On the Underfunding of Mathematics

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I would like to address the issue of the systemic underfunding of mathematics Discovery Grants in NSERC's Evaluation Group 1508. I believe that this is one of the major issues facing our research discipline currently and in the future. Even if this issue is not officially part of the LRP committee's mandate, I think this is a point that must be addressed since it impacts every scientist who receives funding through EG 1508.

My aim here is to provide a list of arguments that might be used by the committee, along with data to support them whenever possible. Several of the arguments in this paper are borrowed from others, without attribution. I am sure that many of these points also apply to statistics; however, I have written this from the perspective of a mathematician and I will make no attempt here either to paint both disciplines with the same brush or to make any fine distinctions between them.

It is essential that we accompany our claims of underfunding with hard data to support them. I have tried to find data from the NSERC Awards Search Engine as well as other on-line sources that are indicated below. I should also note that while I have checked through these data several times, it would be helpful if someone else could take an independent look through the numbers.

1 Arguments to Support Underfunding of Mathematics

1. According to the data provided by NSERC on the 2010 competition, EG 1508 had a minimum grant of $12,000, average grant of $19,656, and maximum grant of $53,000. These figures are the lowest of any other group, by a significant margin. For comparison, the average grants in a few other EGs that have significant significant scientific overlap with mathematics are: Computer Science ($27,044), Civil/Industrial Engineering ($30,131), Physics ($40,828) and Mechanical Engineering ($27,199).

2. David Wehlau collected some very telling data on Discovery Grants in mathematics that is posted on Nassif Ghoussoub's weblog[1] (see Table 3). The data show a clear and steady decline in total DG funding for mathematics since 1997, when viewed as a percentage of the total.

3. The international comparison in Section 2 below indicates that mathematics funding is anomalously low relative to other disciplines, when the Canadian figures are compared to similar programs from granting agencies in other countries.

4. Mathematicians' access to non-NSERC sources of research funding (CIHR, industrial programs, foundations, etc.) is significantly limited compared to applicants from other EGs. This is partly due to the requirement that mathematicians must act in collaboration with application scientists in order for their work to be relevant to industry. Consequently, mathematicians' reliance on NSERC DGs to fund their research is greater on average than in other discipline. Any reductions in NSERC support (either absolute or relative to other disciplines) have a proportionately greater impact in mathematics.

[1] http://ghoussoub.wordpress.com/2011/02/18/20-years-of-nserc-funding-for-discovery

5. The recent NSERC policy of earmarking the bulk of their research budget increases to "industrial" programs has left mathematicians even more disadvantaged relative to other disciplines. Some applied mathematicians have obviously responded to this new reality by re-aligning their research programs more closely with industry. Nonetheless, the sustained negative impacts on the rest of the math community over the past several years are having a detrimental effect on our discipline.

6. NSERC data suggests that HQP expenses make up the majority of NSERC DG

   expenditures – 60% according to recent NSERC data[2]. Since students and PDFs are paid roughly similar salaries across disciplines, any difference in costs of research can mostly be accounted for by differences in the numbers of HQP supported. We should try to get data comparing number of HQP and also discuss funding norms for students/PDFs in math relative to other disciplines. Otherwise, we are vulnerable to the criticism that "mathematicians support fewer HQP and therefore they deserve smaller DGs." This may be the case for some researchers, but is certainly not uniformly true.

   Nonetheless, somewhat lower HQP numbers are still a feature of mathematics. But it is important to point out that this is not due to an unwillingness to contribute to training, or to a lack of relevant/interesting problems for students. A few explanations for why student numbers may tend to be lower in mathematics are:

   - Historically small grants and limited access to other sources of funding mean that Canadian mathematicians cannot support more than a few students at once.
   - Training of HQP in theoretical areas requires a larger investment in terms of supervision and training relative to other disciplines.
   - Expanding on the last point, researchers in experimental disciplines tend to act as "managers" to some extent, with labs running themselves through a more hierarchical management structure. This occurs only very rarely in mathematics research groups.

