Truly Legendary Freedom: Funding, Incentives, and the Productivity of Scientists

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NBER Advancing the Science of Science Funding

Funding for Academic Scientists

We lack a complete understanding how the amount and duration of funding affects scientific output

Empirical challenge:

... there is **little variation** within funding programs

... there is **lots of selection** into different funding programs

Change in Leibniz Prize as Source of Exogenous Variation

Setting: Germany's most important research prize – **Leibniz Prize** of the DFG

- Around ten recipients per year
- Recipients have received seven Nobel prizes, two Fields medals

Reform in 2007 increased

- funding period by two years
- funding amount by €1m

How do elite academic scientists react to a longer funding period and a larger funding amount?

Empirical Approach

Diff-in-diff: Compare scientific output of

... Leibniz prize winners after 2007 (treatment) and

... Leibniz prize winners before 2007 (control),

before and after receiving Leibniz prize

Main Findings

Treated cohorts with more funding and longer funding period...

... **publish less overall**: decreases by more than half

... **publish more in top journals**: increases by more than double

Mechanism: **Complementarity** of additional funding amount and duration

Change in Leibniz Prize funding caused fewer, but better publications

Agenda

The Leibniz Prize

Data

Empirical Framework

Main Results

Mechanism

Conclusion

The Leibniz Prize

Gottfried Wilhelm Leibniz Prize – Overview

Awarded annually to around 10 outstanding researchers since 1986

Open to all disciplines, only formal criterion is affiliation with German research institution

Cannot apply directly – university presidents can nominate researchers and DFG then decides on recipients

Until 2006: Endowed with € 1.55m which could be spent with **truly legendary freedom** over five years

Gottfried Wilhelm Leibniz Prize – Reform in 2007

Change in 2007:

- Increase in funding amount from €1.55M to €2.5M as inflation adjustment
- Increase in funding period from 5 to 7 years due to complaints that time frame was too short for long-term research projects

Selection procedure and selection criteria all remained the same

Data

Data

Focus on **257 winners** – 36 post 2007 – who received prize between 1986 and 2010

Age, gender, field from CVs and DFG

Publication data from Microsoft Academic

Get all publications from 10 years prior to prize to 7 years after for each winner

Primary Outcome Measure: Number of Publications

1. Count all types of publications, irrespective of outlet
2. Count journal publications by journal quality
   - Rank journals by average citations per paper in three years prior to publication (impact factor)
   - Count all publications in top 1%, top 2%, top 3%, etc.

Empirical Framework

Empirical Framework

Diff-in-diff: Compare scientific output of

- ... Leibniz prize winners after 2007 (treatment) and
- ... Leibniz prize winners before 2007 (control),

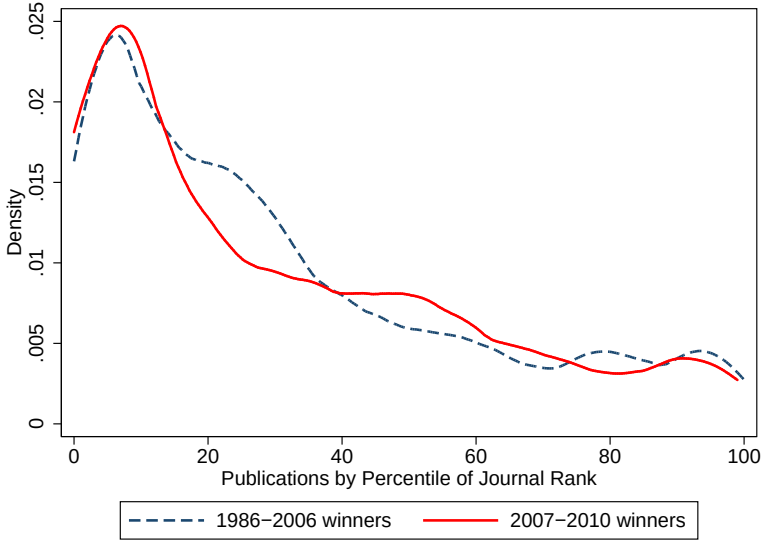
before and after receiving Leibniz prize

Identifying assumption: Earlier prize winners are good counterfactual for later prize winners

Prior to Prize: Balancing Table

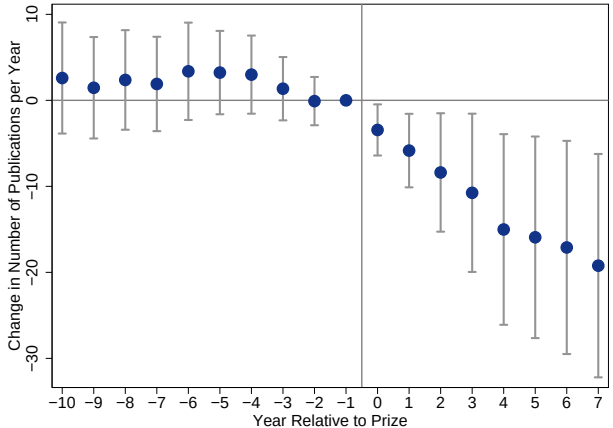
	Year of Prize			
	1986-2006	2007-2010	Difference	
Age at Prize	45.19	45.03	0.16	(0.83)
Age at PhD	27.78	28.03	−0.25	(0.44)
Social Sciences	0.06	0.08	−0.02	(0.62)
Engineering	0.17	0.19	−0.03	(0.71)
Life Sciences	0.31	0.31	0.01	(0.94)
Natural Sciences	0.46	0.42	0.04	(0.62)
Female	0.07	0.19	−0.13*	(0.07)
University	0.78	0.56	0.23**	(0.01)
Number of authors per pub	3.15	3.88	−0.73***	(0.00)
Number of publications per year	6.43	10.89	−4.46***	(0.00)
Observations	221	36	257	

