Department Discussion Paper DDP1809

ISSN 1914-2838

PUBLIC FUNDING OF RESEARCH AND GRANT PROPOSALS IN THE SOCIAL SCIENCES: EMPIRICAL EVIDENCE FROM CANADA

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Revised February, 2020

First Version October, 2018

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I use Social Sciences and Humanities Research Council data to analyze some of the elements shaping the decision of researchers affiliated with Canadian institutions to apply for public research grants. Relying on panel data methods, I find that researchers show an aversion to the instability of funding, hence, to the uncertainty in the policy environment. In particular, both the volatility of the resources granted and the volatility of the funding probability deter researchers from submitting proposals. I then speculate on the possible consequences of the current funding scheme and on the chances to revert some recent worrisome trends in the near future.

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Public Funding of Research and Grant Proposals in the Social Sciences: Empirical Evidence from Canada

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I use Social Sciences and Humanities Research Council data to analyze some of the elements shaping the decision of researchers affiliated with Canadian institutions to apply for public research grants. Relying on panel data methods, I find that researchers show an aversion to the instability of funding, hence, to the uncertainty in the policy environment. In particular, both the volatility of the resources granted and the volatility of the funding probability deter researchers from submitting proposals. I then speculate on the possible consequences of the current funding scheme and on the chances to revert some recent worrisome trends in the near future.

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1 Introduction

Research in the Social Sciences is typically carried out at post-secondary academic organizations. In order to obtain public funding for a project, Canadian researchers can prepare grant proposals. These request financial support from designated grant initiatives. In this article, I study the determinants of the number of grant proposals submitted to a public funding agency by social scientists affiliated with Canadian institutions. I undertake a formal analysis on the mechanisms that might deter scholars from applying to public research grants. In particular, I investigate whether the instability of funding negatively affects the number of submitted applications. The Canadian empirical evidence corroborates this channel, which represents the main finding of this paper.

To the best of my knowledge, there is limited research on the incentives for academic researchers to craft grant proposals. A major obstacle to this line of inquiry is the lack of publicly available datasets containing information on all projects seeking funding, including the unsuccessful ones. Obvious confidentiality issues and intellectual property concerns regarding the researchers with unfunded projects prevent a wide dissemination of these data. The dataset I work with features either a set of disciplines or academic institutions as the units of observation, by-passing the privacy issues, yet still retaining a sufficiently low level of aggregation.

The literature has mainly focused on the consequences of the funding decisions, estimating the elasticity of some measures of research output to public funding. Two contributions that are more closely related to my analysis are von Hippel and von Hippel (2015) and Ayoubia, Pezzoni and Visentina (2019). The former partially circumvented the data challenges by compiling a new dataset, directly surveying researchers in two fields: Astronomy and Psychology. The authors document that grant writing in their sample is extremely time-intensive. Drafting grant proposals on average requires 116 hours for the Principal Investigators and 55 for the Co-Investigators. They also argue that funding rates of less than 20% led one half of grant applicants to abandon their requests for federal research funds, after a multi-year effort. This is potentially inefficient, as they find that some of these projects are indistinguishable in quality from the research that does receive funding. Ayoubia, Pezzoni and Visentina (2019) argue that, apart from the possible financial reward, crafting a grant proposal can have some additional benefits. They rely on a confidential Swiss dataset, with information on all researchers applying for funding to a public grant scheme in the 2008–2012 period. According to the authors, the sunk costs incurred by applicants to prepare their proposals are not fruitless, as there is a positive effect on the scientists' number of publications, the average impact factor of the journals where they publish, and their probability of collaborating with co-applicants. However, their findings are difficult to reconcile with the results in von Hippel and von Hippel (2015), whose respondents reported limited such benefits. A possible explanation for this difference is the underlying institutional setup of the public grant initiatives: the sample in Ayoubia, Pezzoni and Visentina (2019) refers to research that, in order to be eligible for funding by the Swiss National Science Foundation, must be carried out collaboratively. Alternatively, the statistics computed by von Hippel and von Hippel (2015) might not be reliable, because of the small sample size and conceivable self-selection biases, induced for example by disgruntled academics with unsuccessful grant proposals.

In Canada, academic researchers primarily seek funding by submitting proposals to the Social Sciences and

Humanities Research Council (SSHRC), a federal agency founded in 1977.[1] My analysis focuses on what have historically constituted the main SSHRC initiatives, the Standard Research Grants and the Insight programs. The former were replaced in 2012 by the latter, in what represented a major restructuring of the SSHRC grants.[2] These schemes are important in terms of overall funding and are the principal way of financing basic research by both experienced and emerging scholars at Canadian institutions. Among many undertakings, social scientists participate in the debate for the design of key policies, yet the research funding they receive currently accounts for only 0.046% of Canadian public expenditure.

In the literature little is known regarding the incentives for researchers to apply for public funding. My paper contributes to this debate. On the basis of panel data regression analysis, I show that a higher instability of the funding opportunities leads Canadian researchers to submit fewer grant proposals, which is a novel finding. The result is robust along several dimensions, including compiling the dataset using two different units of observation (i.e., the SSHRC academic disciplines or the Canadian academic institutions), and two different time windows (i.e., excluding or including the post 2012 reform years). I also develop a parsimonious economic model with risk averse researchers that rationalizes the empirical findings. The model features imperfect screening: SSHRC assessments are correlated with the underlying true quality of a project, but they are subject to noise, which affects the funding awarded to the projects. The model provides comparative statics with respect to the variance of the noise term: a higher uncertainty dissuades researchers from submitting applications, which is consistent with the estimation results. I then speculate that after the SSHRC reform, Canadian researchers have been trying to learn the new policy environment. In the face of a more uncertain return, some stopped undertaking a costly action. Drawing a parallel from labor economics, I will refer to this circumstance as an instance of discouraged researchers.

1.1 Related Literature

In this subsection, I present a comprehensive literature review.[3]

Regarding the assessment of the benefits and costs of submitting grant proposals, an open question is whether reviewers can show biases towards easily identifiable subsets of researchers, such as minorities and women. Changing attitudes in these biases could partially drive the decisions of researchers to submit applications. Viner, Powell and Green (2004) have emphasized the negative effects of these biases, but their importance may have decreased over time, at least in some disciplines, as argued by Broder (1993). In a simulation study Day (2015) shows that small levels of reviewers' bias can substantially influence the rate at which grant applications are funded. A bias of only 2.8% of the total score is sufficient to determine a statistically significant difference in

[1] The other two federal funding agencies are the Natural Sciences and Engineering Research Council (NSERC), whose mission is fostering discovery and innovation in natural sciences and engineering, and the Canadian Institutes of Health Research (CIHR), whose mission pertains discoveries and innovations that strengthen Canada's health care system and improve the health of Canadians. Researchers might also have access to provincial funding, depending on the location of the institution they are based at. In the Social Sciences provincial funding has not been offered regularly, with the exception of Québec and their Fonds de Recherche du Québec Société et Culture (FRQSC).

[2] For brevity's sake, I am going to refer to either as the SSHRC research grants. Section 2 describes these programs in detail.

[3] For general surveys on the economics of science see Stephan (1996), Antonelli, Franzoni and Geuna (2011) and Stephan (2012).

the number of funded grants across two groups of researchers, one group being a preferred class of investigators.

There is an extensive body of work addressing the fundamental question of whether public research funding increases academic research output. There appears to be consensus on the broad answer, namely, more resources do make researchers more productive. Using U.S. data, Adams and Griliches (1998) and Payne and Siow (2003) find that Federal funding positively affects the number of publications. However, there is some evidence of diminishing returns. Not only public funding, but also private endowments can be used to finance research, and Whalley and Hicks (2014) use an instrumental variable analysis that confirms that total research spending has a substantial and positive effect on the number of papers produced. However, they do not find the same effect on the impact of these contributions: more generous funding does not seem to facilitate breakthroughs.

For Canada, both Fortin and Currie (2013) and Murray et al. (2016) use NSERC data. The former show that impact measures of the researchers' output are weakly correlated with more generous funding, while the latter detect negative biases against researchers working at smaller institutions. On the basis of their results, both contributions make the case for public funding strategies that favor diversity, rather than excellence.

A limitation of most contributions in the literature is the lack of experimental data. Some authors have tried to overcome this shortcoming by tackling the selection and simultaneity issues with an explicit model. This is the method proposed by Arora, David and Gambardella (1998), that rely on Italian biotechnology grant applications, finding that doubling the resources given to a researcher increases their output by 60%. Others have exploited the characteristics of the institutional frameworks to implement program evaluation techniques, as advocated by Jaffe (2002). In this vein, Chudnovsky et al. (2008) exploit the exogenous variation in the availability of funding in Argentina to use both a difference-in-differences estimator and a propensity score matching one. In this setting they find funding has a positive effect on productivity, which is particularly strong for junior researchers.

One notable exception to the effectiveness of public funding is found by Jacob and Lefgren (2011). Using NIH data, their estimates show that receiving approximately $1.7 million USD (the average value of a NIH research grant) leads to only a 7% increase in output, namely one additional publication over the next five years. An explanation that the authors have put forward for their result is that researchers who are just below the NIH funding threshold (the main source of identification in their regression discontinuity design) are able to secure funding from other sources.

Two other papers that exploit a regression discontinuity approach to estimate the causal effect of research funding on research output are Benavente et al. (2012) and Gush et al. (2018). Both find positive effects of funding on productivity, the former relying on data from Chile, the latter from New Zealand.

Mongeon et al. (2016) argue that a concentration of research funds leads to decreasing marginal returns. Their findings also clash with the notion that larger grants lead to groundbreaking discoveries. Given the evidence on decreasing returns of research inputs, a less concentrated allocation of funds might be desirable.

