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The Role of Curiosity in Science: Evidence from Ig Nobel Prizes

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Abstract

The literature on economics and sociology of science have long established that both intrinsic motivation and external incentives are important drives for scientists. While policy options to incentivize scientists through external stimuli (e.g. subsidies, bonuses, and awards) are well examined, empirical studies on how institutions and mechanisms might appeal to scientists' intrinsic motivations (e.g. curiosity, ego, and callings) are less explored.

In this paper, we demonstrate how intrinsic motivation of academic scientists can impact the development of scientific fields by examining the case of the Ig Nobel Prize. We conceptualize Ig Nobel prizes as shocks to the science fields since the prizes are awarded for humorousness in research topics. The primary mechanism of Ig Nobel prizes is to draw attention from the broad scientific community, induce curiosity of individual scientists, and potentially give a boost to the prize-winning research areas.

Using a difference-in-difference research design, we estimate that the marginal effect of Ig Nobel Prize on scientific fields is in average a 47% increase in publication activities, and the effect is sustained years after the Prize. We further show that these dramatic increases are not due to funding flows or surge in low-quality researches, thus ruling out two possible explanations of increased publication activities as responses to funding or opportunistic entries by scientists to catch attentions. We conclude that the only sensible explanation for the Ig Nobel effects is as an "curiosity-inducing" institution that encourage scientists to work on creative ideas out of intrinsic motivations.

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1. Introduction

The literature on economics and sociology of science have long established that both intrinsic motivation and external incentives are important drives for scientists (Dasgupta & David, 1994; Merton, 1973; Stephan, 1996). While policy options to incentivize scientists through external stimuli (e.g. subsidies, bonuses, and awards) are well examined, empirical studies on how institutions and mechanisms might appeal to scientists' intrinsic motivations (e.g. curiosity, ego, and callings) are less explored. Taking advantage of a unique dataset from the Ig Nobel prize, this paper is the first study to empirically investigate the impacts of curiosity-inducing institutions on scientific development. We conceptualize Ig Nobel prizes as shocks to the science fields where the winning research was published. Unlike most scientific prizes, the Ig Nobel prizes are not entirely awarded for academic merits, instead, the prizes are awarded for humorousness in research topics. Therefore, the primary mechanism of Ig Nobel prizes is to draw attention from the broad scientific community, induce curiosity of individual scientists, and potentially give a boost to the prize-winning research areas.

Using a difference-in-difference approach, we estimate the marginal effects of the Ig Nobel Prizes on scientific fields. We find that, comparing to a control group of "normal" science fields matched with similar characteristics but did not receive the Ig Nobel prize, the prize-winning fields have on average witnessed a 47% boost in research activities measured by publication flows. This result is robust under various model specifications. We argue that this strong effect from the Ig Nobel is driven by the intrinsic motivation of scientists. Specifically, the increase in academic activities in the prize-winning fields can only be explained by the "curiosity" of scientists induced by the Ig Nobel winning researches, which are by definition improbable research topics. We rule out alternative explanations such as corresponding funding increases in award-winning fields or opportunistic entries induced by the award, by showing: 1) there is no significant difference between award-winning fields and the comparison group in terms of grant-supported publications, thus the increases in post-award entries cannot be caused by funding flows; 2) the award-winning fields have experienced both sustained increases in publication flows and enhanced publication quality measured by forward citations, rejecting the opportunistic behavior hypothesis. Combining findings from regression models with anecdotal evidences, we argue that the positive impacts of Ig Nobel Prizes on science fields are results of increased research activities of scientists induced by curiosity in highly creative research topics as those identified by Ig Nobel Prize winners.

This study contributes to theories and practices of science policy. In recent decades, science policy making in a range of advanced and emerging economies has emphasized monetary-based incentives to scientists, undermining the scientific rewards system based on intrinsic motivations. This research shows scientist's curiosity, which is a form of intrinsic motives, plays an important role in accelerating scientific progress. Implications of this study also extend to policy debates on public investment in science by showing that a small number of Ig Nobel awardees, whose research topics are controversial, have in fact led the scientific community in moving into highly creative and fruitful research topics.

We organize the paper as follows. In Section 2, we briefly review the literature on intrinsic motivations of scientists, followed by an introduction to the Ig Nobel prizes. We explain why the prizes are shocks to science fields and how the prizes induce curiosity of scientists to engage in particular research topics. We then present our method of data collection and identification strategy in Section 3. In this study, we define scientific fields as groups of papers within a narrow idea space and delineate the boundaries of scientific fields using computer algorithms developed by the US National Library of Medicine (Azoulay, Fons-Rosen, & Zivin, 2015; Azoulay, Furman, Krieger, & Murray, 2015). We use a difference-in-difference (DID) research design to identify the marginal effects of the Ig Nobel Prizes on scientific fields by comparing winning fields to a control group of scientific fields with similar characteristics but without winning Ig Nobel Prizes. Section 4 presents findings from DID models under various specifications, showing the impacts of the Prizes in terms of publication, funding, and citation flows. We also show that these evidences reject two alternative hypotheses of funding flows and opportunistic behaviors. Finally, we discuss implications of our results for theories and practices in science policy in Section 5.

2. Research Background

2.1 Intrinsic Motivation in Science

The sociology and economics of science literatures have long established the importance of nonpecuniary motives in science (Dasgupta & David, 1994; Merton, 1973; Stephan, 1996). At the individual level, scientists are found be intrinsically motivated. They are drawn to the work of science because scientists enjoy the intellectual challenge of doing research, because they find doing science fun, or because the work in science gives them a feeling of accomplishment (Amabile, 1996; Ryan & Deci, 2000). Scientists even tradeoff part of their incomes for the freedom to publish in science (Stern, 2004). At the group level, the scientific enterprise is governed by a priority-based reward system in which scientists receive credit for the intellectual priority of their scientific work. That is, scientists receive credits for publicizing their findings quickly and diffuse their discoveries widely, and in doing so, scientists forgo the ability to profit from their research by giving up the formal intellectual property over their ideas (Merton, 1957). Merton (1973) has pointed out that, for the priority-based system to be effective, scientists must have intrinsic valuations of its unique kinds of nonpecuniary rewards: credit by other scientists to build future researches on their findings, reputation among peer scientists within the community, and prestige and status from being associated with elite institutions. In another word, scientists must display a "taste" for science (Sauermann & Cohen, 2010; Stern, 2004).

Science, as an economic institution, has proven to work efficiently under a system of nonpecuniary rewards. While commercially-oriented knowledge production depends on institutions such as intellectual property, trade secrets, or barriers to entry to provide incentives for innovation (Arrow, 1962; Cohen, Nelson, & Walsh, 2000; Levin et al., 1987; Nelson, 1959), the priority-based reward system in science relies on free flows of knowledge and intrinsic motivations of scientists. From an economics perspective, Dasgupta and David (1987; 1994) analyze the economic efficiency of the priority-based reward system under the assumption that scientists as a group have intrinsic motivations in knowledge creation. They argue that, the Mertonian system of priority-based rewards is more efficient than a pure monetary-based reward system for knowledge production, because the Mertonian system is superior in encouraging the efforts from scientists and facilitating knowledge diffusion, which both maximize the scientist's chances to receive credits in science. If the goal of the scientific enterprise is to maximize the rate of knowledge production and diffusion, as it should be, the priority-based reward system is perhaps the most efficient mechanism.

