CREMA

Center for Research in Economics, Management and the Arts

Do Nobel laureates change their patterns of collaboration following prize reception?

Working Paper No. 2015-10

CREMA Südstrasse 11 CH - 8008 Zürich www.crema-research.ch

Do Nobel laureates change their patterns of collaboration following prize reception?

Ho Fai Chan, Ali Sina Önder, and Benno Torgler*

Abstract We investigate whether Nobel laureates' collaborative activities undergo a negative change following prize reception by using publication records of 198 Nobel laureates and analyzing their coauthorship patterns before and after the Nobel Prize. The results overall indicate less collaboration with new coauthors post award than pre award. Nobel laureates are more loyal to collaborations that started before the Prize: looking at coauthorship drop-out rates, we find that these differ significantly between coauthorships that started before the Prize and coauthorships after the Prize. We also find that the greater the intensity of pre-award cooperation and the longer the period of pre-award collaboration, the higher the probability of staying in the coauthor network after the award, implying a higher loyalty to the Nobel laureate.

Keywords Nobel Prize; Nobel laureate; Award; Network; Coauthors; Recognition; Chemistry; Physics; Physiology or Medicine

*Ho Fai Chan, B. Torgler (corresponding author)
Queensland Behavioural Economics Group (QuBE), School of Economics and Finance, Queensland University of Technology, Brisbane, GPO Box 2434, QLD 4001, Australia
e-mail: benno.torgler@qut.edu.au
Ali Sina Önder
University of Bayreuth, Department of Economics, Universitätsstrasse 30, D-95447 Bayreuth, Germany.

B. Torgler
CREMA, Center for Research in Economics, Management and the Arts, Zurich, Switzerland

Introduction

Although the Nobel Prize is regarded as the highest scientific accolade (Zuckerman 1992), interviews with Nobel laureates (Zuckermann 1996, pp. 218-236) indicate that its reception can lead to disruptions and unintended consequences in the scientific work process because of the abrupt upward mobility it brings, and furthermore "the laureates' relations with their collaborators change most decisively" (Zuckerman 1996, p. 232). In this paper we investigate changes in Nobel laureates' collaboration patterns with their coauthors following the receipt of the Nobel Prize.

Several laureates have reported that the prize erected barriers of deference between themselves and their colleagues, separating them emotionally and putting a distance between them that is "sometimes transformed into envy and the inclination to remove the hero from his pedestal" (Zuckermann 1996, p. 231). The resulting reduction in effective communication and exchange can disrupt the Nobelist's collaboration network, and thus lead to less interaction with collaborators. This is one of the possible ways a Nobelist's collaboration patterns may change following the Prize.

A Nobelist's collaboration patterns may change due to several other factors, such as younger coauthors' willingness to establish an independent reputation (Zuckerman 1996, Merton 1968), or Nobelists' reduced concern with recognition, or Nobelists publishing less out of fear that the newer work might be judged as mediocre (Zuckerman 1996, 229). Nevertheless, some Nobelists choose to maintain their collaboration network in order to keep publishing, perhaps even compensating for the reduced research time caused by increased external activities and post-prize demands by taking advantage of the greater number of students who approach them. When Nobelists are keen to publish, they have an incentive to profit from collaborative work,

bringing additional, complementary knowledge, skills and capacities to a research project. As is often argued, the result of collaboration is more than the sum of the single parts: "[W]hen Watson and Crick set out to author an article together, a new author emerged, one not completely reducible to the two individual authors, James Watson and Francis Crick" (Wray 2006, p. 510). Not only has diversity of perspectives always been crucial to science (Shaman et al. 2013), but collaboration often emerges when the challenge at hand cannot be tackled by a single person (van Rijnsoever and Hessels 2011).

Laureates may also maintain networks because they are accustomed to, and reluctant to deviate from, certain habits of publication frequency. In such cases, network stability can be strengthened by a desire or willingness to mentor young scientists, while collaborative possibilities are heightened by the Nobelist's ability to attract grants and greater access to scientific personnel and money. Collaboration can thus be either a strategic choice (Bozeman and Corley 2004) or one driven by curiosity or the shared excitement of conducting research and experiencing intellectual companionship (Heinze and Kuhlmann 2008, Beaver 2001, Katz and Martin 1997). Continued research effort may also be inspired by positive feedback on quality publications and a reputation for still being active after receiving the Nobel Prize. The net effect is thus hard to predict.

In addition to Zuckerman's (1996) detailed analysis, several other studies focus on Nobel laureates, taking into account such factors as age or career path and productivity (Jones and Weinberg 2011, Kademani et al. 2005, van Dalen 1999, Stephan and Levin 1993), intuition (Marton et al. 1994), recognition across the career (Chan, Gleeson and Torgler 2014), speed of post-prize recognition (Chan and Torgler 2013), the consequences of educational background and methodological orientation (Chan and Torgler 2015), age premium (Baffes and Vamvakidis

2011), case study analysis of collaboration structure (Kademani et al. 2005), collaboration productivity (Chan et al. 2015), family background (Rothenberg 2005), professional ability (Shavinina 2004), predictability of the Nobel Prize (Gingras and Wallace 2010) and knowledge spillover (Ham and Weinberg 2011). In general, the exploration of Nobelists offers several advantages similar to those of a controlled (experimental) environment in that all prize winners have been affected by the same abrupt upward mobility shock and all are researchers with very high intellectual human capital and are thus relatively homogeneous in their collaboration "attractiveness".

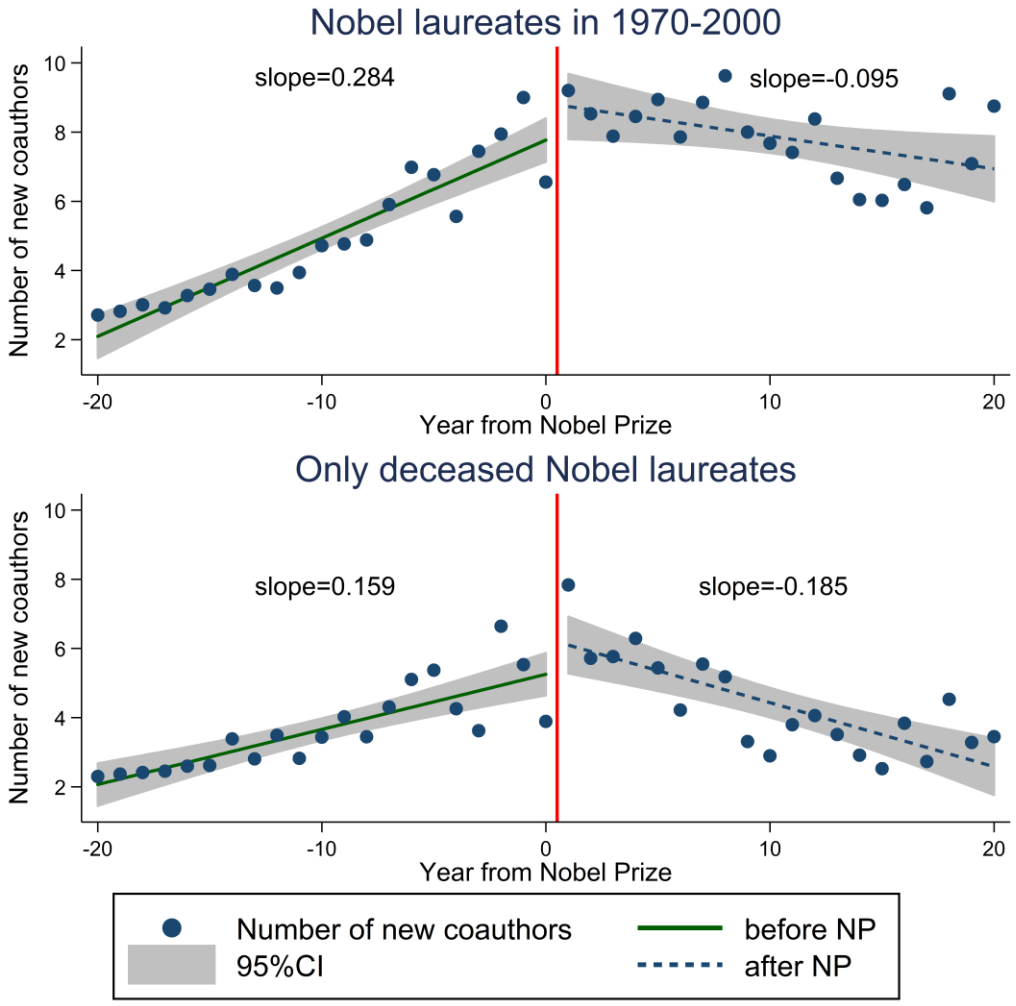
We explore whether coauthorship patterns of Nobel laureates experience a change upon prize reception by analyzing the Nobel laureates' collaboration patterns with their coauthors before and after the award. Specifically, we identify when and how many new coauthors join and leave the Nobelist's collaboration network, measure the dropout rate of coauthors who collaborated with the laureate before the Nobel Prize, and assess whether these dropout rates are negatively correlated with collaboration intensity in the pre-award period. Our study thus contributes to the literature on scientific careers, which grew out of questions related to the skewed distribution of research productivity among scientists (Börner et al. 2010, Stokols et al. 2008, Dietz and Bozeman 2005).