In the literature, there is a crucial debate on the pros and cons of different funding modes, illustrated by Stephan (2012). Azoulay, Graff Zivin and Manso (2011) assess the merits of not penalizing early failures too heavily, exploiting data from the life sciences. They find that researchers sponsored by the HHMI, an institution focusing on long-term outcomes, produce more high-impact articles compared to similar investigators funded by the NIH, which is unforgiving towards early failures. Wang, Lee and Walsh (2018) study how competitive and block funding affect a measure of research novelty. Using data from Japan, they find mixed results: competitive funding seems to foster the creativity of senior scholars, while block funding seems to achieve a similar outcome for less established (junior and female) researchers.

The rest of the paper is organized as follows. Section 2 describes the institutional background. Section 3 contains a thorough panel data analysis, using methods for a limited dependent variable on both discipline-level and institution-level data. The empirical analysis is followed by a stylized theoretical model with risk averse researchers. Section 4 offers a discussion of the main results together with an extensive robustness analysis. Section 5 concludes.[4]

2 SSHRC Grant Initiatives and Related Facts

In this section I concisely describe the main characteristics and institutional features of the SSHRC research grants. I also document the related aggregate trends, which are reported and interpreted in Gordon (2016) as well.

2.1 Institutional Background

SSHRC currently runs a number of initiatives: Insight, Talent, and Connection. Jointly with NSERC and CIHR, it also runs the Canada First Research Excellence Fund (CFREF), a recent and fairly small scheme. The 2017-18 budget shows that $176.7 million (45.4%) was devoted to the Insight initiative, $169.0 million (43.6%) to the Talent initiative, $29.6 million (7.6%) to the Connection initiative, and $12.9 million (3.3%) to the CFREF initiative. Quoting from SSHRC's website, the Insight program's goal is: "to build knowledge and understanding about people, societies and the world by supporting research excellence in all subject areas eligible for funding from SSHRC".[5,6]

The Insight initiative replaced the Standard Research Grants (SRG) in 2012. A major innovation was the creation of two separate competitions: the Insight Grants (IG) and the Insight Development Grants (IDG). These initiatives have separate deadlines, budgets, and adjudication committees. IG proposals are typically due in October, while IDG ones are in February. The related guidelines on how to allocate the overall resources between the two schemes are not disclosed.[7] Normally, researchers affiliated with eligible Canadian post-

[4]Three appendices include further details on the empirical methods used (Appendix A), on the panel dataset compiled for the econometric analysis (Appendix B), and on some additional robustness checks (Appendix C).

[5]The disciplines pertaining to SSHRC are: Anthropology, Archaeology, Archival Science, Classics/Classical and Dead Languages, Communications and Media Studies, Criminology, Demography, Economics, Education, Fine Arts, Folklore, Geography, History, Industrial Relations, Interdisciplinary Studies, Law, Library and Information Science, Linguistics, Literature and Modern Languages, Management/Business/Administrative Studies, Mediaeval Studies, Philosophy, Political Science, Psychology, Religious Studies, Social Work, Sociology, Urban and Regional Studies/Environmental Studies. There is also a residual category labeled Other.

[6]The goals of both the Talent and Connection programs are listed in SSHRC (2019a).

[7]The detailed rules of the three grant schemes can be found in SSHRC (2019a).

secondary institutions cannot submit proposals to both competitions in the same calendar year, while they can do so in two consecutive years (provided they submit substantially different proposals). However, in 2019 this restriction was lifted. Unsuccessful projects can be re-submitted in a future competition of the same type. In particular, some proposals are recommended for funding, but do not receive any because SSHRC runs out of resources.

The IDG are designed to support preliminary research ideas, rather than comprehensive research agendas. These grants allow for a maximum of $75,000 of funding over two years, and 50% of the total available resources are reserved to fund proposals submitted by emerging scholars (i.e., new researchers, within 6 years of obtaining their Ph.D.'s).[8]

The IG are designed to support research excellence, meant to be achieved with a full-fledged research agenda. In their latest incarnation, depending on the project size, applicants can choose between two funding streams. One stream of these grants allows for a maximum of $100,000 of funding over five years, while the other stream provides between $100,000 and $400,000 of funding over the same time horizon.

As for the evaluation of the submitted projects, the IG applications are first assessed by external reviewers, usually with three referees per proposal. Subsequently, a designated (field-specific) adjudication committee ranks all the proposals and decides which ones should be funded. The IDG applications are not assessed by external reviewers, and the funding decisions are made entirely by the (field-specific) adjudication committees. There are strict rules concerning conflicts of interest (potential and objective), which must be declared by the committee members. Any affected proposal is then assessed only by members without a conflict of interest. Both the external reviewers and the adjudication committees must follow specific criteria developed by SSHRC to assess various dimensions of both the proposal and the applicant(s). These are grouped in the Challenge, Feasibility, and Capability areas.

The superseded SRG shared many features with the present-day IG. The SRG was designed to support research programs and develop excellence in those research activities. In their last round, these grants allowed for a maximum of $250,000 of funding over three years, but this limit changed considerably over time. The proposals submitted by new and regular scholars were scored using different criteria. To the best of my knowledge, the SRG allowed for a broader category of eligible expenses. In particular, in the year 2000, the so-called Research Time Stipend (RTS) was introduced, which was in place until 2010. The RTS allowed researchers to buy out some of their teaching duties.

2.2 Aggregate Time Series Evidence

In this subsection I document some facts related to the SSHRC research grants over the 1995-2017 period. In the graphs, the vertical lines represent the implementation of the 2012 SSHRC grants reform, which introduced the Insight initiatives as the new framework for administering and funding research grants.[9]

[8] Whenever the funds are not spent in full at the natural end of the grant, SSHRC has an automatic one-year extension in place. If the funds are not spent by then, usually the managing institutions retain the outstanding balance, which can be used to fund their general research costs.

[9] To ensure comparability between the Standard Research Grants and the Insight initiatives, for the latter I added up the proposals submitted to, and funded by, both Insight schemes.

2.2.1 Grant Proposals and Funding Trends for all SSHRC Disciplines

[Figure 1 about here]

Figure (1) shows four different plots displaying the aggregate trends of all SSHRC disciplines.[10] The first panel depicts the time series of the overall grant proposals submitted, together with the overall number of projects funded. Several patterns emerge. First, both series have trended upward, with both the proposals and the projects funded more than doubling until their peaks in 2011. The series for the number of proposals shows remarkable growth from 2000 until 2011, and since then it has behaved more erratically. A large decline in submissions has been observed in the recent years. The series for the number of projects funded has rather different dynamics. In particular, after the sudden fall in 2012, it decreased slowly until 2015, and only more recently did it partially reverse this trend. The second panel depicts the funding (requested and granted) in millions of real Canadian dollars (CAD). In the first twenty years of the sample, Canadian researchers in the Social Sciences almost tripled their requests in terms of research funds amounts, which reached 400.6 million in 2014. The total funds disbursed have been increasing by a similar factor, with some significant differences. In particular, the latter has decreased between 2004 and 2011, only regaining its 2004 value in 2012. As argued by Gordon (2016), this suggests that there was a period where SSHRC was in a position to accommodate systematically larger budget requests, a tendency that eventually stopped (possibly because of a changing political climate, and/or the rapid growth was deemed unsustainable). The third panel depicts two series related to the grants' success rates. The solid line can be interpreted as the unconditional (ex-post) probability of a proposal being funded, while the dashed line as the share of the total requested funding that was actually paid out. The probability of success has been varying wildly, with a range of 19.7 percentage points. In some years, researchers faced a probability of success in excess of 42%, while more recently, the corresponding figures have been below 24%. The decline in the proposals' success rates started in the late 1990's, with sizable fluctuations around this trend.[11] Historically, the funding success rate has co-moved with the proposals' success rate. The fourth panel displays the average funding per project. The solid line depicts the average amount of grant dollars requested per proposal, while the dashed line is the average amount paid out per successful proposal. These series also changed drastically over time, suggesting some strategic behavior by the researchers and a change in standards applied by SSHRC. In real terms, from its trough to its peak, the amount requested per project increased by 55.2%, from $78,901 to $122,423, with a sudden acceleration after 2011. Perhaps, what is even more spectacular is the narrowing gap between the two series. This suggests that SSHRC, as far as funding decisions are concerned, has relied on both the extensive and the intensive margins, with the related mix changing over time. In particular, the 2012 reform brought about another change: fewer projects were funded overall, but the researchers began obtaining virtually the full amount of their proposed budgets. This new regime has also been discussed by Gordon (2016), who emphasized how this might be due

[10] All pecuniary series are adjusted for inflation using the CPI index, with 2002 as the base year.

[11] Stock-flow dynamics are partially responsible for the large change in the success rate observed following the 2012 reform. This is going to be addressed in Section 4.

to a strategic element. Different committees did not have an incentive to cut the proposed budgets, because the savings made were not retained in the same field. Given the historical values, it is plausible that until the reform took place, researchers were expecting a substantial reduction in their proposed costs, with this downward adjustment intensifying after 2004. However, following the reform, the requested and actual funding almost converged. The increase in the requested funds could be due to a combination of a genuine underlying increase in the cost of doing research (e.g., because of expensive, specialized equipment, or a paradigm shift towards pricey experiments and data collection endeavours) and an attempt to undo the expected trimming of the budgets.

Taken together, these plots suggest that Canadian researchers in the Social Sciences have been facing a turbulent environment, with drastic changes in both the amount of funding received and the likelihood of being funded.

3 Empirical and Theoretical Analysis

In this section I develop a formal analysis on the determinants of the number of grant applications. I first perform a thorough econometric investigation, followed by a simple theoretical model rationalizing some of the empirical findings. In order to study the grant proposal decisions and how they respond to incentives, ideally one would need data at the researcher level. These data are not publicly available due to confidentiality.[12] The published SSHRC data can be compiled with two different levels of aggregation: at the discipline level or at the institution level. I will present regressions for both cases, using similar econometric models for count panel data.[13] Both types of data lead to similar results, which is reassuring. One of the main advantages of using panel data is the availability of estimators that control for time-invariant unobserved heterogeneity. Adams and Griliches (1998) and Payne and Siow (2003) show the importance of doing so in their U.S. data.