While science and innovation are increasingly national priorities, the Mertonian insights into the scientific enterprise are not appreciated by policy makers as it should have been. Since the 1980s, an overemphasis on pecuniary incentives for scientists and inventors has emerged in the course of innovation and science policy making (Peritz, 2008; Stephan, 2012a). These policies are often based on a naïve economics assumption of scientists and inventors responding to monetary incentives. For example, in the innovation policy space, by assuming an exaggerated profit logic for inventors, the patent laws have sharply reduced inventor's freedom to experiment (Peritz, 2008). At the same time, such privatization of basic knowledge via patent could jeopardize advance of science (Nelson, 2004). But it is even more problematic to assume scientists as economic agents in science policy making. In the efforts for building world-class universities and research institutions, a range of developed and emerging economies have deployed policies to incentivize scientists through monetary rewards, such as associating pays and bonuses to journal publications. These policies, while boosting the quantities of publications in these countries, have created a set of more complicated issues, from overproduction of low quality papers to serious violations of research ethics, that seems to be unsolvable under the monetary-based reward system (Stephan, 2012a).

This unfortunate situation is partly due to the fact that, there is a dearth of large-sample empirical research testing the classical Mertonian insights in contemporary settings. The recent literature on the economics of sciences starts to address these issues using modern empirical techniques. Scholars have explored topics such as nonpecuniary incentives for firm innovations (Moser & Nicholas, 2013; Sauermann & Cohen, 2010), wages and scientific orientation of firms (Stern, 2004), dynamics in scientific disciplines (Azoulay, Fons-Rosen, et al., 2015; Azoulay, Furman, et al., 2015). Nevertheless, no empirical studies have yet to explore directly the Mertonian evidences and investigate how intrinsic motivations work on academic scientists.

In this study, we complement the emerging literature in the economics of science by examining the effectiveness of intrinsic motivations among academic scientists. Our setting is the Ig Nobel Prize, which is effectively a shock to scientific fields and can dramatically induce the curiosity of scientists to engage in research topics out of intrinsic motives. Before presenting our empirical analysis, we briefly introduce the case of the Ig Nobel Prize.

2.2. The Ig Nobel Prizes as Shocks to Scientific Fields

The Ig Nobel Prize is a parody of the Nobel Prize. Organized by the Annals of Improbable Research, a scientific humor magazine, the Ig Nobel Prizes have been awarded annually to unusual achievements in scientific research characterized as researches that are absurd-sounding yet generating useful knowledge. In the words of the award organizer, the Ig Nobel Prizes are given to "sciences that first make people laugh, and then make them think" (Abrahams, 2014). Although the Ig Nobel Prize was started as a satirical social criticism, it has gained influences in both scientific community and mainstream media since its inception in 1991. Every year, the Ig Nobel Prizes are presented by Nobel laureates in a ceremony at Harvard University, and the award winners are widely covered by major media outlets around the world. Several Ig Nobel Prize winners have later received Nobel Prizes, including Sir Andre Geim who was awarded a Nobel Prize for his work with graphene in 2010 and became the first person to receive both a Nobel Prize and an Ig Nobel Prize.

We argue that the Ig Nobel Prize is effectively an exogenous shock to scientific fields, providing a rare opportunity to study the behaviors of scientists. The Ig Nobel Prize have two unique characteristics differing it from conventional science awards:

First, the selection process of Ig Nobel Prize winners is not tied to the internal organization of any scientific disciplines. Conventional science awards are in general organized within the boundaries of academic disciplines, reviewed by domain experts, and are given to well recognized achievements within the discipline. All these rules and processes ensure the awardees are received in their scientific communities. The selection of Ig Nobel Prize, however, follows almost the opposite rules. The nomination of award candidates is through the Ig Nobel Prize website by literally anyone. Marc Abrahams, the prize organizer and a non-scientist, screens the nominations and proposes his selections to a committee consisting of a diverse group of academics, journalists, writers, and other non-experts. The committee judges the nominations based on the criterion of "sciences that first make people laugh, and then make them think" and makes the final decision. According to an interview with Marc Abrahams, most winners are surprised to receive the Ig Nobel Prize[1]. In short, the selection of Ig Nobel Prize winners does not conform to rules in scientific disciplines, and results are generally not expected by the expert community.

Second, the Ig Nobel Prize has oversized influences in the broader scientific community. Because of increased specialization in knowledge production, cutting-edge researches nowadays are generally difficult for non-experts to comprehend. Even prestigious science awards such as the Nobel Prize can be difficult to communicate to the general public (Matthews 2009). Thanks to the ingenuity of Ig Nobel Prize organizers and publicity from the mass media, the Ig Nobel Prize winning researches received broad attentions from scientists and non-experts alike. Researches in

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[1] Author's interview with Marc Abrahams on October 12, 2017 in Atlanta, GA.

narrowly specialized topics have experienced a surge in online visits and downloads after receiving the Ig Nobel Prize, according to communications between Ig Nobel Prize organizers and database managers.

The two unique features of the Ig Nobel Prize, which are its independence from the scientific rewards system within disciplines and its broad influences outside of the narrow research areas, allow i to function as a shock to a scientific field. This award is in general not expected by prize-winning scientists let alone by other scientists from prize-winning field. Yet, it can be hardly ignored given the award's wide publicity. The exogenous nature of the Ig Nobel thus makes it possible to have a clean identification of effects of the prize, for which we will elaborate in details in next section on Research Design.

We further argue that, as a shock, the Ig Nobel Prize is especially suitable for studying the role of intrinsic motivations in sciences, for the following reasons:

First, there is no pecuniary reward involved in the Ig Nobel Prize itself. In fact, the Prize winners have to pay for the trip to the award ceremony on their own.

Second, indirectly, research funding flows are not likely to follow the Ig Nobel, either. Given the reputation of the Ig Nobel Prize for being a satire, it is even possible for policy makers to read the prize as a negative signal. In the US, for example, Ig Nobel Prize winning scientists have been criticized by conservative politicians as examples of wasting public funds on "absurd" research topics (Flake, 2016). For both reasons, any positive impacts of the Ig Nobel Prize on scientific fields must be attributed to non-pecuniary motives and mechanisms.

Third, the Ig Nobel Prize winning researches are more likely to have highly creative topics, and they are more likely to attract the "curiosity" of other scientists. A widely accepted definition of creativity is the "improbable combination of ideas with high values" (Boden, 1996). While the Ig Nobel Prize does not select awards on the basis of merits or values, it explicitly identifies researches with improbable combinations of ideas, and thus the papers winning the Prize are more likely to contain creative ideas. The unusual high publicity of the Ig Nobel Prize means these creative ideas are communicated to a broader scientific community. In another word, the Ig Nobel Prize can be a "curiosity-inducing" institution that magnifies the influence of creative ideas and attract more scientists to work on such topics out of intrinsic curiosity.