Prior to Prize: Density of Publications by Journal Quality



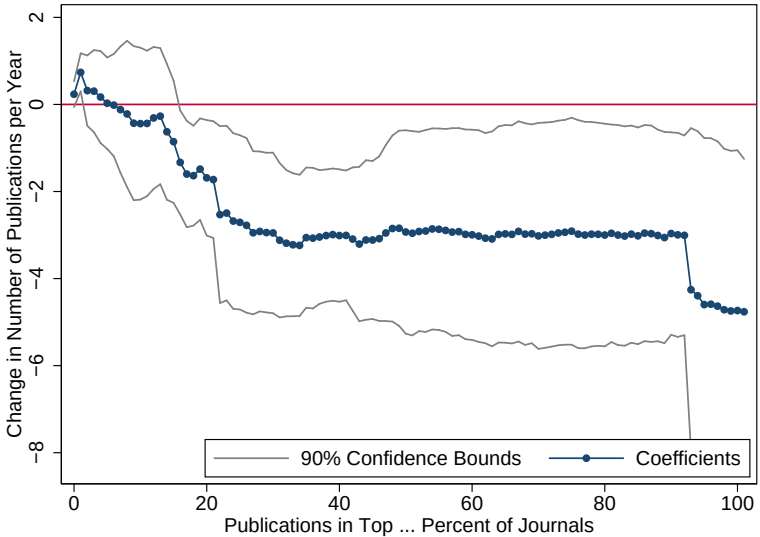
Main Results

Number of Publications Relative to Prize

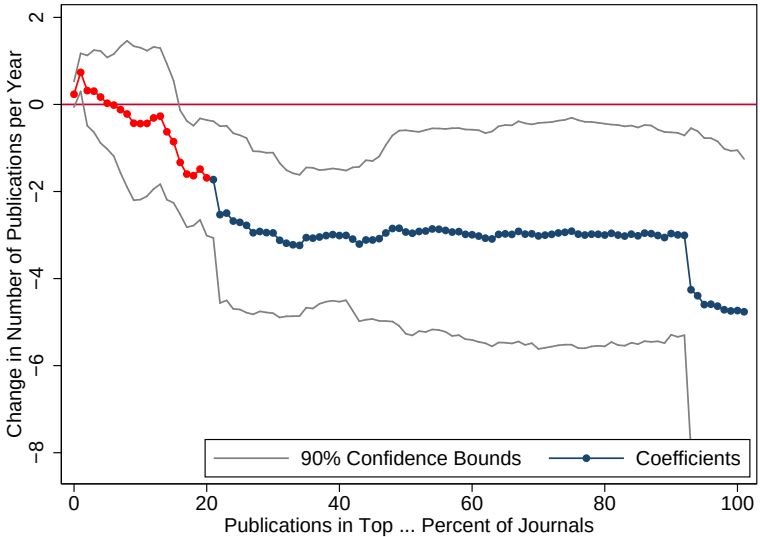


On average, reduction of six to eight publications per year: at least 65% relative to the mean

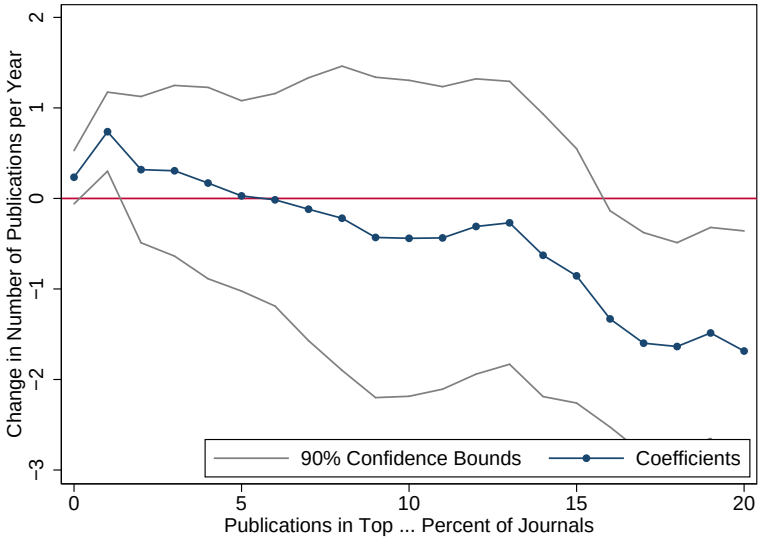
Results by Ranking of Journals



Results by Ranking of Journals



Results by Ranking of Journals – Focus on Top 20%



Concern: Is this Just a Cohort Effect?

Instead of treatment effect of change in Leibniz Prize, could also be **cohort effect**

Peak-career researchers might behave differently in 2007 to 2017 than in 1986 to 2006

Could be due to concurrent changes, e.g. introduction of ERC grants in 2007

Study other prominent scientists in same field and age group who do not receive a Leibniz Prize

Matched Control Group from Wikipedia

Use German Wikipedia and categories in Wikipedia for matching

Christiane Nüsslein-Volhard


Christiane Nüsslein-Volhard (2007)

Christiane Nüsslein-Volhard (* 20. Oktober 1942 in Heyrothsberge bei Magdeburg) ist eine deutsche Biologin und Biochemikerin. Sie beschäftigt sich mit Genforschung und Entwicklungsbiologie und war von 1985 bis 2014 Direktorin der Abteilung Genetik des Max-Planck-Instituts für Entwicklungsbiologie in Tübingen. Sie leitet seither am selben MPI weiterhin eine große Emeritus-Forschungsgruppe mit dem Titel *Color pattern formation*. Sie erhielt 1995 den Nobelpreis für Physiologie oder Medizin für ihre Forschungen über die genetische Kontrolle der frühen Embryonalentwicklung [1] in Fachveröffentlichungen wird ihr Name teilweise mit **CNV** abgekürzt.

Inhaltsverzeichnis [Verbergen]

Leben [Bearbeiten | Quelltext bearbeiten]


Christiane Nüsslein-Volhard (2007)

Christiane Nüsslein-Volhard wurde am 20. Oktober 1942 in Heyrothsberge bei Magdeburg als zweites von fünf Kindern geboren. Ihr Vater Rolf Volhard war Architekt, ihre Mutter Brigitte Haas Kindergärtnerin. Ihre Jugend verbrachte sie im Haus ihres Großvaters, des Herz- und Nierenspezialisten Franz Volhard, nahe Frankfurt am Main, wo ihre Familie nach dem Krieg Zuflucht gesucht hatte. Sie interessierte sich schon früh für Pflanzen und Tiere und wusste schon im Alter von 12 Jahren, dass sie Biologin werden wollte. Beeinflusst von Konrad Lorenz und anderen Verhaltensforschern hielt sie zur Abiturfeier ein Referat über die *Sprache bei Tieren*.

Nach dem Abitur an der Schillerschule in Frankfurt begann sie 1962, Biologie an der Johann-Wolfgang-Goethe-Universität Frankfurt am Main zu studieren. 1964 wechselte sie zum Biochemiestudium an die Eberhard Karls Universität Tübingen. Christiane Nüsslein-Volhard war von 1967 bis 1977 mit dem Physiker Volker Nüsslein verheiratet. Die kinderlose Ehe wurde 1977 geschieden. Ihr Diplom in Biochemie erlangte sie in Tübingen 1968, und war von 1969 an wissenschaftliche Mitarbeiterin am damaligen Tübinger Max-Planck-Institut für Virusforschung. Die Promotion zum Doktor der Naturwissenschaften erfolgte an der Universität Tübingen (1973) im Fach Genetik. Darauf folgte ein Postdoc mit einem Forschungsstipendium 1975/1976 am Laboratorium von Professor Walter Jakob Gehring im Biozentrum Basel, wo sie ihre Forschung zur biologischen Gestaltbildung[2] begann. 1977 war sie als Stipendiatin der Deutschen Forschungsgemeinschaft (DFG) am Laboratorium des Insektenembryologen Professor Klaus Sander an der Universität Freiburg im Breisgau.