A descriptive analysis of collaboration trends

We explore the award's collaborative implications by carefully analyzing all pre and post award publications of 198 Nobel laureates listed in SCOPUS, whose records cover papers published between 1923 and 2013. Our sample comprises 1970 to 2000 Nobel laureates in physics,

chemistry, and medicine or physiology and thus excludes two-time winners John Bardeen (1956 and 1972) and Frederick Sanger (1958 and 1980).

Our first focus of interest is whether a change occurs in arrival of new coauthors in the Nobel laureates' collaboration networks after prize reception. Chan et al. (2015), for example, observe a nonlinear inverted U-shape relation between the number of new coauthors and laureate age, one that on average reaches a peak after age 60. Our results identify a positive trend in new collaborators in the period before the Nobel Prize, which changes abruptly after conferral, with yearly values fluctuating around the value observed at the time of the award (Fig. 1). Because the exact time of the potential breakpoint is known, we use the Chow test to identify a structural break – that is a strong enough (co-author) shift of the pre- and post-award slope – through determining the presence of parameter constancy or homogeneity. This procedure is equivalent to testing whether coefficients in two linear regressions comparing the period before and after the Nobel Prize are equal (fitted line in Fig. 1). In other words, it shows whether the rate of change of collaboration patterns differs before and after receiving the Nobel Prize. In addition, we use a *t*-test for mean-comparison to assess the change in the level of pre- and post-Prize collaboration measures. The results of the Chow test and *t*-test for number of new authors are given in Table 1. While the result of the *t*-test indicates that Nobel laureates have, on average, more new coauthors after receiving the Prize, a statistically significant structural break at the time of Prize receipt is confirmed for Nobel laureates in all age groups (age is defined here as the age of the laureate when she/he received the Prize) and in all three natural science fields. Figure 1, on the other hand, illustrates the structural break that reflects a negative change (from positive slope) in the rate of collaborating with new coauthors in post-award period. This structural break is even stronger when we restrict our sample to deceased Nobel laureates (see Fig. 1).



Note: Green solid line is the linear fit for observations in the pre-award period (including the award year, t = 0). Blue dash line is the linear fit for the observations after the award year (from t = 1). Red line is set at 0.5 to distinguish before and after Nobel Prize.

Fig. 1 Average of Nobelists' new coauthors before and after the Nobel Prize.

Table 1 Chow test for structural breaks and mean comparison t-test: number of new coauthors

Number of new coauthors	**Chow test**			***t*-test**				
Full sample	**DF**	**F-stat.**	**p-value**	**DF**	**Before NP**	**After NP**	**Diff.**	**p-value**
Nobel laureates in 1970-2000	6275	26.91	0.000***	6277	5.01	7.95	-2.93	0.000***
Age for NP <= 46	747	3.91	0.020**	749	4.24	6.61	-2.37	0.000***
46 < Age for NP <= 56	2246	4.01	0.018**	2248	4.95	10.23	-5.29	0.000***
56 < Age for NP <= 66	1873	17.34	0.000***	1875	4.99	6.04	-1.06	0.045**
Chemistry	1965	13.08	0.000***	1967	4.68	8.21	-3.53	0.000***
Physics	2025	13.42	0.000***	2027	4.56	5.87	-1.32	0.048**
Physiology or medicine	2277	8.11	0.000***	2279	5.74	9.42	-3.69	0.000***
Deceased Nobel laureates	**DF**	**F-stat.**	**p-value**	**DF**	**Before NP**	**After NP**	**Diff.**	**p-value**
Nobel laureates in 1970-2000	2852	16.08	0.000***	2854	3.68	4.63	-0.95	0.012**
Age for NP <= 46	132	0.61	0.542	134	1.83	3.74	-1.91	0.001***
46 < Age for NP <= 56	638	3.91	0.021**	640	3.38	5.72	-2.35	0.000***
56 < Age for NP <= 66	1091	5.53	0.004***	1093	3.07	3.56	-0.48	0.31
Chemistry	894	15.5	0.000***	896	3.58	3.96	-0.38	0.336
Physics	752	9.66	0.000***	754	3.65	4.84	-1.19	0.326
Physiology or medicine	1198	2.96	0.052*	1200	3.77	5.03	-1.26	0.002***

Note: Deceased: data up to the end of 2014. *, **, *** represent statistical significance at the 10%, 5% and 1% levels, respectively.

Nobelists constitute a highly heterogeneous group with respect to age. We examine different age cohorts based on award year (Fig. 2). In two of the three age categories (those who received the Prize before 47 and those who received between 57 and 66), the post-award slope is negative. When we compare the results from different fields (Fig. 3), a strong structural break (to a negative slope) is found for chemistry and physics. Overall, we observe a positive trend of collaborating with more coauthors before the Nobel Prize, and this trend turns negative after the Prize, even though the average number of new coauthors is higher in the post-Prize period.

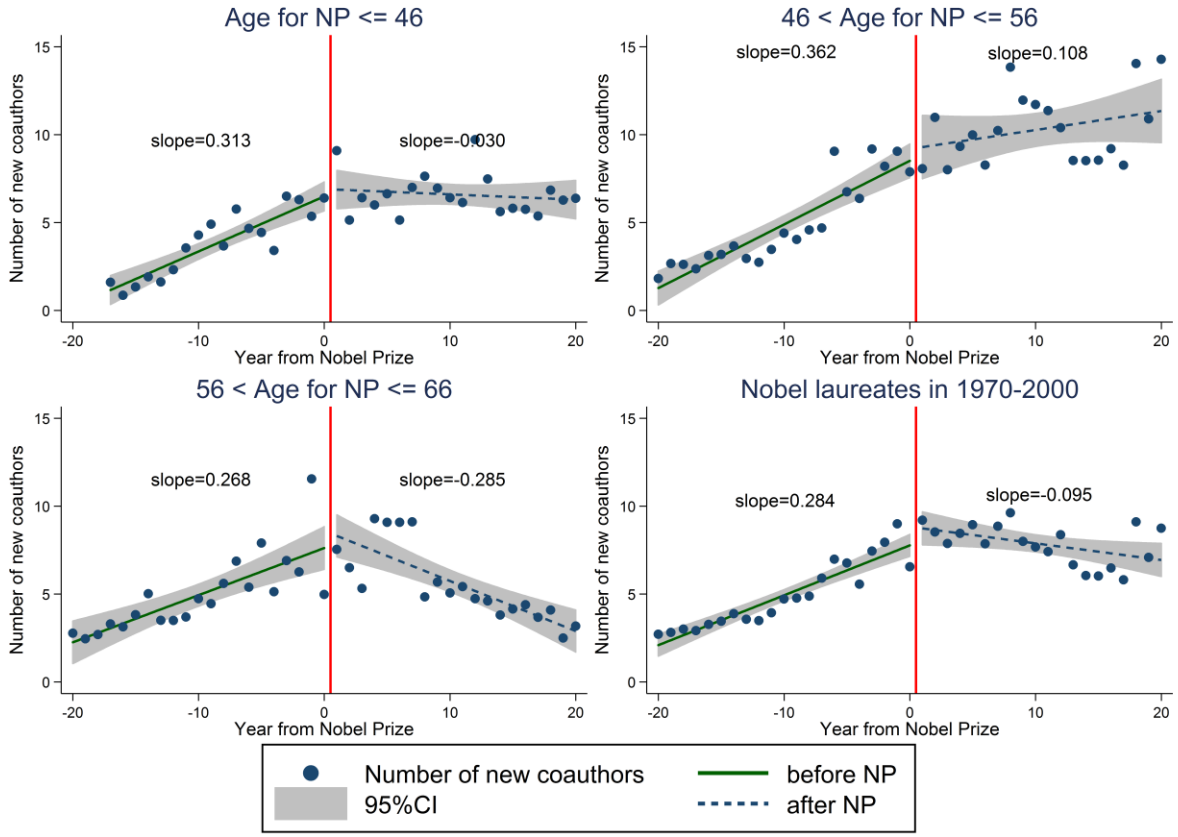


Fig. 2 Different age cohorts based on the age at prize reception.

