	3,642,901	3,642,901	3,642,901
# Coworkers	316,774	316,774	316,774	316,774	316,774
# Deceased	6,289	6,289	6,289	6,289	6,289
Estimator	OLS	OLS	OLS	Poisson	Poisson

Notes: This panel reports the estimated coefficients β^{Real} and β^{All} from specification (2) for the sample of coworkers, considering deceased inventors in EINs of any size. The five outcome variables are as follows: (1) total earnings; (2) labor earnings; (3) an indicator equal to one when the inventor receives a W-2, i.e. is employed; (4) the number of patents the coworker applied for in a given year; (5) the number of forward citations received on patents that the coworker applied for in a given year (therefore, this variable reflects the timing and quality of patent applications by the survivor, not the timing of citations). Under the identification assumption described in Section III.B, β^{Real} gives the causal effect of coworker death on these various outcomes. We do not find any significant effect for any of the outcomes, and the point estimates are positive. These results are qualitatively similar to those presented in Table C1: the absence of a negative effect on coworkers rules out the theory that the large effects documented in Section III are driven by the disruption of the EIN. In contrast with Table C1, we no longer find positive and significant effects on the extensive margin of labor earnings, patents and citations, which could be because the EINs we consider here are too large for any substitutability pattern to operate between inventor coworkers on average. Inventor-year observations are dropped when the lead or lag relative to coworker death is above 9 years. The unbalanced nature of this panel is the same for real and placebo coworkers. Dollar amounts are reported in 2012 dollars. Standard errors are clustered around the deceased inventors. $*p < 0.1$, $**\ p < 0.05$, $***\ p < 0.01$.

Causal Effect of Death of a Coworker in the Same EIN-by-Commuting Zone

Table C3: Causal Effect of Death of a Coworker in the Same EIN-by-Commuting Zone

	Total Earnings	Labor Earnings	Labor Earnings >0	Patent Count	Citation Count
$AfterDeath^{Real}$	402	426	0.00703**	0.0293**	0.0169
s.e.	(671)	(652)	(0.00304)	(0.0145)	(0.0113)
$AfterDeath^{All}$	-535	-710	-0.00621**	-0.0316**	-0.00702*
s.e.	(712)	(644)	(0.00266)	(0.0134)	(0.00401)
Age and Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
Individual Fixed Effects	Yes	Yes	Yes	No	No
# Observations	169,458	169,458	169,458	169,458	169,458
# Coworkers	14,053	14,053	14,053	14,053	14,053
# Deceased	3,802	3,802	3,802	3,802	3,802
Estimator	OLS	OLS	OLS	Poisson	Poisson

Notes: This panel reports the estimated coefficients β^{Real} and β^{All} from specification (2) in the sample of coworkers, imposing the additional restriction that the coworkers had to be located in the same commuting zone as the deceased in the year preceding death. The five outcome variables are as follows: (1) total earnings; (2) labor earnings; (3) an indicator equal to one when the inventor receives a W-2, i.e. has positive labor earnings; (4) the number of patents the coworker applied for in a given year; (5) the number of forward citations received on patents that the coworker applied for in a given year (therefore, this variable reflects the timing and quality of patent applications by the survivor, not the timing of citations). Under the identification assumption described in Section III.B, β^{Real} gives the causal effect of coworker death on these various outcomes. Inventor-year observations are dropped when the lead or lag relative to co-inventor death is above 9 years. The unbalanced nature of this panel is the same for real and placebo inventors. Appendix Table C2 shows that the results are similar on coworker sample keeping EINs of all sizes. Dollar amounts are reported in 2012 dollars. Standard errors are clustered around the deceased inventors. $*p < 0.1$, $** p < 0.05$, $*** p < 0.01$.

C3 Heterogeneity by Relative Ability Levels

Sample Sizes for Results by Relative Ability Levels

Table C4: Sample Sizes for Analysis by Relative Ability Levels

Deceased Earnings Quartile / Survivor Earnings Quartile	1	2	3	4
1	42,431 / 4,040 / 2,706	22,300 / 1,884 / 1,132	1,9619 / 1,706 / 1,062	17,251 / 1,456 / 887
2	20,968 / 1,747 / 1,150	37,390 / 3,382 / 1,625	28,158 / 2,485 / 1,349	17,476 / 1,506 / 975
3	20,085 / 1,685 / 989	15,899 / 1,366 / 617	20,465 / 1,686 / 711	11,696 / 1,071 / 549
4	9,132 / 825 / 354	11,090 / 981 / 379	11,540 / 1053 / 477	14,354 / 1,313 / 535

Notes: This panel reports the sample sizes for each of the sixteen subsamples studied in Table **??**. Each of these subsamples corresponds to a different combination for the total earnings quartiles of the survivor and the deceased. The earnings quartiles are computed three years before death. Within each cell, the sample sizes are reported according to the following format: Number of observations / Number of survivors / Number of deceased. For instance, in the subsample of survivor inventors who were in the lowest earnings quartile three years before death and whose associated deceased was also in the lowest earnings quartile at that time, we have 2,706 real and placebo deceased, 4,040 real and placebo survivors, and 42,431 inventor-year observations.

Distribution of Annual Changes in Log Total Earnings before Co-inventor Death

Table C5: Distribution of Annual Changes in Log Total Earnings before Co-inventor Death

		Mean	SD	10pc	25pc	50pc	75pc	90pc
Total Earnings	Real Survivors	0.039	0.457	-0.0026	0.0169	0.035	0.0867	0.1436
	Placebo Survivors	0.040	0.461	-0.0024	0.0188	0.036	0.0844	0.1401

Notes: This table reports the distribution of year-to-year changes in log total earnings for real and placebo survivor inventors before the year of co-inventor death. The distributions are very similar across the two groups, suggesting that the income processes are similar for both groups and that the placebo inventors can be used as a control group for the analysis reported in Table **??**. The results are similar when considering annual changes in the level of total earnings, the log of labor earnings and the level of labor earnings. For more details on the sample, see Section II.B.

Heterogeneity in the Causal Effect of Co-inventor Death on Labor Earnings by Relative Ability Levels of Co-inventors

Table C6: Heterogeneity in the Causal Effect of Co-inventor Death on Labor Earnings by Relative Ability Levels of Co-inventors

Deceased Earnings Quartile / Survivor Earnings Quartile	1	2	3	4
1	-1,838**	801	15	-407
s.e.	(910)	(1,489)	(881)	(1,383)
2	-2,329*	-1,623**	-675	432
s.e.	(1,288)	(851)	(1,233)	(1,290)
3	-3,381**	-2,932**	-2,054*	-1,809
s.e.	(1,584)	(1,449)	(1,142)	(1,758)
4	-4,268***	-3,868***	-3,956***	-4,955**
s.e.	(1,652)	(1,302)	(1,476)	(2,007)

Notes: This panel reports the estimated coefficient β^{Real} from specification (2), with labor earnings of the survivors as the outcome variable, in sixteen subsamples of the data. Each of these subsamples corresponds to a different combination of the total earnings quartiles of the survivor and the deceased. The earnings quartiles are computed three years before death and sample sizes for each subsample are given in Appendix Table C4. Under the identification assumption described in Section III.B, β^{Real} gives the causal effect of co-inventor death on labor earnings. For instance, the panel shows that if the survivor and the deceased were both in the lowest quartile of total earnings three years before death, the causal effect of co-inventor death on the survivor was a decline of $1,838 in labor earnings. Amounts are reported in 2012 dollars. Standard errors are clustered around the deceased inventors. $^*p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Heterogeneity in the Effect by Relative Ability Level of Co-Inventors, Mean Reversion Patterns

Table C7: Heterogeneity in the Effect by Relative Ability Level of Co-Inventors, Mean Reversion Patterns

Panel A: Mean Reversion Patterns in Total Earnings Around Co-inventor Death

Deceased Earnings Quartile / Survivor Earnings Quartile	1	2	3	4
1	14,763***	3,373	-1,397	-18,977***
s.e.	(2,138)	(2,136)	(2,844)	(3,994)
2	14,493***	380	1,536	-13,665***
s.e.	(2,329)	(1,356)	(1,845)	(2,947)
3	15,237***	3,410**	1,087	-18,473***
s.e.	(2,401)	(1,425)	(2,200)	(3,803)
4	17,183***	-671	3,384	-13,539***
s.e.	(4,243)	(2,681)	(2,599)	(3,814)

Notes: This panel reports the estimated coefficient β^{All} from specification (2), with total earnings of the survivors as the outcome variable, in sixteen subsamples of the data. Each of these subsamples corresponds to a different combination of the total earnings quartiles of the survivor and the deceased. The earnings quartiles are computed three years before death and sample sizes for each subsample are given in Appendix Table C4. β^{All} gives the predictive effect of placebo co-inventor death on total earnings, conditional on year, age and individual fixed effects. For instance, the panel shows that if the placebo survivor and deceased were both in the lowest quartile of total earnings three years before death, then after the placebo death of their co-inventor, the total earnings of placebo survivor inventors tended to increase by $14,763. Amounts are reported in 2012 dollars. Standard errors are clustered around the deceased inventors. *$p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Panel B: Mean Reversion Patterns in Labor Earnings Around Co-inventor Death

Deceased Earnings Quartile / Survivor Earnings Quartile	1	2	3	4
1	10,437***	-1,221	-2,107	-11,581***
s.e.	(1,699)	(1,359)	(2,093)	(3,391)
2	10,295***	1,046	-3,679**	-5,783*
s.e.	(1,591)	(905)	(1,456)	(3,354)
3	13,446***	964	-1,152	-6,895***
s.e.	(1,945)	(1,014)	(1,171)	(2,355)
4	19,292***	-1,697	-1,556	-6,576***
s.e.	(2,518)	(1,317)	(1,598)	(2,356)

Notes: This panel reports the estimated coefficient β^{All} from specification (2), with labor earnings of the survivors as the outcome variable, in sixteen subsamples of the data. Each of these subsamples corresponds to a different combination for the total earnings quartiles of the survivor and the deceased. The earnings quartiles are computed three years before death and sample sizes for each subsample are given in Appendix Table C4. β^{All} gives the predictive effect of placebo co-inventor death on total earnings, conditional on year, age and individual fixed effects. For instance, the panel shows that if the placebo survivor and deceased were both in the lowest quartile of total earnings three years before death, then after the placebo death of their co-inventor, the total earnings of placebo survivor inventors tended to increase by $10,437. Amounts are reported in 2012 dollars. Standard errors are clustered around the deceased inventors. *$p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Heterogeneity in the Effect by Relative Ability Level of Co-Inventors, Proxied for by Relative Citation Level

