Geography and Innovation: Evidence from Nobel Laureate Physicists

Bruce A. Weinberg

www.bruceweinberg.net

Introduction

- Belief that ideas spillover across innovators
- Motivates agglomerations of innovators
  - Silicon Valley
- Little quantitative evidence, especially at the individual level

This Study

- Are Nobel laureate physicists more likely to start or do their Prize-winning work while around more other Nobel laureate physicists?

Our Focus

- Vertical spillovers at extreme right tail:
  1. People with great achievements
  2. Effect on most important work
  3. Effect of other important people
- Living in same city versus shorter interactions
- Within field, not between (e.g. Jacobs)
- Stage of career, work, discipline, and time
- Questions versus answers
- Focus on ideas, not production
- Specific Environments

Context

- Basic science with wide-ranging commercial applications
  - Nuclear physics, solid state physics (Kragh [1999])
- Physics is particularly interesting because of quantum revolution (Kuhn [1962])
  - Begins in late 19th century; culminates in 1920s; but work continues (Pais [1986])

Specific Locations

Cavendish Laboratory, Cambridge University

Niels Bohr Institute, University of Copenhagen

Location Characteristics and People

- Both interactive and relatively non-hierarchical
- Bohr models institute after Rutherford
- NBI is model for Cold Spring Harbor through Max Delbrück and Basel Institute for Immunology through Niels Jerne