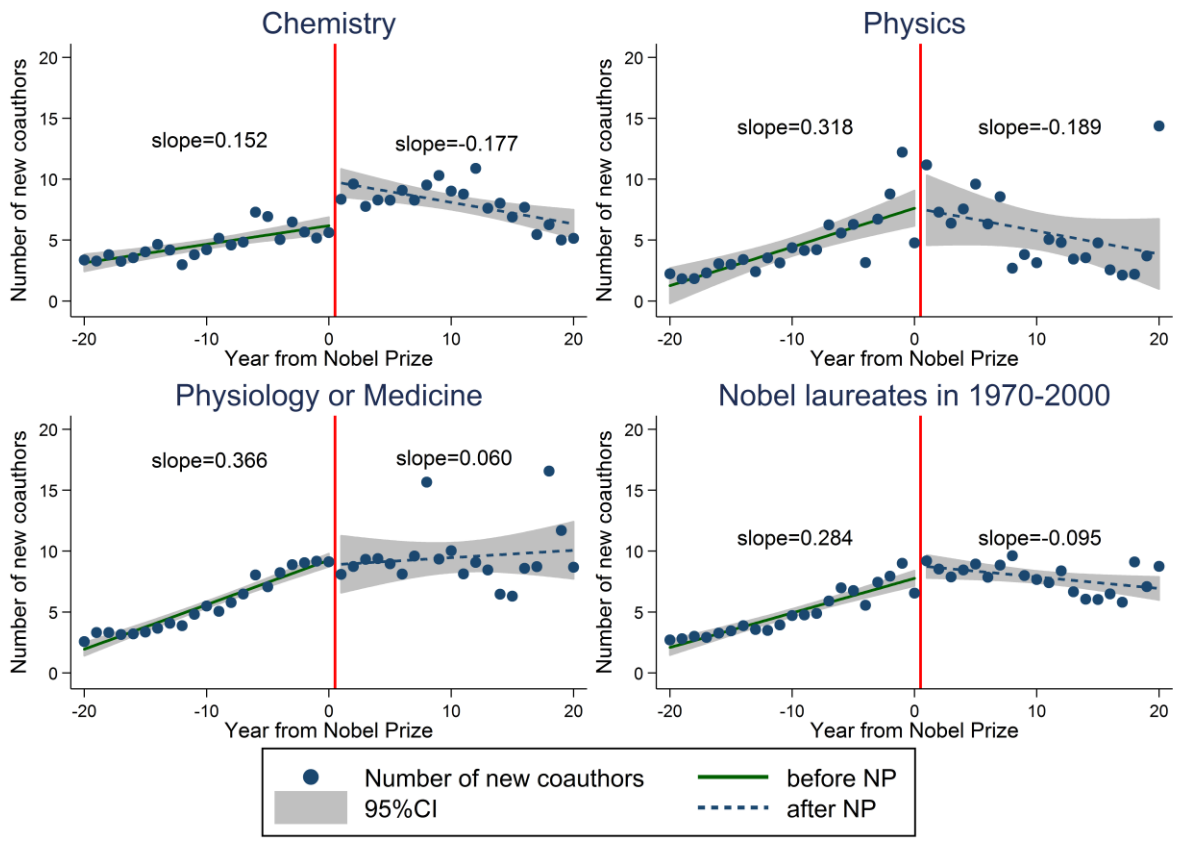


Fig. 3 Number of new coauthors by field

Next, we normalize the number of new coauthors by the size of the current coauthor network (see Fig. 4). In this case, the slope suggests that the trend for new coauthors is decreasing before the Nobel Prize but relatively stable after it. This pattern indicates a structural break (statistically significant at the 1% level) similar to that shown in Table 2. In fact, when we test for the same set of subgroups, structural changes are observed in most cases, although less so for deceased laureates.

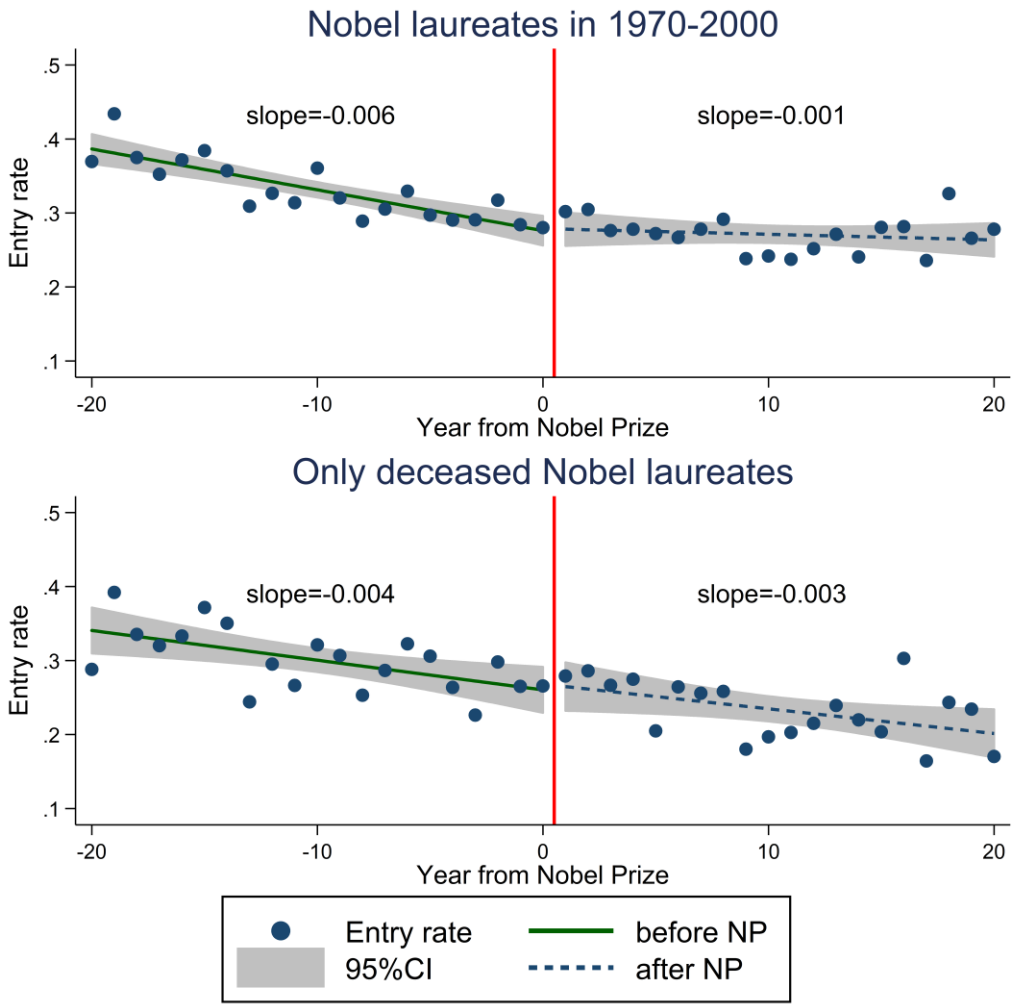


Fig. 4 New coauthors divided by the number of existing coauthors.