Table C8: Top-Down Spillovers With Citation Metric, Causal Effects on Total Earnings

Panel A: Heterogeneity in the Causal Effect of Co-Inventor Death on Total Earnings by Citation Quartiles

Deceased Citation Quartile / Survivor Citation Quartile	1	2	3	4
1	-2,512	-1,521	432	520
s.e.	(1,734)	(1,202)	(1,405)	(1,102)
2	-3,234*	-2,689**	-532	-1,102
s.e.	(1,874)	(1,280)	(1,982)	(1,309)
3	-5,832**	-3,441*	-3,313**	-2,421
s.e.	(2,713)	(1,856)	(1,529)	(2,482)
4	-6,721*	-4,980**	-5,231*	-7,037**
s.e.	(3,589)	(2,426)	(2,732)	(3,532)

Notes: This panel reports the estimated coefficient β^{Real} from specification (2), with total earnings of the survivors as the outcome variable, in sixteen subsamples of the data. Each of these subsamples corresponds to a different combination for the total forward citation quartiles of the survivor and the deceased. The citation quartiles are computed three years before death. β^{Real} gives the predictive effect of placebo co-inventor death on total earnings, conditional on year, age and individual fixed effects. For instance, the panel shows that if the placebo survivor and deceased were both in the lowest quartile of total citations three years before death, then after the death of their co-inventor, the total earnings of real survivor inventors tended to decrease by $2,512 but this number is not statistically significant. Amounts are reported in 2012 dollars. Standard errors are clustered around the deceased inventors. *$p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Panel B: Causal Effect of the Death of a "Superstar" Inventor (Deceased in top 2% of Citation Distribution)

	Total Earnings	Labor Earnings	Patent Count	Citation Count	Count of Patents in top 5% of Citations
$AfterDeath^{Real}$	-12,237***	-8,224***	-0.161293***	-0.169329***	-0.03328***
s.e.	(4,421.879)	(2,913.425)	(0.05416)	(0.058372)	(0.012163)
Age and Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
Individual Fixed Effects	Yes	Yes	No	No	No
# Observations	13,611	13,611	13,611	13,611	13,611
# Survivors	1,150	1,150	1,150	1,150	1,150
# Deceased	188	188	188	188	188
Estimator	OLS	OLS	Poisson	Poisson	Poisson

Notes: This panel reports the estimated coefficient β^{Real} from specification (2) for a subsample of survivors associated with "superstar" inventors, who were in the top 2% of the citation distribution three years before death. In this sample, the causal effects of co-inventor death are very large. Amounts are reported in 2012 dollars. Standard errors are clustered around the deceased inventors. *$p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

C4 Additional Heterogeneity Analysis

Heterogeneity by Degree of Co-Invention Overlap between Survivors

Table C9: Heterogeneity by Degree of Collaboration Overlap between Survivors

	Total Earnings	Labor Earnings	Labor Earnings >0	Patent Count	Citation Count
$AfterDeath^{Real}$	-3,830***	-2,702***	-0.00921**	-0.09102***	-0.09032 ***
s.e.	(873)	(698)	(0.00384)	(0.0242)	(0.02443)
$AfterDeath^{Real} \cdot Overlap$	-363.23**	-301.231**	-0.000122*	-0.000923**	-0.001032**
s.e.	(170.421)	(132.2432)	(0.00006838)	(0.000434762)	(0.00051823)
Age and Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
Individual Fixed Effects	Yes	Yes	Yes	No	No
# Observations	325,726	325,726	325,726	325,726	325,726
# Survivors	27,500	27,500	27,500	27,500	27,500
# Deceased	9,428	9,428	9,428	9,428	9,428
Estimator	OLS	OLS	OLS	Poisson	Poisson

Notes: This table reports the estimated coefficients in the vectorη^{Real} from specifications of the following form:

$$Y_{it} = \begin{array}{c} \beta^{Real} AfterDeath_{it}^{Real} + \eta^{Real} X_i \cdot AfterDeath_{it}^{Real} + \beta^{All} AfterDeath_{it}^{All} + \\ \eta^{All} X_i \cdot AfterDeath_{it}^{All} + \sum_{j=25}^{70} \lambda_j 1_{\{age_{it}=j\}} + \sum_{m=1999}^{2012} \gamma_m 1_{\{t=m\}} + \alpha_i + \epsilon_{it} \end{array}$$

The interacted regressor X_i is the degree of co-invention overlap. It is defined as the average percentage that survivor inventors have in common with other inventors associated with the same deceased. Standard errors are clustered around the deceased inventors. *$p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Interacted Deceased Fixed Effects

Table C10: Heterogeneity in the Effect by Intensity of Collaboration Between Deceased and Survivor Inventors with Interacted Deceased Fixed Effects

η^{Real}	Total Earnings	Labor Earnings	Non-Labor Earnings	Patent Count	Citation Count
Co-patent Share	-85.221**	-48.214**	-21.260**	-0.00149**	-0.00159*
s.e.	(42.612)	(22.632)	(10.16627)	(0.0006678)	(0.00084)
Collaboration Length	-1,142.521**	-630.231**	-390.001**	-0.02958**	-0.03001*
s.e.	(516.744)	(269.091)	(161.6715)	(0.014621)	(0.016169)
Collaboration Recency	390.231**	302.132**	137.811*	0.00612**	0.00532*
s.e.	(185.82)	(145.213)	(78.4756)	(0.002705)	(0.003034)
# Co-patents	68.163	49.292	623.211	0.0014	0.00142
s.e.	(149.230)	(159.521)	(523.06)	(0.02429)	(0.0153)
# Patents	-29.0111	-49.102	-3.011	-0.00121	-0.00102
s.e.	(51.304)	(52.041)	(62.444)	(0.00387)	(0.002321)
Survivor's Age at Death	123.78	21.110	55.921	-0.002113*	-0.00201*
s.e.	(81.172)	(69.721)	(67.1923)	(0.001241)	(0.00112)
Age and Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
Individual Fixed Effects	Yes	Yes	Yes	Yes	Yes
Deceased by After Death Fixed Effects	Yes	Yes	Yes	Yes	Yes
# Observations	294,150	294,150	294,150	294,150	294,150
# Survivors	25,049	25,049	25,049	25,049	25,049
# Deceased	8,202	8,202	8,202	8,202	8,202
Estimator	OLS	OLS	OLS	Negative Binomial	Negative Binomial

Notes: This table reports the estimated coefficients in the vectorη^{Real} from the following specification:

$$Y_{it} = \begin{array}{c} \beta^{Real} AfterDeath_{it}^{Real} + \eta^{Real} X_i \cdot AfterDeath_{it}^{Real} + \lambda^{Real,Deceased(i)} \cdot AfterDeath_{it}^{Real} \\ +\beta^{All} AfterDeath_{it}^{All} + \eta^{All} X_i \cdot AfterDeath_{it}^{All} + \lambda^{All,Deceased(i)} \cdot AfterDeath_{it}^{Real} \\ + \sum_{j=25}^{70} \lambda_j 1_{\{age_{it}=j\}} + \sum_{m=1999}^{2012} \gamma_m 1_{\{t=m\}} + \alpha_i + \epsilon_{it} \end{array} \quad (1)$$

The difference with the table reported in Table **??** is the inclusion of interacted "deceased fixed effects" for the treatment effect, denoted $\lambda^{Real,Deceased(i)}$ for the effect of treatment and $\lambda^{All,Deceased(i)}$ for the treatment effect. As a result, the various point estimates of interest are now estimated from residual variation across co-inventors associated with the same deceased. The outcome variables reported in the five columns are total earnings, labor earnings, an indicator turning to one if the inventor receives a W2, the number of patents the survivor inventor applied for in a given year, and the number of forward citations received on patents that the survivor applied for in a given year (therefore, this variable reflects the timing and quality of patent applications by the survivor, not the timing of citations). The regressors are defined in the main text as well as in Table **??** and are demeaned so that the point estimates for the average causal effects are identical to Table **??**. Standard errors are clustered around the deceased inventors. $*p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table C11: Heterogeneity in the Causal Effect of Co-Inventor Death on Total Earnings by Relative Ability Levels with Interacted Deceased Fixed Effects

Deceased Earnings Quartile / Survivor Earnings Quartile	1	2	3	4
1	-2,431	-1,289	1,080	871
s.e.	(1,722)	(1,481)	(1,922)	(1,110)
2	-3,703*	-2,901**	-930	-1,521
s.e.	(2,141)	(1,389)	(1,898)	(1,451)
3	-5,301*	-3,998*	-3,331*	-2,122
s.e.	(2,708)	(2,043)	(1,821)	(2,899)
4	-6,103*	-4,930*	-5,132*	-6,845**
s.e.	(3,647)	(2,780)	(2,802)	(3,390)

Notes: This panel reports the estimated coefficient on interaction terms in a specification similar to specification (2), but with 16 interactions corresponding to a different combination of the total earnings quartiles of the survivor and the deceased, and with interacted deceased fixed effects as in Appendix Table C10. The earnings quartiles are computed three years before death and sample sizes for each subsample are given in Appendix Table C4. Under the identification assumption described in Section III.B, the point estimates give the causal effect of co-inventor death on total earnings for various subsamples. The difference between this table and Table **??** is the inclusion of interacted "decesaed fixed effects": the various point estimates are now estimated based on residual variation across co-inventors associated with the same deceased. Standard errors are clustered around the deceased inventors. *$p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

The Causal Effect of Co-inventor Death for Academic vs. Private Sector Collaborations

Table C12: Employment Types across Subsamples (%)

Panel A. University vs. Non-University Employment

Subsample	Missing EIN	Non-University EIN	University EIN
Deceased	2.61	91.17	6.22
Survivors	10.67	83.53	5.80

Panel B. Probability Matrix for Collaboration Types

	P(no EIN)	P(non-university EIN)	P(university EIN)
Conditional on Co-inventor working in non-university EIN	9.4%	87.07%	3.51%
Conditional on Co-inventor working in university EIN	9.5%	48.86%	41.61%
Conditional on Co-inventor without EIN	22.1%	72.8%	5.0%

Notes: This table shows summary statistics on the frequency of collaboration in the private sector, academic, and both. The statistics are computed in the year prior to death for deceased-survivor dyads for which the EIN is known.