3.1 Discipline-level Panel Data Analysis

I collected the data from the annual SSHRC reports. In this sample, the units of observation are the 29 SSHRC disciplines. I start by considering the 1995-2011 period, namely the Standard Research Grants years.[14]

The number of proposals is a count variable, hence, I rely on panel data generalizations of the Poisson regression model, controlling for unobserved heterogeneity with fixed effects. The dependent variable ($proposals_{d,t}$) is the

[12]SSHRC maintains a researchers' database that is easily accessible. However, this contains information only on the projects that were granted funding in one of their initiatives, which is clearly a selected sample. For a discussion on the possible effects of selectivity biases see Arora and Gambardella (2005).

[13]I also tried to implement a difference-in-differences approach, using the NSERC disciplines as the control group. Irrespective of the concerns about the tenability of the parallel trend and common support assumptions, such an analysis is not feasible because of data limitations. During the 2009-2017 period, NSERC published the same data as SSHRC on their own competition results only in one year. In particular, the success rates by discipline have been published, while the number of proposals has not (and cannot be re-constructed with the available information).

[14]The details of the data construction are included in Appendix A. In particular, over the sample period, I kept a fixed definition for the disciplines. The years 1995 and 1996 are used to compute the lagged variables and the rolling coefficient of variations, but are not used for the dependent variable. This, combined with the timing of the success rate, explains why the number of observations is constant across specifications. The results for the period 1995-2017 are reported in Appendix C.

number of research grant proposals submitted to SSHRC in a specific discipline (d), and in a given fiscal year (t). The benchmark specification of the econometric model takes the following form:[15]

$$\mathbb{E}[proposals_{d,t}|\mathbf{X}_{d,t}] = Exp\,(\beta_0 + \beta_1 proposals_{d,t-1} + \beta_2 awardedcad_{d,t} + \beta_3 successrate_{d,t} + \beta_4 cv\_awardedcad_{d,t-1} + \beta_5 cv\_successrate_{d,t-1} + \eta_d + \lambda_t)\,. \quad (1)$$

In terms of explanatory variables, I rely on: a) an autoregressive component of order 1 ($proposals_{d,t-1}$); b) the dollar amount of grants awarded in a discipline ($awardedcad_{d,t}$); c) the success rate in each discipline ($successrate_{d,t}$); d) the rolling coefficients of variation of the last two variables ($cv\_awardedcad_{d,t-1}$ and $cv\_successrate_{d,t-1}$).[16]

[Table 1 about here]

Table (1) reports the regression results for four –progressively richer– specifications. Column (1) refers to a basic specification that omits the two variables capturing the funding instability, which are included in all the other regressions, presented in columns (2) to (4).
The estimated coefficient on $proposals_{d,t-1}$, the autoregressive term, is always positive and highly significant. This seems to reflect institutional features leading to reinforcement effects, such as the existence of field-specific associations that facilitate obtaining information on the grant initiatives and feedback on the grant proposals.

If researchers were to be risk neutral, only the expected monetary value of a grant would influence their decisions. The regressions allow for more general cases, whereby $awardedcad_{d,t}$, the value of the grants awarded, and $successrate_{d,t}$, the funding probability, enter separately and are treated symmetrically. The estimates for these two control variables are not always statistically significant, but they are both negative. This is consistent with the idea that scholars working in a discipline that has recently obtained generous grants with a high success rate do not need to apply immediately for additional funding.

The two regressors denoting the coefficients of variation are meant to identify the effect of the funding instability. Their estimated parameters have a negative sign in all specifications. Both the volatility of the resources granted and the volatility of the funding probability deter researchers from submitting proposals. A possible interpretation of this result is that most projects require an extended period of time to come to fruition. For instance, a steady source of funding allows the PI's to hire the same research assistants for a long time

[15] The (d,t) indexes refer to the cross-sectional and time series dimensions of the panel dataset, respectively. $\mathbf{X}_{d,t}$ is the vector of regressors and $\mathbb{E}$ is the conditional expectation operator. Poisson models are used to fit non-negative random variables, so they rely on an exponential formulation of the conditional mean function, denoted by $Exp(.)$ in Eq. (1). The β_j's, $j = 0, ..., 5$, are parameters to be estimated. η_d stands for the unobservable (time-invariant) idiosyncratic effect. λ_t are time dummies included to control for aggregate changes.

[16] cv_x_{t-1} is the rolling coefficient of variation of the explanatory variable x, in the three-year window before period t. I use a three-year window as, in the on-line reports, usually SSHRC lists the statistics of the last three rounds of that initiative. I also experimented with a five-year window, and the results were similar, at the cost of losing more observations. For the success rate and the grants awarded I adopted the following timing: the index t refers to the deadline of the grant competition, not the year where the results are announced.

horizon, reducing the need, the time, and the related risks of training new collaborators, especially after a period characterized by limited funding. Another reason could be the need to collect primary data over a long period of time, or to purchase prolonged access to expensive databases. Similarly, researchers relying on specialized labs to perform experiments might need to undertake several exploratory rounds, followed by the final runs. In the absence of stable funding, the investigators might not be in a position to obtain further results. This could be problematic, for example, when addressing the concerns that inevitably arise during the peer review publication process.

Regressions (3) and (4) introduce a lag structure on both the awarded amounts and the success rates. The future values $awardedcad_{d,t+1}$ and $successrate_{d,t+1}$ are meant to capture the effects of forward looking behavior. Lacking data on expectations, for the future variables I use the realized values. The rationale behind including them is that researchers have an appreciation of the quality of their prospective proposals, eventually submitting them only when they will be deemed ready for external scrutiny. The negative coefficient on the future success rate suggests that this delaying effect is at play. If a researcher (correctly) believes that the probability of getting funded will increase in the future (say, because of an announced expansion in the SSHRC budget, or additional time spent polishing an incomplete application) this will have a negative effect on the current number of proposals. Overall, the parameter estimates for both regressors are statistically significant, but the fact that the two signs differ does not have a simple explanation. This could be due to working with series that do not reflect the actual expectations of the researchers at the time of taking the grant crafting decision.

The past values $awardedcad_{d,t-1}$ and $successrate_{d,t-1}$ are meant to capture the effects of backward looking behavior, possibly including the dynamics caused by changes in the grant schemes rules. Also in this case, the different signs are hard to reconcile.

An important consideration is that the inclusion of the lag structure does not alter the parameters of interest. Both the sign and the size of the estimated parameters on the two volatility variables are found to be robust across specifications.

Because of the plausible strong correlation between some fields, the discipline-level analysis might suffer from some biases, whose effects on the estimated parameters are hard to assess. In the next subsection I still use the SSHRC data, but with a different level of aggregation.

3.2 Institution-level Panel Data Analysis

For this part of the analysis, I compiled data from 15 annual SSHRC reports, detailing the competition statistics for the post-secondary institutions participating in a specific round of the SRG initiative. In this sample, a unit of observation is a post-secondary institution that applied for at least one research grant in the 1997-2011 period.[17] This dataset provides some advantages: it allows use of the geographical location as a control variable in regressions with random effects, and it stems from a more coherent aggregation of researcher-level information.[18] In particular, academic institutions are the entities formally in charge of handling SSHRC grant applications and funding. Typically, they established research offices, whose job is to support the development of grant proposals and to administer the funding obtained from research grants.

Since I observe the same academic institutions for several years, I can construct variables capturing the cumulated histories deriving from past outcomes. In a learning set-up, these can be interpreted as proxies for the uncertain talent in research, that conceivably the academic institutions are also trying to assess. They are meant to approximate the ability of groups of researchers affiliated with the same institution, while they are in the process of learning their academic type.[19]

The econometric model extends Eq. (1), using more regressors in its more general specification:

$$\begin{aligned}\mathbb{E}[proposals_{i,t}|\mathbf{X}_{i,t}] = Exp\,(\beta_0 + \beta_1 proposals_{i,t-1} + \beta_2 awardedcad_{i,t} + \beta_3 successrate_{i,t} \\ + \beta_4 awardedcad_{i,t+1} + \beta_5 successrate_{i,t+1} + \beta_6 awardedcad_{i,t-1} + \beta_7 successrate_{i,t-1} \\ + \beta_8 cv\_awardedcad_{i,t-1} + \beta_9 cv\_successrate_{i,t-1} + \beta_{10} tot\_awardedcad_{i,t-1} + \beta_{11} tot\_proposals_{i,t-1} + \eta_i + \lambda_t)\,.\end{aligned}$$

The dependent variable ($proposals_{i,t}$) is the number of research grant proposals submitted to SSHRC by an academic institution (i) in a given fiscal year (t).[20]

[Table 2 about here]

[17] There are reports available also for the years 1995 and 1996. However, some observables are not reported, hence I dropped these two years. There are up to 145 institutions. More detailed sample selection criteria and the full list of institutions in the dataset are reported in Appendix B.

[18] It is hard to know whether the unobservable characteristics of the post-secondary institutions have been changing over time. Some indirect, and by all means imperfect, evidence is related to their ranking. Although the relative academic standing and prestige of some institutions did evolve in the sample period, there were no drastic changes in terms of entry and exit from this market. A notable exception is represented by the Ontario Institute of Technology, which was founded in 2002. Since then it has been quite active in its research endeavors, applying for and receiving a number of grants.

[19] Implementing this step in the discipline-level dataset would be less justifiable, because it would imply a ranking of the different fields.

[20] Variables whose names display the *tot* prefix stand for running totals at the academic institution level. $tot\_awardedcad_{i,t-1}$ stands for the cumulative dollar value of grants received. Similarly, $tot\_proposals_{i,t-1}$ stands for the cumulative number of proposals submitted. η_i stands for the unobservable (time-invariant) idiosyncratic effect. Time dummies λ_t are included to control for aggregate changes, as well as geographical dummy variables (when identified).

The regression results are included in Table (2).[21] Overall, the results obtained with the institution-level data are in line with the estimates computed with the discipline-level panel. In particular, researchers in the Social Sciences are dissuaded from applying for research grants when funding becomes more volatile. In columns (1) to (4), not only does the instability of funds received matter, but also the instability of the success rate has a negative impact.