3. Research Design and Data

The primary data work of this study is to estimate the marginal effects of the Ig Nobel Prize on scientific fields. We focus on prize-winning researches in natural science while excluding the social science ones, mainly because the number of prize-winning social science papers is small and social science fields are not comparable to those in natural sciences. Our unit of analysis is a scientific field, by which we mean a topical area in which scientists pursue related ideas. In another word, our definition of a scientific field is an idea space for related researches. It is generally much narrower than an academic discipline but it also allows for transdisciplinary researches that compete in the same idea space. We use a difference-in-difference (DID) method to allow for a clean identification of the effects of the Prizes.

There are two challenges in operationalizing this research design. First, the boundary of a scientific field as an idea space is usually fluid and not well-defined. It requires us to develop a strategy to identify papers in or out of a field based on its research topics. Second, to estimate the marginal effect of the Ig Nobel Prize, we need to control for various background noises through a control group of comparable fields. We illustrate our strategies to overcome both challenges in the following sections.

3.1 Delineating Scientific Fields

There are a few existing methods to delineate scientific fields. One method is to use the classifications from Web of Science Subject Categories (WSSCs) as boundaries of scientific fields. Publication records indexed in Web of Science Core Collection are assigned to at least one of the 250 WSSCs. However, using WSSCs has several issues, including 1) the classification of WSSCs is generally based on broad academic disciplines; 2) WOSCs are assigned to journals rather than to individual publications, which by definition leave features and ideas in dividual papers uncounted. These characteristics will cause the fields identifieid by WSSCs to be generally too broad for this study. And these WSSC fields contain a range of ideas and topics well beyond the field we defined as a space of closely related ideas. Another option is to use backward citation information. Yet citation-based networks also suffer from two issues: 1) papers are cited for various reasons, including for theory, method, tools, data, and even negative citations (Catalini, Lacetera, & Oettl, 2015). Thus papers in one citation network is not automatically justified to be in the same topical area. 2) finding the boundary of a citation network can be equally arbitrary, which does not solve the issue of boundary deliniation.

We use a computer algorithm-based approach to identify papers within the same research topical area, which we define as the boundary of a scientific field. Azoulay and colleague have recently developed a method of delineate the boundaries of scientific fields using PMRA algorithm (Azoulay, Fons-Rosen, et al., 2015; Azoulay, Furman, et al., 2015). The PMRA algorithm is developed by the US National Library of Medicine's PubMed database in the purpose of identifying related articles to the focal article. The PMRA algorithm is based on "term frequency–inverse document frequency" (TFIDF), which is a numerical statistical method intended to reflect how important a word (keyword in this case) is to do document in a collection (Lin & Wilbur, 2007). The PMRA algorithm exploits the unique feature of PubMed database, that is, every article indexed by PubMed have MESH keywords assigned to them by professional librarians of National Library of Medicine. Therefore, based on MESH keywords, the PMRA algorithm provides a list of "close" articles to the focal article. These articles constitute an idea space of researches sharing similar topics, or a scientific field in this study. Because each article is assigned with MESH keywords from professional librarians, scientific fields delineated using this method are objective and free from potential social network influence (Azoulay, Fons-Rosen, et al., 2015).

3.2 Constructing the Counterfactuals

To estimate the marginal effects of Ig Nobel Prizes on scientific fields, we need to distinguish the effects of the Prize from various background noises, including general trends in scientific progress (which had generated a growing number of publications in most fields of sciences) and life cycles of individual scientific fields. Our strategy is to construct a set of counterfactuals, that is scientific fields with similar characteristics of the prize-winning fields but do not experience shocks from the Ig Nobel prizes, and use a difference-in-difference technique to identify post-prize changes. We follow Azoulay, Furman, et al. (2015) to construct the counterfactuals in the following steps.

We identify Ig Nobel Prize winning fields through publications linked with each Ig Nobel Prize. Most Ignoble prizes are linked to specific publications in scientific journals. Out of a total of 267 Ig Nobel prizes from 1992[2] to 2016, 158 awards are associated with at least one academic publication, which is not surprising since the prizes are selected mainly based on their humorous nature rather than their academic contributions. From these 158 awards, 188 unique academic publications are identified. We restrict the sample to 108 publications that are indexed by the PubMed. From these publications, we construct 108 scientific fields using the PMRA algorithm to identify their respective scientific fields, i.e. publications sharing similar ideas and topics.

The control group of publications are paired with the 108 Ig Nobel publications based on the criterion that they appeared next to (i.e. before and after) the focal publication in the same journal, volume, and issue[3]. The underlying idea of this method is that these publications, by appearing in the same volume and issue in the same journal, share the most similarities of the focal publications. Yet, the selection of these publications is random since the ordering of papers in a journal is generally random (Azoulay, Furman, et al., 2015). Finally, these "control" publications are used to delineate scientific fields ("counterfactual fields") using the same PMRA algorithm method.

3.3 Data

The basic information about the Ig Nobel prize, including prize year, topic, and linked publications, are obtained from Improbable Research, the Ig Nobel Prize organizer's website (https://www.improbable.com/ig/winners/). Bibliometric information regarding prize-winning publications is obtained from PubMed database with exception of forward citation data, which was obtained from Web of Science (WOS) database by matching PubMed bibliometric data with PubMed ID (PMID)[4]. First, 108 publications associated with Ig Nobel Prizes from 1992 to 2016 are identified to obtain their respective scientific fields from the PubMed database, using the PMRA algorithm method. These scientific fields contain 10,369 articles, while "control" scientific fields contain 62,623 articles. We restrict our sample in two following ways. First, in order to preserve minimum of 8 years of post-Prize activities in these scientific fields, we restrict our sample to those that received the Ig Nobel Prizes from 1992 to 2008. Second, we restrict our

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[2] Although Ig Nobel Prize was started in 1991, citation information is available from 1992.
[3] We used three publications before and after the focal publication as control publications. Therefore, the focal publication can have maximum of 6 control publications. If the focal publication is the last article in its issue, only three publications before the focal publication are used as a control.
[4] PMID is unique ID given to all publications indexed in PubMed.

publication records to those that were published from year 1967 to 2016.[5] We end up with 60 Ig Nobel fields and 280 matched control fields. The total of 340 fields have 44,691 publications (Table 3.1).

Around 15.5% of the publications sample are from the Ig Nobel Prize-winning fields. Publications that were supported by academic grants, indicated by grant acknowledgement bibliometric information, takes up 10.6% of the sample. The average number of citations is 34.7. In the process of obtaining forward citation data from WOS, around 18.5% of the original data or 8,255 publications could not find a match in the WOS database and are thus discarded in the analysis. As expected, both grants and citations are highly skewed to the right. Around 46% of the sample publications were published after the Ig Noble prizes. "New" authors that appears after the Ig Noble prizes published around 36% of the sample, while the incumbent authors published 10% of the sample after the prize[6]. Lastly, scientific fields from prizing winning publications that had impact factors greater than 20 take up around 12.2% of the sample. To prepare for analysis, we transform the raw publication data into a panel data set with each scientific field as the unit of observation. The panel data set run from year 1967 to 2016. The panel data set has a total of 50 years × 340 fields = 17,000 field-year observations.