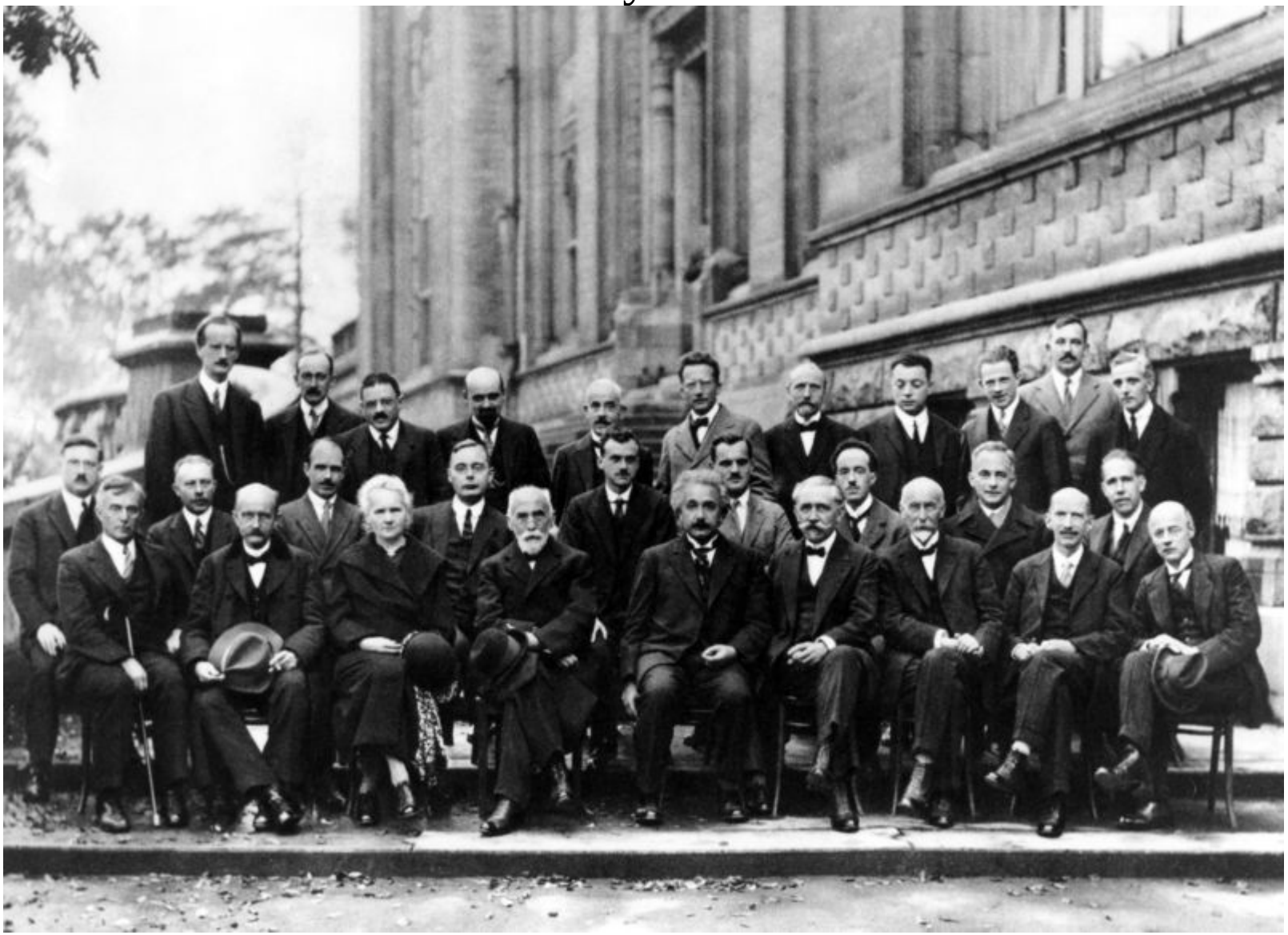
The Environment

“Freedom from financial constraints and from bureaucratic regulations, so graciously and generously provided by Roche, has given all members the chance to organize their scientific and social life in the [Basel] Institute [for Immunology] in the scientific spirit of the Niels Bohr Institute in Copenhagen during the 1920s and 1930s, where an international group of physicists developed a model of scientific teamwork on a free and equal basis. Max Delbrück, a pupil of Niels Bohr and scientific mentor of Niels Jerne, used to remark that one of the essential ingredients of free teamwork had to be ‘joyful disrespect’ for any possible hierarchy among the members of a team. Chaos is prerequisite to develop the creativity needed to detect the world which we have not yet discovered.” – Fritz Melchers, 1994.