Table C13: Causal Effect for Collaborations between Academia and the Private Sector

	Total Earnings	Labor Earnings	Non-Labor Earnings	Patent Count	Citation Count
$AfterDeath^{Real}$	-3,420.106**	-2,030.120***	-1,620.120	-0.1092**	-0.1239**
s.e.	(1625.234)	(918.136)	(1058.824)	(0.04457)	(0.05341)
Age and Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
Individual Fixed Effects	Yes	Yes	Yes	No	No
# Observations	18,730	18,730	18,730	18,730	18,730
# Survivors	1,584	1,584	1,584	1,584	1,584
# Deceased	519	519	519	519	519
Estimator	OLS	OLS	OLS	Poisson	Poisson

Notes: This panel reports the estimated coefficient on interaction terms in a specification similar to specification (2), but in a subsample were either the deceased or the survivor were working in academia and the other in the private sector in the year preceding death. Standard errors are clustered around the deceased inventors. *$p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table C14: Heterogeneity Analysis: Academic versus. Private Sector Collaborations

	Total Earnings	Labor Earnings	Non-Labor Earnings	Patent Count	Citation Count
$AfterDeath^{Real} \cdot Academic$	423.829	-830.120	1,020.120	-0.03891	-0.0412
s.e.	(462.194)	(6244.234)	(882.231)	(0.0451)	(0.05102)
$AfterDeath^{Real}$	-3,969***	-2,593.362***	-1,345.52**	-0.0875***	-0.09823***
s.e.	(1032.326)	(867.439)	(561.416)	(0.0244)	(0.02553)
Age and Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
Individual Fixed Effects	Yes	Yes	Yes	No	No
# Observations	237,985	237,985	237,985	237,985	237,985
# Survivors	19,992	19,992	19,992	19,992	19,992
# Deceased	6,788	6,788	6,788	6,788	6,788
Estimator	OLS	OLS	OLS	Poisson	Poisson

Notes: This panel reports the estimated coefficient on interaction terms in a specification similar to specification (2), but with an interaction term for academic collaboration and restricting the sample to collaborations that are either "purely academic" or "purely in the private sector." Standard errors are clustered around the deceased inventors. *$p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

The Causal Effect of Co-inventor Death for Inventors Who Do Not Switch EINs After Co-Inventor Death

Table C15: Heterogeneity Depending on whether Inventors Switch EINs After Death

	Total Earnings	Labor Earnings	Non-Labor Earnings	Patent Count	Citation Count
$AfterDeath^{Real} \cdot StaySameFirm$	301.566	-394.231	420.425	-0.0103	0.01321
s.e.	(363.201)	(412.117)	(451.201)	(0.01502)	(0.02018)
$AfterDeath^{Real}$	-3,687***	-2,623***	-1,245**	-0.0802***	-0.1003***
s.e.	(987.231)	(851.912)	(578.23)	(0.02548)	(0.02851)
Age and Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
Individual Fixed Effects	Yes	Yes	Yes	No	No
# Observations	325,726	325,726	325,726	325,726	325,726
# Survivors	27,500	27,500	27,500	27,500	27,500
# Deceased	9,428	9,428	9,428	9,428	9,428
Estimator	OLS	OLS	OLS	Poisson	Poisson

Notes: This panel reports the estimated coefficient on interaction terms in a specification similar to specification (2), but with an interaction term conditioning on an endogenous outcome - whether the survivor stays in the same EIN after death. We show that this interaction term is not predictive of the strength of the treatment effect, which confirms that the effect is not driven by traditional firm-specific capital. Standard errors are clustered around the deceased inventors. $*p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

The Team Promotion Channel

Table C16: Heterogeneity Depending on whether Team is Unique in the EIN

	Total Earnings	Labor Earnings	Non-Labor Earnings	Patent Count	Citation Count
$AfterDeath^{Real} \cdot UniqueTeam$	-253	-230	335	0.00921	0.0232
s.e.	(363.201)	(412.117)	(451.201)	(0.01923)	(0.0242)
$AfterDeath^{Real}$	-3,421***	-2,833***	-1,023**	-0.0922***	-0.0992***
s.e.	(1007.213)	(987.312)	(489.01)	(0.02955)	(0.02911)
Age and Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
Individual Fixed Effects	Yes	Yes	Yes	No	No
# Observations	281,902	281,902	281,902	281,902	281,902
# Survivors	24,247	24,247	24,247	24,247	24,247
# Deceased	8,214	8,214	8,214	8,214	8,214
Estimator	OLS	OLS	OLS	Poisson	Poisson

Notes: This panel reports the estimated coefficient on interaction terms in a specification similar to specification (2), where the interacted variable is now a dummy turning to one when the team was the only team of inventors in the EIN in the year prior to death. We show that this interaction term is not predictive of the strength of the treatment effect, which suggests that the effect is not driven by differential "promotion" of teams within EINs. Standard errors are clustered around the deceased inventors. $*p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

The Causal Effect of Co-Inventor Death across EIN and Geographic Boundaries

Panel A of Table C17 shows that the effect of co-inventor death on labor earnings is entirely driven by survivors who were in the same EIN as the deceased at the time of death. In contrast, the second column shows that the effect of co-inventor death on non-labor earnings is similar regardless of whether or not the survivor and the deceased were in the same EIN. Panel B of Table C17 shows a similar pattern based on the location of survivor and deceased inventors across commuting zones.

Table C17: The Causal Effect of Co-inventor Death across EIN and Geographic Boundaries

Panel A: Within and Across EINs

	Labor Earnings	Non-Labor Earnings	Patent Count	Citation Count
$AfterDeath^{Real}$	-113	-1,225**	-0.07071**	-0.07892**
s.e.	(964)	(583)	(0.03321)	(0.0353)
$AfterDeath^{Real} \cdot SameEIN$	-3,974***	122	-0.05928	-0.05123
s.e.	(1,465)	(983)	(0.06956)	(0.04326)
Age and Year Fixed Effects	Yes	Yes	Yes	Yes
Individual Fixed Effects	Yes	Yes	Yes	Yes
# Observations	260,807	260,807	260,807	260,807
# Survivors	21,972	21,972	21,972	21,972
# Deceased	7,589	7,589	7,589	7,589
Estimator	OLS	OLS	Poisson	Poisson

Notes: This panel reports the estimated coefficients β^{Real} and $\widetilde{\beta^{Real}}$ from the following specification:

$$Y_{it}= \beta^{Real} AfterDeath_{it}^{Real} + \beta^{All} AfterDeath_{it}^{All} + \widetilde{\beta^{Real}} AfterDeath_{it}^{Real} \cdot SameEIN + \widetilde{\beta^{All}} AfterDeath_{it}^{All} \cdot SameEIN + \sum_{j=25}^{70} \lambda_j 1_{\{age_{it}=j\}} + \sum_{m=1999}^{2012} \gamma_m 1_{\{t=m\}} + \alpha_i + \epsilon_{it}$$

using similar notation to Section III.B and where $SameEIN$ is an indicator equal to one when the survivor and the deceased were in the same EIN during the three years that preceded death. $SameEIN$ is equal to 0 when the survivor and the inventor were in different EINs during the three years that preceded death. We exclude from the sample the survivor-deceased pairs that were not always in the same EIN or always in a different EIN during the three prior to death, or who were self-employed or unemployed, or for whom employment data is missing. 20.1% of the survivors are thus excluded. $SameEIN$ is equal to 1 for 46% of survivors in the sample. See Table **??** for details about the outcome variables. Standard errors are clustered around the deceased inventors. *$p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Panel B: Within and Across Commuting Zones

	Labor Earnings	Non-Labor Earnings	Patent Count	Citation Count
$AfterDeath^{Real}$	-182	-1,411**	-0.09393***	-0.1229***
s.e.	(529)	(563)	(0.02901)	(0.02856)
$AfterDeath^{Real} \cdot SameCZ$	-4,049***	534	0.00093	0.0209
s.e.	(1,350)	(610)	(0.05512)	(0.0212)
Age and Year Fixed Effects	Yes	Yes	Yes	Yes
Individual Fixed Effects	Yes	Yes	No	No
# Observations	292,752	292,752	292,752	292,752
# Survivors	24,686	24,686	24,686	24,686
# Deceased	8,579	8,579	8,579	8,579
Estimator	OLS	OLS	Poisson	Poisson

Notes: This panel reports the estimated coefficients β^{Real} and $\widetilde{\beta^{Real}}$ from the following specification:

$$Y_{it} = \beta^{Real} AfterDeath_{it}^{Real} + \beta^{All} AfterDeath_{it}^{All} + \widetilde{\beta^{Real}} AfterDeath_{it}^{Real} \cdot SameCZ + \widetilde{\beta^{All}} AfterDeath_{it}^{All} \cdot SameCZ + \sum_{j=25}^{70} \lambda_j 1_{\{age_{it}=j\}} + \sum_{m=1999}^{2012} \gamma_m 1_{\{t=m\}} + \alpha_i + \epsilon_{it}$$

using similar notation to Section III.B and where $SameCZ$ is an indicator variable equal to one when the survivor and the deceased were in the same commuting zone during the three years that preceded death. $SameCZ$ is equal to 0 when the survivor and the deceased were in different commuting zones during the three years that preceded death. We exclude from the sample the survivor-deceased pairs that were not always in the same commuting zone or always in a different commuting zone during the three years prior to death. 10.24% of the survivors are thus excluded. $SameCZ$ is equal to 1 for 55% of survivors in the sample. See Table **??** for details about the outcome variables. Standard errors are clustered around the deceased inventors. *$p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Heterogeneity by Intensity of Collaboration between Deceased and Survivor Inventors, Introducing Interacted Regressors One at a Time

Table C18: Heterogeneity by Intensity of Collaboration
between Deceased and Survivor Inventors, Introducing Interacted Regressors One at a Time

η^{Real}	Total Earnings					
Co-patent Share	-102.132***					
s.e.	(38.652)					
Collaboration Length		-1,529.199**				
s.e.		(559.203)				
Collaboration Recency			678.221***			
s.e.			(241.35)			
# Co-patents				-162.521**		
s.e.				(76.412)		
# Patents					23.123	
s.e.					(42.23)	
Survivor's Age at Death						-76.13
s.e.						(58.23)
Age and Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Individual Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
# Observations	325,726	325,726	325,726	325,726	325,726	325,726
# Survivors	27,500	27,500	27,500	27,500	27,500	27,500
# Deceased	9,428	9,428	9,428	9,428	9,428	9,428
Estimator	OLS	OLS	OLS	OLS	OLS	OLS