Similar to the discipline-level panel, the number of proposals show a positive and significant autocorrelation. A sensible interpretation in this context could be that whenever the research office at a post-secondary institution is effective in reducing the administrative burden, it makes the development of proposals less arduous for a protracted period. Alternatively, the institutions that were lucky in the past have more funds available to help researchers develop competitive proposals.

The sign on both the value of the awarded grants and on the success rate is also consistent with the results in the previous subsection. These parameters are now estimated more precisely.

Researchers appear to be forward looking, but the related mechanism might be somewhat different from the one described above. The future success rate is not statistically significant, and the future value of the grants received still has a positive sign. The backward looking variables do not seem to be extremely important.

As for the relevance of the two cumulated history variables, $tot\_awardedcad_{i,t-1}$ and $tot\_proposals_{i,t-1}$, comparing the estimates in columns (3) and (4) reveals that they play a minor role. This seems to indicate that the academic institutions have a somewhat accurate assessment of their research strengths and weaknesses, which are captured by the idiosyncratic effects η_i.

3.3 A Stylized Economic Model with Risk Averse Researchers

In this subsection I present a simple model with risk averse researchers that rationalizes some of the empirical findings. For tractability, I assume a static environment and a continuum of potential researchers, whose mass is normalized to 1.[22] Researchers are expected-utility maximizers, and decide whether to apply for a research grant by considering the utility they can derive from their current project of quality q, which could obtain an uncertain level of funding ε. The utility function is of the Constant Absolute Risk Aversion (CARA) family, with risk aversion parameter $\alpha > 0$, $U(\varepsilon) = 1 - e^{-\alpha\varepsilon}$. The quality of a project is randomly drawn from an exogenously given normal distribution with mean μ_q and variance σ_q^2, $q \sim N(\mu_q, \sigma_q^2)$, and it is observed by the researcher. There is a funding institution, which has a fixed budget B to allocate. The funding institution cannot observe the true quality of the projects seeking funding, rather only an imperfect measure ε is observed, which is the sum of the true quality and a noise term s. This error arises, for example, from the limited time spent by the evaluation committee on each application, and from projects assigned to evaluators that may differ in taste and familiarity with a research topic. The evaluators observe $\varepsilon = q + s$, which (by an appropriate choice of units)

[21] The Random Effects (RE) are assumed to follow a gamma distribution, and the null hypothesis of their absence is always rejected at the 1% level. The estimates for the Fixed Effects (FE) specification of the model are very similar, and are included in Table 4 in Appendix C.

[22] A dynamic analysis can only be carried out numerically. Given the lack of researcher-level data, the parameterization of the model would be problematic.

also corresponds with the monetary amount assigned to a worthy project. The noise term s is randomly drawn from an exogenously given normal distribution with mean $\mu_s = 0$ and variance σ_s^2, $s \sim N(0, \sigma_s^2)$, so that ε is an unbiased measure for the average quality. To retain tractability, the quality q and the noise s are assumed to be independent, and the imperfect measure of a project's quality is also normally distributed, $\varepsilon \sim N(\mu_q, \sigma_q^2 + \sigma_s^2)$, with density $f(\varepsilon)$.

The CARA and normality assumptions allow computation of the expectations in closed form, and the unconditional expected utility arising from the random funding ε is $\mathbb{E}\left[1 - e^{-\alpha\varepsilon}\right] = \mathbb{E}\left[1 - e^{-\alpha(q+s)}\right] = 1 - e^{-\alpha q} e^{\frac{1}{2}\alpha^2\sigma_s^2}$, where $\mathbb{E}\left[.\right]$ denotes an expectation, and the last term exploits the formula for the mean of a log-normally distributed random variable. Since only some projects obtain funding, this expectation needs to be adjusted by the following factors: the probability of getting funded, $Pr(\varepsilon \geq \underline{\varepsilon})$, and the potential funding, conditional on the imperfect quality measure to be above the funding threshold, $\varepsilon \geq \underline{\varepsilon}$. I assume that the threshold $\underline{\varepsilon}$ is positive, common knowledge, and exogenously given.[23] κ is the (fixed) utility cost of preparing a research proposal, and $\overline{U} \geq 0$ stands for the utility associated with the outside option, namely not submitting a proposal. This can be interpreted as a mix of leisure and alternative sources of revenues, such as publishing books or consulting jobs.

The decision of submitting a grant proposal depends on whether the expected utility of doing so, $EU(\varepsilon)$, is higher than the utility value of the outside option. The decision problem of a researcher can be expressed as $Max\left\{EU(\varepsilon), \overline{U}\right\}$, where the expected utility, net of the utility cost is:

$$EU(\varepsilon) = Pr(\varepsilon \geq \underline{\varepsilon})\left[1 - e^{-\alpha q + \frac{1}{2}\alpha^2\sigma_s^2}\right]\frac{\Phi(\alpha\sigma_s - \epsilon)}{\Phi(-\epsilon)} - \kappa \tag{2}$$

The first term in the expression for the expected utility represents the probability of obtaining funding, which happens whenever the assessment of the evaluation committee is greater than the threshold $\underline{\varepsilon}$.[24] The probability multiplies two terms, representing the expected utility conditional on obtaining funding, whose formula relies on the CARA utility function and the properties of a truncated log-normal distribution.

Eq. (2) can be used to find the endogenous quality threshold $\underline{q}$, which identifies the marginal researcher, the one that is indifferent between submitting an application or not:

$$Pr(\underline{q} + s \geq \underline{\varepsilon})\left[1 - e^{-\alpha\underline{q} + \frac{1}{2}\alpha^2\sigma_s^2}\right]\frac{\Phi(\alpha\sigma_s - \underline{\epsilon})}{\Phi(-\underline{\epsilon})} - \kappa = \overline{U} \tag{3}$$

Exploiting the properties of probabilities, the symmetry of the standard normal, and rearranging the terms

[23]The analysis is in partial equilibrium with respect to $Pr(\varepsilon \geq \underline{\varepsilon})$, which is a whole schedule, as it depends on q. The model could be closed by considering the budget constraint of the funding agency as the equation for the endogenous value of $\underline{\varepsilon}$, which would be $B = \int_{\underline{\varepsilon}}^{\infty} \varepsilon f(\varepsilon) d\varepsilon$. The analytical challenge is that this is a highly non-linear equation in $\underline{\varepsilon}$, which in turn depends in a complex way on the endogenous quality threshold $\underline{q}$ defined below. This breaks down the convenient normality result that simplifies the computation of the conditional expectations.

[24]In Eq. (2), $\Phi(.)$ denotes the CDF of the standard normal, $\epsilon \equiv \frac{\underline{\varepsilon} - q}{\sigma_s}$ and similarly $\underline{\epsilon} \equiv \frac{\underline{\varepsilon} - \underline{q}}{\sigma_s}$, and the term associated with the complement probability $[1 - Pr(\varepsilon \geq \underline{\varepsilon})]$ drops out of the equation, as in that instance the project receives no funding and $\left[1 - e^{-\alpha \cdot 0}\right] = 0$.

leads to the following expression, whose left (right) hand side is monotonically increasing (decreasing) in $\underline{q}$:

$$\Phi(\alpha\sigma_s - \underline{\epsilon}) = \left[\frac{1}{1 - e^{-\alpha\underline{q} + \frac{1}{2}\alpha^2\sigma_s^2}}\right](\overline{U} + \kappa) \tag{4}$$

The model captures some salient features of the data: a positive mass of potential researchers that do not submit a grant proposal, coupled with dispersion in the funding received by the applicants.

In this framework, it is possible to compute how researchers are going to respond to an increase in the uncertainty of funding, captured by an exogenous increase in σ_s.[25] This leads to fewer applications submitted, as the response of the expected utility to an increase in uncertainty is negative: $\frac{\partial EU(\varepsilon)}{\partial \sigma_s} < 0$.[26] Figure (2) plots the curves representing the expected utility of submitting a grant proposal. These are decreasing whenever the sign of the derivative is negative. Notice also that researchers with a higher quality project have a higher expected utility. An increase in the funding uncertainty, captured by an increase in the noise σ_s^2, leads to a lower expected utility, net of the utility cost κ. Since the value of the outside option $\overline{U}$ is not affected by changes in uncertainty, the mass of projects satisfying the inequality decreases, and fewer researchers submit an application.

[Figure 2 about here]

4 Discussion

In this section I first present a robustness analysis. I then move to a broader discussion of both the results and the data.

4.1 Robustness Analysis

The regression results show that researchers in the Social Sciences disliked the funding instability experienced during the SRG regime. A natural question is to what extent can the estimates obtained in the period before the 2012 reform be used to shed some light also on the more recent trends. One can speculate that the policy change increased the unpredictability of receiving a grant, which could partially explain the persistent decline in the number of applications. I consider two robustness checks that focus on elements that might undermine the applicability of the results to the more recent past. Another check deals with the reliability of the results based on the institution-level panel.

[25] In partial equilibrium, one can easily compute the comparative statics with respect to the funding probability, which leads to $\frac{\partial EU(\varepsilon)}{\partial Pr(.)} > 0$. Perturbing σ_s is more subtle, yet it still drives a change in the funding probability.

[26] The inequality is subject to the following restriction on the parameters, where $\phi(.)$ denotes the PDF of the standard normal: $\left[1 - e^{-\alpha q + \frac{1}{2}\alpha^2\sigma_s^2}\right]\left[\left(\alpha + \frac{\varepsilon - q}{\sigma_s^2}\right)\phi(\alpha\sigma_s - \epsilon)\Phi(-\epsilon) - \left(\frac{\varepsilon - q}{\sigma_s^2}\right)\Phi(\alpha\sigma_s - \epsilon)\phi(-\epsilon)\right] > e^{-\alpha q + \frac{1}{2}\alpha^2\sigma_s^2}\alpha^2\sigma_s\Phi(\alpha\sigma_s - \epsilon)\Phi(-\epsilon)$.