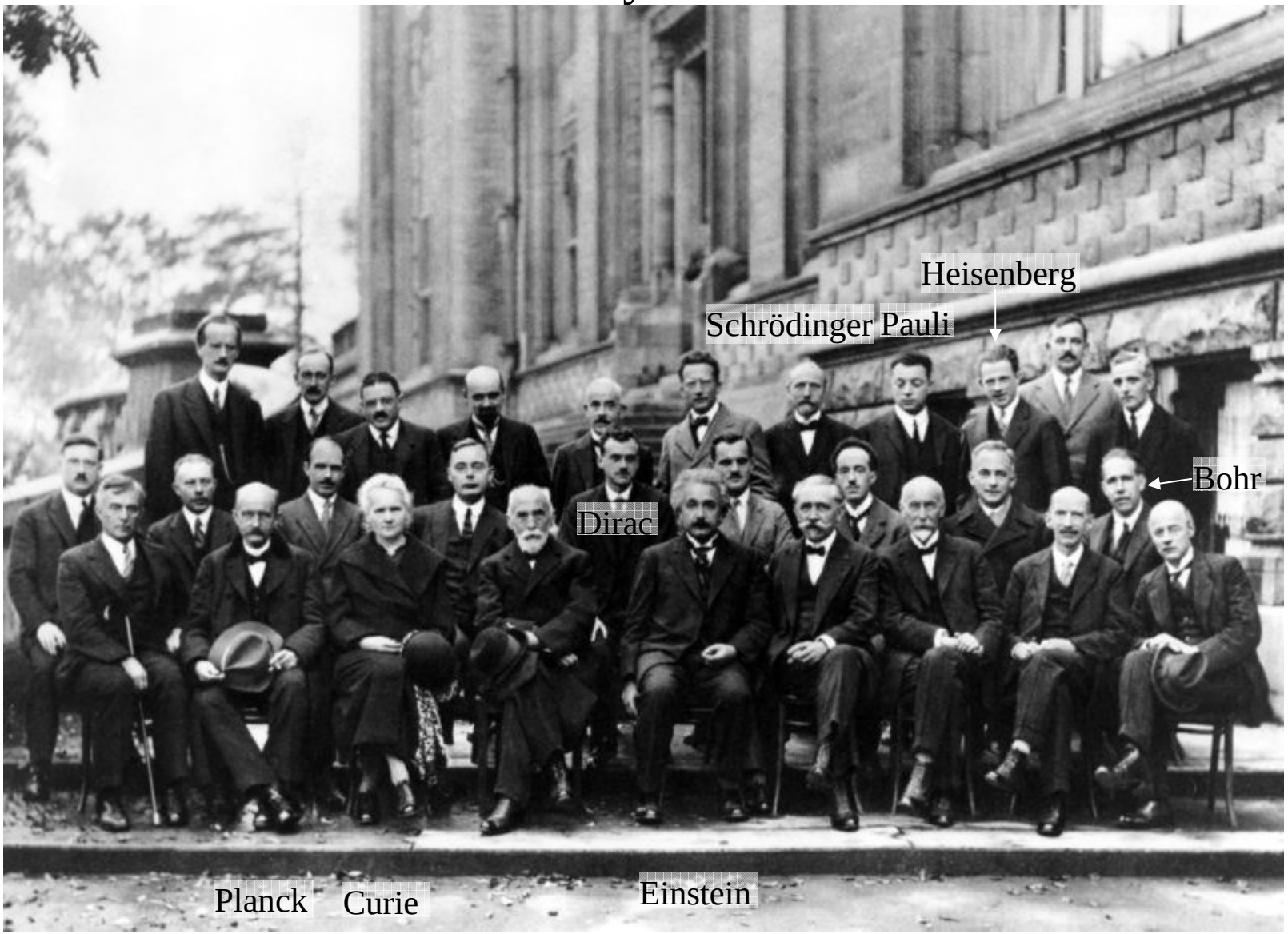
The Environment

“The [Basel] Institute for [Immunology] knows no hierarchies other than those of experience and excellence. It has no departments, and all members have the equal right to choose with whom and on what they wish to work.” – Fritz Melchers, 1994.

1927 Solvay Conference



1927 Solvay Conference



Causality

- Many important innovators associated with other important innovators
- Do these associations improve their work?
- Or, do important guys seek out other important guys?

Our Approach to Causality

- Look at starting versus doing work
- Look at timing of changes in number of laureates present
- Ideally randomly assign people to be around other Nobel laureates

Possibilities for Random Assignment

- Physicists fleeing Nazis
  - Too few (at least for our purpose!)

- Share-shift index
  - Shut down own-mobility
  - Look at number of people in each location in each year
  - Impacts people differently because they are in different places

Data

- Institutional affiliation of every Nobel laureate physicist for entire career
  - From time of highest degree-3 to age 66
- When the person started his/her Prize-winning work (Levin & Stephan)
- The year the work was done (Jones)

Individual-Level Data

- Look at specific ages, times, types of work
- Allows us to construct a range of measures of potential spillovers
  - Number of Nobel laureates present
  - Look at specific locations
  - See if specific people have effects
  - Effect of being around people when they are doing their prize-winning work

Table 1. Most Frequent Locations.

City	Number of Laureates	Number of Years
New York City, NY, USA	50	661
Boston, MA, USA	34	593
San Francisco, CA, USA	33	517
Princeton, NJ, USA	32	259
Cambridge, England	30	497
Chicago, IL, USA	25	248
Berlin, Germany	21	282
Paris, France	18	427
Gottingen, Germany	15	109
Los Angeles, CA, USA	15	239
Geneva, Switzerland	14	142
Zurich, Switzerland	14	167
Ithaca, NY, USA	13	160
London, England	13	166
Washington, DC, USA	13	59
Copenhagen, Denmark	12	126
Munich, Germany	12	97

Estimation

- Logit model for starting or doing Prize-winning work

  - For people who have not yet started / done their Prize-winning work, what is related to the probability of starting / doing it?

- Discrete-time hazard model

Figure 1. Distribution of Experience at Began Nobel Work.