Notes: This table reports the estimated coefficients in the vectorη^{Real} from specifications of the following form:

$$Y_{it} = \begin{array}{c} \beta^{Real} AfterDeath^{Real}_{it} + \eta^{Real} X_i \cdot AfterDeath^{Real}_{it} + \beta^{All} AfterDeath^{All}_{it} + \\ \eta^{All} X_i \cdot AfterDeath^{All}_{it} + \sum_{j=25}^{70} \lambda_j 1_{\{age_{it}=j\}} + \sum_{m=1999}^{2012} \gamma_m 1_{\{t=m\}} + \alpha_i + \epsilon_{it} \end{array}$$

The interacted regressor X_i changes across the columns. The regressors are defined in the main text as well as in Table 6 and are demeaned so that the point estimates for the average causal effects are identical to Table **??**. Standard errors are clustered around the deceased inventors. *$p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Heterogeneity by Survivor's Age at Co-Inventor Death

Table C19: Heterogeneity in Causal Effect of Co-Inventor Death by Survivor's Age Quartile

	Total Earnings	Labor Earnings	Labor Earnings >0	Patent Count	Citation Count
$AfterDeath^{Real}$	-3,484***	-2,526***	- 0.00476	-0.09781***	-0.10962***
s.e.	(1,102)	(724)	(0.00312)	(0.02915)	(0.03451)
$AfterDeath^{Real} \cdot AgeQ2$	33	-218	0.00014	-0.00385	0.02808
s.e.	(549)	(412)	(0.00088)	(0.0046)	(0.03602)
$AfterDeath^{Real} \cdot AgeQ3$	-990	-149	-0.00451**	0.001311	-0.00129
	(950)	(567)	(0.00208)	(0.04823)	(0.00314)
$AfterDeath^{Real} \cdot AgeQ4$	-1,533	-1,011	-0.00964***	-0.0498*	-0.00535
	(1,288)	(738)	(0.00352)	(0.02959)	(0.00371)
Age and Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
Individual Fixed Effects	Yes	Yes	Yes	No	No
# Observations	325,726	325,726	325,726	325,726	325,726
# Survivors	27,500	27,500	27,500	27,500	27,500
# Deceased	9,428	9,428	9,428	9,428	9,428
Estimator	OLS	OLS	OLS	Poisson	Poisson

Notes: This panel reports the estimated coefficients β^{Real} and $\widetilde{\beta_{Qk}^{Real}}$ from the following specification:

$$Y_{it} = \beta^{Real} AfterDeath_{it}^{Real} + \beta^{All} AfterDeath_{it}^{All} + \sum_{k=2}^{4} \widetilde{\beta_{Qk}^{Real}} AfterDeath_{it}^{Real} \cdot AgeQk + \sum_{k=2}^{4} \widetilde{\beta^{All}} AfterDeath_{it}^{All} \cdot AgeQk + \sum_{j=25}^{70} \lambda_j 1_{\{age_{it}=j\}} + \sum_{m=1999}^{2012} \gamma_m 1_{\{t=m\}} + \alpha_i + \epsilon_{it}$$

using similar notation to Section III.B and where $AgeQk$ is an indicator equal to one when the survivor is in the k-th quartile of age at co-inventor death. The specification with the Poisson estimator for columns 4 and 5 of the table is similar. The table shows that there is no significant heterogeneity in the causal effect of co-inventor death on the various outcomes by age quartile, except on the extensive margin of labor earnings, where the effect is driven by survivors who were older at the time of co-inventor death. For younger survivor inventors, the point estimate for the effect on the extensive margin of labor earnings is an imprecisely estimated zero. The sample includes all real and placebo survivor inventors in a 9-year window around the year of co-inventor death, i.e. inventor-year observations are dropped when the lead or lag relative to co-inventor death is above 9 years. The unbalanced nature of this panel is the same for real and placebo inventors. Dollar amounts are reported in 2012 dollars. Standard errors are clustered around the deceased inventors. $*p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Probability of Changing EINs

Table C20: Causal Effect of Co-Inventor Death on the Probability of Changing EINs

	Changing EIN
$AfterDeath_{it}^{Real}$	-0.00124
s.e.	(0.00192)
$AfterDeath_{it}^{All} \cdot SmallEIN$	0.00798**
s.e.	(0.004016)
Age and Year Fixed Effects	Yes
Individual Fixed Effects	Yes
# Observations	266,087
# Survivors	22,740
# Deceased	8,382
Estimator	OLS

Notes: This panel reports the estimated coefficients β^{Real} and $\widetilde{\beta^{Real}}$ from the following specification:

$$ChangingEIN_{it} = \begin{array}{c} \beta^{Real} AfterDeath_{it}^{Real} + \beta^{All} AfterDeath_{it}^{All} \\ + \widetilde{\beta^{Real}} AfterDeath_{it}^{Real} \cdot SmallEIN + \widetilde{\beta^{All}} AfterDeath_{it}^{All} \cdot SmallEIN \\ + \sum_{j=25}^{70} \lambda_j 1_{\{age_{it}=j\}} + \sum_{m=1999}^{2012} \gamma_m 1_{\{t=m\}} + \alpha_i + \epsilon_{it} \end{array}$$

where (1) $ChangingEIN_{it}$ is an indicator variable equal to 1 if the deceased is employed in a different EIN in year t compared with the year prior to co-inventor death; (2) $SmallEIN$ is an indicator equal to one if the survivor was in an EIN with less than one hundred employee in the year prior to coinventor death; (3) the rest of the specification is similar to specification (2) in the main text. The table shows that in general co-inventor death does not have a statistically significant impact on an inventor's probability of changing EINs. However, survivor inventors who are in a small EIN are more likely to change EINs after co-inventor death. This finding is consistent with the view that the survivor inventor may be looking for new co-inventors and may change EINs to do so. Dollar amounts are reported in 2012 dollars. Standard errors are clustered around the deceased inventors. *$p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Probability of Getting a New Co-Inventor

Table C21: Causal Effect of Co-Inventor Death on the Probability of Getting a New Co-inventor

	New Co-Inventor In Year
β^{Real}	0.05899
s.e.	(0.067409)
β^{All}	-0.107534*
s.e.	(0.060466)
Age and Year Fixed Effects	Yes
Individual Fixed Effects	Yes
# Observations	325,726
# Survivors	27,500
# Deceased	9,428
Estimator	OLS

Notes: This panel reports the estimated coefficients β^{Real} and β^{All} for specification (2), using as an outcome variable the number of new coinventors of the survivor in a given year. This variable is built using data on patent applications and counts the number of new co-inventors of the survivor in a given year, i.e. the number of inventors who apply for a patent with the survivor in this year and who had never applied for a patent with the survivor in any of the previous years. We find no statistically significant effect, and the point estimate is small in magnitude. This suggests that the survivor inventor is not able to find substitutes for the deceased co-inventor, which may explain the strength of the effect on the survivor's earnings and patents documented in Table **??**. Note that the outcome variable in this table is not a perfect measure of changes in collaboration patterns, since it is based on patent applications, i.e. we can observe the new co-inventor only when a patent application is filed. This creates a censoring problem, which however is similar for treated and control inventors. The sample includes all real and placebo survivor inventors in a 9-year window around the year of co-inventor death, i.e. inventor-year observations are dropped when the lead or lag relative to co-inventor death is above 9 years. The unbalanced nature of this panel is the same for real and placebo inventors. Dollar amounts are reported in 2012 dollars. Standard errors are clustered around the deceased inventors. *$p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Heterogeneity by EIN Size

Table C22: Heterogeneity in Causal Effect of Co-Inventor Death by EIN Size Quartile

	Total Earnings	Labor Earnings	Labor Earnings >0	Patent Count	Citation Count
$AfterDeath^{Real}$	-3,506***	-2,537***	-0.0094**	-0.0989***	-0.1020 ***
s.e.	(878)	(690)	(0.0041)	(0.0245)	(0.0234)
$AfterDeath^{Real} \cdot EINQ2$	-422	169	0.0008	0.0012	0.0023
s.e.	(633)	(587)	(0.0013)	(0.0093)	(0.0036)
$AfterDeath^{Real} \cdot EINQ3$	-395	-365	-0.0003	-0.0123	0.0032
	(533)	(453)	(0.0021)	(0.0187)	(0.0092)
$AfterDeath^{Real} \cdot EINQ4$	198	-204	-0.0023	0.0021	0.0182
	(643)	(346)	(0.0017)	(0.0163)	(0.015)
Age and Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
Individual Fixed Effects	Yes	Yes	Yes	No	No
# Observations	284,707	284,707	284,707	284,707	284,707
# Survivors	23,925	23,925	23,925	23,925	23,925
# Deceased	8,768	8,768	8,768	8,768	8,768
Estimator	OLS	OLS	OLS	Poisson	Poisson

Notes: This panel reports the estimated coefficients β^{Real} and $\widetilde{\beta^{Real}_{Qk}}$ from the following specification:

$$Y_{it} = \beta^{Real} AfterDeath^{Real}_{it} + \beta^{All} AfterDeath^{All}_{it} + \sum_{k=2}^{4} \widetilde{\beta^{Real}_{Qk}} AfterDeath^{Real}_{it} \cdot EINQk + \sum_{k=2}^{4} \widetilde{\beta^{All}} AfterDeath^{All}_{it} \cdot EINQk + \sum_{j=25}^{70} \lambda_j 1_{\{age_{it}=j\}} + \sum_{m=1999}^{2012} \gamma_m 1_{\{t=m\}} + \alpha_i + \epsilon_{it}$$

using similar notation to Section III.B and where $EINQk$ is an indicator equal to one when the survivor is in the k-th quartile of EIN size in the year of co-inventor death. The specification with the Poisson estimator for columns 4 and 5 of the table is similar. The table shows that there is no significant heterogeneity in the causal effect of co-inventor death on the various outcomes by EIN quartile. The sample includes all real and placebo survivor inventors who received a W2 at the time of co-inventor death. Inventor-year observations are dropped when the lead or lag relative to co-inventor death is above 9 years. The unbalanced nature of this panel is the same for real and placebo inventors. Dollar amounts are reported in 2012 dollars. Standard errors are clustered around the deceased inventors. *$p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Heterogeneity by Citizenship Status

Table C23: Heterogeneity in Causal Effect of Co-Inventor Death by Survivor's Citizenship Status