[5] Although the first Ig Nobel Prize starts in 1991, some of the Prize-winning articles were published long before that. In fact, the earliest prize-winning article was published in 1967.
[6] "Fuzzy Matching" algorithm from VantagePoint Software was used to disambiguate author names. (https://thevantagepoint.com/)

Table 3.1 Summary of Statistics for Raw Publication Data

Variable	Obs	Mean	Std. Dev.	Min	Max
Prize winning Publications	44,691	0.155	0.362	0	1
After-Prize Publications	44,691	0.461	0.499	0	1
Grants Supported Publications	44,691	0.106	0.308	0	1
Number of Grants	44,691	0.241	1.089	0	60
Citations	36,436	34.76	72.87	0	2,503
Publication Year	44,691	1998.843	11.651	1967	2016
Prize Year	44,691	2001.003	5.075		
Incumbents Publications	44,691	0.639	0.480	0	1
Incumbents Publications after Prize	44,691	0.100	0.300	0	1
Publications from High Impact Field	44,691	0.122	0.327	0	1

3.4 Variables

❖ Dependent Variables

The focus of this study is to estimate impacts of the Prize on scientific fields. We operationalized three dependent variables, *Publication Flow*, *Grant Flow* and *Total Fwd Citation* to measure different dimensions of change in the fields. *Publication Flow* captures the yearly flow of publications from prize-winning and control scientific fields. As shown in the Table 3.2, the average publication flow is around 2.63 publications a year with a standard deviation of 4.25. The distribution of *Publication Flow* is skewed to the right and highly over-dispersed. *Grant Flow* captures the yearly-field flow of a number of grants associated with publications. To construct this variable, we sum up funding acknowledgments of publications for each yearly field observation. On average, there are 0.63 grants per scientific fields. *Total Fwd Citation* variable is the average number of total citations received by publications in scientific fields, which is used as a measure of the paper's quality. The average *Total Fwd Citation* is 74.49 with a standard deviation of 216.94. While *Publication Flow* and *Grant Flow* are directly obtained from PubMed database, *Total Fwd*

Citation is obtained from Web of Science database[7]. All dependent variables are skewed to the right and highly over-dispersed.

Table 3.2 Summary of Statistics For Panel Data (Field-Year Observations)

Variable	Obs	Mean	Std. Dev.	Min	Max
Publication Flow	17,000	2.629	4.253	0	104
Grant Flow	17,000	0.634	3.064	0	98
Total Fwd Citation	17,000	74.492	216.942	0	5,593
Post-Prize	17,000	0.297	0.457	0	1
Ignoble Field	17,000	0.176	0.381	0	1
Prize Year	17,000	2001.159	5.180	1992	2008
Field Year	17,000	1991.5	14.431	1967	2016
Field Size	17,000	139.974	114.203	53	1,643
Field's base year	17,000	1995.032	8.019	1967	2008
Maturity	17,000	14.030	9.390	0	46

❖ Independent Variables

A set of variables including *Post-prize, Ignoble field, Prize year, Field year* and *Maturity* are used for our estimations. *Post-prize* is a dummy variable that captures both Ig Noble and control fields' time periods after Ig Nobel prizes are awarded. *Ignoble field* is a time-invariant dummy variable with value "1" indicating Ig Nobel fields and "0" for control fields. *Prize year* is a time-invariant variable representing Ignoble prize year for both Ignoble and control fields. As explained in the previous section, *Prize year* ranges from 1992 to 2008. *Field year* is a time-varying variable measured as the calendar year of a scientific field. This variable is used to control for yearly variations of publication activities. This field-year ranges from 1967, the first year of the prize-winning publication, to 2016.

It is often argued that scientific fields have their own life cycles and experience formation, growth and decline in academic activities. In a larger scale, the idea is in parallel with the concept of normal science (Kuhn 1962) and research program (Lakatos 1980). Measuring this maturation is difficult since understanding the maturity of scientific field can be highly subjective and often be wrong due to unpredictable nature of direction of science. We use following ways to control

[7] When PubMed's prize-winning publication data was not indexed by the Web of Science database, the whole field was dropped.

for this "maturity". Our delineation of scientific field is based on PMRA algorithm. The algorithm finds a related article with respect to the focal publication (prize-winning publications). Because of this reason, year distribution of fields tends to be normally distributed around the year of the focal publication. We exploit this characteristic of fields constructed by PMRA algorithm. *Maturity* is then calculated by taking absolute year difference between *Field's base year* and *Field Year*. *Field's base year* is the calendar year of the publications linked to Ignoble Prize[8]. Therefore, *Maturity* will control for some maturation effects that are unique to every fields.

4. Empirical Results

4.1 Baseline Analysis

Figure 4.1 Average Publication Flow

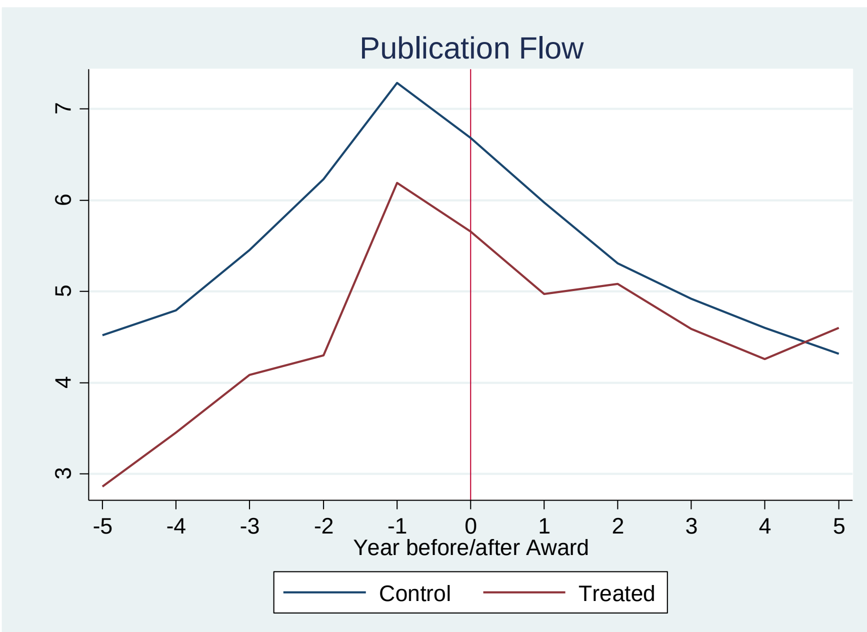


Figure 4.1 illustrates average publications flow for both prize-winning fields and control fields. The horizontal axis represents a number of year before and after the Ignoble prize (calendar year may differ by fields). Notice that the prize-winning fields have an almost parallel trend with control fields before receiving the Ignoble prize. The difference in an average number of publications of prize-winning fields and control fields then starts to narrow one year after the prize. In the fifth year after the Ignoble prize, average publication flow for prize-winning field is higher

[8] As explained in the previous section, field's base year can be much earlier than the Prize year. This the rationale behind selecting field-year as early as 1967.

than the control field. Figure 4.1 is intuitive but only provides limited information. The first three regression employs following econometric specification, which is shown in equation (1).