Von 1978 bis 1980 fungierte sie als Forschungsgruppenleiterin am neu aufgebauten Europäischen Molekularbiologischen Laboratorium (EMBL) in Heidelberg. Dort arbeitete sie mit Eric F. Wieschaus zusammen, mit dem sie später den Nobelpreis erhielt. Danach war sie Nachwuchsgruppenleiterin am Friedrich-Miescher-Laboratorium der Max-Planck-Gesellschaft in Tübingen (1981–1984) und seit 1985 schließlich Direktorin und Wissenschaftliches Mitglied am Max-Planck-Institut für Entwicklungsbiologie in Tübingen. Ein Jahr später, 1986, erhielt sie den Gottfried-Wilhelm-Leibniz-Preis der Deutschen Forschungsgemeinschaft, die höchste Auszeichnung in der deutschen Forschung. Es folgten Gast-Lehraufträge an der *Harvard Medical School* der Harvard University (1988, 1991), der Yale University (1989), der Rockefeller University in New York (1991) und der Indiana University (1994). An der Tübinger Universität hat sie seit 1991 eine Honorarprofessur inne.

Einzelnachweise [Bearbeiten | Quelltext bearbeiten]

1. ↑ Informationen der Nobelstiftung zur Preisverleihung 1995 an Christiane Nüsslein-Volhard (englisch)
2. ↑ Petra Nellen: *Nüsslein-Volhard, Christiane.* 2005, S. 1058.
3. ↑ *Custom Model Generation Solutions Management* (englisch). Webseite von Taconic Farms, Inc. Abgerufen am 16. Juli 2018.
4. ↑ Mitgliedseintrag von *Christiane Nüsslein-Volhard* (mit Bild und CV) bei der Deutschen Akademie der Naturforscher Leopoldina, abgerufen am 15. Juli 2016.
5. ↑ *Nüsslein-Volhard übernimmt Pour-le-mérite-Vorsitz.* Schwäbisches Tagblatt, Tübingen

Träger des Nobelpreises für Physiologie oder Medizin Einklappen

1901: von Behring | 1902: Ross | 1903: Finsen | 1904: Pawlow | 1905: Koch | 1906: Golgi, Cajal | 1907: Laveran | 1908: Metschnikow, Ehrlich | 1909: Kocher | 1910: Kossel | 1911: Gullstrand | 1912: Carrel | 1913: Richet | 1914: Bárány | 1915–1918: *nicht verliehen* | 1919: Bordet | 1920: Krogh | 1921: *nicht verliehen* | 1922: Hill, Meyerhof | 1923: Banting, Macleod | 1924: Einthoven | 1925: *nicht verliehen* | 1926: Fibiger | 1927: Wagner-Jauregg | 1928: Nicolle | 1929: Eijkman, Hopkins | 1930: Landsteiner | 1931: Warburg | 1932: Sherrington, Adrian | 1933: Morgan | 1934: Whipple, Minot, Murphy | 1935: Spemann | 1936: Dale, Loewi | 1937: Szent-Györgyi | 1938: Heymans | 1939: Domagk | 1940–1942: *nicht verliehen* | 1943: Dam, Doisy | 1944: Erlanger, Gasser | 1945: Fleming, Chain, Florey | 1946: Muller | 1947: C. Cori, G. Cori, Houssay | 1948: Müller | 1949: Hess, Moniz | 1950: Kendall, Reichstein, Hench | 1951: Theiler | 1952: Waksman | 1953: Krebs, Lipmann | 1954: Enders, Weller, Robbins | 1955: Theorell | 1956: Cournand, Forßmann, Richards | 1957: Bovet | 1958: Beadle, Tatum, Lederberg | 1959: Ochoa, Komberg | 1960: Burnet, Medawar | 1961: Békésy | 1962: Crick, Watson, Wilkins | 1963: Eccles, Hodgkin, Huxley | 1964: Bloch, Lynen | 1965: Jacob, Lwoff, Monod | 1966: Rous, Huggins | 1967: Granit, Hartline, Wald | 1968: Holley, Khorana, Nirenberg | 1969: Delbrück, Hershey, Luria | 1970: Katz, von Euler, Axelrod | 1971: Sutherland | 1972: Edelman, Porter | 1973: von Frisch, Lorenz, Tinbergen | 1974: Claude, de Duve, Palade | 1975: Baltimore, Dulbecco, Temin | 1976: Blumberg, Gajdusek | 1977: Guillemin, Schally, Yalow | 1978: Arber, Nathans, Smith | 1979: Cormack, Hounsfield | 1980: Benacerraf, Dausset, Snell | 1981: Sperry, Hubel, Wiesel | 1982: Bergström, Samuelsson, Vane | 1983: McClintock | 1984: Jerne, Köhler, Milstein | 1985: Brown, Goldstein | 1986: Cohen, Levi-Montalcini | 1987: Susumu | 1988: Black, Elion, Hitchings | 1989: Bishop, Varmus | 1990: Murray, Thomas | 1991: Neher, Sakmann | 1992: Fischer, Krebs | 1993: Roberts, Sharp | 1994: Gilman, Rodbell | 1995: Lewis, **Nüsslein-Volhard**, Wieschaus | 1996: Doherty, Zinkernagel | 1997: Prusiner | 1998: Furchgott, Ignarro, Murad | 1999: Blobel | 2000: Carlsson, Greengard, Kandel | 2001: Hartwell, Hunt, Nurse | 2002: Brenner, Horvitz, Sulston | 2003: Lauterbur, Mansfield | 2004: Axel, Buck | 2005: Marshall, Warren | 2006: Fire, Mello | 2007: Capecchi, Evans, Smithies | 2008: zur Hausen, Barré-Sinoussi, Montagnier | 2009: Blackburn, Greider, Szostak | 2010: Edwards | 2011: Beutler, Hoffmann, Steinman | 2012: Gurdon, Yamanaka | 2013: Rothman, Schekman, Südhof | 2014: O'Keefe, M. Moser, E. Moser | 2015: Campbell, Ōmura, Youyou | 2016: Ōsumi | 2017: Hall, Rosbash, Young | 2018: Allison, Honjo

Kategorien: Genetiker | Entwicklungsbiologe | Hochschullehrer (Eberhard Karls Universität Tübingen) | Nobelpreisträger für Physiologie oder Medizin | Träger des Großen Bundesverdienstkreuzes mit Stern und Schulterband | Träger des Albert Lasker Award for Basic Medical Research | Träger des Pour le Mérite (Friedensklasse) | Träger des Verdienstordens des Landes Baden-Württemberg | Träger des Louisa-Gross-Horwitz-Preises | Träger des Deutschen Stifterpreises | Träger des österreichischen Ehrenzeichens für Wissenschaft und Kunst | Träger des Bayerischen Maximiliansordens für Wissenschaft und Kunst | Leibnizpreisträger | Mitglied der European Molecular Biology Organization | Mitglied der National Academy of Sciences | Auswärtiges Mitglied der Royal Society | Mitglied der Academia Europaea | Mitglied der Berlin-Brandenburgischen Akademie der Wissenschaften | Mitglied der Nordrhein-Westfälischen Akademie der Wissenschaften | Mitglied der Leopoldina (20. Jahrhundert) | Wissenschaftliches Mitglied der Max-Planck-Gesellschaft | Mitglied der Heidelberger Akademie der Wissenschaften | Mitglied der Akademie der Wissenschaften zu Göttingen | Mitglied der American Academy of Arts and Sciences | Mitglied der American Philosophical Society | Mitglied der Académie des sciences | Mitglied der Gesellschaft Deutscher Naturforscher und Ärzte | Namensgeber für einen Asteroiden | Ehrenmitglied des Physikalischen Vereins | Ehrendoktor der Albert-Ludwigs-Universität Freiburg | Ehrendoktor der Harvard University | Ehrendoktor der Princeton University | Ehrendoktor der Universität Utrecht | Ehrendoktor der University of St Andrews | Ehrendoktor der Eberhard Karls Universität Tübingen | Ehrendoktor der University of Oxford | Ehrendoktor der University of Bath | Ehrendoktor der University of Sheffield | Ehrenbürger von Tübingen | Deutscher | Geboren 1942 | Frau