Table 2 Chow test for structural breaks and mean comparison t-test: entry rate

Entry rate	**Chow test**			***t*-test**				
Full sample	**DF**	**F-stat.**	**p-value**	**DF**	**Before NP**	**After NP**	**Diff.**	**p-value**
Nobel laureates in 1970-2000	5881	6.55	0.001***	5883	0.33	0.27	0.06	0.000***
Age for NP <= 46	667	17.16	0.000***	669	0.43	0.3	0.14	0.000***
46 < Age for NP <= 56	2147	4.26	0.014**	2149	0.37	0.29	0.08	0.000***
56 < Age for NP <= 66	1778	0.93	0.397	1780	0.29	0.25	0.04	0.002***
Chemistry	1916	8.79	0.000***	1918	0.33	0.27	0.06	0.000***
Physics	1777	1.6	0.202	1779	0.31	0.25	0.06	0.000***
Physiology or medicine	2180	5.7	0.003***	2182	0.35	0.29	0.05	0.000***
Deceased Nobel laureates	**DF**	**F-stat.**	**p-value**	**DF**	**Before NP**	**After NP**	**Diff.**	**p-value**
Nobel laureates in 1970-2000	2623	0.2	0.821	2625	0.3	0.24	0.06	0.000***
Age for NP <= 46	115	4.29	0.016**	117	0.44	0.27	0.17	0.003***
46 < Age for NP <= 56	600	2.03	0.133	602	0.32	0.25	0.08	0.001***
56 < Age for NP <= 66	1013	0.29	0.751	1015	0.29	0.23	0.05	0.002***
Chemistry	874	3.28	0.038**	876	0.3	0.23	0.08	0.000***
Physics	622	1.15	0.317	624	0.27	0.24	0.04	0.187
Physiology or medicine	1119	2.59	0.075*	1121	0.32	0.25	0.07	0.000***

Note: *, **, *** represent statistical significance at the 10%, 5% and 1% levels, respectively.

We move on to analyzing the dropout of coauthors (termination of collaboration), and we first focus only on scientists who were collaborating with the laureate *before* conferral of the Nobel Prize. Based on ex post information, we are able to identify the year of the last cooperation, which is simply the last year of available publication data, and we take the year after the last collaboration as the termination year of collaboration. We can thus report separate results not only for deceased Nobel laureates but also for collaborators who began working with the laureate before the Prize. We observe a particularly strong increase in the number of *pre-award* coauthor dropouts in the 10-year period before the Prize, reaching the highest number of dropouts in the year of the prize (see Fig. 5 and Table 3). After that, the number of pre-award coauthor dropouts falls drastically until it is almost zero, which could imply that, even though we

have no counterfactual to test the assumption, the prize itself may promote a high level of coauthor sustainability.

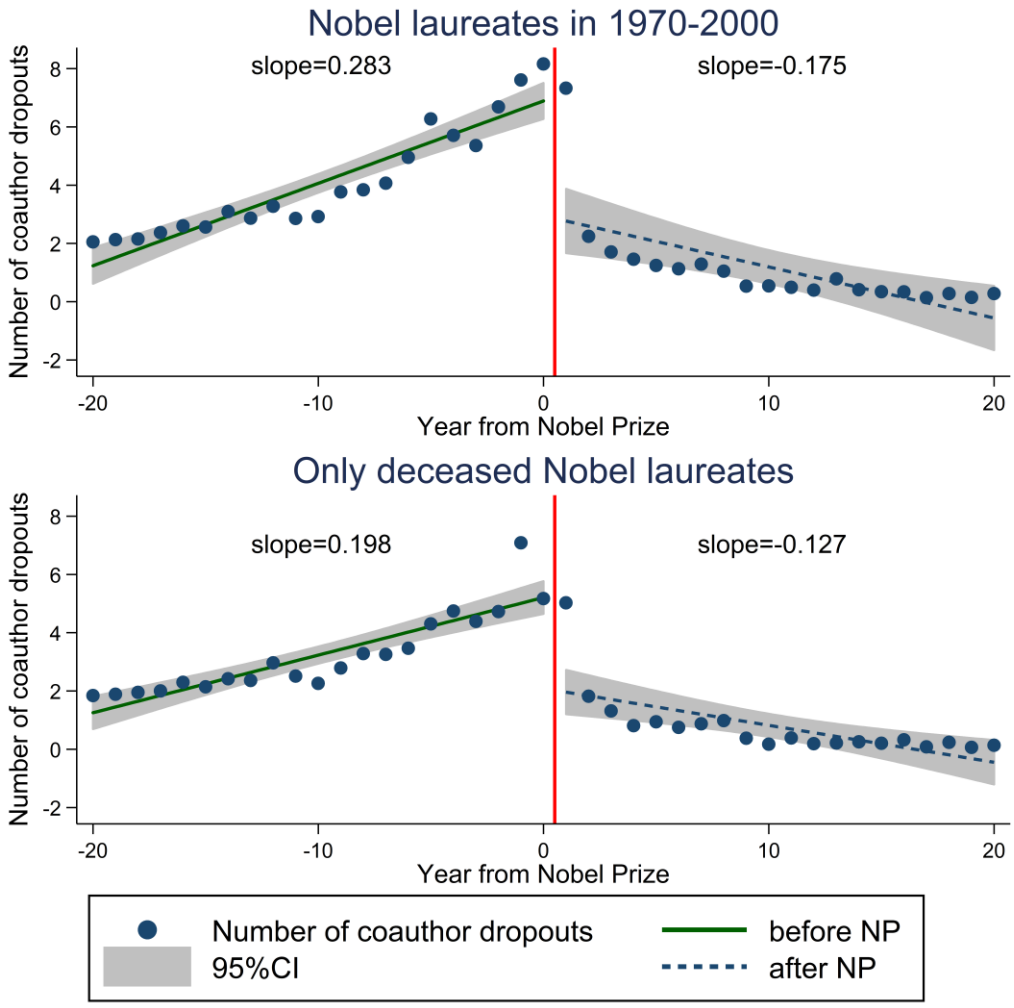


Fig. 5 Number of pre-award coauthor dropouts.

Table 3 Chow test for structural breaks and mean comparison t-test: number of pre-award coauthor dropouts

Number of pre-award coauthor dropouts	**Chow test**			***t*-test**				
Full sample	**DF**	**F-stat.**	**p-value**	**DF**	**Before NP**	**After NP**	**Diff.**	**p-value**
Nobel laureates in 1970-2000	6272	228.7	0.000***	6274	4.13	1.31	2.83	0.000***
Age for NP <= 46	747	40.16	0.000***	749	2.97	0.76	2.21	0.000***
46 < Age for NP <= 56	2243	127.68	0.000***	2245	3.89	1.32	2.57	0.000***
56 < Age for NP <= 66	1873	71.1	0.000***	1875	4.22	1.1	3.13	0.000***
Chemistry	1965	72.16	0.000***	1967	4.07	1.05	3.02	0.000***
Physics	2025	44.44	0.000***	2027	3.58	1.28	2.3	0.000***
Physiology or medicine	2274	166.73	0.000***	2276	4.71	1.55	3.16	0.000***
Deceased Nobel laureates	**DF**	**F-stat.**	**p-value**	**DF**	**Before NP**	**After NP**	**Diff.**	**p-value**
Nobel laureates in 1970-2000	2852	64.79	0.000***	2854	3.25	0.95	2.29	0.000***
Age for NP <= 46	132	8.37	0.000***	134	1.26	0.44	0.82	0.024**
46 < Age for NP <= 56	638	49.26	0.000***	640	2.85	0.75	2.11	0.000***
56 < Age for NP <= 66	1091	31.45	0.000***	1093	2.59	0.83	1.76	0.000***
Chemistry	894	25.69	0.000***	896	3.23	0.81	2.42	0.000***
Physics	752	12.39	0.000***	754	3.35	0.97	2.38	0.003***
Physiology or medicine	1198	55.78	0.000***	1200	3.18	1.05	2.12	0.000***

Note: *, **, *** represent statistical significance at the 10%, 5% and 1% levels, respectively.

The stability is also driven, however, by the fact that fewer pre-award coauthors are still collaborating, some having already left the network. Thus, we inspect the pre-award coauthor dropout rate, as measured by the number of pre-award coauthors dropouts divided by the number of current pre-award coauthors in the coauthorship network. We observe a relatively stable dropout rate at around 20 percent, on average (e.g., 1 out of 5 coauthors stops collaborating every year), before the Nobel Prize, and a decreasing dropout rate after the Prize, indicating higher level of collaboration sustainability (see Fig. 6 and Table 4).

