Worldwide research output in probability and statistics: an update

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Abstract: The authors update the work of Genest (1997, 1999) on world research output in probability and statistics. The rankings they produce of countries and institutions are based on a survey of papers published between 1986 and 2000 in 25 specialized journals of high reputation in these two fields. The contribution of Canadian probabilists and statisticians is highlighted.

La production mondiale de recherche en probabilités et statistique : une mise à jour

Résumé : Les auteurs actualisent les travaux de Genest (1997, 1999) sur la production mondiale de recherche en probabilités et en statistique. Les palmarès de pays et d'établissements de haut savoir qu'ils produisent s'appuient sur une recension des écrits parus entre 1986 et 2000 dans 25 revues spécialisées de renom dans ces deux disciplines. L'apport des probabilistes et statisticiens canadiens est mis en évidence.

1. INTRODUCTION

In Canada, the Natural Sciences and Engineering Research Council (NSERC) is the primary source of public funding for fundamental and applied research in the statistical sciences. In the context of a periodic review of this agency's budget allocations between disciplines, productivity rankings of countries and institutions based on paper, author and adjusted page counts were derived a few years ago by the first author (Genest 1997, 1999) in order to assess Canada's contribution to the volume of new methodology generated annually in probability theory and statistics.

These studies were based on a survey of 25 peer-reviewed journals of high international repute, nine specializing in probability theory and 16 in statistics, over the period 1985–95. An updated version of the same data base was also used on a subset of statistics journals by Gil, Peña & Rodríguez (2000) to compare the performance of European countries.

Publication counts merely measure scientific activity, not the influence or value of the results it produces. Nonetheless, productivity indicators are deemed to be of strategic importance by science policy makers worldwide. In view of the broad support given to this type of bibliometric work and the enthusiastic interest generated in the community by previous reports, excerpts of the update that was prepared recently for NSERC's 2002 Reallocations Exercise seemed well worth publishing.

The methodology is briefly described in Section 2 and rankings of countries and institutions based on gross and per capita or per contributor production are given in Sections 3 and 4, respectively. Section 5 provides details on the Canadian performance, and a few summary statistics about the nationality of the most prolific probabilists and statisticians appear in Section 6.

As in earlier editions, the interpretation of data is obviously contingent on the choice of journals, time period and counting rules. The readers are also reminded that particularly at finer levels, ranks depend on scores that do not always reflect significant distinctions between successive positions.

2. THE DATA

The data consist of all research articles published between 1986 and 2000 inclusively in the 25 international refereed journals listed in Table 1. The 16 statistics journals are those considered in Genest (1997), and the nine probability journals are those used by Genest (1999).

TABLE 1: Journals included in the study with the number of articles (ART), authors (AUT), distinct authors (DIS), countries (CTR), institutions (INS) and adjusted pages (PAG) published between 1986 and 2000; F is the scale factor used to convert the nominal number of pages published in each journal into PAG, the equivalent number of pages of *The Annals of Statistics* or of *The Annals of Probability*. This factor changed to 1.70 in 1999 for *Biometrics*.

Journal	ART	AUT	DIS	CTR	INS	PAG	F
Advances in Applied Probability	906	1530	946	44	410	16411	1.03
Annales de l'I. H. P. : Probabilités et Statistiques	403	640	453	32	182	8418	0.84
Annals of Applied Probability	448	817	567	33	254	10298	1.00
Annals of Probability	1331	2140	984	43	384	27823	1.00
Journal of Applied Probability	1445	2346	1476	53	597	16177	1.05
Journal of Theoretical Probability	585	911	588	41	305	9625	0.83
Probability Theory and Related Fields	1223	1915	1075	46	423	24348	0.90
Stochastic Models	518	931	591	34	292	10717	1.00
Stochastic Processes and their Applications	1330	2150	1319	44	527	23016	1.02
Annals of Statistics	1751	2897	1374	41	494	31185	1.00
Annals of the Institute of Statistical Mathematics	804	1344	902	42	417	10877	0.94
Australian & New Zealand Journal of Statistics	538	921	626	38	279	6964	1.14
Biometrics	1959	3981	2314	52	742	23972	1.19
Biometrika	1399	2504	1513	45	566	15253	1.18
Canadian Journal of Statistics	667	1208	810	41	320	8302	1.06
International Statistical Review	354	556	458	37	249	6200	1.21
Journal of Multivariate Analysis	1098	1838	1139	50	506	15780	0.84
Journal of Statistical Planning and Inference	2102	3686	2289	59	825	27442	0.94
Journal of the American Statistical Association	2361	4437	2356	52	739	37746	1.96
Journal of the Royal Statistical Society Series B	654	1194	796	33	329	10882	1.15
Scandinavian Journal of Statistics	524	835	611	34	295	7143	1.06
Statistica Neerlandica	320	560	427	28	191	4537	1.02
Statistica Sinica	582	1091	736	33	313	9724	1.07
Statistical Science	901	1231	822	28	296	10704	1.66
Technometrics	634	1155	713	31	344	8258	1.54