Matched Control Group from Wikipedia

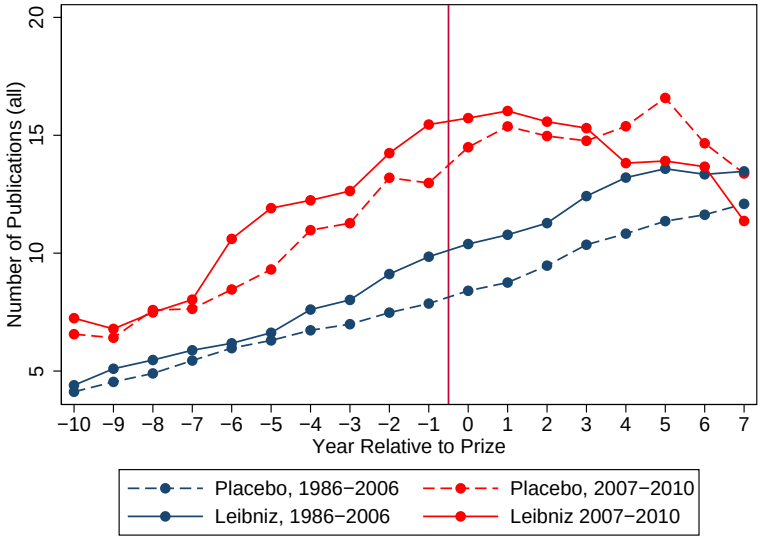
Use German Wikipedia and categories in Wikipedia for matching

Match on

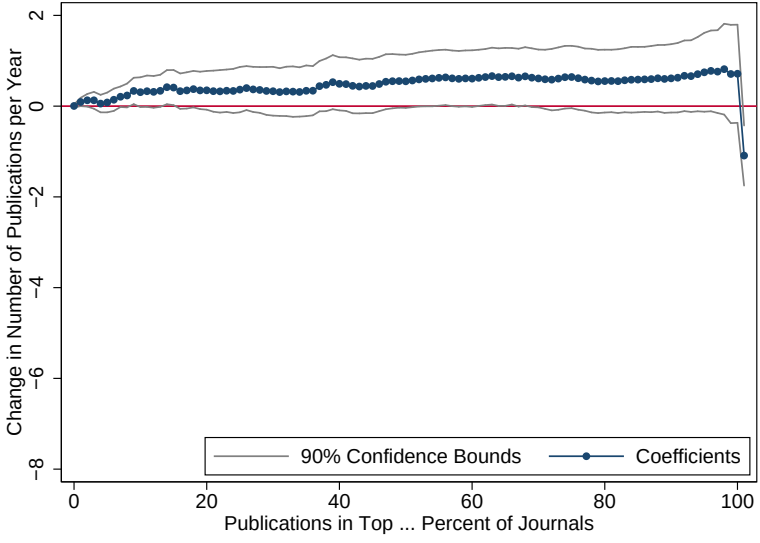
- Gender
- Year of birth
- (Broad) scientific field
- Academic scientist in Germany

Results in 1,819 matched control scientists

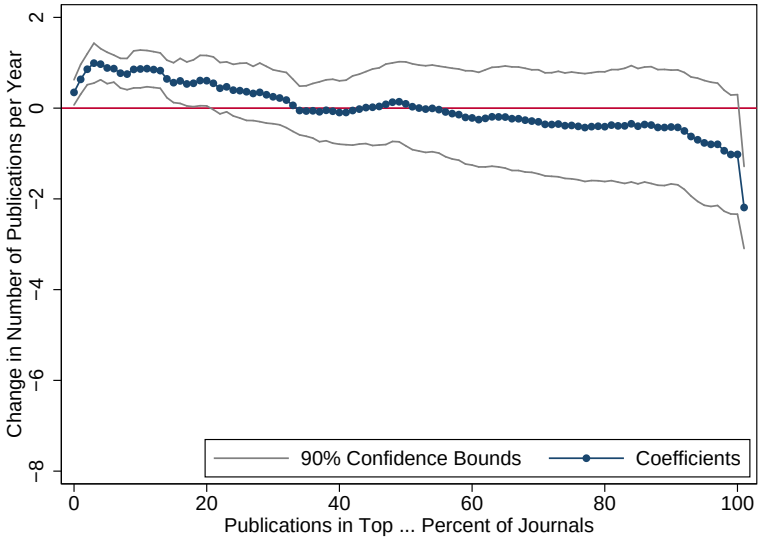
Controls from Wikipedia are Comparable to Leibniz Recipients



Placebo Test: No Evidence of Cohort Effects



Controlling for Cohort Effects Does not Change Results



Mechanism

Disentangling Effect of Additional Time and Money

Later prize winners publish less overall, but more in top journals in response to increase in funding amount **and** duration

But, is it money, time, or both that matters?

Exploit that funding of Leibniz Prize stayed constant at €1.55M from 1986 to 2006, but money lost 45% of its value

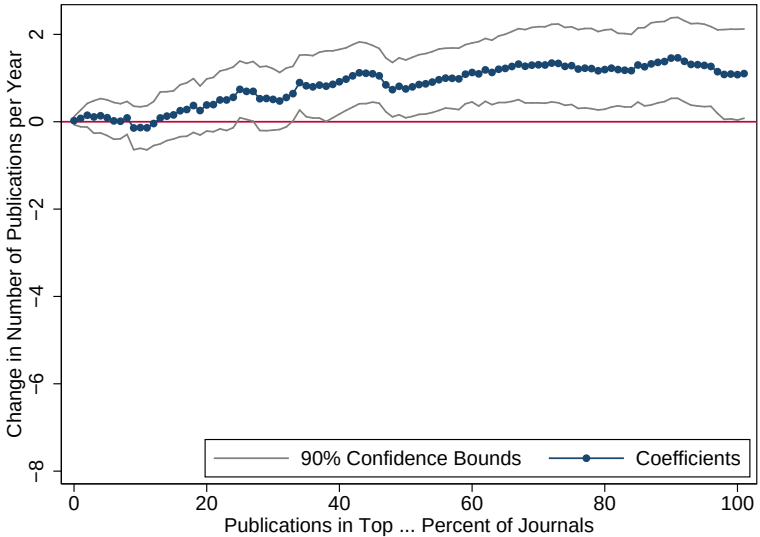
	Year of Prize		
	1986-1992	2000-2006	2007-2010
Real Funding Amount	€2.35M	€1.74M	€2.54M
Funding Duration	5 years	5 years	7 years