4.1.1 Parameter Instability

To what extent is the recent decline in grant proposals submitted to SSHRC explained by the increased instability is an open question. A legitimate concern is that the 2012 policy change induced a structural break in the regression model. As a partial check of how important this problem might be, I ran the same regression as in Section 3.1 on the whole 1995-2017 sample, which includes both the pre and post reform period.[27] As shown in Table 3 in Appendix C, the sign, size and significance levels of most parameters are similar to the benchmark estimates. Two estimates are more heavily affected: the parameters on both the success rate and its volatility double in size, but remain negative and become highly significant. This suggests that structural breaks should not overturn the main empirical findings.

4.1.2 Stock-flow Dynamics

Gordon (2016) points out that stock-flow dynamics are at least partially responsible for the change in the success rate following the 2012 reform. Data limitations prevent to perform a systematic econometric analysis controlling for their effect.[28] I deal with this issue by considering the consequences on the number of applications of a postulated behavioral assumption, namely the absence of researchers discouraged by the increased funding uncertainty. By design, this shuts down any possible change in the grant proposals submission decisions driven by the increased instability. At the same time, it allows for the stock of unfunded researchers to change, with the "queue" getting longer after the reform because of the falling probability of funding. In the analysis I use a data generating process that projects the historical trends, until they are disrupted by an unanticipated policy reform. The reform extends the average length of a grant from 3 to 4 years, inducing stock-flow dynamics. Specifically, I work with the observed average growth rates in: the SSHRC budget (4.4% per year), the funds applied for by the researchers (5.7% per year), and the net inflow of new potential researchers, captured by the long-run increase in faculty members in the social sciences (1.5% per year). For trimming the proposed budgets, to replicate the main features of the observed series, I consider a sequence of values: 25% in the early years, 35% close to the reform, and 15% for three rounds after the reform. The initial value of the active researchers is chosen to match the observed success rate in the pre-reform periods. The dynamics of this simple "accounting" model allows computation of the otherwise unobservable stock of active researchers. This coincides with the number of grant applications, as I impose the assumption that all active and eligible (i.e., that are not grant holders) researchers do submit a grant application.[29]

[27] Performing this robustness check on the institution-level panel is not worthwhile. Starting from the 2014 fiscal year only the success rate is reported. This has the problematic consequence that it is not possible to reconstruct the number of applications for the large number of institutions that do not get funded. All the waves after 2013 have to be dropped. Aggregating the IG and IDG for only two years does not seem reasonable, as it would only provide an assessment of the short term response, which the time series data showed to be potentially different from the longer term one.

[28] The relevant stocks have to be included in the econometric model as an observable variable, while in the SSHRC dataset the active or potential researchers are unobservable.

[29] Since this is an aggregate analysis, for simplicity all researchers request the same amount. Proposals are funded until the SSHRC budget is fully allocated.

[Figure 3 about here]

Figure (3) follows the same structure of Figure (1), plotting the computed outcomes. The solid lines are generated under the assumption of no discouraged researchers. The lines with a short dash are generated by a similar model, which assumes that the baseline share of discouraged researchers is 15%, which decreases to 5% in the year before the reform, and increases to 30% in the post reform years.[30]

Both versions of the model replicate: i) the long-run increase in the available funding and a fast increase in the requested amounts at the time of the reform (Panel 2); ii) the slow decline in the success rates in the pre-reform period, its sudden drop, and the subsequent settling down to a new lower level (Panel 3); iii) the long-run increase in the funding per-project and the narrowing of the differential between the funds requested and received (Panel 4).

The main consideration arising from this robustness check is that the stock-flow dynamics induced by the SSHRC reform do not account for the behavior of the grant proposals submitted after 2012 (Panel 1). The plot shows that the projected paths under the business-as-usual assumption are affected by the stock-flow dynamics, but in a way that is at odds with the actual series. The observed series increased in the year following the reform, then it almost leveled for two years and started decreasing afterwards. Stock-flow dynamics imply an increase in the series for two periods, followed by a short-lived dip. Furthermore, unlike in the data, the number of applications always stays well above the corresponding value recorded in the year of the reform.[31]

The analysis shows that the reform changed the researchers' attitude towards submitting grant proposals beyond what is implied by stock-flow dynamics. Matching the "M-shaped" behavior in the applications seen in the data is easily achieved by imposing that an appropriate number of researchers become discouraged. What makes this step informative is that the needed changes in this parameter appear to be reasonable.

4.1.3 Academic Institutions: Size Vs. Funding Volatility

A possible concern related to working with the academic institutions panel is that an unobservable characteristic, such as their size, might be the main determinant in generating a steady and stable flow of research grants. This could cause a problem with the estimated parameters, because of an omitted variable bias. Fundamentally, this reinforces the need for using estimators that control for idiosyncratic effects. The size of Canadian academic institutions is a highly persistent characteristic, which is going to be picked up by the time-invariant component of the error term η_i.

If size were to be the only determinant in explaining the volatility of funding, the estimates associated with the funding instability variables could be severely biased. As an additional check, lacking information on the number of potential researchers, I collected some recent data on enrollments. I ranked the academic institutions

[30] For ease of comparison between the two cases, both model-generated series for the number of applications, for the funding per project, and for the available funding are normalized to 100 in year 1.

[31] I experimented with other parameter values, and these results are robust to other plausible assumptions on the growth rates in the SSHRC budgets, the trimming behavior of the adjudication committees, and the growth rates in the number of potential researchers in the Social Sciences.

by their size, dividing them in quartiles. There is indeed a negative correlation between the size of an institution and the funding instability.

To deal with this potential issue, I try to control for the institutions' size using a proxy. Lacking systematic information on the number of potential researchers and on the students enrolled in the social sciences, I added the number of researchers in the teams submitting a grant proposal as an additional control variable. Obviously, the number of grant proposals and the associated number of researchers are jointly determined. This would cause a simultaneity issue in the regressions. I then rely on the lagged value of the number of researchers as an additional explanatory variable. The inclusion of this regressor neither considerably alters the estimates nor the significance level of the parameters of interest. The results are robust, and are reported in Table 5 in Appendix C.

4.2 Taking Stock

In many respects, the Canadian experience is not unique. For Australia, Fretz and Veall (2001) report sizable differences across disciplines in both the funding rates and the awarded amounts. For the U.S., Stephan (2012) documents that the National Science Foundation (National Institute of Health) had research proposals funded at rates between 20% and 37% (10% and 40%). Furthermore, in the early 2000's the NSF increased the average grant size by 41%, with the side effect of reduced success rates. Given the different nature of the two systems, though, in the U.S. the number of applications (both overall and per applicant) increased. As argued above, this has not been the case for Canada. Conceivably, since Canadian post-secondary institutions typically do not rely on "soft money" to pay for their faculties' salaries (e.g., the summer support is guaranteed, as standard contracts for faculty members pay a salary for 12 months) Canadian researchers in the Social Sciences did not face an immediate and substantial cost of reduced research funding, with a number of researchers abandoning the routine of crafting grant proposals. They started seeking less public funding for their projects, which, especially for tenured faculties, can be less salient for their future careers and economic outcomes. I argued that part of the decline can be attributed to a more uncertain environment and to a deteriorating likelihood of success.

Some further observations can help understanding the current circumstances for Canadian researchers in the Social Sciences. In real terms, the growth rate of Canadian GDP in the 1995-2017 period has been 70.7%, the growth rate of SSHRC funds devoted to research grants was 158.3%. However, the resources distributed to some disciplines have grown more slowly: one of the worst performers was Economics, whose figure was only 62.5%. With a plummeting number of grant proposals prepared, in Canada the level of competition in the Social Sciences is declining. Coupled with stagnating resources in some disciplines, this may hurt the quality of research produced by Canadian scholars. In the absence of direct financial gains, experienced academics need appropriate incentives to invest time towards crafting strong grant proposals.

[Figure 4 about here]

The first panel in Figure (4) plots the Herfindahl concentration index for the SSHRC grants, computed with the institution-level panel. The index is quite volatile, ranging from 0.0456 to 0.0533. For the first ten years of the sample, the index showed a declining trend, which eventually reverted. Compared to the value of the index observed in many industries, the Canadian SSHRC grants do not seem to be overly concentrated. However, it is not obvious which sectors might represent a valid benchmark.

The second panel in Figure (4) shows the series with the number of faculties and student enrollment. Both have increased substantially. These data are aggregate, so they also include students and faculties in disciplines that are outside SSHRC's scope. However, the relative importance of the SSHRC disciplines has stayed virtually constant, as in 1997 and 2007 (the two years with relevant data) they accounted for 67.7% and 67.3% of the degrees granted by Canadian universities, respectively.[32] Applying an adjustment to these figures would not affect the trend. The Students-Teacher ratio has risen from 36.4 in 1992 to 44.6 in 2016, a 22.5% increase. This implies increased demands for teaching duties and student supervision. This dimension also does not seem to have created more chances to generate research output at a steady pace.

The total number of Principal Investigators and Co-investigators winning a grant in 2016 is estimated to be $1,994$.[33] To put this figure in perspective, the number of potential researchers in the Social Sciences can be estimated by summing the number of full-time faculties (full, associate and assistant professors), and multiplying this figure by 67% (the share of students obtaining degrees in the SSHRC disciplines).[34] In 2016, this figure was $27,501$. Assuming that the average duration of a grant is 3 years, this means that 21.6% of academics received some form of SSHRC funding in 2016.

5 Conclusions

In this paper I provided some empirical evidence on the determinants of the decision to apply for public research grants. Using data on Canadian researchers in the Social Sciences, I documented a number of facts, with an emphasis on the researchers' aversion to the instability of public funding. In particular, using panel data estimators that control for unobserved heterogeneity (i.e., the talent in research), I found that the volatilities of both the probability of funding and of the value of the awarded grants deter researchers from submitting grant proposals.

SSHRC, and other granting institutions, could try to smooth the value of grants awarded over time. This would prevent the detrimental effects of funding instability on the number of grant proposals. In a transitional period, some resources should be set aside, allowing a stock of wealth to be built. This would then be used to smooth fluctuations in budgets.