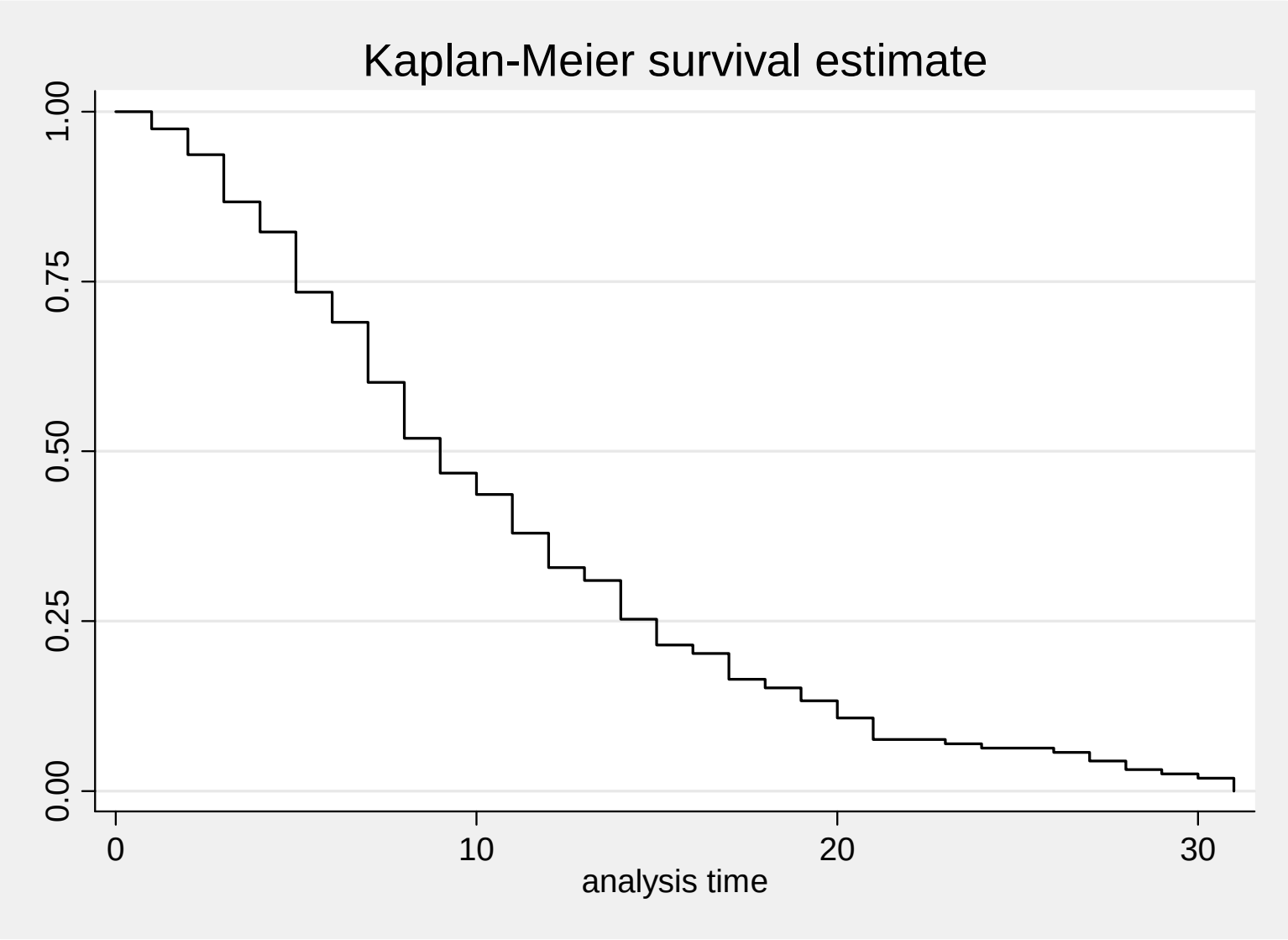


Table 2. Being with other Laureates Currently.