Pairwise comparisons between the three groups

Effect of Additional Funding Amount

	Year of Prize		
	1986-1992	**2000-2006**	2007-2010
Real Funding Amount	**€2.35M**	**€1.74M**	€2.54M
Funding Duration	**5 years**	**5 years**	7 years

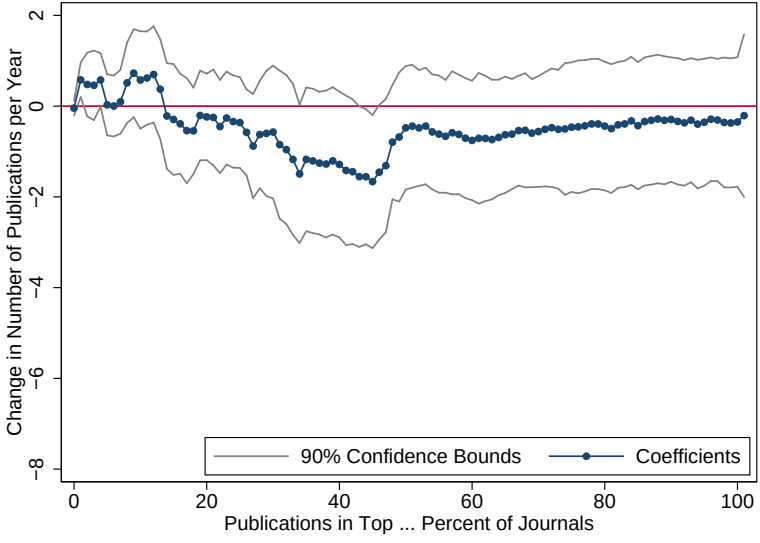
Effect of Additional Funding Amount



Effect of Additional Funding Duration

	Year of Prize		
	1986-1992	2000-2006	**2007-2010**
Real Funding Amount	**€2.35M**	€1.74M	**€2.54M**
Funding Duration	**5 years**	5 years	**7 years**

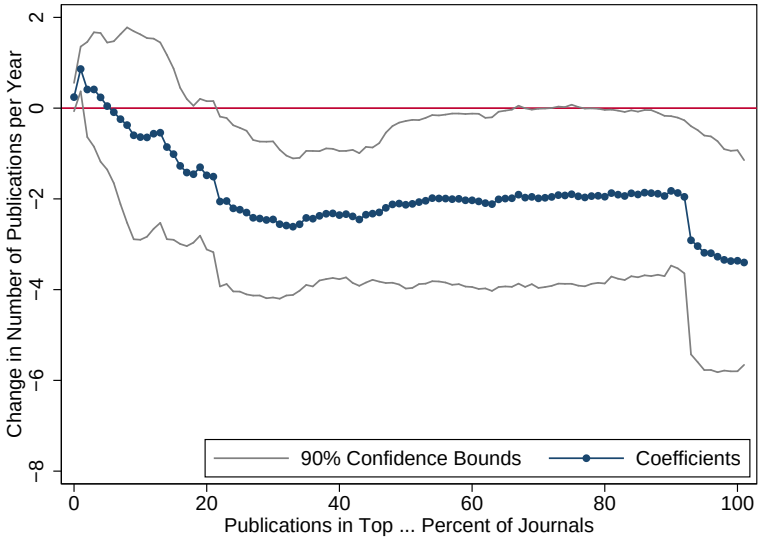
Effect of Additional Funding Duration



Combined Effect of Additional Funding Amount and Duration

	Year of Prize		
	1986-1992	**2000-2006**	**2007-2010**
Real Funding Amount	€2.35M	**€1.74M**	**€2.54M**
Funding Duration	5 years	**5 years**	**7 years**

Combined Effect of Additional Funding Amount and Duration



Conclusion

Conclusion

Additional funding amount **and** duration led to

... focus on publications in top outlets, but

... comes at price of large reduction in overall number of publications

Contributes to literature on the science of science funding due to **within** Leibniz Prize comparison – cleanly isolates effect of additional funding amount and duration

Azoulay et al. (2011), Benavente et al. (2012), Gush et al. (2018), Jacob and Lefgren (2011), Lerchenmueller (2018), Li et al. (2015), Myers (2019), Stephan (2012), Veugelers et al. (2019), Wang et al. (2018), Whalley et al. (2014)

Thank You!

Comments welcome:

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Backup

Commonness of Reference Journal Combinations: Details

Excerpt of references of Azoulay et al. (2011):

Papke, Leslie E. and Jeffrey M. Wooldridge. 1996. "Econometric Methods for Fractional Responses with an Application to 401(k) Plan participation Rates." *Journal of Applied Econometrics* 11(6): 619–632.

Robins, James M., and Andrea Rotnitzky. 1995. Semiparametric Efficiency in Multivariate Regression Models with Missing Data. *Journal of the American Statistical Association* 90(429): 122- 129.

Rosenbaum, Paul R. and Donald B. Rubin. 1983. "The Central Role of the Propensity Score in Observational Studies for Causal Effects." *Biometrika* 70(1): 41-55.

Rubin, Donald B. 1974. "Characterizing the Estimation of Parameters in Incomplete-Data Problems." *Journal of the American Statistical Association* 69(346): 467-474.

Santos Silva, J.M.C. and Silvana Tenreyro. 2006. "The Log of Gravity." *The Review of Economics and Statistics* 88(4): 641-658.

Four unique journals referenced by article: JAE, JASA, Biometrika, REStat

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Commonness of Reference Journal Combinations: Details

Co-citation matrix for all publications in a year:

$$M = \begin{bmatrix} & \text{Biometrika} & \text{JAE} & \text{JASA} & \text{REStat} \\ \text{Biometrika} & / & 5 & 6 & 9 \\ \text{JAE} & 5 & / & 7 & 8 \\ \text{JASA} & 6 & 7 & / & 4 \\ \text{REStat} & 9 & 8 & 4 & / \end{bmatrix}$$

Calculate commonness for each journal combination, i.e.

$$S_{JAE,JASA} = \frac{N_{JAE,JASA}}{\frac{N_{JAE}}{N} \cdot \frac{N_{JASA}}{N} \cdot N} = \frac{7}{\frac{20}{39} \cdot \frac{17}{39} \cdot 39} = 0.80$$

Sort all journal combinations within each paper by commonness and define

- (negative logarithm of) 10th percentile as novelty
- (logarithm of) 50th percentile as conventionality