(1) $PublicationFlow_{\mathrm{ijt}} = f(\beta_1 PostPrize_{jt} + \beta_2 IgnobleField_i + \beta_3 PostPrize_{jt} \times IgnobleField_i + \beta_4 Maturity_{it} + \delta_j + \gamma_t; \varepsilon_{\mathrm{ijt}})$

$Publication\ Flow_{\mathrm{ijt}}$ is number of publications for field *i*, field-group *j*[9], in calendar year *t*. β_1 measures the effects of Ig Nobel prize on control from j^{th} field-group (placebo effect). β_2 measures the average difference between the prize-winning field and control field before Ig Nobel prize. β_3 captures the marginal effects of Ig Nobel Prize on prize-winning fields. β_4 controls maturation effect that is unique to each field. This could take care of time-varying idiosyncratic errors that might not be resolved by field fixed effects. δ_j captures the field-group fixed effects while γ_t captures the calendar-year time trend.

First two columns of Table 4.1 show pooled OLS regressions with log-transformed dependent variables. Model (4-1) controls for maturity effects but does not incorporates year and field-group fixed effects. In average, the prize-winning field has 11.8% fewer publication flows than the control fields before the prize. The marginal effect of the Ignoble Prize, which is captured by the interaction term between *Ignoble Field* and *Post-Prize*, is around 21.3%. However, the potential signaling and attraction effects of the prize on scientists may be influenced by the time-invariant characteristics of the fields. Therefore, in Model (4-2), we incorporate field-group and time fixed effects to resolve these potential unobserved heterogeneities. The marginal effect of the Ig Noble prize is slightly smaller (21.0%) but remains statistically significant at 1% level.

[9] Field-group is uniquely assigned to prize-winning field and its paired control fields. Rationale behind using field-group fixed effect instead of field fixed effect is the potential presence of correlation between prize-winning field and its paired fields. This is plausible scenario since they are drawn from same issue and volume of same journal. Yet, the results stayed unchanged under field fixed effects specification.

Table 4.1 Baseline Specifications

	OLS (Robust SEs, adjusted for clustering by field-group, are reported in parentheses) Dep Var = ln(1+Publications)		***Conditional Fixed Effects Negative Binomial*** [Incidence-rate ratios in brackets in bottom line] (Bootstrapped SEs reported in parentheses) Dep Var = Publications		
	(4-1) Linear Model without FEs	(4-2) Linear Model with Year and Field-group FEs	(4-3) Count Model with Year and Field-group FEs	(4-4) Count Model with Diff-in-Diff Specification with Year and Field FEs	(4-5) Count Model based only on variation within Prize-winning Field
Main Variables					
Post-Prize	0.563 (0.040)**	0.113 (0.064)†	-0.053 (0.084) [1.504]	0.032 (0.057) [1.032]	0.252 (0.098)* [1.287]
Ignoble Field	-0.118 (0.045)*	-0.115 (0.043)*	-0.199 (0.074)** [0.820]		
Ignoble Field × Post-Prize	0.213 (0.065)**	0.210 (0.064)**	0.256 (0.095)** [1.292]	0.387 (0.102)** [1.473]	
Control Variables					
Maturity	YES	YES	YES	YES	YES
Year Fixed Effects		YES	YES	YES	YES
Field-Group Fixed Effects		YES	YES		
Field Fixed Effects				YES	YES
Constant	1.300	1.544	1.494	0.598	0.436
Observations	17,000	17,000	17,000	17,000	3,000
R^2	0.304	0.416			
Log Likelihood			-31,519.44	-28,865.65	-4,833.63
Number of Groups		60	60	340	60

Note that Field group is uniquely assigned to prize-winning field and its matched control fields.
†$p < 0.10$, *$p < 0.05$, **$p < 0.01$.

To account for highly skewed count data in dependent variable, we move away from the OLS baseline estimations. Negative binomial regression is suitable for accounting for overdispersion in dependent variable[10] (Hausman, Hall, & Griliches, 1984). Model (4-3) controls for field-group and calendar year. The marginal effect can be calculated by subtracting 1 from incidence-rate ratio (incidence-rate ratio is shown in the bracket). The marginal effect of the Ig Nobel Prize in this model is statistically significant at 1% level and is in the magnitude of 29%, and the effect is modestly larger than that in OLS models.

We now employ following specification, equation (2), to implement difference-in-difference technique for within-variation panel estimation.

(2) $$PublicationFlow_{\mathrm{it}} = f(\beta_1 PostPrize_t + \beta_3 PostPrize_t \times IgnobleField_i + \beta_4 Maturity_{it} + \delta_i + \gamma_t; \varepsilon_{\mathrm{it}})$$

$\beta_2 IgnobleField_i$ is dropped since this is time-invariant. Fixed effects are now based on each scientific field *i*, instead of on field-group *j*. This model is treating each field separately to account for unique field-specific time-invariant characteristics. Notice that number of field groups have increased to 340 from 60. The marginal effect of the Ig Noble prize is statistically significant at 1% level with coefficient of 0.387, which is equivalent to 47% boost in publication flow.

In the previous section, we argue that Ig Nobel prize is at least strongly exogenous to prize-winning fields. If this is the case, one should expect the Ig Nobel prize to have statistically significant effects on the prize-winning fields without paired control groups. Model (4-5) shows the panel estimation without control groups. The marginal effect is a 29% boost in publications flows and statistically significant at 5% level. This estimation shows that the marginal effect of the Ignoble prize is very robust even without the DID estimation.

So far, we have established that there are increased post-prize publication activities in the prize-winning scientific fields. Yet the models on publication flows tell little about the underlying mechanism driving publication activities. In the following sections, we examine two alternative explanations of the surge in publication activities, which are increased funding in wining fields and opportunistic entries of lower-quality researches. Ruling out these two alternative hypothesis provides further evidence to make the case of the role of curiosity.

[10] The marginal effect of the Ignoble Prize stayed robust under the Poisson conditional fixed effects

4.2 Is the surge in publications due to increases in funding flows?

One alternative explanation of the post-Prize surge in publication activities is that the additional publications are driven by increased funding in respective scientific fields. The allocation of funds has profound influences on the direction of scientist efforts (Dasgupta & David, 1994; Stephan, 1996). Although we have explained that certain US politicians are hostile to Ig Nobel Prize winners and their research, these are not strong evidences to predict funding flows in the fields. There are other possible mechanisms that Ig Nobel Prizes drive funding flows, such that managers and scientists in funding agencies might respond more to the scientist community than to politicians, or funding agencies in non-US countries might have different preferences. In short, to uncover the mechanism of Ig Nobel Prize's influence on scientific fields, we have to examine its impacts on flow of funded research.

We estimate the effects of the Ig Nobel Prize on flow of funded research in scientific fields using the specification in equation (3):

$$(3) \quad Grant_{\mathrm{it}} = f(\beta_1 PostPrize_{it} + \beta_2 PostPrize_{it} \times IgnobleField_i + \beta_3 Maturity_{it} + \beta_4 PublicationFlow_{it} + \delta_i + \gamma_t; \varepsilon_{\mathrm{it}})$$

Dependent variable, $Grant_{\mathrm{it}}$ is yearly grants flow for a scientific field *i* in year *t*. Bibliometric information was used to construct field-year level flow of funded research[11]. β_1 captures the "placebo" effects on control fields and β_2 captures the marginal effects of the prize on flow of funded research. $\beta_4 PublicationFlow_{it}$ is included in the model to control for the yearly flow of publications in the field.