	Total Earnings	Labor Earnings	Labor Earnings>0	Patent Count	Citation Count
$AfterDeath^{Real}$	-3,675***	-2,604***	-0.0982***	-0.079***	-0.1056***
s.e.	(918)	(683)	(0.0328)	(0.0243)	(0.0271)
$AfterDeath^{Real} \cdot Foreigner$	-727	-506	0.0083	-0.0463 **	0.0263
s.e.	(663)	(421)	(0.0098)	(0.0214)	(0.0209)
Age and Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
Individual Fixed Effects	Yes	Yes	Yes	No	No
# Observations	325,726	325,726	325,726	325,726	325,726
# Survivors	27,500	27,500	27,500	27,500	27,500
# Deceased	9,428	9,428	9,428	9,428	9,428
Estimator	OLS	OLS	OLS	Poisson	Poisson

Notes: This panel reports the estimated coefficients β^{Real} and $\widetilde{\beta^{Real}}$ from the following specification:

$$Y_{it} = \begin{array}{c} \beta^{Real} AfterDeath^{Real}_{it} + \beta^{All} AfterDeath^{All}_{it} + \widetilde{\beta^{Real}} AfterDeath^{Real}_{it} \cdot Foreigner + \widetilde{\beta^{All}} AfterDeath^{All}_{it} \cdot Foreigner \\ + \sum_{j=25}^{70} \lambda_j 1_{\{age_{it}=j\}} + \sum_{m=1999}^{2012} \gamma_m 1_{\{t=m\}} + \alpha_i + \epsilon_{it} \end{array}$$

using similar notation to Section III.B and where *Foreigner* is an indicator turning to one when the survivor inventor is not a US citizen (about 20% of inventors are foreigners). The table shows that there is no significant heterogeneity in the causal effect of co-inventor death by citizenship status, except for patent count. This result is consistent with the notion that it may be more difficult for foreign inventors to find new co-inventors, hence a stronger decline in citations, but at the same time they may not be rewarded for performance on the same basis as US inventors, explaining the absence of differential effect on earnings. The sample includes all real and placebo survivor inventors in a 9-year window around the year of co-inventor death, i.e. inventor-year observations are dropped when the lead or lag relative to co-inventor death is above 9 years. The unbalanced nature of this panel is the same for real and placebo inventors. Dollar amounts are reported in 2012 dollars. Standard errors are clustered around the deceased inventors. *$p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Heterogeneity by Network Size

Table C24: Heterogeneity in Causal Effect of Co-Inventor Death by Survivor's Network Size

	Total Earnings	Labor Earnings	Labor Earnings> >0)	Patents	Citations	New Co-inventor
β^{Real}	-3,573***	-2,615***	-0.0095***	-0.0891***	-0.0952***	0.0239
s.e.	(857)	(706)	(0.0034)	(0.0237)	(0.0232)	(0.0632)
$\beta^{Real} \times Small\ Network$	-534	-283	0.0012	-0.0057	0.0067	0.0884
s.e.	(614)	(450)	(0.0023)	0.0102	(0.0192)	(0.059)
Age and Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Individual Fixed Effects	Yes	Yes	Yes	No	No	Yes
# Observations	325,726	325,726	325,726	325,726	325,726	325,726
# Survivors	27,500	27,500	27,500	27,500	27,500	27,500
# Deceased	9,428	9,428	9,428	9,428	9,428	9,428
Estimator	OLS	OLS	OLS	OLS	Poisson	OLS

Notes: This panel reports the estimated coefficients β^{Real} and $\widetilde{\beta^{Real}}$ from the following specification:

$$Y_{it} = \begin{array}{l} \beta^{Real} AfterDeath_{it}^{Real} + \beta^{All} AfterDeath_{it}^{All} \\ +\widetilde{\beta^{Real}} AfterDeath_{it}^{Real} \cdot SmallNetwork + \widetilde{\beta^{All}} AfterDeath_{it}^{All} \cdot SmallNetwork \\ + \sum_{j=25}^{70} \lambda_j 1_{\{age_{it}=j\}} + \sum_{m=1999}^{2012} \gamma_m 1_{\{t=m\}} + \alpha_i + \epsilon_{it} \end{array}$$

using similar notation to Section III.B and where $SmallNetwork$ is an indicator turning to one when the size of the co-inventor network of the survivor inventor is below median at the time of death. The table shows that there is no significant heterogeneity in the causal effect of co-inventor death by network size. This result is qualitatively similar when considering other interaction terms (linear, quartile) based on survivor's network size at the time of death. An explanation for this finding is that the observed network of co-inventors at the time of death may be a noisy proxy for the survivor's actual network, given that collaborations are ongoing before patent applications are filed. Overall, the network size variable appears to be a less reliable indicator of the difficulty for the survivor to recover from the death of his co-inventor than the measures of collaboration intensity presented in Table **??**. The sample includes all real and placebo survivor inventors in a 9-year window around the year of co-inventor death, i.e. inventor-year observations are dropped when the lead or lag relative to co-inventor death is above 9 years. The unbalanced nature of this panel is the same for real and placebo inventors. Dollar amounts are reported in 2012 dollars. Standard errors are clustered around the deceased inventors. *$p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

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Appendix D

Additional Results on the Nature of Team-Specific Capital

D1 Tests of "Match" View

Table D1: Distributions of Number of Inventors

Distribution	Mean	SD	p10	p25	p50	p75	p90
Number of Inventors in Survivor's CZ-EIN	3.17	29.34	1	1	1	2	4
Number of Inventors in Survivor's Technology Category within CZ-EIN	2.47	18.23	1	1	1	1	3
Number of Inventors in Survivor's Technology Subcategory within CZ-EIN	2.15	13.57	1	1	1	1	3
Number of Inventors in Survivor's CZ	1,025	3,744	7	24	84	404	1883
Number of Inventors in Survivor's Technology Category within CZ	165.11	708.35	1	4	15	64	281
Number of Inventors in Survivor's Technology Subcategory within CZ	45.83	243.03	1	2	5	19	74

Notes: This table presents summary statistics on the number of inventors in the survivor's EIN-by-commuting zone or commuting zone, considering in turn all inventors, inventors in the same NBER technology category as the survivor, and inventors in the same NBER technology subcategory as the survivor. The statistics are computed in the year preceding co-inventor death. See Hall et al. (2001) for a definition and description of technology categories and subcategories.

Table D2: Heterogeneity by Density of Inventors in Survivor's Technology Subcategory within CZ-EIN

	Total Earnings	Labor Earnings	Non-Labor Earnings	Patents	Citations	New Co-inventor
$AfterDeath^{Real}$ $\cdot InventorDensity\ (S.D.)$	23.452	53.429	-40.120	-0.0321	0.00912	0.1853**
s.e.	(29.315)	(44.524)	(45.577)	(0.0535)	(0.00829)	(0.09545)
Age and Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Individual Fixed Effects	Yes	Yes	Yes	No	No	Yes
# Observations	297,017	297,017	297,017	297,017	297,017	297,017
# Survivors	25,089	25,089	25,089	25,089	25,089	25,089
# Deceased	8,554	8,554	8,554	8,554	8,554	8,554
Estimator	OLS	OLS	OLS	Poisson	Poisson	OLS

Notes: This table documents the heterogeneity in the treatment effect depending on the density of inventors in the survivor's technology subcategory, within the inventor's CZ-EIN in the year preceding co-inventor death (denoted "inventor density" in the regression table, and standardized by its standard deviation). The specification is similar to specification (3), except that the interacted controls now include only the density of inventors. The results with inventor density as the interacted variable are similar to those with the number of inventors presented in the main text in Section V.B. Appendix Tables D3 and D4 offer similar specifications with alternative proxies for local inventor labor market thickness. Standard errors are clustered around the deceased inventors. $^*p < 0.1$, $^{**}\ p < 0.05$, $^{***}\ p < 0.01$.

Table D3: Heterogeneity by Density of Inventors in Survivor's Technology Subcategory within CZ

	Total Earnings	Labor Earnings	Non-Labor Earnings	Patents	Citations	New Co-inventor
$AfterDeath^{Real}$ $\cdot InventorDensity\ (S.D.)$	-42.234	70.23	-90.212	0.00453	0.00532	0.238*
s.e.	(37.593)	(50.164)	(100.235)	(0.00626)	(0.006307)	(0.126)
Age and Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Individual Fixed Effects	Yes	Yes	Yes	No	No	Yes
# Observations	325,726	325,726	325,726	325,726	325,726	325,726
# Survivors	27,500	27,500	27,500	27,500	27,500	27,500
# Deceased	9,428	9,428	9,428	9,428	9,428	9,428
Estimator	OLS	OLS	OLS	Poisson	Poisson	OLS

Notes: This table documents the heterogeneity in the treatment effect depending on the density of inventors in the survivor's technology subcategory, within the inventor's commuting zone in the year preceding co-inventor death (denoted "inventor density" in the regression table, and standardized by its standard deviation). The specification is similar to specification (3), except that the interacted controls now include only the density of inventors. The results presented here at the commuting zone level are similar to those at the CZ-EIN level presented in the main text and in Appendix Table D2. Standard errors are clustered around the deceased inventors. $^*p < 0.1$, $^{**}\ p < 0.05$, $^{***}\ p < 0.01$.

Table D4: Heterogeneity by Number of Inventors in Survivor's vs. Other Technology Subcategory within CZ-EIN

	Total Earnings	New Co-inventor	Total Earnings	New Co-inventor
$AfterDeath^{Real}$ $\cdot InventorNumber$ $(S.D.)$	44.345	0.0575	-25.456	0.263**
s.e.	33.594	(0.0435)	(27.576)	(0.1323)
Measure	Other Tech Classes	Other Tech Classes	Same Tech Class	Same Tech Class
Age and Year Fixed Effects	Yes	Yes	Yes	Yes
Individual Fixed Effects	Yes	Yes	Yes	Yes
# Observations	297,017	297,017	297,017	297,017
# Survivors	25,089	25,089	25,089	25,089
# Deceased	8,554	8,554	8,554	8,554
Estimator	OLS	OLS	OLS	OLS

Notes: This table documents the heterogeneity in the treatment effect depending on the number of inventors in the survivor's technology subcategory, within the inventor's CZ-EIN in the year preceding co-inventor death (denoted "inventor number" in the regression table, and standardized by its standard deviation). The specification is similar to specification (3), except that the interacted controls now include only the density of inventors. The results show that the interacted variable is predictive of the treatment effect for "new co-inventor" only when it is built based on the same technology class as the survivor, not other technology class. This is reassuring because it confirms that this measure does not capture broad trends in local concentration of inventors regardless of their technology class, and therefore that it is likely to capture the "match" term we are interested in. Standard errors are clustered around the deceased inventors. *$p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

D2 Tests of "Experience" View

As discussed in Section V.A, team-specific capital can result from a "match" component which is constant over time or from an "experience" component which increases the value of the collaboration over time. The idiosyncratic value of a collaborative relationship may also vary over the lifecycle of an inventor, e.g. if it is more difficult to substitute for co-inventors later in life. From the point of view of inventor i, the idiosyncratic value of a collaborative relationship with inventor j at time t (denoted V_{ijt}) can be conceptualized as resulting from a match component θ_0^{ij}, an experience component θ_1 and lifecycle covariates X_{it}:

$$V_{ijt} = \theta_0^{ij} + \theta_1(t - T_{ij}) + \gamma X_{it} + \epsilon_{ijt}$$

where T_{ij} denotes the time of the first collaboration between i and j.