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Text Similarity: Details

1. Take abstract of each publication (available for around 67% of publications) as one document
2. Standard pre-processing: Remove stopwords and tokenize
3. Employ TF-IDF weighting

$$\text{tf.idf}(t, D) = \frac{\text{Frequency of term } t \text{ in document } D}{\text{Max. Frequency of a term } t' \text{ in document } D} \cdot \log \frac{\text{Number of Documents}}{\text{Number of Documents with term } t}$$

4. Compute cosine similarity between tf-idf vectors
5. For similarity measure relative to early publications:
   - Aggregate all abstracts from 10 years prior to prize to 6 years prior to prize into one document
   - Compute similarity relative to this one document

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Additional Dependent Variables

	Text Sim. I	Text Sim. II	Novelty	Conventionality
Post Prize	−0.00	−0.01*	0.10**	−0.01
	(0.00)	(0.00)	(0.05)	(0.03)
Post Prize × Post 2007	−0.00	−0.02***	−0.08	0.05
	(0.01)	(0.01)	(0.09)	(0.09)
Fixed Effects	Year	Year	Year	Year
Mean Dep.	0.08	0.13	−0.70	1.87
R^2	0.06	0.39	0.03	0.02
Winners	252	248	256	256
Observations	3536	2536	3974	3974

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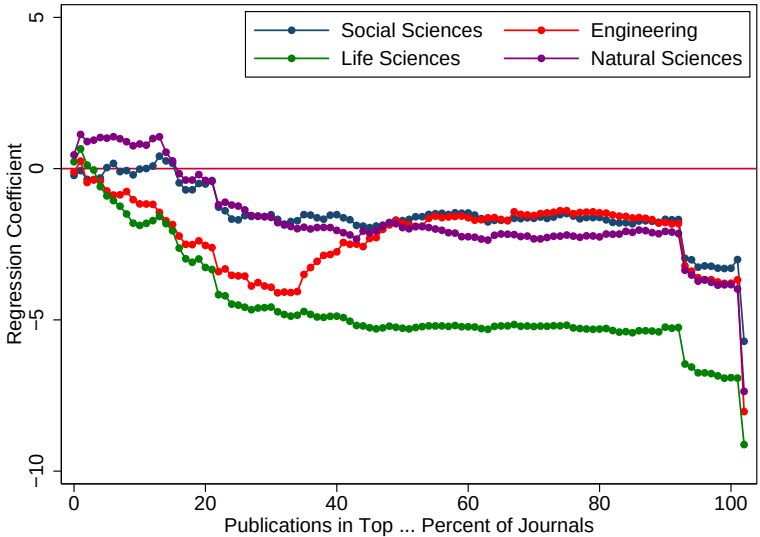
Heterogeneity by Subjects



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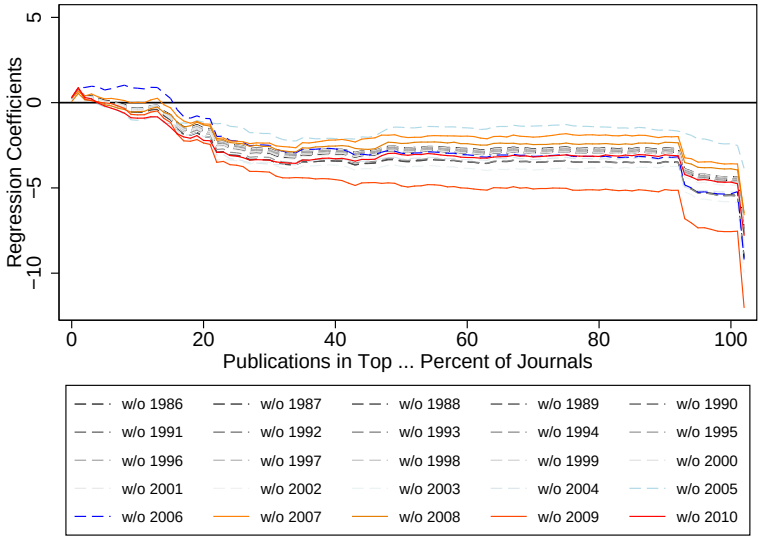
Dropping Individual Prize Cohorts



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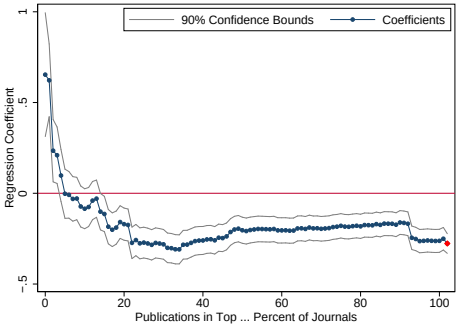
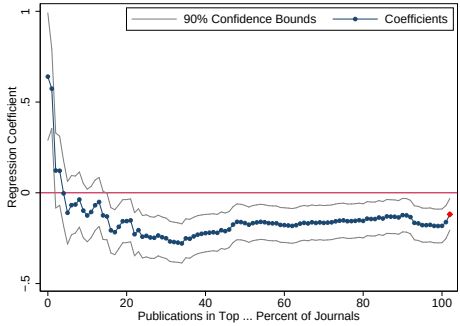
Count Data Models



Fixed Effects Poisson



Negative Binomial Model

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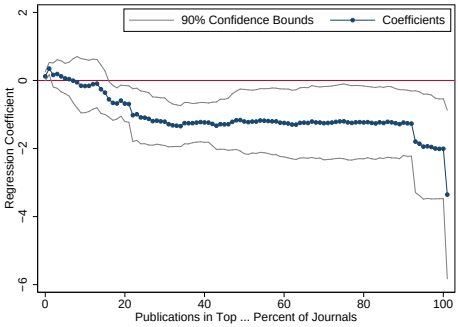
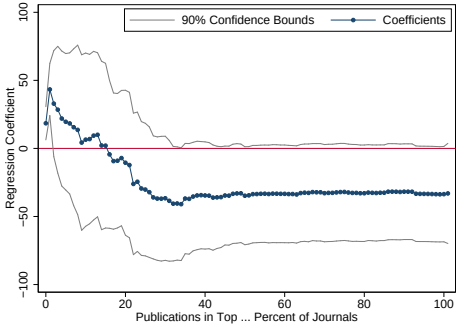
Weighted Dependent Variables



Normalized with $\sqrt{\text{No. of authors}}$



Weighted w/ 3-year forward citations

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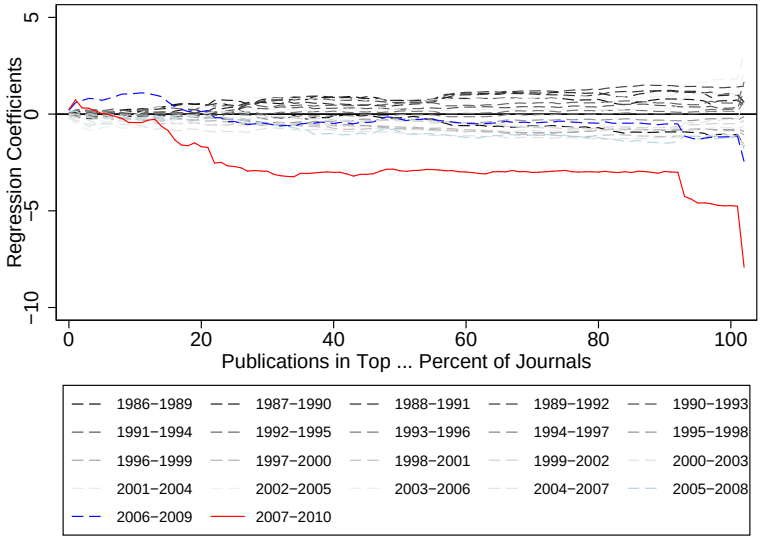
Falsification Exercise