7. There is some evidence to suggest that a significant number of mathematicians (and especially first-time applicants) are fleeing the EG 1508 for other EGs. There is no difference in the actual costs of research whether the applicant sits in one EG or the other, and yet a much higher grant can be obtained by applying to the non-math EG. The data on mathematicians' average grants in Section 3 supports this argument. However, the option of applying to another EG is not open to many mathematicians, especially those in the pure sub-group.

8. The loss of MITACS NCE funds in 2012 will have a serious impact on funding of mathematics research in Canada. Since upwards of 80% of NCE project funds are spent on HQP, this impact will be felt most intensely in the area of training of graduate students and postdocs. We could include data on the total of MITACS project funding received in departments of mathematics and get a concrete measure of its impact by comparing to the NSERC DG budget for mathematics.

9. I think it is clear to most mathematicians that mathematics in Canada is a strong discipline; it compares well with other countries worldwide and is worthy of funding at internationally competitive levels. However, this claim is in direct contrast with the 2008 STIC report[3] (Fig. 16 on page 32) which indicates that mathematics is the only discipline in Canada with a negative "average relative impact factor." This discrepancy must be addressed since it is sure to be taken into account by NSERC and/or the CCA panel and used to counter any arguments we might make about the strength of mathematics in Canada. Can someone identify flaws in the STIC methodology? Are there concrete measures we can provide indicating the strength of our discipline?

[2]See the International Review of the NSERC Discovery Grants Program at http://www.nserc-crsng.gc.ca/NSERC-CRSNG/Reports-Rapports/consultations-consultations_eng.asp.

[3]http://www.stic-csti.ca/eic/site/stic-csti.nsf/eng/h_00011.html

10. One possible way to counter the STIC report is to look at specific instances where mathematicians have competed directly with scientists from other disciplines on a level playing field. A few examples:

    - In recent Discovery Accelerator Supplement competitions, there are examples of mathematicians (in this case, I mean researchers from math departments) who are funded from a non-math EG that also received a DAS award. Are these numbers large enough to make a convincing case? Data from the current competition should definitely be included once they are available.
    - The track record of the MITACS NCE is clear evidence of mathematicians' ability to leverage industry *cash support* for both pure and applied research in the context of collaborative and long-term projects in industrial problems. The success of this effort in leveraging industry contributions has yet to be matched by any NCE or other similar research organization led from another discipline.

11. A small increase in the math DG budget would have a major impact on remedying the worst of the budget effects suffered in the 2011 DG competition. There is evidence to suggest that as little as $200,000 would have had a major corrective effect – incidentally, this amount is less than two bin-A DG awards from all but two of the other EGs. Considering the size of the total NSERC DG budget, this is a very small adjustment that would have had a comparably huge positive effect on the outcome of the DG competition for mathematics – a small price to pay for righting past injustices. That said, I think we also need to be careful to argue that an amount of this size is still insufficient to solve the much larger problem of the long-standing funding deficit in mathematics.

12. It is frustrating to hear the standard NSERC response that any budget reallocation must wait until the CCA report is completed. This report is only due to be written next year, and any EG reallocation is likely to require another 1-2 years before being actually implemented at NSERC. The underfunding issue is crippling the discipline right now, and if the current state of affairs continues for another 2-3 years then the impacts on mathematics will be even more severe. Is it really necessary to wait so long to at least partially correct the budget disparities discussed in the previous point?

2 International Comparison of Grant Levels by Discipline

In Table 1 below, I have compared the average math Discovery Grants (amounts in $000's) to grants in other disciplines, with the ratio of the DG amount to that in mathematics being the key indicator (rather than the absolute grant amount). To afford an international comparison and emphasize the anomalously low funding of mathematics in Canada, I have included similar figures for other granting agencies in the latest year available – namely, NSF in the USA, EPSRC in the UK, and ARC in Australia. International ratios of grants in other disciplines to those in math hover around an average of 1.3, while in Canada the ratio ranges from 1.4 to 2.8. Clearly, something is amiss!

Table 1: Comparison of research grants by discipline and funding agency.