The summary statistics presented in Table 1 are

(i) *the number of articles* (ART) published in the journal, including discussions but excluding editorials, letters to the editors, book reviews, corrigenda, notices and the like;

(ii) *the number of authors* (AUT), summed over all articles;

(iii) *the number of distinct authors* (DIS), institutions (INS), and countries (CTR) represented in the journal;

(iv) *the number of pages* (PAG) of the journal devoted to research articles, multiplied by a conversion factor F, in order to make the printed surface of journal pages comparable to that of *The Annals of Statistics* and *The Annals of Probability*. The values of F are of course the same as those given by Genest (1997, 1999), but the factor for *Biometrics* was increased from 1.19 to 1.70 as of 1999 to reflect a change in that journal's size.

Overall, the probability segment of the data base comprises 8189 articles, 146,833 (adjusted) pages, and 4594 distinct authors affiliated with 1173 separate institutions from 62 countries worldwide. As for the statistics segment of the study, it includes 16,648 articles, 234,969 (adjusted) pages, and 9631 distinct authors affiliated with 2255 separate institutions from 83 different countries. For simplicity, Czechoslovakia, Yugoslavia and the USSR were considered as undivided entities, and the two Germanies were counted as one. North and South Korea were also treated as a unified country, and Hong Kong was taken as part of Mainland China, but not Taiwan.

Genest (1997, 1999) indicated that his rankings were fairly insensitive to the inclusion or exclusion of statistics journals sponsored by national associations, with the exception of the *Journal of the American Statistical Association* (JASA), whose volume is clearly too large to ignore. This remains true here. Concerning publications of the national statistical societies—and the *Annales de l'Institut Henri-Poincaré* in probability—it is actually worth pointing out that they have generally much greater individual, institutional and national diversity (as measured by the ratios DIS/AUT, CTR/ART and INS/ART derived from Table 1) than *The Annals of Probability* and *The Annals of Statistics*, which score lowest on the three counts. As might have been anticipated, perhaps, the journal of the International Statistical Institute has the highest ratios of all.

For additional discussion on the representativeness (and subjectivity) of the choice of journals, and on differences in the publishing habits of probabilists and statisticians, please refer to Genest (1997, 1999); Gil, Peña & Rodríguez (2000) provide additional insights. In interpreting the probability rankings, however, one should bear in mind the presence of a sizable bias against constituents, researchers and institutions of the former USSR, as the Soviet journal *Teoriya Veroyatnostei i Ee Primeneniya* had to be ignored for lack of authors' affiliations for part of the period considered.

3. NATIONAL RANKINGS

Tables 2–7 below compare the research productivity of world countries in probability and statistics in terms of their overall national output, their production per capita, and their performance relative to the number of contributors in each country. While each of the tables in Genest (1997, 1999) listed 25 entries, this number is reduced to 15 here, so that the results for the two disciplines could appear on the same page and be compared more easily.

All rankings are based on variable PAG*. To compute its value for a given institution, a sum is taken, over all articles, of the number of adjusted pages of each paper times the number of its authors who list this institution as their primary affiliation; variable ART* is defined similarly. Summing over all institutions in a given country leads to the rankings described in this section; the tallies by institution are reported in Section 4.

To give a dynamic view of research productivity, rankings based on the variable PAG* for the periods 1986–1990, 1991–1995, and 1996–2000 are provided. When such rankings also involved the number DIS of distinct contributors, that variable was summed over the appropriate period; note, however, that the variable POP refers to an average population figure for the 15-year period only.

Tables 2 and 3, based on variable PAG*, list the 15 countries having the largest gross national production (GNP) in probability and statistics, respectively. In both fields, the first five positions are occupied by the same countries as in Genest (1997, 1999), and their ranks hardly vary over time. Note that rankings based on PAG, ART* or ART would not affect the first places either.

TABLE 2: Top 15 countries for gross national production (GNP) of research in probability from 1986 to 2000, inclusively. The ranks are based on variable PAG*.

Rank 86–00	Rank 86–90	Rank 91–95	Rank 96–00	Country	PAG*	PAG	ART*	ART
1	1	1	1	USA	95308	55478	4933	2960
2	2	2	2	France	31468	20368	1506	982
3	3	3	3	Germany	17551	11279	958	635
4	4	4	4	UK	13518	8555	798	523
5	5	5	5	Canada	9933	5355	519	293
6	9	9	6	Australia	6969	3974	458	271
7	8	7	7	Israel	6910	3586	367	197
8	6	6	12	Japan	6708	4607	377	257
9	7	8	9	Netherlands	6333	3378	367	207
10	10	10	14	Italy	5344	2521	279	140
11	14	12	8	USSR	5212	3018	268	163
12	21	11	10	China	4434	2727	280	177
13	11	15	11	Sweden	4340	3039	236	168
14	16	16	13	Spain	3718	1659	205	94
15	18	13	15	Switzerland	3374	2151	173	113

TABLE 3: Top 15 countries for gross national production (GNP) of research in statistics from 1986 to 2000, inclusively. The ranks are based on variable PAG*.