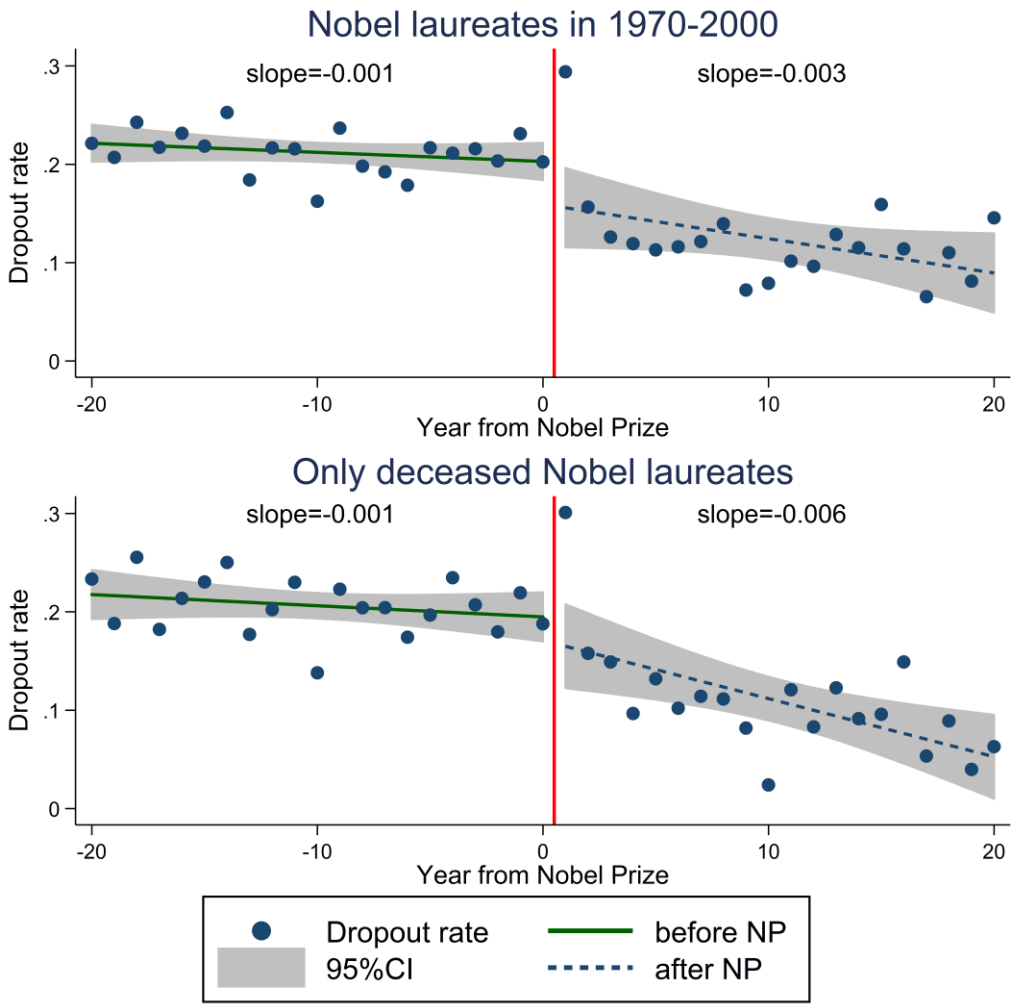


Fig. 6 Dropout rates for pre-award coauthors.

Table 4 Chow test for structural breaks and mean comparison t-test: dropout rates for pre-award coauthors

Dropout rates for pre-award coauthors	**Chow test**	***t*-test**

Full sample	DF	F-stat.	p-value	DF	Before NP	After NP	Diff.	p-value
Nobel laureates in 1970-2000	5705	13.07	0.000***	5707	0.21	0.13	0.08	0.000***
Age for NP <= 46	602	2.46	0.086*	604	0.23	0.12	0.11	0.000***
46 < Age for NP <= 56	2086	8.75	0.000***	2088	0.22	0.12	0.1	0.000***
56 < Age for NP <= 66	1731	10.87	0.000***	1733	0.19	0.13	0.07	0.000***
Chemistry	1869	5.4	0.005***	1871	0.22	0.12	0.1	0.000***
Physics	1713	0.73	0.481	1715	0.2	0.12	0.09	0.000***
Physiology or medicine	2115	10.78	0.000***	2117	0.21	0.14	0.07	0.000***
Deceased Nobel laureates	**DF**	**F-stat.**	**p-value**	**DF**	**Before NP**	**After NP**	**Diff.**	**p-value**
Nobel laureates in 1970-2000	2548	7.58	0.001***	2550	0.21	0.12	0.09	0.000***
Age for NP <= 46	115	0.73	0.484	117	0.22	0.11	0.11	0.039**
46 < Age for NP <= 56	569	5.87	0.003***	571	0.21	0.11	0.09	0.000***
56 < Age for NP <= 66	970	6.5	0.002***	972	0.2	0.13	0.07	0.000***
Chemistry	845	2.63	0.072*	847	0.21	0.12	0.09	0.000***
Physics	611	0.23	0.796	613	0.2	0.13	0.07	0.005***
Physiology or medicine	1084	6.81	0.001***	1086	0.21	0.12	0.09	0.000***

Note: *, **, *** represent statistical significance at the 10%, 5% and 1% levels, respectively.

Next we explore potential sources of heterogeneity using different age cohorts (see Fig. 7) as well as field (Fig. 8). When our calculations are based on number of coauthor dropouts, we do observe a post-prize structural break (see also Table 3); however, when they are based on dropout rate (Table 4), we do not observe a structural break for the youngest age cohorts and in physics (and chemistry to a lesser extent).

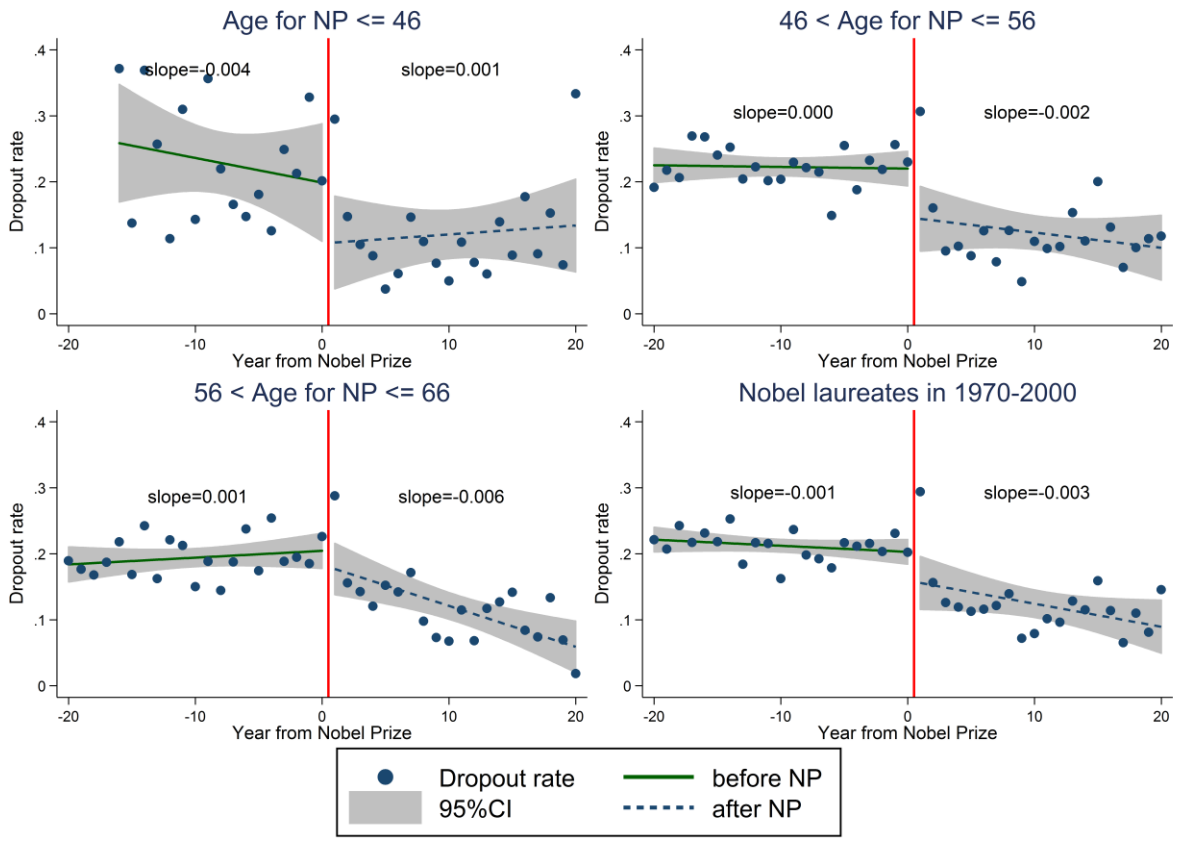


Fig. 7 Dropout rate by age cohort.