[32] Statistics Canada, CANSIM table 477-0014.

[33] This estimates excludes the collaborators, as their expenses cannot be directly financed, and they are not restricted to be affiliated with a Canadian institution. It is likely to be an upper bound, as some researchers received funding in multiple projects.

[34] This might be a crude estimate, potentially prone to a sizable error. However, I am not aware of any systematic Canadian data source on academic researchers by discipline.

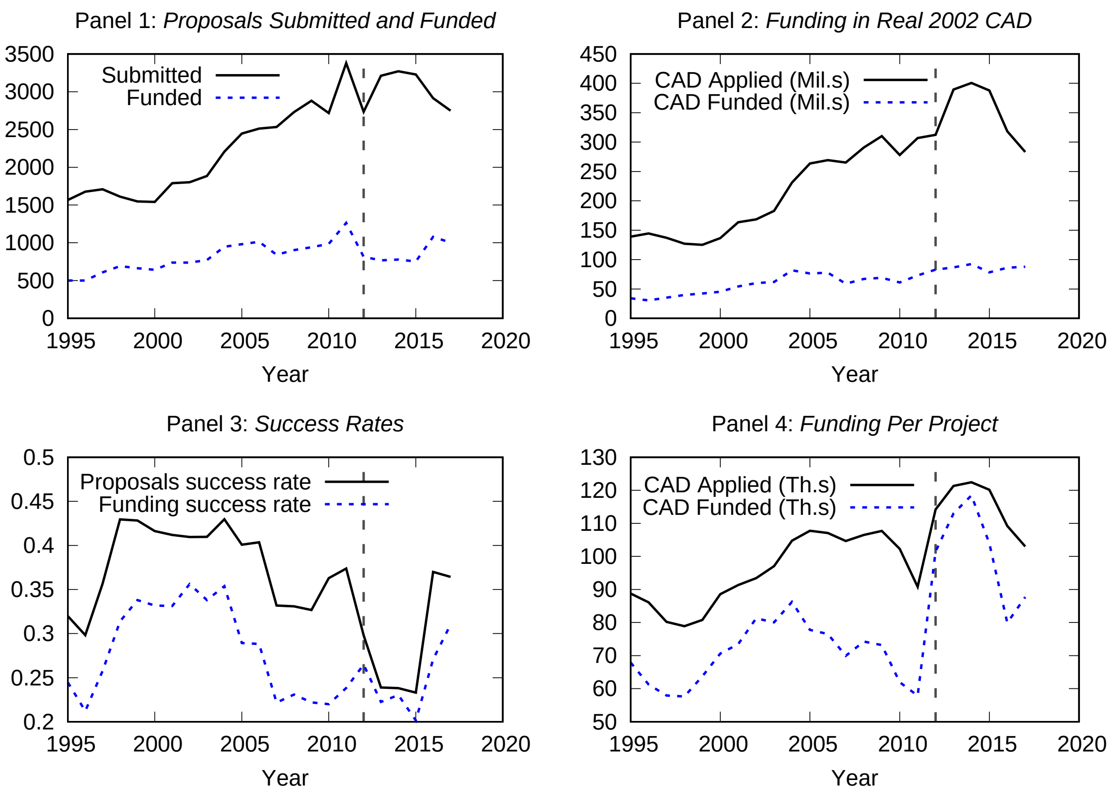

Figure 1: Trends for All SSHRC Disciplines, 1995-2017. The vertical lines represent the implementation of the 2012 SSHRC grants reform. Source: Author's calculations from SSHRC yearly reports.

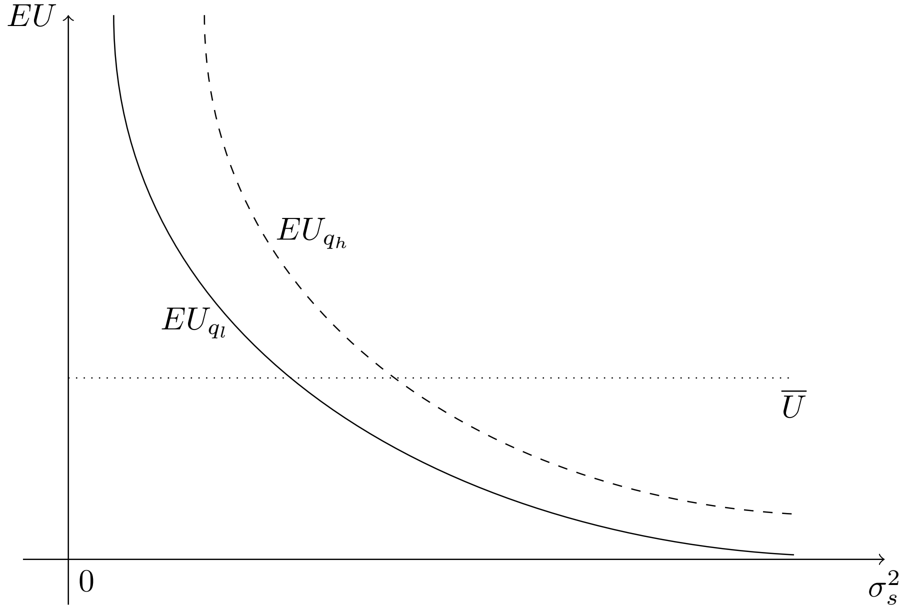

Figure 2: The research grant application decision. EU_q stands for the expected utility of submitting a proposal with true quality q, with $q_h > q_l$. $\overline{U}$ stands for the outside option of not submitting a proposal. σ_s^2 stands for the variance of the noise term in the assessment of the quality of a project.

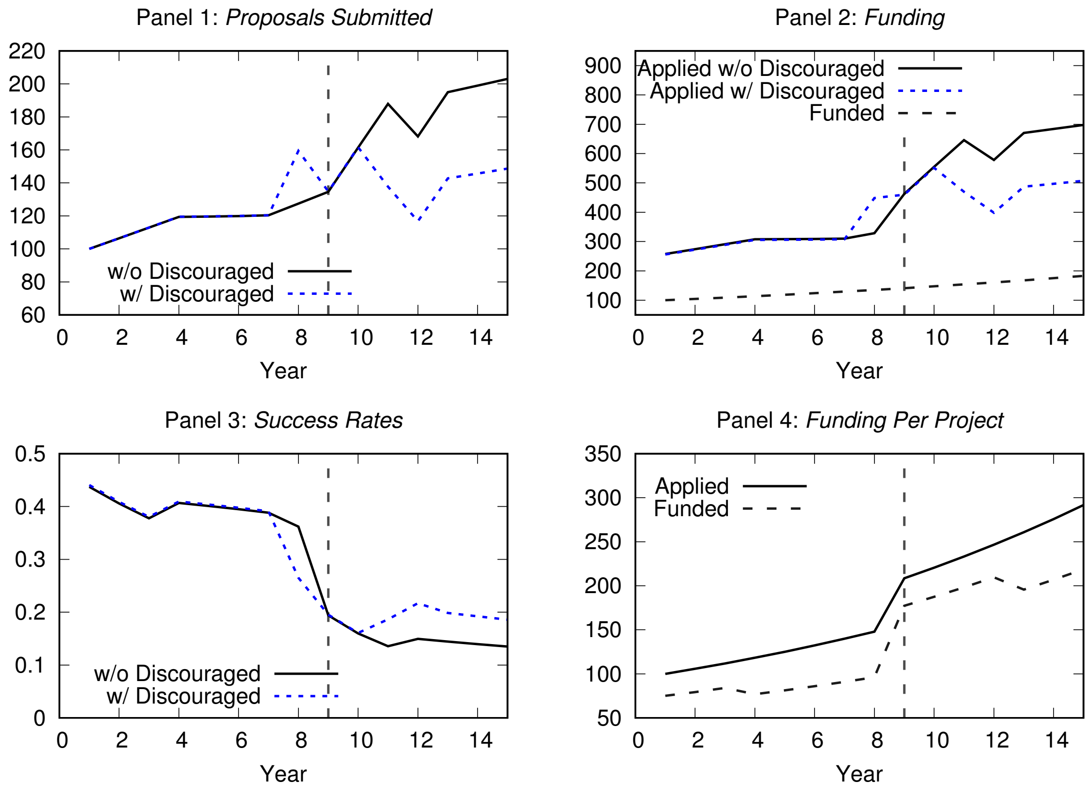

Figure 3: Stock-flow dynamics Vs. discouraged researchers. The vertical lines represent the implementation of the reform (in year 9). The solid lines are generated by a model assuming that there are no discouraged researchers. The lines with a short dash are generated by a model assuming that the baseline share of discouraged researchers is 15%, which decreases (increases) to 5% (30%) in the pre (post) reform period (periods). For ease of comparison, some model-generated series in levels are normalized to 100 in year 1. In Panel 4 the series with and without discouraged researchers overlap perfectly.