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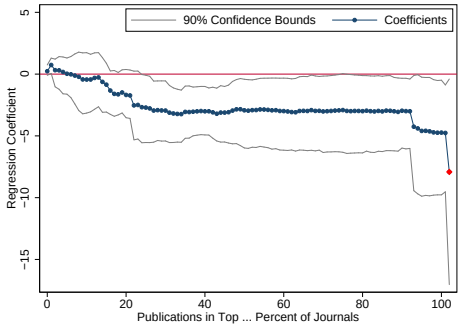
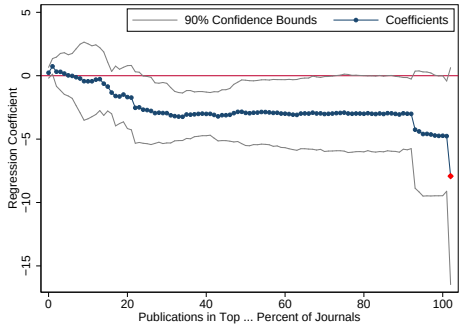
Main Results by Journal Quality

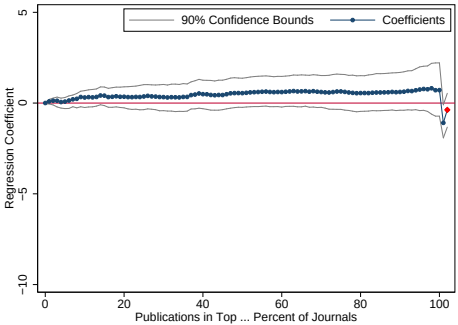


Restricted Wild Cluster Bootstrap

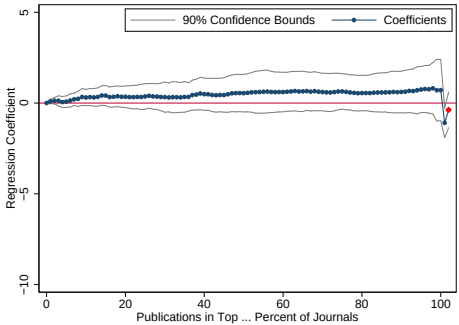


Unrestricted Wild Cluster Bootstrap

Placebo Test

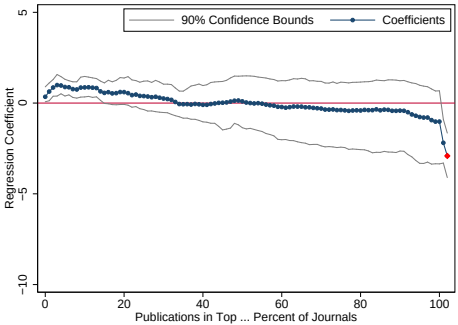


Restricted Wild Cluster Bootstrap

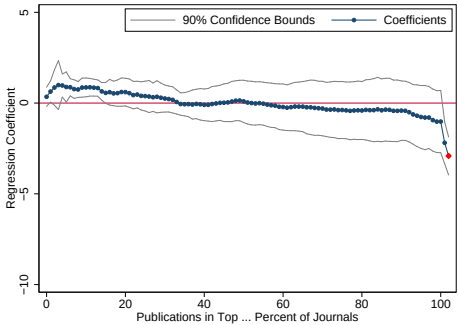


Unrestricted Wild Cluster Bootstrap

Triple Difference

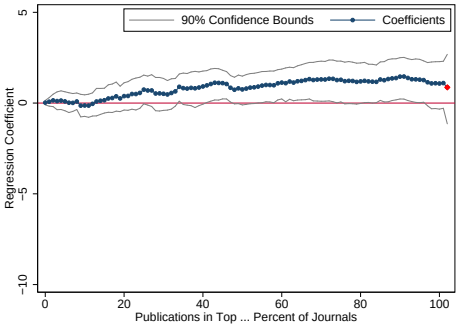


Restricted Wild Cluster Bootstrap

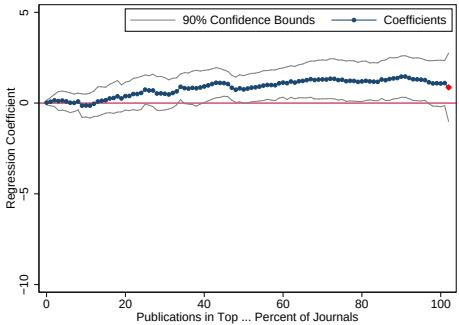


Unrestricted Wild Cluster Bootstrap

Effect of Additional Funding Amount

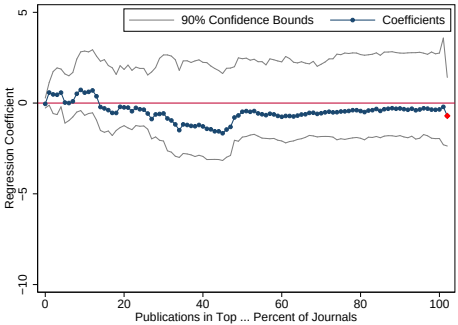


Restricted Wild Cluster Bootstrap

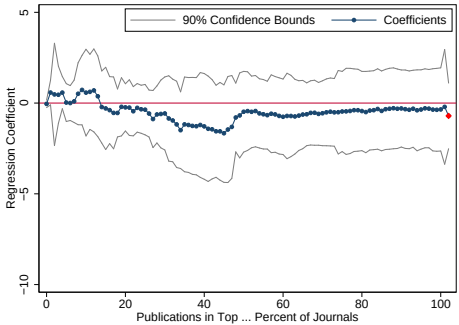


Unrestricted Wild Cluster Bootstrap

Effect of Additional Funding Duration

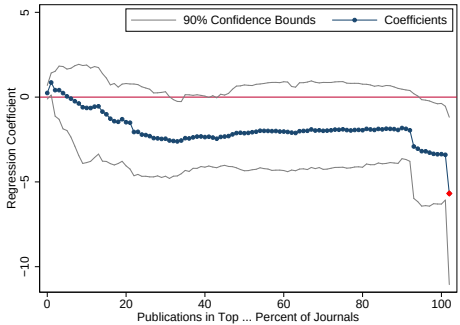


Restricted Wild Cluster Bootstrap

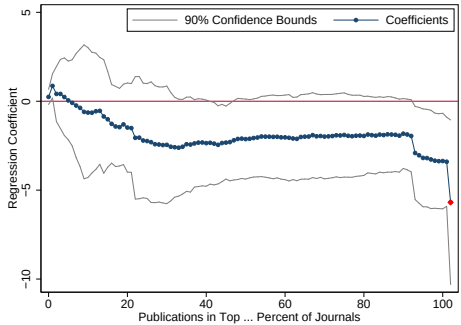