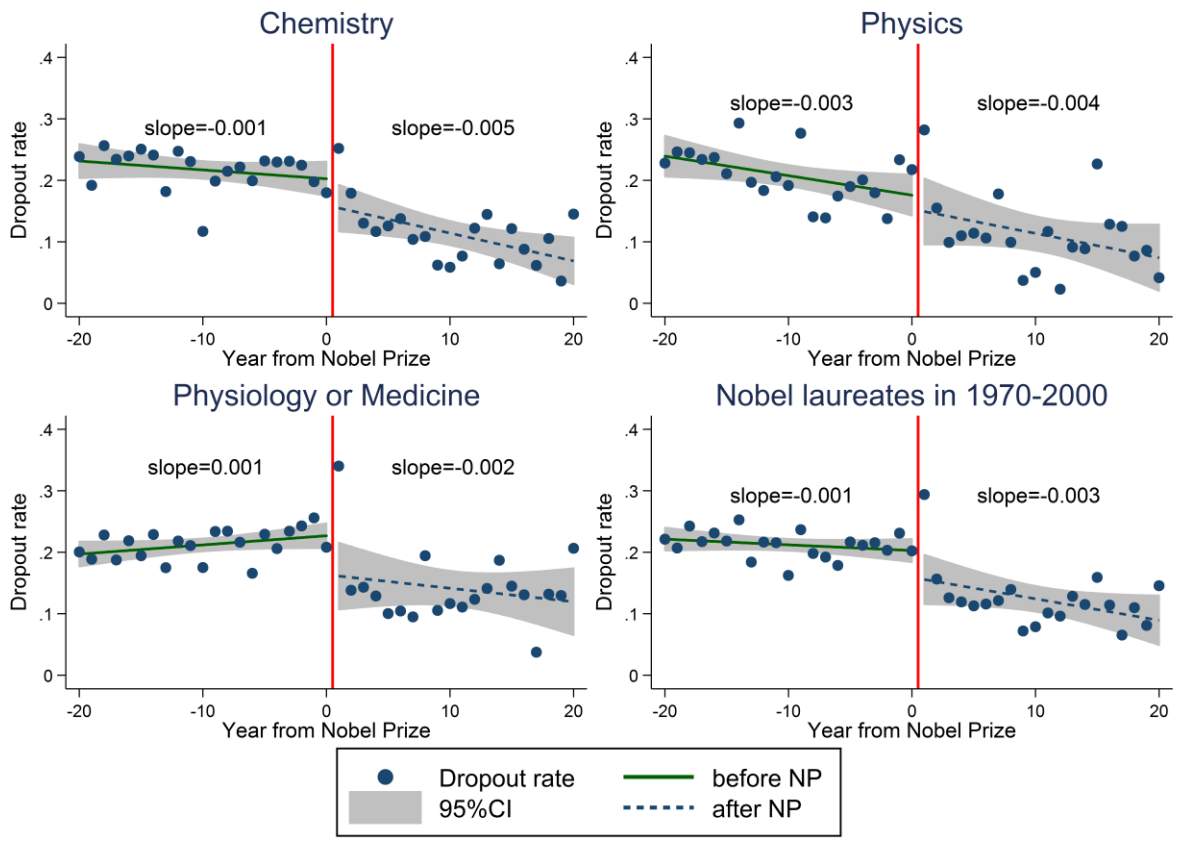


Fig. 8 Dropout rate by field.

So far, we calculate dropout rates based on coauthorship relations that were established prior to the reception of the Prize. With the inclusion of coauthorships that start after the reception of the Prize (number of dropped out coauthors divided by the number of current coauthors regardless of the start of the collaboration), we obtain a structural break only for the overall sample (statistically significant at the 5% level), but no significant structural break for separate age cohorts and fields (Table 5); moreover, in this case, the slope changes from negative in the pre-award period to positive in the post-award period (Fig. 9). In addition, no structural break is observed for the subsample of deceased laureates, and the pre- and post-award levels of

dropout rates are not significantly different except for physiology or medicine and the 56 to 66 age cohort albeit only by 3 percent.

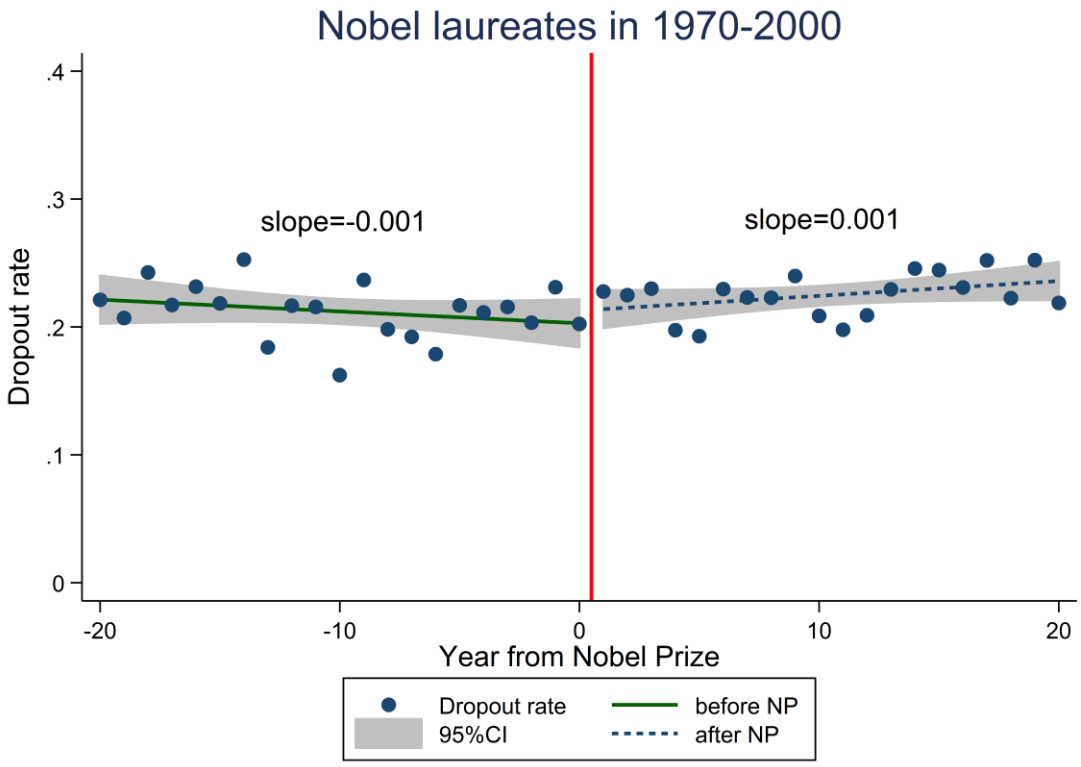


Fig. 9 Dropout rates including post-award coauthors.

Table 5 Chow test for structural breaks and mean comparison t-test: dropout rates for all coauthors

Natural dropout rates for post-award coauthors	**Chow test**			***t*-test**				
Full sample	**DF**	**F-stat.**	**p-value**	**DF**	**Before NP**	**After NP**	**Diff.**	**p-value**
Nobel laureates in 1970-2000	5985	2.68	0.069*	5987	0.21	0.22	-0.01	0.042**
Age for NP <= 46	686	1.29	0.276	688	0.23	0.22	0.00	0.863
46 < Age for NP <= 56	2179	1.04	0.354	2181	0.22	0.23	0.00	0.637
56 < Age for NP <= 66	1799	0.35	0.701	1801	0.19	0.22	-0.03	0.005***
Chemistry	1933	2.21	0.11	1935	0.22	0.22	-0.01	0.529
Physics	1836	2.14	0.118	1838	0.20	0.20	0.00	0.877
Physiology or medicine	2208	0.07	0.933	2210	0.21	0.24	-0.03	0.002***
Deceased Nobel laureates	**DF**	**F-stat.**	**p-value**	**DF**	**Before NP**	**After NP**	**Diff.**	**p-value**
Nobel laureates in 1970-2000	2675	0.61	0.545	2677	0.21	0.21	0.00	0.953
Age for NP <= 46	120	0.96	0.384	122	0.22	0.20	0.02	0.693
46 < Age for NP <= 56	609	1.19	0.306	611	0.21	0.21	0.00	0.975
56 < Age for NP <= 66	1027	0.12	0.886	1029	0.20	0.21	-0.02	0.187
Chemistry	880	0.1	0.904	882	0.21	0.20	0.02	0.241
Physics	648	1.66	0.191	650	0.20	0.20	0.00	0.847
Physiology or medicine	1139	0.09	0.911	1141	0.21	0.21	-0.01	0.533

Note: *, **, *** represent statistical significance at the 10%, 5% and 1% levels, respectively.