	Starting	Doing
Log(Laureates Present)	1.304 (0.132)	1.120 (0.109)
Theorist	1.479 (0.291)	1.585 (0.309)
Experience	1.087 (0.013)	1.082 (0.010)
Cohort	1.060 (0.062)	1.090 (0.061)
Cohort^2	1.101 (0.027)	1.085 (0.025)
Cohort^3	1.012 (0.003)	1.010 (0.003)
Observations	1,851	2,502

Quantifying Estimates

- Probability of starting work: 9.4%
- Standard deviation in log(Laureates): .6
- 1 SD increase in log(Laureates) raises probability by 18%
- Raises probability to 11.1%

Table 3. Being with other Laureates Recently.

	Starting	Doing
Log(Laureates, 5-Year Av.)	1.245 (0.139)	1.226 (0.129)
Theorist	1.472 (0.289)	1.590 (0.310)
Experience	1.086 (0.013)	1.082 (0.010)
Cohort	1.060 (0.062)	1.087 (0.061)
$Cohort^2$	1.098 (0.027)	1.089 (0.025)
$Cohort^3$	1.012 (0.003)	1.010 (0.003)
Observations	1,856	2,502

- Note: On average 4 years between starting and doing Prize-winning work.

Causality

- Timing of changes in number of laureates present around prize-winning work
- If top places recruit people after starting their work, number of laureates should increase *after* starting work
- If laureates improve work, number of laureates should increase *before* starting work

Figure 2. Laureates Present around Start of Prize-Winning Work.