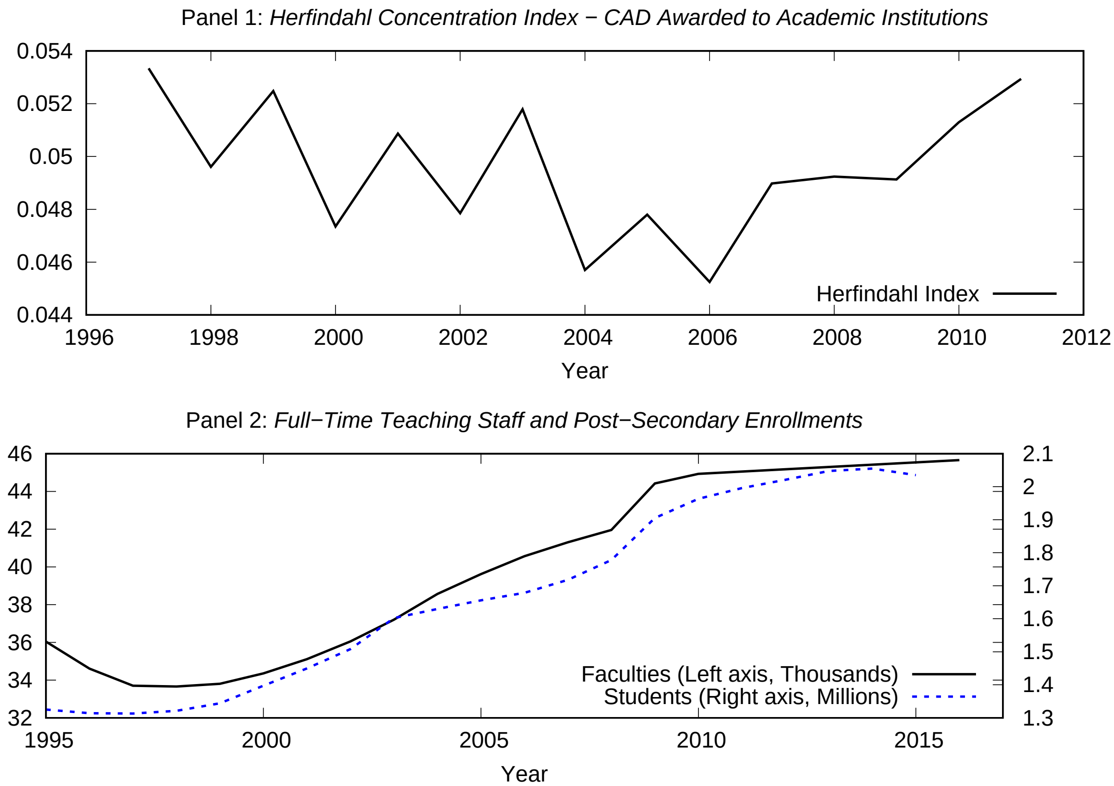

Figure 4: Trends for Herfindahl index, Faculties and Students, 1995-2016. The vertical lines represent the implementation of the 2012 SSHRC grants reform. Source: Author's calculations from SSHRC yearly reports and CANSIM data, series V53451372 and V79657395. For the Faculties series, the years from 2011 to 2015 are missing and are filled with a linear interpolation of the 2010 and 2016 data. The Herfindahl concentration index can only be computed for all SSHRC Disciplines.

	(1)	(2)	(3)	(4)
$proposals_{d,t-1}$	0.00189***	0.00187***	0.00155***	0.00209***
	(0.000396)	(0.000396)	(0.000400)	(0.000416)
$awardedcad_{d,t}$	-0.00924	-0.00410	-0.0467***	-0.0409***
	(0.0117)	(0.0119)	(0.0126)	(0.0127)
$successrate_{d,t}$	-0.216**	-0.308***	-0.119	-0.0952
	(0.108)	(0.113)	(0.114)	(0.114)
$cv\_awardedcad_{d,t-1}$		-0.214***	-0.200***	-0.194***
		(0.0660)	(0.0662)	(0.0670)
$cv\_successrate_{d,t-1}$		-0.142*	-0.139*	-0.134*
		(0.0836)	(0.0838)	(0.0848)
$awardedcad_{d,t+1}$			0.0887***	0.101***
			(0.00822)	(0.00869)
$successrate_{d,t+1}$			-0.402***	-0.447***
			(0.110)	(0.111)
$awardedcad_{d,t-1}$				-0.0423***
				(0.00924)
$successrate_{d,t-1}$				0.00571
				(0.112)
N	411	411	411	411

Standard errors in parentheses. * $p < 0.125$, ** $p < 0.05$, *** $p < 0.01$.

Table 1: Poisson panel data regressions for the number of grant applications ($proposals_{d,t}$), discipline-level data, 1995-2011. The regressions include time dummies and discipline fixed-effects. $cv\_x_{d,t-1}$ stands for the 3-year rolling coefficient of variation of the explanatory variable x before period t.

	(1)	(2)	(3)	(4)
$proposals_{i,t-1}$	0.00581***	0.00486***	0.00524***	0.00702***
	(0.000651)	(0.000663)	(0.000690)	(0.000744)
$awardedcad_{i,t}$	-0.0618***	-0.0827***	-0.0675***	-0.0578***
	(0.0137)	(0.0140)	(0.0142)	(0.0148)
$successrate_{i,t}$	-0.297***	-0.220***	-0.291***	-0.192**
	(0.0763)	(0.0763)	(0.0783)	(0.0785)
$cv\_awardedcad_{i,t-1}$	-0.103**	-0.0772*	-0.0863*	-0.104**
	(0.0502)	(0.0502)	(0.0503)	(0.0510)
$cv\_successrate_{i,t-1}$	-0.151***	-0.164***	-0.178***	-0.110**
	(0.0549)	(0.0549)	(0.0555)	(0.0559)
$awardedcad_{i,t+1}$		0.0883***	0.106***	0.118***
		(0.0110)	(0.0115)	(0.0116)
$successrate_{i,t+1}$		0.0228	-0.0279	0.0359
		(0.0757)	(0.0766)	(0.0772)
$awardedcad_{i,t-1}$			-0.0531***	-0.0112
			(0.0114)	(0.0130)
$successrate_{i,t-1}$			-0.159**	-0.128*
			(0.0763)	(0.0762)
$tot\_awardedcad_{i,t-1}$				0.00167
				(0.00390)
$tot\_proposals_{i,t-1}$				-0.000465***
				(0.000168)
N	1041	1041	1041	1041

Standard errors in parentheses. * $p < 0.125$, ** $p < 0.05$, *** $p < 0.01$.

Table 2: Poisson panel data regressions for the number of grant applications ($proposals_{i,t}$), institution-level data, 1997-2011. The regressions include time and province dummies, and institution random-effects. $cv\_x_{i,t-1}$ stands for the 3-year rolling coefficient of variation of the explanatory variable x before period t. $tot\_x_{i,t}$ stands for the running total at the post-secondary institution level up to period t.

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Appendix A - Data and Estimation

- The raw data on the SSHRC grants used in this paper can be downloaded from the following website:

  `http://www.sshrc-crsh.gc.ca/results-resultats/stats-statistiques/index-eng.aspx`

- Notes for the discipline panel dataset creation: a) if in a year there are no applications submitted in a discipline, the related awarded funding is set to zero. b) From 1997, "Literature" becomes "Literature and Modern Languages". I computed the intermediate sums, as this discipline used to be disaggregated into several languages. c) In 1998, there is a "Not applicable" category with 1 application, distinct from the "Other" category: I dropped it. d) From 2000, the "Administrative Studies" discipline was relabeled as "Management/Business/Administrative Studies". For consistency, I relabeled the former category also for the first part of the sample. e) In 2001 and 2002 "Folklore" is not included: I assigned missing values. There is also a new discipline: "Women's Studies". "Nursing" and "Public Health" were in the "Other" category, and I included "Women's Studies" under "Other" as well. f) In 2007, "Modern Languages and Literature" becomes "Literature and Modern Languages". I relabeled the former category also for the first part of the sample. g) From 2005, "Women's Studies" and "Medical Studies" no longer appear as disciplines. h) In 2005, "Archival Science" does not appear: I treated it as a missing value. i) In 2013, the IDG has an "Unknown" category with a 25% success rate: I dropped it.

- The estimation was performed with STATA SE 15.1, and the panel data regressions use STATA built-in estimators and commands.

- Since the number of proposals is a count variable, I relied on a panel data version of a poisson regression with Random Effects or Fixed Effects. The typical STATA commands are:

  - For the discipline-level data:

    ```
    xtpoisson applications lapplications lsuccessrate lawardedcad successrate
              awardedcad awardedcad_cv successrate_cv i.year, fe
    ```

  - For the institution-level data:

    ```
    xi, noomit:  xtpoisson applications lapplications lsuccessrate lawardedcad
       successrate awardedcad awardedcad_cv successrate_cv i.year i.region
    ```

Appendix B - List of Academic Institutions

Id	*Institution*	*Id*	*Institution*
1	*Memorial*	31	*HEC Montréal*
2	*U Prince Edward Island*	32	*ENAP*
3	*Acadia*	33	*INRS*
4	*Cape Breton*	34	*Télé-université*
5	*Dalhousie*	35	*UQÀChicoutimi*
6	*King's College (Halifax)*	36	*UQÀHull*
7	*Mount Saint Vincent*	37	*UQÀMontréal*
8	*NS Agricultural College*	38	*UQÀRimouski*
9	*NS College of Art and Design*	39	*UQOutaouais*
10	*Saint Mary's*	40	*UQAbitibi-Témiscamingue*
11	*Sainte-Anne*	41	*UQTrois-Rivières*
12	*St. Francis Xavier*	42	*Sherbrooke*
13	*Atlantic Baptist College*	43	*Dawson College*
14	*Moncton*	44	*Marianopolis College*
15	*Mount Allison*	45	*Collège Valleyfield*
16	*New Brunswick*	46	*Vanier College*
17	*St. Thomas*	47	*Brock*
18	*Cégep de Maisonneuve*	48	*Carleton*
19	*Cégep Drummondville*	49	*Collège Dominicain*
20	*Cégep du Vieux Montréal*	50	*Confederation College*
21	*Cégep Édouard-Montpetit*	51	*Guelph*
22	*Collège John Abbott*	52	*Lakehead*
23	*Collège Lionel-Groulx*	53	*Laurentian*
24	*Collège Saint-Jean-sur-Richelieu*	54	*McMaster*
25	*Bishop's*	55	*Nipissing*
26	*Concordia*	56	*Ontario Bible College*
27	*Laval*	57	*OCAD University*
28	*McGill*	58	*Ontario Institute of Technology*
29	*Montréal*	59	*Ottawa*
30	*École Polytechnique de Montréal*	60	*Queen's*