Discipline	NSERC 2008-09	NSF 2009	EPSRC 2010	ARC 2010
Math Sci.	$19.6 (1.0)	US$138 (1.0)	£350 (1.0)	AU$112 (1.0)
Comp. Sci.	$27.0 (1.4)	US$188 (1.4)	?	AU$112 (1.0)
Mech. Eng.	$27.2 (1.4)	US$120 (0.87)	£459 (1.3)	AU$112 (1.0)
Physics	$40.8 (2.1)	US$138 (1.0)	£501 (1.4)	AU$130 (1.2)
Chemistry	$55.1 (2.8)	?	£412 (1.2)	AU$130 (1.2)

A number of comments are in order here to highlight differences in the funding norms in the granting programs of the international agencies represented here:

- For some agencies (e.g., NSF) the grant amount includes PI salary support, while for NSERC such expenses are not allowed. Consequently, grant amounts cannot be compared directly. However, assuming salary amounts are roughly comparable across disciplines, the ratio of grant size relative to math should afford a reasonable comparison.
- For NSERC[4]: Grant amounts are average figures taken from the 2008-09 competition results.
- For NSF[5]: Math and Physics are grouped together. The amounts represent a total of grants from many programs with different durations, including conference grants.
- For EPSRC[6]: Computer Science is bundled with Math (I think). The figure represents the average total funding for grants that can last anywhere of from 1 to 5 years, and also includes Institutes.
- For ARC[7]: Math, Engineering and Computer Science are grouped together, as are Physics and Chemistry. The amount shown is a yearly value for 3-year grants.
- Since the math institutes technically support basic research, should they be included in this figure? NSERC might claim that we should. Total annual funding for BIRS, PIMS, Fields and CRM from the NSERC MRS program is $4.08M. If this figure is included in the annual Discovery Grants total, then the "average grant" increases significantly. But then we'd also need to include the MRS-like facilities in other disciplines and countries to get a reasonable comparison (e.g., NSF Institutes, Newton Institute in the UK, Perimeter Institute, etc.). I'm not sure it's possible to make a sensible comparison.

3 Comparison of Average Grant Amounts in Math

The data in this section are taken from the NSERC Awards Search Engine, searching for grants held in departments of mathematics (department = "math") and separated by GSC/EG. Table 2 summarizes the amounts of grants held during fiscal 2009/10. Data on new grants awarded in competition year 2010 are then listed in Table 3, which has no overlap with the data in the Table 2. These results are reported by Evaluation Group, so that pure/applied mathematics and statistics are not separated.

Table 2: Summary of grants held in mathematics departments in fiscal 2009/10, separated by GSC.

GSC	Funding	# grants	Avg. grant
Pure/Applied A	$6,296,700	353	$17,837
Pure/Applied B	4,504,335	253	17,803
Statistics	2,704,807	152	17,794
Other GSCs	4,857,596	199	24,410
Total	$18,363,438	957	$19,188

Table 3: Summary of grants awarded to mathematics departments in the 2010 competition.

EG	Funding	# grants	Avg. grant
Math/Stats	$2,911,180	149	$19,538
Other EGs	757,200	27	28,044
Total	$3,668,380	176	$20,843

[4] http://www.nserc-crsng.gc.ca/_doc/Professors-Professeurs/2010-DG-CompStat_e.pdf
[5] http://www.nsf.gov/nsb/publications/2010//nsb1027.pdf
[6] http://gow.epsrc.ac.uk/ListProgrammes.aspx
[7] http://www.arc.gov.au/ncgp/dp/DP11_selrpt.htm

Some observations:

- The average grants in Table 2 are fairly consistent between mathematics and statistics.
- There is a significant difference in average grant amount for mathematicians applying to EG 1508 versus other EGs. This gap was approximately \$7,000 pre-2010 and increased to \$8,500 in the 2010 competition.
- One notable feature of the 2010 competition was the increase in the average math grant amount by about \$2,000, accompanied by a lower success rate. Table 4 provides a comparison of success rates for the past few years, drawn from NSERC data[8].

Table 4: Success rates in recent competitions.

Year	Pure/Applied	Statistics
2008	76.6%	69.7%
2009	64.4%	67.0%
2010	61.9%	

[8] http://www.nserc-crsng.gc.ca/NSERC-CRSNG/FactsFigures-TableauxDetailles_eng.asp