Multivariate analysis

In this section, we conduct a multivariate analysis that estimates the time effects before and after the Nobel Prize. In those cases that explore the number of new coauthors or the number of dropouts, we use random effects negative binomial model that takes into account the individual heterogeneity of the laureates and the overdispersion in our data (see specifications (1) and (2) in Table 6). The variance in the number of new coauthors (dropouts) is nearly 25 (15) times larger than the mean. When working with the dropout rate we use a simple random effects model (see specifications (3) to (6)). As controls, we employ laureate age (age and square of age) to take

into account a scientist's career development, the gender of a scientist[1], as well as research field. For the time dummies, the reference period is the first 5 years after the Nobel Prize.

The results clearly show that the number of new coauthors increases after receipt of the Prize, but, all else being equal, is smaller in the post-award period. For example, the estimated marginal effect for 6 to 10 years after the prize on the number of new coauthors is 1 indicating that in this time period, the laureate has on average one more collaborator per year compared to the reference period (specification (1)). The new entry rate, however, indicates that differences before and after the 5-year post-award period are not statistically significant (specification (3)). The number of dropouts (specification (2)) is also smaller for the periods 6 to 20 years after prize reception compared to directly after the Nobel Prize. Only the period 5 years before the award shows a larger number of dropouts (statistically significant at the 1% level), an average of 1.95 per year more in relation to the reference period. These results remain robust when considering the pre-award coauthor dropout rates (specification (4)) except that the outcome for the period 11 to 20 years before the prize is no longer statistically significant. Finally, the result for the dropout rate that also takes into account post-award coauthors are not significant for each period before and after Prize reception.

For the field and age controls, we observe that physics shows more stability than the physiology/medicine control group, reporting fewer new coauthors and also fewer dropouts. The age at which the Nobel laureate receives the prize also matters in terms of arrival and dropout of coauthors: younger scholars are more vulnerable to dropout than more senior or mature researchers yet they tend to collaborate with more new researchers.

[1] An abundant literature has shown significant gender difference in research collaboration structure; see Abramo et al. (2013) for a recent review.

Table 6 Effects before and after the Nobel Prize

	Negative Binomial (NB) Random effects	Negative Binomial (NB) Random effects	GLS Random Effects	GLS Random Effects	GLS Random Effects
Dep. var.	# new coauthors	# coauthor dropouts	Entry rate (# new coauthors / # current coauthors)	Dropout rate (# pre-award coauthor dropouts / # current pre-award coauthors)	Dropout rate (# coauthor dropouts / # current coauthors)
Indep. var.	(1)	(2)	(3)	(4)	(5)
16 to 20 years before Prize	-.487***	-.524***	2.2e-03	.027	.016
	(.127)	(.158)	(.039)	(.024)	(.024)
	-5.75	*-2.11*			
11 to 15 years before Prize	-.449***	-.259**	-.016	.027	8.2e-03
	(.1)	(.124)	(.031)	(.019)	(.019)
	-5.3	*-1.04*			
6 to 10 years before Prize	-.245***	9.4e-03	-.01	9.9e-03	-.017
	(.075)	(.093)	(.022)	(.015)	(.015)
	-2.89	*.038*			
1 to 5 years before Prize	-.104**	.482***	-.011	.038***	4.4e-03
	(.053)	(.063)	(.015)	(.012)	(.012)
	-1.22	*1.95*			
1 to 5 years after Prize	(Ref.)	(Ref.)	(Ref.)	(Ref.)	(Ref.)
6 to 10 years after Prize	.085	-.816***	-4.6e-03	-.057***	.01
	(.054)	(.08)	(.016)	(.013)	(.012)
	1.00	*-3.29*			
11 to 15 years after Prize	.051	-1.07***	-5.4e-04	-.038**	9.1e-03
	(.077)	(.114)	(.023)	(.016)	(.016)
	.599	*-4.31*			
16 to 20 years after Prize	.133	-1.36***	.025	-.045**	.019
	(.105)	(.166)	(.032)	(.022)	(.02)
	1.57	*-5.49*			
Chemistry	-3.8e-03	-.057	-.024	-.011	-4.2e-03
	(.063)	(.076)	(.029)	(.01)	(9.9e-03)
	-.057	*-.288*			
Physics	-.952***	-1.01***	-.036	-.015	-.018*
	(.063)	(.074)	(.029)	(.01)	(9.9e-03)
	-9.21	*-3.34*			
Physiology or Medicine	(Ref.)	(Ref.)	(Ref.)	(Ref.)	(Ref.)
Female	-.695***	-.533**	-.042	-.039	-.012
	(.155)	(.218)	(.082)	(.027)	(.027)
	-8.2	*-2.15*			
Age for NP <= 46	.532***	-.363**	9.0e-03	-7.6e-03	.021
	(.147)	(.178)	(.053)	(.025)	(.024)
	7.08	*-1.27*			
46 < Age for NP <= 56	.172**	-.192*	.018	5.3e-03	.019
	(.086)	(.101)	(.034)	(.014)	(.014)
	1.9	*-.728*			
56 < Age for NP <= 66	(Ref.)	(Ref.)	(Ref.)	(Ref.)	(Ref.)
Age for NP > 66	.084	.376***	.069*	.03*	8.5e-03
	(.093)	(.109)	(.038)	(.016)	(.016)
	.883	*1.9*			
Age	.133***	.096***	-.018***	-3.1e-03	-9.7e-04
	(1.0e-02)	(.013)	(2.7e-03)	(2.1e-03)	(2.0e-03)
	1.57	*.385*			
Age^2	-1.3e-03***	-1.1e-03***	1.2e-04***	1.8e-05	1.1e-05
	(7.4e-05)	(1.0e-04)	(1.7e-05)	(1.6e-05)	(1.5e-05)
	-.015	*-4.5e-03*			
Observations	6279	6276	5885	5709	5989
Number of Nobel laureate	190	189	190	189	190
LR Chi^2	815.7	1506.0	267.7	208.9	24.8
Prob. > Chi^2	0.000	0.000	0.000	0.000	0.053

Notes: standard errors in parentheses. The symbols *, **, *** represent statistical significance at the 10%, 5% and 1% levels, respectively.

Next, we look for evidence of loyalty to (or of) the Nobelist by assessing whether more pre-award interactions are associated with a lower dropout probability of the pre-award coauthors (Table 7). We apply a probit model (specifications (7) and (8)) for the binary dependent variable loyalty (1 = have at least one publication together after the Prize reception) and use OLS (specifications (9) and (10)) and negative binomial regression models (specifications (11) and (12)) to explore whether pre-award and post-award collaboration intensity are positively correlated. We control for the length of the collaboration before the Nobel Prize, which allows us to hold it constant when exploring pre-award collaboration intensity. In addition to research field, we also measure the laureate's age when the collaboration first started (in relation to each pair).

According to our results, a longer pre-award collaboration history between laureates and their coauthors and a greater number of pre-award publications increases the probability that coauthors will not drop out of the network before the Nobel Prize. For example, 10 more pre-award publications over the average would raise the probability of staying in the network by 7.7 percentage points. Interestingly, our results also show that Nobelists who received the prize at quite a young age (i.e., under age 47) are more likely to maintain their collaborators compared to the reference group who received it between the ages of 47 and 56. The last four specifications show that, all else begin equal, the extent of pre-award collaboration and collaboration length are positively correlated with the number of post-award collaborations.