The regression results are reported in Table 4.2. Model (4-6) shows field and year fixed effect OLS regression. The coefficient for β_2 is negative but not statistically significant. Model (4-7) shows negative binomial version of the same specification. Again, the coefficient for β_2 is not statistically significant. We cannot reject the null hypothesis that Ig Nobel prizes has zero effects on flow of funded research in the prize-winning fields.

[11] We acknowledge that using "funding acknowledgement" text data is far from constructing an ideal proxy for flow of research grants. However, our aim is not to show the effects of the prize on field-level funding activities, but to show its effects on frequencies of "funded research".

Table 4.2 Effects on Grant Flows

	(4-6) ***OLS*** (Robust SEs, adjusted for clustering by field-group, are reported in parentheses) Dep Var = ln(1+Grants)	(4-7) ***Conditional Fixed Effects Negative Binomial*** [Incidence-rate ratios in brackets in bottom line] (Bootstrapped SEs reported in parentheses) Dep Var = Grants
Main Variables		
Post-Prize	0.047 (0.028)	0.265 (0.107)* [1.303]
Ignoble Field × Post-Prize	-0.051 (0.051)	0.039 (0.172) [1.039]
Control Variables		
Maturity	YES	YES
Number of Publications	YES	YES
Year Fixed Effects	YES	YES
Field Fixed Effects	YES	YES
Constant	0.147	-17.726
Observations	14,000	14,000
R^2	0.301	
Log Likelihood		-7,923.84
Number of Groups	280	280

Note 60 groups were dropped because of small variation. †$p < 0.10$, *$p < 0.05$, **$p < 0.01$.

4.3 Is the surge in publications due to opportunistic behaviors?

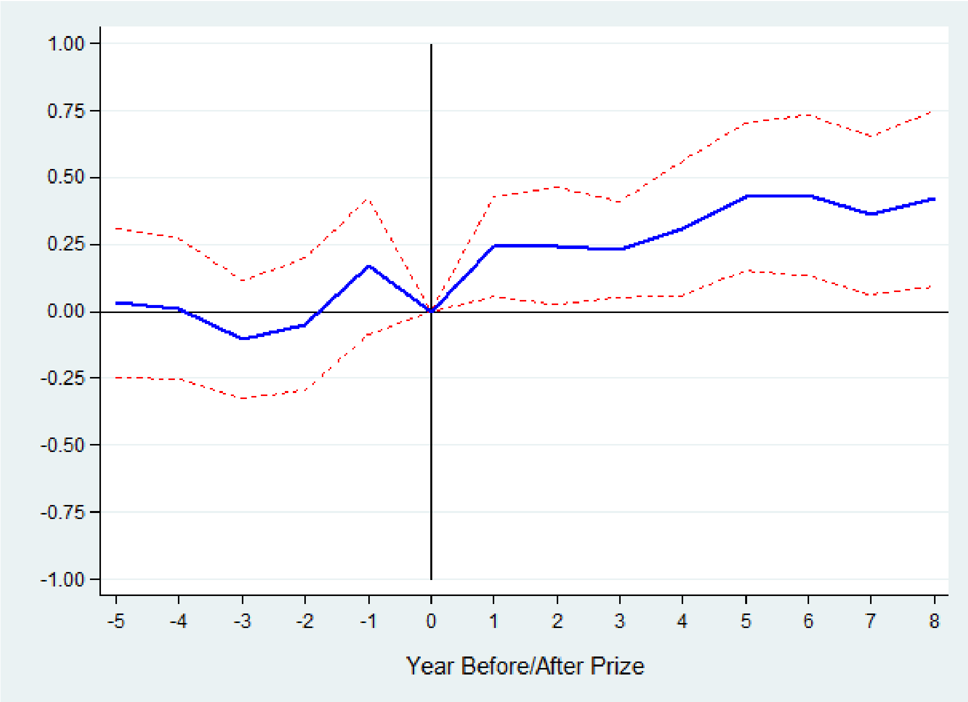
Another alternative explanation to the surge in the post-Prize publications is that the increased publicity of the research topics covered by the Ig Nobel Prize simply attract more opportunistic entries. By opportunistic entries, we mean that these additional publications are from scientists who opportunistically take advantages of increased publicity in the topics to publish. If that is the case, the post-Prize publication activities in the winning fields should exhibit two characteristics:

First, the increases in publication activities could be a short-term phenomenon. Since these opportunistic entries are driven by the temporary boost in publicities in the research topics, their authors are not likely to take a long-term commitment to the field. We should expect publication activities in prize-winning fields drop to a normal level after a period of time.

Second, the publications generated by opportunistic entries are likely to have a lower quality in average. Since these publications are generated by researchers who want to publish quickly and capture the trend of “hot” topics, they are more likely to be done less rigorously, to target low-hanging fruits, and to have less substantial contributions. We should expect prize-winning fields to receive less citations than control fields after controlling for publication flows, if the winning fields are experiencing opportunistic entries.

We test the timing aspect of the opportunistic entry hypothesis by examining the impacts of the Prize on scientific fields in an extended period of time. Using the difference-in-difference model in Model 4-4, we estimate the pre- and post-Prize difference in publication flows between the winning fields and control fields by adding interaction term between pre- and post-prize year dummy variables. We choose a 13-year span (five years before the Prize and eight years after the Prize), which is extremely long for the evolution of any scientific fields, for the estimation. The results with 90% confidence intervals are plotted in Figure 4.1. Our estimation shows that, prior to the Ig Nobel Prize, there is no statistically significant difference in publication flows between the winning and control fields. After the Prize, the difference is significant and persistent. In the long run, the marginal effects of the Ig Nobel Prize only become stronger. The estimation results in Figure 4.1. clearly rejects the hypothesis that increased publication activities in the winning fields is a short-term phenomenon.

Figure 4.1 Pre- and Post-Prize Differences in Publication Flows



Notes: Figure plots year-by-year pre- and post-Prize boosts to publication flows in the Prize-winning fields, computed from negative binomial regression with field and calendar-year fixed effects and dummy variables for each year preceding and following In Noble prize. The marginal effects are shown by the blue line. The upper and lower bound (90% confidence interval) are shown by two red dotted lines.

We test the quality aspect of the opportunity entry hypothesis by estimating the differences in total forward citation between prize-winning fields and control flows, using specifications in equation (4). Note this is a variation of the model (4-4) and equation (2).

(4) $$Total\ Fwd\ Citation_{\mathrm{it}} = f(\beta_1 PostPrize_{it} + \beta_2 PostPrize_{it} \times IgnobleField_i + \beta_3 Maturity_{it} + \beta_4 PublicationFlow_{it} + \delta_i + \gamma_t; \varepsilon_{\mathrm{it}})$$

Estimation results are reported in Table 4.3. Model (4-8) shows the field and calendar-year fixed effects OLS regression in a difference-in-difference setting. The variable of the interest, $\beta_2$is positive and statistically significant at 10% level. The marginal effect is around 20.5% increase in total citations for the prize-winning fields. Model (4-9) is the negative binomial estimation with the same specification. The marginal effect of the Ig Nobel Prize on citations is positive and statistically significant at 10% level. The marginal effect is around 20.1% boost in total citations for the prize-winning fields. These results reject the alternative hypothesis that the increased publication activities in the winning fields are driven by opportunistic entry with lower quality papers. The reality is the opposite: the winning fields are having more higher quality papers than the control fields.