To separately identify θ_0^{ij} and θ_1, the ideal experiment would follow three steps: randomly assign inventors to work in teams; separate the teams after t years of collaboration, where t varies randomly across teams; test whether the loss in output is larger for teams that were separated later, controlling for inventor age at separation. This ideal empirical design can be approximated in our setting, using the difference between the year of co-inventor death and the year of first collaboration as a measure of "potential length of collaboration", which could serve as an instrument for the actual length of the collaboration between the two inventors. Note that the length of potential collaboration is collinear with age effects:

$$\begin{aligned} PotentialCollaborationLength_{ij} &\equiv YearCoinventorDeath_{ij} - YearFirstCollaboration_{ij} \\ &= AgeAtCoinventorDeath_i - AgeAtFirstCollaboration_i \end{aligned}$$

In our non-experimental setting, the formation of teams is endogenous and, therefore, the age at first collaboration could be correlated with match quality θ_0^{ij} (e.g. if inventors who think alike and were trained in the same schools are more likely to meet earlier in life). Because of the collinearity between potential collaboration length and age effects shown in the equation above, we cannot control for both age at first collaboration and age at co-inventor death. However, we can introduce a number of controls that are not collinear with potential collaboration length but that control for the specific environment in which the survivor first met with the deceased as well as for potentially varying "fixed match quality" over the lifecycle of the survivor.

A first approach to address the potential concern that survivor's age at first collaboration may be correlated with the team's "fixed match quality" is to restrict the sample to large EINs and inventors who started collaborating while they were in the middle of their career, between 35 and 50. Intuitively, if the career stage of the survivor is correlated with the fixed match quality, we would expect the estimates in this restricted sample to be very different compared with the full sample. In contrast, if the effect is driven by the returns to experience with the team, we would expect them to be stable. The results are reported in Appendix Table D5: we find that the point estimates are stable and similar to those of Panel B of Table **??** in the main text.

A second approach to address the potential concern that the survivor's age at first collaboration may be correlated with the team's "fixed match quality" is to introduce interacted control for 5-year age bins for the survivor. Intuitively, if the career stage or lifecycle of the survivor is correlated with the fixed match quality, we would expect the estimates to be very sensitive to the inclusion of such controls. In contrast, if the effect is driven by the returns to experience with the team, we would expect them to be stable. The results are reported in Appendix Table D6: the point estimates are stable and similar to those of Panel B of Table **??** in the main text.

Table D5: Heterogeneity by Length of Potential Collaboration for Mid-Career Matches in Large EINs

	Total Earnings	Labor Earnings	Non-Labor Earnings	Patent Count	Citation Count
$AfterDeath^{Real}$ $\cdot$*Potential Collaboration Length*	-867.428**	-546.232**	-243.276	-0.0223**	-0.0242**
s.e.	(361.124)	(231.081)	(168.977)	(0.01061)	(0.01123)
Age and Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
Individual Fixed Effects	Yes	Yes	Yes	No	No
Interacted Controls	Survivor's Age at First Patent and Survivor's Age at Co-Inventor Death				
Restricted Sample	First Collaboration in a Large EIN (>10,000 W2s) in Mid-Career (Age between 35 and 50)				
# Observations	48,262	48,262	48,262	48,262	48,262
# Survivors	4,125	4,125	4,125	4,125	4,125
# Deceased	1,714	1,714	1,714	1,714	1,714
Estimator	OLS	OLS	OLS	Poisson	Poisson

Notes: This table documents the heterogeneity in the treatment effect depending on the length of potential collaboration between the survivor and the deceased, which is defined as the number of years between the first joint patent application from the survivor and the deceased and the year of death. In Section V.B., we discussed the collinearity between potential collaboration length, survivor's age at first collaboration and survivor's age at co-inventor death. To address the potential concern that survivor's age at first collaboration may be correlated with the team's "fixed match quality", we restrict the sample to large EINs and inventors who started collaborating while they were in the middle of their career, between 35 and 50. Intuitively, if the career stage of the survivor is correlated with the fixed match quality, we would expect the estimates in this restricted sample to be very different compared with the full sample. In contrast, if the effect is driven by the returns to experience with the team, we would expect them to be stable. We find that the point estimates are in fact very stable and similar to those of Panel B of Table **??** in the main text. Standard errors are clustered around the deceased inventors. *$p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table D6: Heterogeneity by Length of Potential Collaboration Controlling For Career Stages

	Total Earnings	Labor Earnings	Non-Labor Earnings	Patent Count	Citation Count
$AfterDeath^{Real}$ $\cdot Potential\ Collaboration\ Length$	-923.167***	-645.218***	-214.989	-0.0201**	-0.02156**
s.e.	(329.561)	(258.019)	(134.591)	(0.00957)	(0.01088)
Age and Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
Individual Fixed Effects	Yes	Yes	Yes	No	No
Interacted Controls	Survivor's Age at First Patent, Survivor's 5-year Age Bin at First Collaboration, and Survivor's Age at Co-Inventor Death				
# Observations	325,726	325,726	325,726	325,726	325,726
# Survivors	27,500	27,500	27,500	27,500	27,500
# Deceased	9,428	9,428	9,428	9,428	9,428
Estimator	OLS	OLS	OLS	Poisson	Poisson

Notes: This table documents the heterogeneity in the treatment effect depending on the length of potential collaboration between the survivor and the deceased, which is defined as the number of years between the first joint patent application from the survivor and the deceased and the year of death. In Section V.B., we discussed the collinearity between potential collaboration length, survivor's age at first collaboration and survivor's age at co-inventor death. To address the potential concern that survivor's age at first collaboration may be correlated with the team's "fixed match quality", we introduce interacted controls for 5-year age bins for the survivor. Intuitively, if the career stage or lifecycle of the survivor is correlated with the fixed match quality, we would expect the estimates to be very sensitive to the inclusion of such controls. In contrast, if the effect is driven by the returns to experience with the team, we would expect them to be stable. We find that the point estimates are in fact very stable and similar to those of Panel B of Table **??** in the main text. Standard errors are clustered around the deceased inventors. *$p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

D3 Results for Heterogeneity by Team Structure

Table D7: Heterogeneity by Degree of Within-Team Heterogeneity: Horse Race between CV Measures

	Total Earnings	Labor Earnings	Non-Labor Earnings	Patent Count	Citation Count
$AfterDeath^{Real} \cdot \frac{CV^{AGE}}{SD(CV^{AGE})}$	-380.912**	-301.242**	-130.120	-0.01203**	0.0702
s.e.	(181.3867)	(125.416)	(108.320)	(0.005868)	(0.005238)
$AfterDeath^{Real} \cdot \frac{CV^{WAGE}}{SD(CV^{WAGE})}$	-162.912	18.842	-56.253	0.00335	-0.0812
s.e.	(178.24)	(89.234)	(70.231)	(0.0060213)	(0.007291)
$AfterDeath^{Real} \cdot \frac{CV^{CITES}}{SD(CV^{CITES})}$	-92.912	-110.102	42.856	-0.00803*	-0.02032***
s.e.	(154.325)	(102.l23)	(72.291)	(0.004598)	(0.00696)
Age and Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
Individual Fixed Effects	Yes	Yes	Yes	No	No
Interacted Controls	Relative ability level, Survivor's age at co-inventor death				
# Observations	325,726	325,726	325,726	325,726	325,726
# Survivors	27,500	27,500	27,500	27,500	27,500
# Deceased	9,428	9,428	9,428	9,428	9,428
Estimator	OLS	OLS	OLS	Poisson	Poisson

Notes: This table shows heterogeneity in the treatment effect depending on the degree of within-team heterogeneity. We compute the within-team coefficients of variation (CV) for age, cumulative forward citations and labor earnings. These three variables are computed in one of the years prior to co-inventor death in which the team applied for a patent; in case the team applied for multiple patents or the inventor was part of multiple teams with the deceased, one patent is selected at random. We then interact each of these variables, which we standardize by their respective standard deviations, with the post-death dummy. We introduce relative ability level (measured by relative earnings quartiles, as in Table **??**) and survivor's age at co-inventor death as interacted controls. Standard errors are clustered around the deceased inventors. $*p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table D8: Closed Triad Analysis in Subsample with Team Structure Controls

	Total Earnings	Labor Earnings	Non-Labor Earnings	Patent Count	Citation Count
$AfterDeath^{Real}$ $\cdot DeceasedClosedTriad$	-752.13**	-812.15**	-121.21	-0.02133**	-0.01973**
s.e.	(361.321)	(351.221)	(97.281)	(0.00921)	(0.009632)
Age and Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
Individual Fixed Effects	Yes	Yes	Yes	No	No
Interacted Controls	Relative Ability Levels, Deceased Wage, Age CV, Wage CV, Cites CV, Survivor's Age at Co-inventor Death				
# Observations	15,232	15,232	15,232	15,232	15,232
# Survivors	1,360	1,360	1,360	1,360	1,360
# Deceased	680	680	680	680	680
Estimator	OLS	OLS	OLS	Poisson	Poisson

Notes: This table uses the sample of "closed triads", defined in the main text in Section V. C., and shows heterogeneity in the treatment effect depending on whether or not the deceased closed the triad. We introduce several controls interacted with the post-death dummy: relative ability level (measured by relative earnings quartiles, as in Table **??**), the deceased wage, survivor's age at co-inventor death, and measures of within-team heterogeneity (within-team coefficients of variation for age, wage and cumulative forward citations). Standard errors are clustered around the deceased inventors. $*p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table D9: Closed Triad Analysis in Full Sample