Unrestricted Wild Cluster Bootstrap

Combined Effect of Additional Funding Amount and Duration

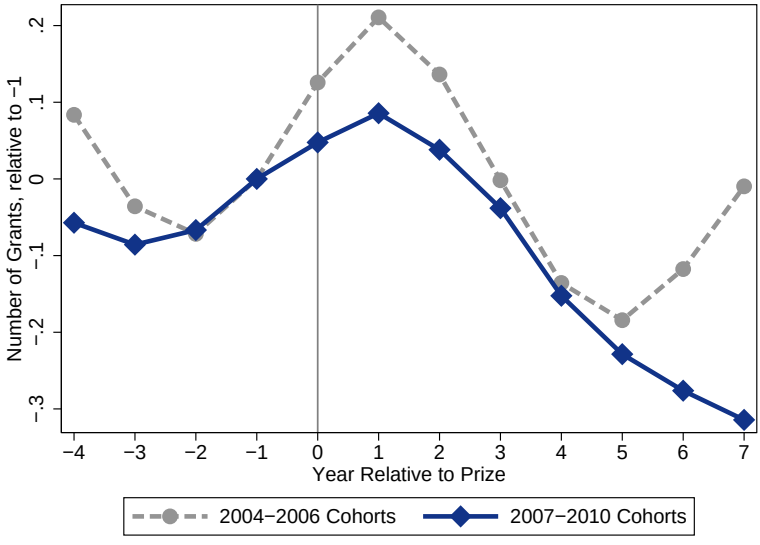


Restricted Wild Cluster Bootstrap



Unrestricted Wild Cluster Bootstrap

Number of Other Grants



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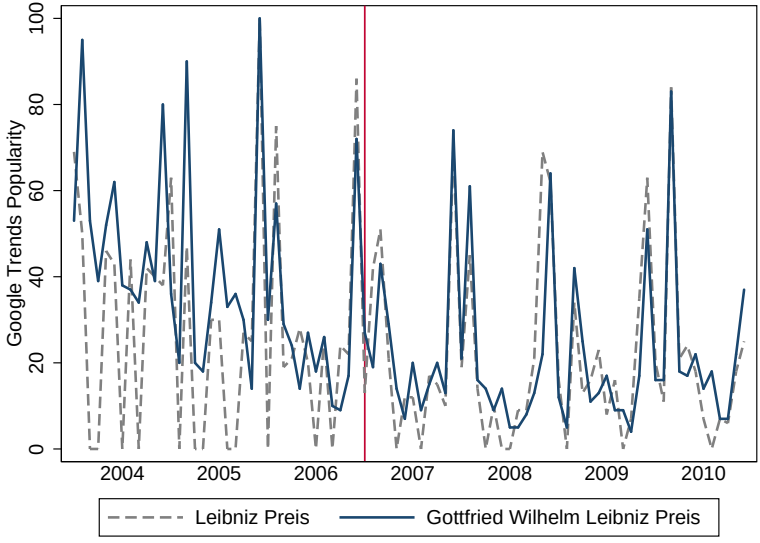
Google Search Frequencies



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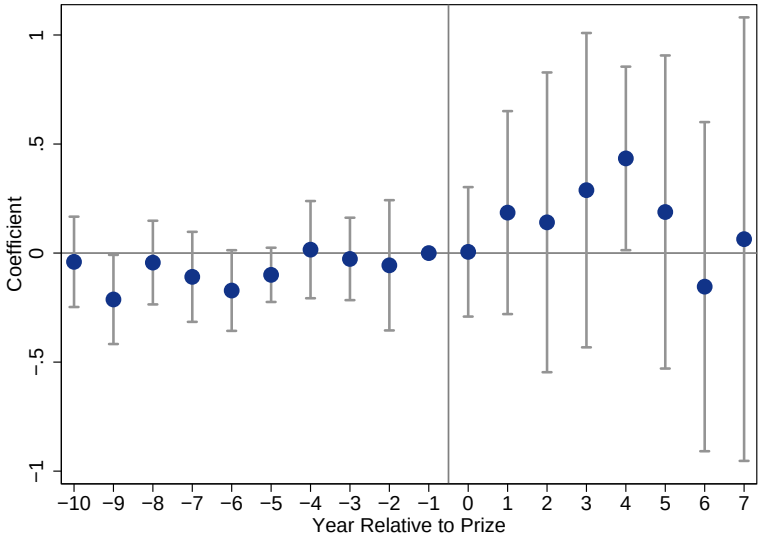
Time-varying Coefficients: Top 1%



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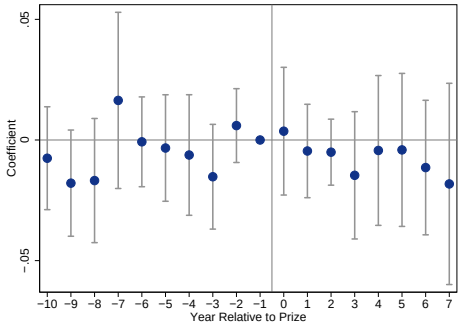
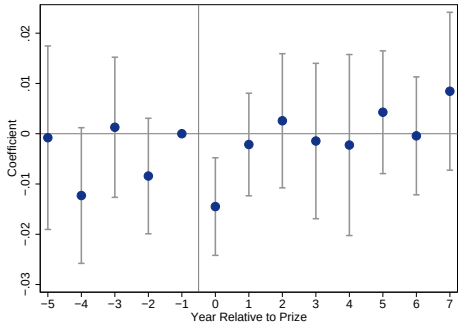
Time-varying Coefficients: Text Similarity



Text Similarity I



Text Similarity II

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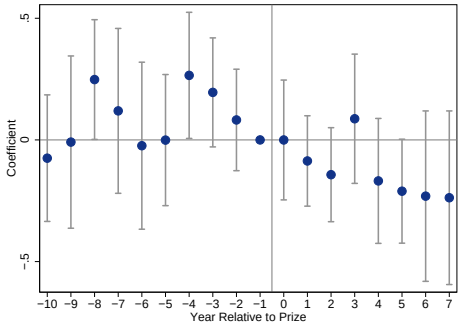
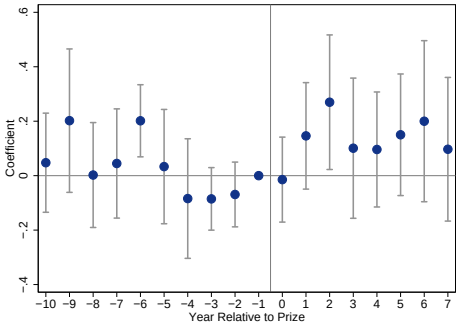
Time-varying Coefficients: Novelty and Conventionality



Novelty



Conventionality

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