Table 4.3 Effects on Citation Flows

	(4-8) **OLS** (Robust SEs, adjusted for clustering by field-group, are reported in parentheses) Dep Var = ln(1+Fwd Citations)	(4-9) ***Conditional Fixed Effects Negative Binomial*** [Incidence-rate ratios in brackets in bottom line] (Bootstrapped SEs reported in parentheses) Dep Var = Fwd Citations
Main Variables		
Post-Prize	0.275 (0.093)**	0.384 (0.075)** [1.412]
Ignoble Field × Post-Prize	0.205 (0.119)†	0.147 (0.086)† [1.201]
Control Variables		
Maturity	YES	YES
Number of Publications	YES	YES
Year Fixed Effects	YES	YES
Field Fixed Effects	YES	YES
Constant	1.801	-1.689
Observations	17,000	17,000
R^2	0.559	
Log Likelihood		-57106.46
Number of Groups	340	340

Note †*p* < 0.10, **p* < 0.05, ***p* < 0.01.

(Note: Additional analyses from sub-populations are conducted to observe potential heterogeneity in the treatment effect. These includes sub-populations of high impact fields (as measured by impact factors) and of incumbent authors. The estimated results are presented in the appendix A and B. The authors apologize that due to time constraints, they did not update the additional results in the main text).

5. Discussion and Conclusion

Through estimating the impacts of Ig Nobel Prize on publications, grants, and citations, we have shown a set of interesting characteristics of the Ig Nobel effects: The Prize has driven up publication activities in the scientific field where the winning paper was published; The boost in publication activities is as strong as 47% more papers when comparing to the control group, and such boost has sustained in several years following the Prize; The additional publications are likely to be high-quality researches, since there are overall more citations in winning fields; There is no significant difference in funding flows between the winning fields and comparable fields in the post-Prize period. In another word, there is no additional funding to drive the boost in publication activities.

How to explain these characteristics of the Ig Nobel Prize effects? What is the underlying motivations for scientist behaviors? We argue that the only sensible explanation is that scientists are driven by intrinsic motivations to increase productivity and enhance quality in the Ig Nobel winning scientific fields even without extra resource flow into the field. Specifically, the motivation to invest in the fields and topics is the curiosity induced by the highly creative ideas in Ig Nobel prize winning researches. Such an explanation is consistent with classical Mertonian insights into scientist behaviors: intrinsically motivated scientists exert more efforts into knowledge creation and accelerate the rate of knowledge diffusions (Merton, 1973).

There are policy implications in our findings. The overemphasis on monetary incentives for scientists in a number of Asian countries, while initially helped boosting scientific production, are encountering all sorts of issues from distorted incentives to publishing low-quality papers to serious violations of research ethics (Stephan, 2012b). We argue the solution to difficulties in science systems in these countries is a return to the priority-based rewards system that encourages scientists to pursue topics out of intrinsic motives. The effects of the Ig Nobel Prize have shown that such system will continue to be efficient in knowledge creation while avoiding many of the downfalls from monetary incentives.

The impacts of the Ig Nobel Prize also suggest the role of a small number of scientists in generating creative ideas and lead the development of scientific fields. While the Ig Nobel Prize magnifies the influences of these creative ideas, it has to be attributed to the ingenuity of these scientists. There is no surprise that several of the Ig Nobel Prize winners later receive the Nobel

Prizes. Unfortunately, many of these scientists and their research have been misunderstood by the society because their ideas are “absurd”. In the US, for example, there are politicians using Ig Nobel Prize-winning researches as examples of “wasteful” science and excuses to attack federal supports for science and innovation (Flake, 2016). By demonstrating the actual effects of the Ig Nobel Prize on scientific fields, we argue that the society should be tolerant to scientists and improbable ideas in sciences. After all, curiosity drives science.

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Appendix A: Sub-population of Publications from Incumbent Authors[12]

Table A1. Effects on Publications

	(Original Model) ***Conditional Fixed Effects Negative Binomial*** [Incidence-rate ratios in brackets in bottom line] (Bootstrapped SEs reported in parentheses) Dep Var = Publications	(Incumbents) ***Conditional Fixed Effects Negative Binomial*** [Incidence-rate ratios in brackets in bottom line] (Bootstrapped SEs reported in parentheses) Dep Var = Publications
Main Variables		
Post-Prize	0.032 (0.057) [1.032]	-1.435 (0.75) ** [0.238]
Ignoble Field × Post-Prize	0.387 (0.102)** [1.473]	0.231 (0.135) † [1.260]
Control Variables		
Maturity	YES	YES
Year Fixed Effects	YES	YES
Field Fixed Effects	YES	YES
Constant	0.598	1.137
Observations	17,000	17,000
Log Likelihood	-28,865.65	-22319.36
Number of Groups	340	340

All models are based on Negative Binomial Conditional Fixed Effects. †$p < 0.10$, *$p < 0.05$, **$p < 0.01$.

[12] "Fuzzy Matching" algorithm from VantagePoint Software was used to disambiguate author names. (https://thevantagepoint.com/)

Table A2. Effects on Grant Flows

	(Original Model) ***Conditional Fixed Effects Negative Binomial*** [Incidence-rate ratios in brackets in bottom line] (Bootstrapped SEs reported in parentheses) Dep Var = Grants	(Incumbents) ***Conditional Fixed Effects Negative Binomial*** [Incidence-rate ratios in brackets in bottom line] (Bootstrapped SEs reported in parentheses) Dep Var = Grants
Main Variables		
Post-Prize	0.265 (0.107)* [1.303]	0.422 (0.140)** [1.524]
Ignoble Field × Post-Prize	0.039 (0.172) [1.039]	-0.222 (0.245) [0.801]
Control Variables		
Maturity	YES	YES
Number of Publications	YES	YES
Year Fixed Effects	YES	YES
Field Fixed Effects	YES	YES
Constant	-17.726	-18.700
Observations	14,000	10,300
R^2		
Log Likelihood	-7,923.84	-4632.83
Number of Groups	280	206

Note 60 groups were dropped because of small variation. †$p < 0.10$, *$p < 0.05$, **$p < 0.01$.