Table 7 Pre-award collaboration intensity and loyalty

	Probit	Probit	OLS	OLS	NB Reg	NB Reg
Dep. var.	Loyalty	Loyalty	Post NP collaboration	Post NP collaboration	Post NP collaboration	Post NP collaboration
Indep. var.	(7)	(8)	(9)	(10)	(11)	(12)
Number of pre-NP collaboration	.048***	.049***	.268***	.268***	.222***	.22***
	(.018)	(.018)	(.087)	(.087)	(.021)	(.022)
	7.7e-03	*7.8e-03*			*1.4e+21*	*9.4e+20*
Collaboration start year (from NP year)	.069***	.079***	.05***	.088***	.148***	.158***
	(5.5e-03)	(6.5e-03)	(.012)	(.024)	(.015)	(.017)
	.011	*.013*			*9.1e+20*	*6.7e+20*
Chemistry	.076	.084	.257	.167	.356*	.323
	(.085)	(.082)	(.177)	(.147)	(.205)	(.202)
	.013	*.014*			*2.6e+21*	*1.6e+21*
Physics	-.088	-.096	.419	.332	.373	.344
	(.102)	(.101)	(.453)	(.413)	(.264)	(.279)
	-.013	*-.015*			*2.8e+21*	*1.7e+21*
Physiology or medicine	(Ref.)	(Ref.)	(Ref.)	(Ref.)	(Ref.)	(Ref.)
Female	-.074	-.045	.526	.576	.791	.785
	(.296)	(.301)	(.377)	(.388)	(.602)	(.608)
	-.012	*-7.2e-03*			*4.9e+21*	*3.3e+21*
Age for NP <= 46	.268**		1.17		.045	
	(.121)		(.988)		(.334)	
	.047				*3.5e+20*	
46 < Age for NP <= 56	.089		.691		.145	
	(.102)		(.436)		(.226)	
	.014				*1.2e+21*	
56 < Age for NP <= 66	(Ref.)		(Ref.)		(Ref.)	
Age for NP > 66	-.029		-.146		-.212	
	(.125)		(.16)		(.306)	
	-4.4e-03				*-1.5e+21*	
Nobelist age at the first collaboration		-.067***		-.046		.051
		(.022)		(.068)		(.061)
		-.011				*2.2e+20*
Nobelist age at the first collaboration^2		5.7e-04***		8.0e-05		-6.0e-04
		(2.1e-04)		(7.3e-04)		(6.0e-04)
		9.1e-05				*-2.5e+18*
Number of paired collaborations	20202	20202	20202	20202	20202	20202
Pseudo R^2/R^2	0.162	0.163	0.136	0.135		
Prob. > chi2/F/chi2	0.000	0.000	0.000	0.000	0.000	0.000

Notes: Standard errors in parentheses. Marginal effects in italics. *, **, *** represent statistical significance at the 10%, 5% and 1% levels, respectively.

Conclusions

As Zuckerman's (1996) interviews with Nobel laureates suggest, upward mobility does not always result in positive outcomes. Our results do in fact demonstrate a decreasing trend of new coauthors joining a Nobelist's post award collaboration network. This finding is robust across most divisions of Nobelists based on age and field, with the only exception of laureates in physics, where there is no observable structural break. Our multivariate analysis suggests that the number of new coauthors increases after the Nobel Prize. With respect to the distance argument, we find no evidence that coauthors who were actively collaborating with the Nobel laureate before the award leave after the prize. On the contrary, not only does the dropout probability of pre-award coauthors decrease during the post award period, the number of dropouts increases quite substantially before the award.

The multivariate analysis further demonstrates that the dropout rates decrease 6 to 20 years after the Nobel Prize (relative to the 1 to 5 year post-award reference period). Once we include post-award coauthors, however, the dropout rates turn out not statistically different from that during 1 to 5 years after the Prize. The finding that the intensity of pre-award publications and the length of pre-award collaboration history with the Nobelist reduces the probability of a coauthor leaving the laureate's network implies that loyalty does matter.

This study is inherently descriptive because we offer no counterfactual such as a control group of scientists with similar coauthor structure and pre-award development to compare with the Nobelists over time. Such a control group, however, although it would allow the inference of causal relationship between the variables and the award, would be extremely difficult to find. One approach might be to look at scientists who were nominated as laureates but did not receive

the prize, a list of whom is provided by the Nomination Archive[2] (albeit currently only up to 1963, which is useless for our 1970–2000 dataset). Moreover, even when focusing on nominees, we cannot assume that their coauthor network patterns are similar in the pre-award period, and substantial differences make comparison even more difficult. This current study contributes to this approach by suggesting an important first step in identifying possible Nobel Prize effects; namely, the use of a Chow test to identify structural breaks. Future studies could thus take these insights as a starting point for generating more precise size effects of being awarded the Nobel Prize.

References

Abramo G., D'Angelo, C. A., & Murgia, G. (2013). Gender differences in research collaboration. *Journal of Informetrics, 7*, 811–822.

Baffes, J. & Vamvikidis, A. (2011). Are you too young for the Nobel Prize? *Research Policy*, *40*, 1345–1353.

Beaver, D. d. (2001). Reflections on scientific collaboration, (and its study): past, present, and future. *Scientometrics, 52*, 365–377.

Börner, K., Contractor, N, Falk-Krzesinski, HJ, Fiore, SM, Hall, K. L., Keyton, J., Spring, B., Stokols, D., Trochim, Q., Uzzi, B. (2010). A multi-level systems perspective for the science of team science. *Science Translational Medicine, 2*(49), cm24.

[2] http://www.nobelprize.org/nomination/archive/

Bozeman, B. & Corley, E. (2004). Scientists' collaboration strategies: implications for scientific and technical human capital. *Research Policy*, *33*, 599–616.

Chan, H. F. & Torgler, B. (2013). Time-lapsed awards for excellence. *Nature*, *300*: 29.

Chan, H. F. & Torgler, B. (2015). The Implications of Educational and Methodological Background for the Career Success of Nobel Laureates: An Investigation of Major Awards. *Scientometrics*, *102*, 847–863

Chan, H. F., Gleeson, L., & and Torgler, B. (2014). Awards Before and After the Nobel Prize: A Matthew Effect and/or a Ticket to One's Own Funeral. *Research Evaluation*, *23*, 210–220.

Chan, H. F., Önder, A. S., & Torgler, B. (2015). The First Cut is the Deepest: Repeated Interactions of Coauthorship and Academic Productivity in Nobel Laureate Teams. CREMA Working Papers No 2015–04, CREMA, Zurich.

Dietz, J. S. & Bozeman, B. (2005). Academic careers, patents, and productivity: industry experience as scientific and technical human capital. *Research Policy*, *34*, 349–367.

Heinze, T. & Kuhlmann, S. (2008). Across institutional boundaries? Research collaboration in German public sector nanoscience. *Research Policy*, *37*, 888–899.

Ham, J. C., & Weinberg, B. A. (2011). Geography and innovation: Evidence from Nobel laureates. Unpublished manuscript.

Jones, B. F. & Weinberg, B. A. (2011). Age dynamics in scientific creativity. *PNAS*, *108*, 18910–18914.

Kademani, B. S., Kalyana, V. L., Kumar, V., & Mohan, L. (2005). Nobel laureates: Their publication productivity, collaboration and authorship status. *Scientometrics*, *62*, 261–268.

Katz, S. J. & Martin, B. R. (1997). What is research collaboration? *Research Policy*, *26*, 1–18.

Marton, F., Fensham, P., & Chaiklin, S. (1994). A Nobel's eye view of scientific intuition: discussions with the Nobel prize-winners in physics, chemistry and medicine (1970-86). *International Journal of Science Education*, *16*, 457–473.

Merton, R. K. (1968). The Matthew effect in science. The reward and communication systems of science are considered. *Science*, *159*, 56–63.

Rothenberg, A. (2005). Family background and genius II: Nobel laureates in Science. *Canadian Journal of Psychiatry*, *50*, 918–925.

Shaman, J., Solomon, S., Colwell, R. R., & Field, C. B. (2013). Fostering advances in interdisciplinary climate science. *PNAS*, *110*, 3653–3655.

Shavinina, L. V. (2004). Explaining high abilities of Nobel laureates. *High Ability Studies*, *15*, 243–254.

Stephan, P. E. & Levin, S. G. (1993). Age and the Nobel Prize revisited. *Scientometrics*, *28*, 387–399.

Stokols, D., Hall, K. L., Taylor, B. K., & Moser, R. P. (2008). The Science of Team Science: Overview of the Field and Introduction to the Supplement. *American Journal of Preventive Medicine*, *25*, S77–S.89.

van Dalen, H. P. (1999). The golden age of Nobel economics. *The American Economist*, *43*, 19–35.

van Rijnsoever, F. J. & Hessels L. (2011). Factors associated with disciplinary and interdisciplinary research collaboration. *Research Policy*, *40*, 463–472.

Wray, K. B. (2006). Scientific authorship in the age of collaborative research. *Studies in History and Philosophy of Science, 37,* 505–514.

Zuckerman, H. (1992). The Proliferation of Prizes: Nobel Complements and Nobel Surrogates in the Reward System of Science. *Theoretical Medicine, 13,* 217–31.

Zuckerman, H. (1996). *Scientific elite: Nobel laureates in the United States*. New Brunswick: Transaction Publishers.