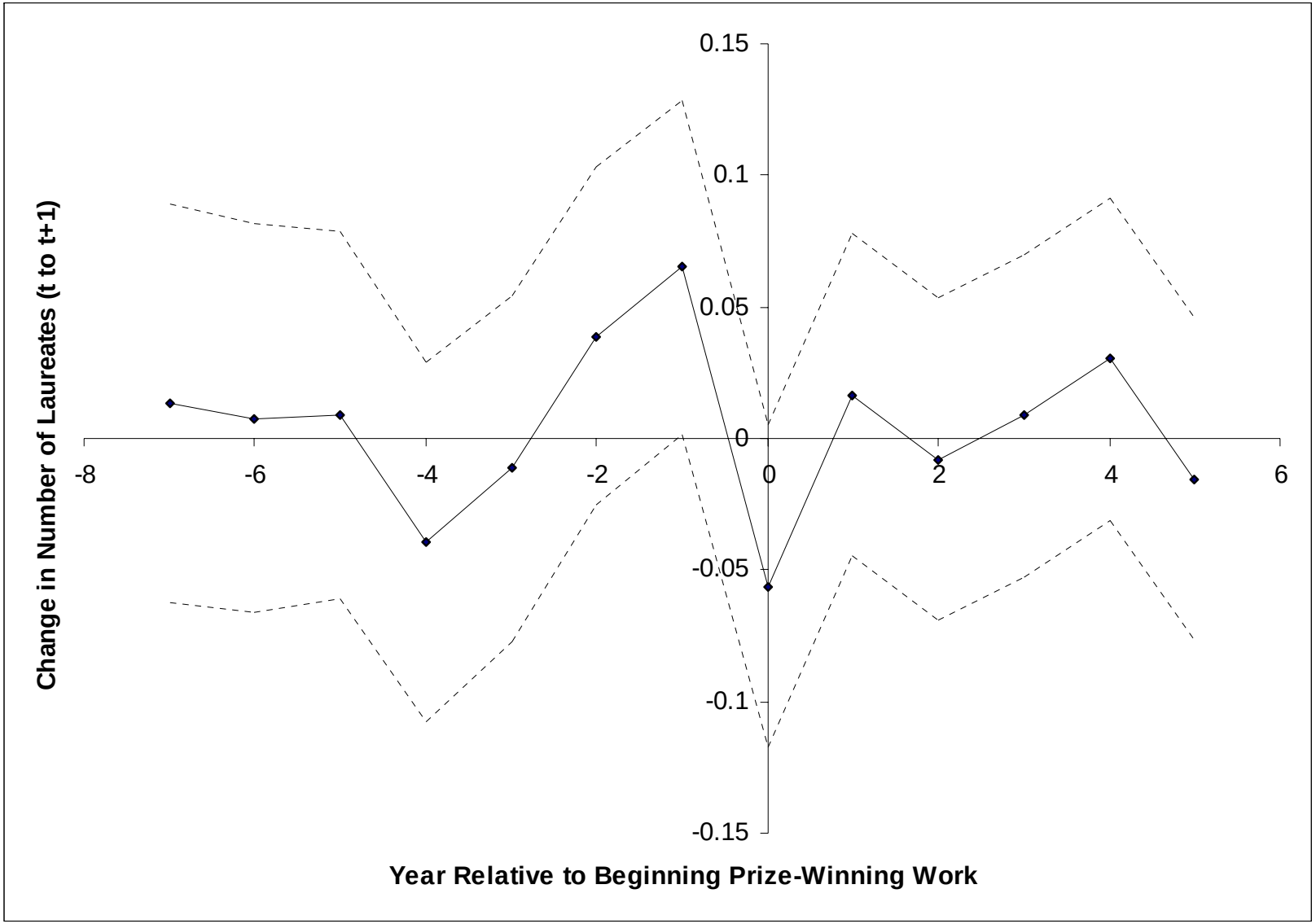


Table 4. Being in Places that have a lot of Laureates.

	Starting
Log(Laureates Ever)	0.935 (0.292)
Theorist	1.260 (0.552)
Experience	1.134 (0.219)
Cohort	1.131 (0.128)
$Cohort^2$	1.072 (0.046)
$Cohort^3$	1.008 (0.006)
Observations	1,851

Table 5. Specific Locations.

New York	1.443	(0.387)	0.923	(0.350)
Boston	1.799	(0.606)	1.244	(0.504)
San Francisco	1.260	(0.430)	0.876	(0.356)
Princeton	1.923	(0.719)	1.637	(0.633)
Cambridge	1.743	(0.518)	1.192	(0.444)
Chicago	0.186	(0.189)	0.157	(0.160)
Berlin	0.856	(0.395)	0.645	(0.317)
Paris	0.865	(0.330)	0.667	(0.275)
Los Angeles	1.140	(0.648)	0.964	(0.557)
Gottingen	0.679	(0.376)	0.558	(0.319)
Zurich	0.929	(0.412)	0.898	(0.402)
Geneva	0.542	(0.338)	0.436	(0.279)
Washington	0.913	(0.694)	0.870	(0.664)
London	2.319	(1.276)	2.107	(1.167)
Ithaca	2.545	(1.346)	2.234	(1.194)
Munich	0.788	(0.593)	0.767	(0.578)
Copenhagen	2.823	(1.540)	2.659	(1.451)
Laureates Present Currently			1.328	(0.222)
F-Test of Locations	0.073		0.208	
F-Test of Locations & No. Laureates			0.054	
Observations	1,851		1,851	

Table 6. Being with Specific People.

	Starting		Starting	
Niels Bohr	1.089	(1.217)	1.107	(1.250)
Ernest Rutherford	2.124	(0.734)	1.911	(0.668)
J. J. Thomson	1.380	(1.113)	1.220	(0.996)
Theorist	1.545	(0.310)	1.529	(0.307)
Experience	1.086	(0.013)	1.089	(0.013)
Cohort	1.108	(0.066)	1.091	(0.066)
Cohort^2	1.087	(0.026)	1.096	(0.027)
Cohort^3	1.011	(0.003)	1.011	(0.003)
Laureates Present Currently			1.256	(0.129)
Observations	1,838		1,838	

Other Analyses

- **No evidence** that:
  - Spillovers change over time
  - Spillovers change over the life cycle
  - Spillovers are greater for people involved in quantum revolution
  - People who recently did Prize-winning work have bigger effects
  - Einstein has an effect

Interpreting Coefficients

- Have estimated effect on timing of someone who does Prize-winning work
- Interested in the effect on whether someone does Prize-winning work
- Probably lower, except for people who are close to doing Prize-winning work
- But, some people may be less affected

Conclusions

- Some relationship between presence of other Nobel Laureates and probability of starting Prize-winning work
- Causal effects are likely smaller
- Effects could be different for other types of spillovers
- Conferences may be enough