	Total Earnings	Labor Earnings	Non-Labor Earnings	Patent Count	Citation Count
$AfterDeath^{Real}$ $\cdot DeceasedClosedTriad$	-889.221**	-851.15**	-168.21*	-0.02423**	-0.01831**
s.e.	(389.991)	(373.191)	(99.321)	(0.01102)	(0.009145)
Age and Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
Individual Fixed Effects	Yes	Yes	Yes	No	No
Interacted Controls	Relative Ability Levels, Deceased Wage, Age CV, Wage CV, Cites CV, Survivor's Age at Co-inventor Death				
# Observations	325,726	325,726	325,726	325,726	325,726
# Survivors	27,500	27,500	27,500	27,500	27,500
# Deceased	9,428	9,428	9,428	9,428	9,428
Estimator	OLS	OLS	OLS	Poisson	Poisson

Notes: This table is similar to Appendix Table D8 but uses the full sample, instead of the restricted sample of closed triads defined in the main text in Section V.C. Standard errors are clustered around the deceased inventors. $*p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table D10: Heterogeneity by Geographic Dispersion of Team

	Total Earnings	Labor Earnings	Non-Labor Earnings	Patent Count	Citation Count
$AfterDeath^{Real}$	-1,038.219**	-480.342	-1,312**	-0.0891***	-0.1104***
s.e.	(491.943)	(313.912)	(320.023)	(0.0036185)	(0.003968)
$AfterDeath^{Real} \cdot Colocated$	-2,739.121***	-3,857.452***	487.34	-0.00102	0.01233*
s.e.	(1010.233)	(1469.901)	(432.121)	(0.004537)	(0.006892)
Age and Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
Individual Fixed Effects	Yes	Yes	Yes	No	No
# Observations	325,726	325,726	325,726	325,726	325,726
# Survivors	27,500	27,500	27,500	27,500	27,500
# Deceased	9,428	9,428	9,428	9,428	9,428
Estimator	OLS	OLS	OLS	Poisson	Poisson

Notes: This table studies heterogeneity in the treatment effect by the degree of geographic dispersion of the team. The variable *Colocated* is a dummy equal to 1 when all team members were in the same commuting zone in the year preceding death. The table shows that the effect is larger when the team was co-located, which is consistent with the results from Section IV.C. on close-knit teams. Appendix Table A9 shows that, for any teams size, a large percentage of teams are co-located. Standard errors are clustered around the deceased inventors. *$p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table D11: Heterogeneity by Team Size

	Total Earnings	Labor Earnings	Labor Earnings >0	Patent Count	Citation Count
$AfterDeath^{Real}$	-3,610***	-2,512***	-0.00939**	-0.09563***	-0.09281 ***
s.e.	(869)	(684)	(0.00394)	(0.0239)	(0.02452)
$AfterDeath^{Real} \cdot TeamSize$	-122.213	-169.213	0.0008	-0.00132	0.002452
s.e.	(423.240)	(587.2913)	(0.0013)	(0.009821)	(0.00462)
Age and Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
Individual Fixed Effects	Yes	Yes	Yes	No	No
# Observations	325,726	325,726	325,726	325,726	325,726
# Survivors	27,500	27,500	27,500	27,500	27,500
# Deceased	9,428	9,428	9,428	9,428	9,428
Estimator	OLS	OLS	OLS	Poisson	Poisson

Notes: This table studies heterogeneity in the treatment effect by team size. When the survivor was part of more than one team with the deceased, their reference team is picked at random. The table shows that team size is not a strong predictor of the heterogeneity in the treatment effect. Standard errors are clustered around the deceased inventors. *$p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

D4 Interpretation of the Findings

Does Team-Specific Capital Create a Wedge between Private and Social Welfare?

The paper has established empirically the relevance of team-specific capital, which generates a multiplier effect between co-inventors. This multiplier effect may cause a wedge between the private and social returns to the accumulation of team-specific capital. We have shown that team-specific capital should not be conceptualized as the "fixed match quality" of a team because it accumulates over time, likely due to relationship-specific investments. On its own, our natural experiment cannot be used to conclude whether or not this process leads to a wedge between private and social welfare. Perhaps the employer internalizes all effects, or perhaps the mobility of inventors across both teams and firms creates a wedge between private and social returns. Nonetheless, we briefly discuss this issue here from a theoretical standpoint.

Human capital externalities arise in any situation when the investment of an individual in their skills creates benefits for other agents in the economy. Acemoglu (1996) shows that such externalities naturally arise when the labor market is characterized by costly search. However, we have shown that our evidence on team-specific capital is not consistent with the main prediction of search models, because inventors are affected in a similar way by the loss of a co-inventor regardless of the thickness of the inventor market they work in (Panel A of Table **??**). Therefore, if team-specific capital generates a wedge between private and social welfare, it should be via a different mechanism.

Another approach could be that individuals do not take into account the fact that increasing their own knowledge enriches the learning environment for people in their team. In this case, the social returns would exceed the private returns. We have shown that knowledge transmission is a feature of teams and part of what makes team-specific capital valuable, but we found that the magnitude of this effect is small relative to the overall effect (Table **??**).

Therefore, we are left to conclude that if team-specific capital creates a wedge between private and social welfare, it should more simply be through its impact on innovation, which induces knowledge externalities and business stealing effects (Aghion and Howitt, 1992). The accumulation of team-specific capital results in more innovation, and it is commonly thought that the private returns to innovation are inferior to the social returns to innovation (hence a range of policies like the R&D tax credit). Therefore it may be sufficient to incentivize innovation downstream to lead inventors to optimally accumulate team-specific capital upstream. On the basis of our evidence and of standard models of search or social interation, there does not seem to be a *prima facie* case for believing that team-specific capital induces additional distortions into the innovation system.[§]

What Does the Reduced-form Effect of an Inventor's Death Imply about Complementarity and Substitutability Patterns between Inventors?

Consider a survivor inventor and a prematurely deceased inventor who used to be co-inventors, coworkers, or part of an extended co-inventor network. As mentioned in the main text of the paper, our quasi-experiment does not deliver insights about general substitution and complementarity patterns between these inventors. The reduced-form effects we identify correspond to the idiosyncratic effect of an inventor on their co-inventors, coworkers and second-degree connections. Formally, the sign of our reduced-form coefficients identifies substitutability and complementarity patterns between two inventors conditional on irreplaceability. A non-zero point estimate rejects the null that all of the tasks performed by the prematurely deceased inventor were perfectly replaceable (i.e. it is not possible for the surviving inventor to find another inventor playing the exact same role as the deceased inventor). However, we cannot reject that at least some of the tasks performed by the deceased were replaceable. The sign of the point estimate for the effect of inventor death on the various outcomes of interest reflects complementarity and substitutability patterns for the tasks performed by the prematurely deceased inventors that were not replaceable, and only for those tasks. Specifically, a positive (negative) point estimate tells use that those tasks were on average substitutable for (complementary with) the tasks performed by the survivor inventor. In contrast, we do not learn about complementarity and substitutability patterns for the tasks performed by the deceased that were replaceable.

Other Implications

Taken together, our findings show that identifying the magnitude and nature of spillover effects between inventors is central to innovation and tax policy design, because the impact of any policy may depend greatly not just on a given inventor's behavior but on a "multiplier effect" that affects the broader innovation process, in particular through productivity-enhancing interactions between teams. Given our finding that team-specific capital primarily accumulates over time (Panel B of Table **??**), from an institutional point of view it appears preferable to encourage long-term col-

[§] A possible counterargument is that team-specific capital may lead to a hold-up problem between inventors in the same team, because our evidence is consistent with the idea that the accumulation of team-specific capital results from relationship-specific investments (Panel D of Table **??**). However, hold-up arises only when part of the return on an agent's relationship-specific investments is ex post expropriable by his trading partner. This appears unlikely given the rules of the intellectual property system, which impose to acknowledge all inventors' contribution to the inventive process, otherwise the patent could easily be invalidated in court.

laborations so that team-specific capital has time to accumulate. For instance, academic research centers often organize temporary visits of academics from other institutions and face a choice between organizing short-term (e.g. a quarter) or longer-term visits (e.g. a year). On the basis of our evidence, it seems preferable to organize longer-term visits so that team-specific capital has time to accumulate.

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Appendix E

Econometric Considerations

What is Identified In Specification (1)?

This appendix considers specification (1) introduced in Section III and asks what is identified about the coefficients $\{\beta^{Real}(k)\}$ and $\{\beta^{All}(k)\}$. k denotes the year relative to co-inventor death, which can be expressed as the difference between the time of co-inventor death (CDT_i) and time τ (so $k = \tau - CDT_i$). We delay imposing any "normalization" on the model and we note that $\forall \mu \in R$:

$$\begin{aligned} \beta^{All}(\tau - CDT_i) + \gamma(\tau) + \alpha(i) &= [\beta^{All}(\tau - CDT_i) - \mu(\tau - CDT_i)] + [\gamma(\tau) + \mu \cdot \tau] + [\alpha(i) - \mu \cdot CDT_i] \\ &= \widetilde{\beta^{All}}(\tau - CDT_i) + \widetilde{\gamma}(\tau) + \widetilde{\alpha}(i) \end{aligned}$$

Therefore, any function of the full vector coefficients, $G(\beta^{All}(.))$, is not identified unless $G(\beta^{All}(.)+h(.)) = G(\beta^{All}(.))$ for any linear function $h(k) = \alpha_1 + \alpha_2 k$. This observation helps understand which predictive effects are identified.[¶] If $G(\beta^{All}, \gamma, \alpha)$ is identified, then we can evaluate it and we will get a well-defined predicted value. In specification (1), any solution to the least-squares fit gives the same value for $G(\beta^{All}, \gamma, \alpha)$. Although the solution of the least-square fit in specification (1) is not unique because the regressor matrix does not have full column rank, there is a unique predicted value.

The intuition for this result is that the set of leads and lags associated with $\beta^{All}(k)$ applies to all individuals in the sample. As a result, when we first-difference the data to eliminate the individual fixed effects, we lose information about a linear trend that could affect all individuals either through the $\beta^{All}(k)$ coefficients or through the year or age fixed effects. So $\beta^{All}(k)$, the age fixed effects and the year fixed effects are identified only up to a linear time trend. In practice, when estimating specification (1), we can drop any two dummies within the set of age or year with fixed effects or within the set of leads and lags $\beta^{All}(k)$. This will serve as our "normalization" for the linear trend.

[¶]The point of a "normalization" is that imposing it will not affect the value of a predictive effect that is identified: to be identified means identified without any normalization.

In contrast, $\beta^{Real}(k)$ is associated with a set of leads and lags that can turn to one only for the real survivors. As a result, $\beta^{Real}(k)$ is identified up to a level shift affecting all coefficients. Due to the individual fixed effects, one of the $\beta^{Real}(k)$ must be normalized to zero, as is usually the case in estimators with a full set of leads and lags around an event.