Table: Units of Observation in the Panel Dataset

Id	*Institution*	*Id*	*Institution*
61	*Redeemer University College*	91	*Algonquin College of Applied Arts*
62	*Royal Military College*	92	*Canadian College of Naturopathic Medicine*
63	*Ryerson*	93	*Hearst University*
64	*Saint Paul*	94	*Humber College*
65	*Sault College of Applied A&T*	95	*Institute for Christian Studies*
66	*Sudbury U*	96	*McMaster Divinity College*
67	*Seneca College*	97	*Brandon*
68	*Sheridan Institute of TAL*	98	*Canadian Mennonite U*
69	*St. Michael's Hospital*	99	*Manitoba*
70	*Toronto*	100	*Université de Saint-Boniface*
71	*Pontifical Institute of Mediaeval Studies*	101	*Winnipeg*
72	*Trinity College (UoT)*	102	*Briercrest College and Seminary*
73	*St. Michael's College (UoT)*	103	*Regina*
74	*Victoria College (UoT)*	104	*Campion College*
75	*Wycliffe College (UoT)*	105	*Luther College Regina*
76	*Toronto School of Theology*	106	*Saskatchewan*
77	*Trent*	107	*St Thomas More Collegiate*
78	*Waterloo*	108	*Alberta*
79	*Renison College*	109	*Ambrose U/Canadian Bible College*
80	*St. Paul's United College*	110	*Athabasca*
81	*Saint Jerome's U*	111	*Augustana University College*
82	*Western Ontario*	112	*Calgary*
83	*Brescia University College*	113	*Concordia University Edmonton*
84	*Huron College*	114	*The King's University (Edmonton)*
85	*King's University College*	115	*Lethbridge U*
86	*Knox College*	116	*Taylor College and Seminary*
87	*Wilfrid Laurier*	117	*Grant MacEwan*
88	*Windsor*	118	*Medicine Hat College*
89	*York*	119	*Mount Royal University*
90	*Algoma University College*	120	*Southern Alberta Institute of Technology*

Table: Units of Observation in the Panel Dataset

Id	*Institution*
121	*Grande Prairie Regional*
122	*Lethbridge Community*
123	*Red Deer College*
124	*St. Mary's University College*
125	*U of British Columbia*
126	*Regent College*
127	*Fraser Valley U*
128	*Kwantlen Polytechnic University*
129	*Northern British Columbia*
130	*Northern Lights College*
131	*Okanagan College*
132	*Royal Roads U*
133	*Simon Fraser*
134	*Thompson Rivers*
135	*Trinity Western*
136	*Victoria*
137	*British Columbia Institute of Technology*
138	*Camosun College*
139	*Capilano University*
140	*Vancouver Island U*
141	*North Island College*
142	*Columbia Bible College*
143	*Emily Carr University of Art & Design*
144	*Vancouver School of Theology*
145	*Yukon College*

Table: Units of observation in the institution panel dataset. Notes: a) Yukon is lumped together with Atlantic Canada in terms of geographical region. b) In the year 2000 the Research Time Stipend was introduced, which lasted until 2010: I consider the total requested and awarded (inclusive of the RTS). c) U of Michigan, Kalamazoo, Cambridge applied (most likely due to researchers that moved) but were dropped as they are outside Canada. d) Institutions that changed name were kept as the same institution (e.g., in 2005 University College of the Cariboo was renamed as Thompson Rivers University). e) The Technical University of British Columbia applied in 2002, but it was in operation only between 1999 and 2002 (it was dropped from the dataset). f) The First Nations University of Canada had a complicated history (it was put on probation and applied only in 2006, so it was dropped from the dataset). g) Tyndale UC applied only in 2011 (it was dropped from the dataset). h) The following institutions had their name listed in the SSHRC reports, but never applied in the sample period and were dropped in some regressions: Cégep du Vieux Montréal, Cégep Édouard-Montpetit, Confederation College, St. Michael's Hospital, Southern Alberta Institute of Technology.

Appendix C - Robustness

	(1)	(2)	(3)	(4)	(5)
	All	All	All	All	No small
$proposals_{d,t-1}$	0.00170***	0.00170***	0.000911***	0.00100***	0.000917***
	(0.000236)	(0.000237)	(0.000247)	(0.000256)	(0.000248)
$awardedcad_{d,t}$	0.0190***	0.0224***	0.00187	0.00176	0.00178
	(0.00699)	(0.00709)	(0.00729)	(0.00733)	(0.00731)
$successrate_{d,t}$	-0.390***	-0.538***	-0.385***	-0.367***	-0.400***
	(0.0939)	(0.0985)	(0.0992)	(0.0996)	(0.101)
$cv\_awardedcad_{d,t-1}$		-0.219***	-0.202***	-0.213***	-0.207***
		(0.0522)	(0.0521)	(0.0524)	(0.0525)
$cv\_successrate_{d,t-1}$		-0.305***	-0.317***	-0.335***	-0.356***
		(0.0631)	(0.0631)	(0.0635)	(0.0648)
$awardedcad_{d,t+1}$			0.0707***	0.0756***	0.0714***
			(0.00503)	(0.00552)	(0.00505)
$successrate_{d,t+1}$			-0.513***	-0.521***	-0.575***
			(0.0954)	(0.0956)	(0.0983)
$awardedcad_{d,t-1}$				-0.00794	
				(0.00585)	
$successrate_{d,t-1}$				-0.220**	
				(0.0968)	
N	571	571	571	571	546

Standard errors in parentheses. * $p < 0.125$, ** $p < 0.05$, *** $p < 0.01$.

Table 3: Poisson panel data regressions for the number of grant applications ($proposals_{d,t}$), discipline-level data, 1995-2017. The regressions include time dummies and discipline fixed-effects. $cv\_x_{d,t-1}$ stands for the 3-year rolling coefficient of variation of the explanatory variable x before period t. The specification *No small* drops the observations for smaller disciplines, whose name and category changed over time.

	(1-FE)	(2-RE)	(3-RE)
$proposals_{i,t-1}$	0.00642***	0.00677***	0.00631***
	(0.000746)	(0.000747)	(0.000914)
$awardedcad_{i,t}$	-0.0549***	-0.0522***	-0.0650***
	(0.0148)	(0.0150)	(0.0209)
$successrate_{i,t}$	-0.233***	-0.186**	-0.221**
	(0.0797)	(0.0771)	(0.0871)
$cv\_awardedcad_{i,t-1}$	-0.0949*	-0.102**	-0.0991*
	(0.0511)	(0.0510)	(0.0511)
$cv\_successrate_{i,t-1}$	-0.0900*	-0.111**	-0.115**
	(0.0561)	(0.0555)	(0.0557)
$awardedcad_{i,t+1}$	0.117***	0.121***	0.124***
	(0.0117)	(0.0116)	(0.0119)
$successrate_{i,t+1}$	-0.0229	0.0318	0.0233
	(0.0777)	(0.0769)	(0.0776)
$awardedcad_{i,t-1}$	-0.0135		
	(0.0130)		
$successrate_{i,t-1}$	-0.161**		
	(0.0772)		
$proposalsfunded_{i,t-1}$			0.00221
			(0.00252)
$tot\_awardedcad_{i,t-1}$	0.00270	0.00995	0.0111
	(0.00391)	(0.00758)	(0.00769)
$tot\_proposals_{i,t-1}$	-0.000490***	-0.000247	-0.000201
	(0.000168)	(0.000206)	(0.000212)
$tot\_propfunded_{i,t-1}$		-0.00117	-0.00135*
		(0.000787)	(0.000814)
N	1017	1041	1041

Standard errors in parentheses. * $p < 0.125$, ** $p < 0.05$, *** $p < 0.01$.

Table 4: Poisson panel data regressions for the number of grant applications ($proposals_{i,t}$), institution-level data, 1997-2011. The regressions include time dummies, and either institution Fixed-Effects (FE) or institution Random-Effects (RE), and province dummies. $cv\_x_{i,t-1}$ stands for the 3-year rolling coefficient of variation of the explanatory variable x before period t. $tot\_x_{i,t}$ stands for the running total up to period t.

	(1)	(2)	(3)	(4)
$proposals_{i,t-1}$	0.00661***	0.00545***	0.00649***	0.00645***
	(0.00107)	(0.00108)	(0.00112)	(0.00113)
$awardedcad_{i,t}$	-0.0609***	-0.0822***	-0.0527***	-0.0580***
	(0.0137)	(0.0140)	(0.0151)	(0.0148)
$successrate_{i,t}$	-0.298***	-0.221***	-0.186**	-0.190**
	(0.0763)	(0.0763)	(0.0772)	(0.0785)
$cv\_awardedcad_{i,t-1}$	-0.103**	-0.0771	-0.103**	-0.104**
	(0.0502)	(0.0502)	(0.0510)	(0.0510)
$cv\_successrate_{i,t-1}$	-0.148***	-0.162***	-0.112**	-0.112**
	(0.0550)	(0.0550)	(0.0555)	(0.0560)
$researchers_{i,t-1}$	-0.000418	-0.000312	0.000166	0.000312
	(0.000445)	(0.000446)	(0.000499)	(0.000456)
$awardedcad_{i,t+1}$		0.0884***	0.121***	0.118***
		(0.0110)	(0.0116)	(0.0116)
$successrate_{i,t+1}$		0.0185	0.0348	0.0403
		(0.0760)	(0.0775)	(0.0775)
$awardedcad_{i,t-1}$				-0.0104
				(0.0131)
$successrate_{i,t-1}$				-0.127*
				(0.0762)
$tot\_awardedcad_{i,t-1}$			0.00886	0.00143
			(0.00825)	(0.00392)
$tot\_proposals_{i,t-1}$			-0.000264	-0.000461***
			(0.000212)	(0.000168)
$tot\_propfunded_{i,t-1}$			-0.00105	
			(0.000865)	
N	1041	1041	1041	1041

Standard errors in parentheses. * $p < 0.125$, ** $p < 0.05$, *** $p < 0.01$.

Table 5: Poisson panel data regressions for the number of grant applications ($proposals_{i,t}$), institution-level data, 1997-2011. The regressions include time dummies, institution Random-Effects (RE), and province dummies. $cv\_x_{i,t-1}$ stands for the 3-year rolling coefficient of variation of the explanatory variable x before period t. $tot\_x_{i,t}$ stands for the running total at the post-secondary institution level up to period t.