Figure A1. Pre- and Post-Prize Differences in Publication Flows for Population

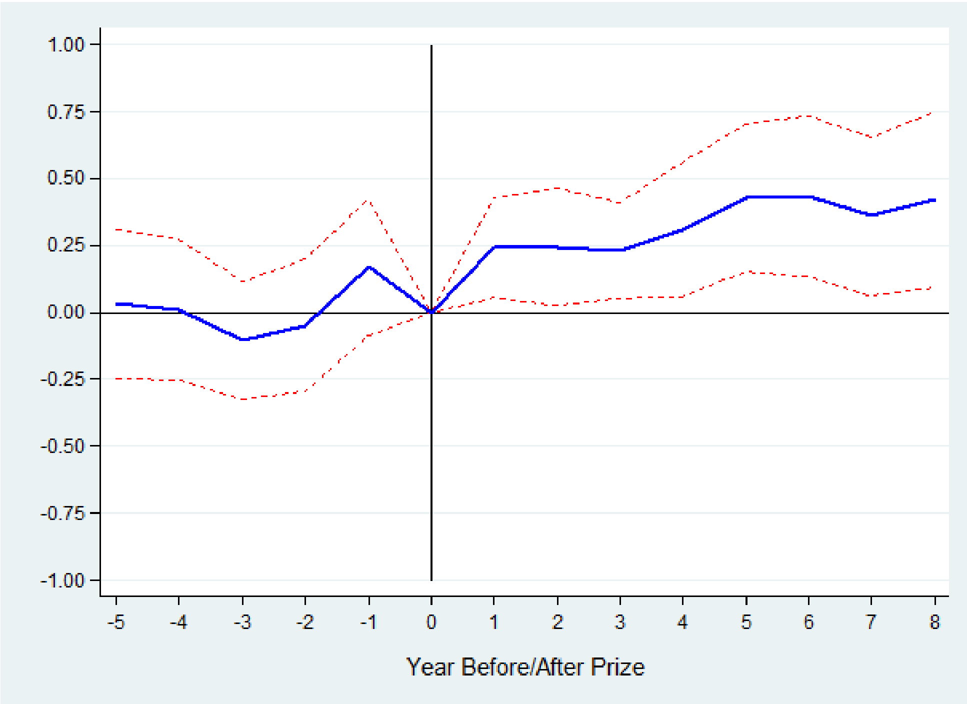
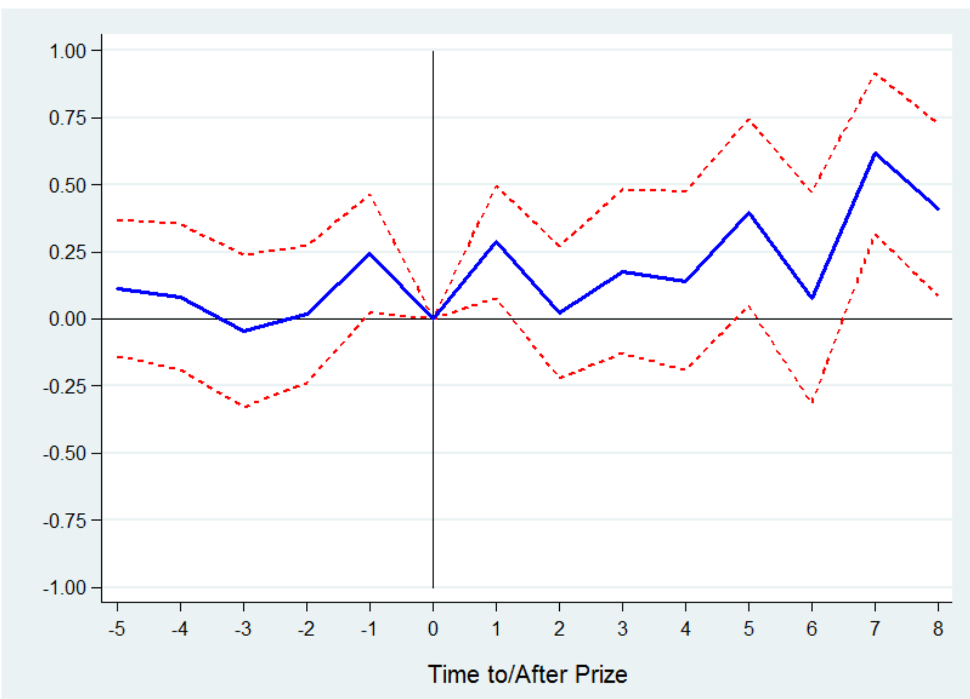


Figure A2. Figure A1. Pre- and Post-Prize Differences in Publication Flows for Incumbents



Notes: Both figures plot year-by-year pre- and post-Prize boosts to publication flows in the Prize-winning fields, computed from negative binomial regression with field and calendar-year fixed effects and dummy variables for each year preceding and following In Noble prize. The marginal effects are shown by the blue line. The upper and lower bound (90% confidence interval) are shown by two red dotted lines.

Table A3. Effects on Citation Flows

	(Original Model) ***Conditional Fixed Effects Negative Binomial*** [Incidence-rate ratios in brackets in bottom line] (Bootstrapped SEs reported in parentheses) Dep Var = Cites	(Incumbents) ***Conditional Fixed Effects Negative Binomial*** [Incidence-rate ratios in brackets in bottom line] (Bootstrapped SEs reported in parentheses) Dep Var = Cites
Main Variables		
Post-Prize	0.384	-1.098
	(0.075)**	(0.210)
	[1.468]	[0.334]
Ignoble Field × Post-Prize	0.147	-0.046
	(0.086)†	(0.141)
	[1.158]	[0.955]
Control Variables		
Maturity	YES	YES
Number of Publications	YES	YES
Year Fixed Effects	YES	YES
Field Fixed Effects	YES	YES
Constant	-1.689	-1.333
Observations	17,000	17,000
R^2		
Log Likelihood	-57106.46	-45940.98
Number of Groups	340	340

Note 60 groups were dropped because of small variation. †$p < 0.10$, *$p < 0.05$, **$p < 0.01$.

Appendix B: Sub-populations of Publications from High Impact Field[13] and Ordinary Fields.

Table B1. Effects on Publications (High Impact Field vs Ordinary Field)

	(Original Model) ***Conditional Fixed Effects Negative Binomial*** [Incidence-rate ratios in brackets in bottom line] (Bootstrapped SEs reported in parentheses) Dep Var = Publications	(High Impact Field) ***Conditional Fixed Effects Negative Binomial*** [Incidence-rate ratios in brackets in bottom line] (Bootstrapped SEs reported in parentheses) Dep Var = Publications	(Ordinary Field) ***Conditional Fixed Effects Negative Binomial*** [Incidence-rate ratios in brackets in bottom line] (Bootstrapped SEs reported in parentheses) Dep Var = Publications
Main Variables			
Post-Prize	0.032 (0.057) [1.032]	0.022 (0.187) [1.022]	0.029 (0.059) [1.029]
Ignoble Field × Post-Prize	0.387 (0.102)** [1.473]	0.199 (0.256) [1.220]	0.440 (0.115)** [1.553]
Control Variables			
Maturity	YES	YES	YES
Year Fixed Effects	YES	YES	YES
Field Fixed Effects	YES	YES	YES
Constant	0.598	-0.123	0.778
Observations	17,000	2,600	14,400
Log Likelihood	-28,865.65	-4179.23	-24611.01
Number of Groups	340	52	288

All models are based on Negative Binomial Conditional Fixed Effects. †$p < 0.10$, *$p < 0.05$, **$p < 0.01$.

[13] High Impact fields are the fields in which their focal publications are published in journals that have 20 or higher impact factors.