Empirical Relevance

Our specifications (1) and (2) are an application of the standard difference-in-differences estimator to our setting. The current practice in the literature with a setting similar to ours, for instance Azoulay *et al.* (2010) and Oettl (2012), is to use specifications including age, year and individual fixed effects only, without including L_{it}^{All} (as in specification (1)) or $AfterDeath_{it}^{All}$ (as in specification (2)). Becker and Hvide (2013) present a specification similar to our specification (2), but appropriately testing for pre-trending requires using specification (1), as we do.

The point that age, year and individual fixed effects may not fully account for trends in life-time earnings and patents around co-inventor death is a simple but crucial one. Had we not included $AfterDeath_{it}^{All}$ in specification (2), we would have over-estimated the effect of co-inventor death on the probability of being employed by 50% (Table **??**, Panel B), we would have spuriously concluded that an inventor death causes a decline in the patents and in the probability of being employed of this inventor's coworkers and second-degree connections (Table C1, Panels A and B), and we would have mistaken mean-reversion patterns for heterogeneity in the causal effect of co-inventor death by relative ability level of the survivor and the deceased (Table C7).

On the Interpretation of β^{All} in Specification (2)

In this section, we explain why the interpretation of the magnitude of the coefficient β^{All} in specification (2) requires caution. As described above at the beginning of this appendix, the set of coefficients $\beta^{All}(k)$, the age fixed effects and the year fixed effects are identified only up to a linear time trend. In a recent methodological paper, Borusyak and Jaravel (2016) show that this collinearity also has implication for specification (2), where we try to summarize the effect of death post-death.

Intuitively, the $\beta^{All}(k)$ coefficients are identified from an "event study": all control inventors (the placebo survivors) receive treatment at some point in time, but one could hope that the exact timing is random. This observation makes it clear that our setting for the control inventors is identical to what Borusyak and Jaravel (2016) study.[‖] They show that in commonly-used "static" regressions analogous to our specification (2), with a treatment dummy instead of a full set of leads and lags around the treatment event, OLS does not recover a weighted average of the treatment effects: long-term effects are weighted negatively. In other words, the coefficient β^{All} in specification (2) may be outside of the convex hull of the dynamic effects $\beta^{All}(k)$ for $k \geq 0$.

We refer the reader to Borusyak and Jaravel (2016) for the intuition and formal derivation of this claim. For our purposes here, the lesson is that the magnitude of β^{All} in specification (2) may be misleading. This is not an important concern because this coefficient is not of intrinsic interest. In Appendix Table C1, we found negative and statistically significant β^{All} coefficients for the coworkers and second-degree connection. This result could in principle be driven by the negative weighting issue raised by Borusyak and Jaravel (2016). However, we repeated the analysis for these tables without individual fixed effects (which immediately solves the collinearity issue) and still found negative and statistically significant coefficients. We conclude that the negative β^{All} coefficients result from the way the sample was built, as discussed in Appendix Table C1.

[‖] In contrast, none of these points apply to the set of coefficients β_k^{Real}, which is identified by comparison with the control group and does not suffer from any collinearity problem.

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Appendix F

Data Appendix

This section documents the most important steps for the construction of the matched inventor-taxpayer database from Bell et al. (2015) and provides a comparison of the distribution of Census firm size and EIN size.

F.1 Data Construction

F.1.1 Data Preparation

- **Suffix Standardization**. Suffixes may appear at the end of taxpayers' first, middle, or last name fields. Any time any of these fields ends with a space followed by "JR", "SR", or a numeral I-IV, the suffix is stripped out and stored separately from the name[**].

- **First name to imputed first/middle name**. The USPTO separates inventor names into "first" and "last," but the Treasury administrative tax files often separate names into first, middle, and last. In practice, many inventors do include a middle initial or name in the first name field. Whenever there is a single space in the inventor's first name field, for the purposes of matching, we allow the first string to be an imputed first name, and the second string to be an imputed middle name or initial. The use of these imputed names is outlined below.

F.1.2 Pseudo code for Match on Name and Location

The exact matching stages are as follows. We conduct seven progressive rounds of matching. Inventors enter a match round only if they have not already been matched to a taxpayer in an earlier round. Each round consists of a name criterion and a location criterion. The share of data matched in each round is noted, with an impressive 49% being exact matches on the first stage.

- The matching algorithm takes as input a relation of inventor data and five relations of Treasury administrative tax files:

[**]Numerals I and V are only permissive suffixes at the end of a last name field, as these may be middle initials in a middle name field.

- Input relations:
  - Inventors(inv_id, first, last, imputed_first, imputed_middle, suffix) - directly from USPTO
  - NamesW2(irs_id, first, middle, last, suffix) - all names used by individual on W2 information returns; name field is recorded as first, middle, and last
  - Names1040(irs_id, first, middle, last) - all self-reported names from 1040 forms[††]
  - Nameln1W2(irs_id, fullname) - all names from W2, but a separate variable not recorded as first, middle, last that was more frequently present
  - CitiesW2(irs_id, city, state) - all cities reported on W2
  - Zips1040(irs_id, name) - all zip codes reported on 1040
- Output relation:
  - Unique-Matches (inv_id, irs_id)

- **Stage 1**: Exact match on name and location.
  - Name match: The inventor's last name exactly matches the taxpayer's last name. Either the inventor's first name field exactly matches the concatenation of the Treasury administrative tax files first and middle name fields or the Treasury administrative tax files middle name field is missing, but the first name fields match. If an imputed middle name is available for the inventor, candidate matches are removed if they have ever appeared in Treasury administrative tax files with a middle name or initial that conflicts with the inventor's.
  - Location match: The inventor's city and state must match some city and state reported by that taxpayer exactly.
  - 49% of patents are uniquely matched in this stage.

- **Stage 2**: Exact match on imputed name data and location.
  - Name match: The inventor's last name exactly matches the taxpayer's last name and the taxpayer's last name is the same as the inventor's imputed first name. Either the inventor's imputed middle name/initial matches one of the taxpayer's middle/initial name

[††]We only take names off of 1040s for those who file singly because it proved difficult to parse names of those list them jointly

fields, or one of the two is missing. For inventors with non-missing imputed middle names, priority is given to matches to correct taxpayer middle names rather than to taxpayers with missing middle names. As above, candidate matches are removed if they have ever appeared in Treasury administrative tax files with a conflicting middle name or initial.

- Location match: As above, the inventor's city and state must match some city and state reported by that taxpayer exactly.
- 12% of patents are uniquely matched in this stage.

- **Stage 3**: Exact match on actual or imputed name data and 1040 zip cross-walked.

  - Name match: The inventor's last name exactly matches the taxpayer's last name. The inventor's first name matches the taxpayer's first name in one of the following situations, in order of priority:

  1. Inventor's firstname is the same as the taxpayer's combined first and middle name.
  2. Inventor's imputed firstname matches taxpayer's and middle names match on initials.
  3. The inventor has no middlename data, but inventor's firstname is the same as the taxpayer's middle name.

  - As always, taxpayers are removed if they are ever observed filing with middle names in conflict with the inventor's.
  - Location match: The inventor's city and state match one of the city/state fields associated with one of the taxpayer's 1040 zip codes.
  - 3% of patents are uniquely matched in this stage.

- **Stage 4**: Same as previous stage, but using 1040 names instead of names from W2's.

  - Name match: The inventor's name matches the name of a 1040 (or matches without inventor's middle initial/name, and no taxpayer middle initials/names conflict with inventor's).
  - Location match: The inventor's city and state must match some city and state reported by that taxpayer exactly.

  - 6% of patents are uniquely matched in this stage.

- **Stage 5**: Match using W2 full name field.

  - Name match: The inventor's FULL name exactly matches the FULL name of a taxpayer on a W2.
  - Location match: The inventor's city and state match one of the city/state fields associated with one of the taxpayer's 1040 zip codes.
  - 8% of patents are uniquely matched in this stage.

- **Stage 6**: Relaxed match using W2 full name field.

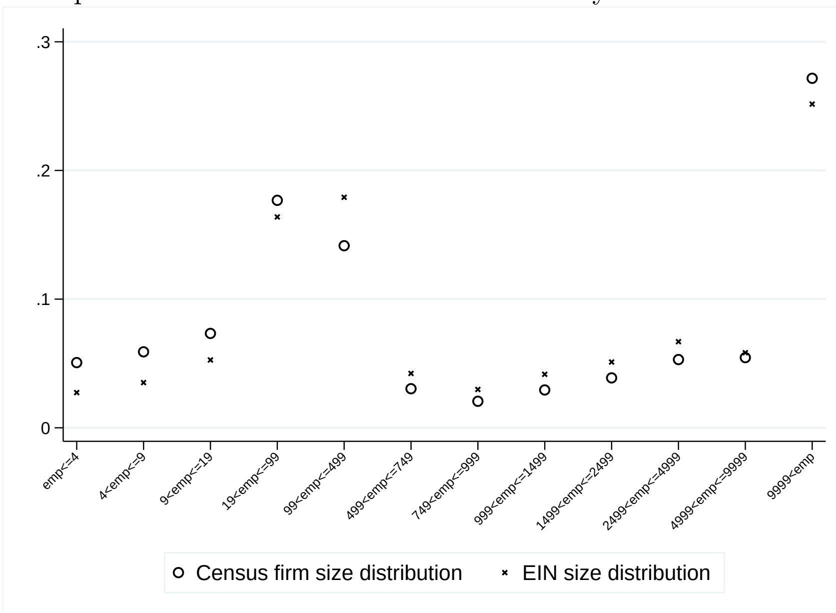
  - Name match: The inventor's full name (minus the imputed middle name) exactly matches the full name of a taxpayer on a W2.
  - Location match: The inventor's city and state match one of the city/state fields associated with one of the taxpayer's 1040 zip codes.
  - 1% of patents are uniquely matched in this stage.

- **Stage 7**: Match to all information returns.

  - Name match: The inventor's full name exactly matches the full name of a taxpayer on any type of information return form.
  - Location match: The inventor's city and state match one of the city/state fields associated with one of the taxpayer's information return forms.
  - 6% of patents are uniquely matched in this stage.

F.2 A Comparison of the Firm Size Distribution in Census Data and EIN Size Distribution in Treasury Administrative Tax Files

Figure F1: Comparison of Census Firm Size and Treasury EIN Size Distributions, 2002



Notes: This figure shows the distribution of firm size in the Census distribution and EIN size in Treasury tax files, based on 2002 data. The distributions are very similar.