Rank 86–00	Rank 86–90	Rank 91–95	Rank 96–00	Country	PAG*	PAG	ART*	ART
1	1	1	1	USA	223208	119589	14929	8345
2	2	2	2	Canada	32581	17643	2355	1320
3	3	3	3	UK	27460	15481	1881	1125
4	4	4	4	Australia	22189	11676	1536	847
5	6	5	5	Germany	17259	10582	1123	690
6	7	7	8	Netherlands	11338	6249	700	398
7	9	6	6	France	10541	5475	673	349
8	5	8	11	Japan	9697	6214	733	483
9	17	13	7	China	7441	3955	546	301
10	22	10	9	Taiwan	7021	3551	468	248
11	8	9	13	India	6319	3287	587	315
12	21	12	10	Spain	5445	2466	360	169
13	10	11	15	Denmark	4934	2943	316	203
14	18	14	14	Belgium	4369	1977	256	118
15	25	17	12	Italy	4103	2174	260	141

Overall, the United States (USA), the United Kingdom (UK), Canada and Germany can be said to be very strong in both disciplines. France is another leading contributor in probability (2nd), while Australia is a major player in statistics (4th).

Comparing the periods 1986–90 and 1996–2000 in the field of probability, one can observe major improvements in the performance of China (which moved up 11 positions) and the USSR (+6), but a relative decline of activity in Japan (-6). Data not shown also reveal a resurgence of Taiwan (+7, from 26th to 19th) and a gradual descent of Hungary (-9, from 12th to 21st), Belgium (-5, 15th to 20th) and India (-4, 19th to 23rd) between the two periods.

In statistics, a comparison of the periods 1986–90 and 1996–2000 highlights important rises in productivity in Italy (+13), Taiwan (+13), Spain (+11), and China (+10), while Japan (-6), Denmark (-5) and India (-5) were suffering losses. Of greatest concern, but not apparent in Table 3, is Poland's drop (-12, from 12th to 24th). Other countries that lost ground include Norway (-7, 13th to 20th), Finland (-6, 15th to 21st), and Israel (-5, from 11th to 16th).

Since GNP figures tend to favour large (developed) countries, it may be useful to correct for population size, as is done in Tables 4 and 5. Most of the POP figures used to that end were excerpted from Kidron & Segal (1992). The results, which are once again consistent with earlier findings (Genest 1997, 1999), throw light on the exceptional contribution of smaller nations such as Israel (1st in probability, 5th in statistics), Denmark (9th, 3rd) and the Netherlands (5th, 7th), among others. Nonetheless, France continues to fare well in probability (2nd) and in statistics, the representation of Australia, Canada and the USA (1st, 2nd, 4th) remains strong. Most countries actually make the two lists; exceptions among leading countries in probability are France (19th in statistics), Iceland (20th), Germany (17th), and Hungary (24th). Among top statistics producers, New Zealand is only 21st in probability; Finland is 18th, Belgium is 16th, and Taiwan 27th.

A comparison of the periods 1986–90 and 1996–2000 shows great improvements in probabilistic activity per capita both in Switzerland (+8) and Singapore (+12). The gradual rise in productivity in China and the USSR is clearly perceptible over time, but still leaves them 21st and 32nd respectively, for the period 1996–2000. Table 4 shows that Hungary lost eight positions (from 9th in 1986–90 to 17th in 1996–2000); meanwhile, Belgium lost four (11th to 15th), and India gained one on a per capita basis, though it ranks only 48th overall in the study period.

In statistics, it can be seen from Table 5 that New Zealand and Belgium both moved up five ranks, but that Taiwan and Singapore did even better, gaining ten and seven places, respectively. Other spectacular improvements, not documented in the table, include China (+12), Italy (+8) and Spain (+7). On the other hand, Japan (-11), Poland (-9), India (-7) all lost ground, and a downward trend is perceptible in Denmark and Finland (-4 each).

Finally, Tables 6 and 7 give rankings based on PAG*/DIS, i.e., taking into account the number of distinct contributors in each country. What is reflected here, therefore, is the national effort, as measured by the productivity of people working in probability or statistics research in a given country. Because denominators are sometimes small, these rankings tend to be dominated by small, internationally competitive groups rather than by large nations, as illustrated by Iceland's first rank in probability, but on the basis of a single contributor!

If a threshold of 50, say, is arbitrarily fixed for variable DIS, French probabilists are seen to be the most productive worldwide, followed by Americans, Swedes, Israeli and Swiss colleagues. In statistics, the top five positions would be occupied by Belgium, the USA, Canada, Denmark and Australia. Thus, although some of these countries train large numbers of researchers who sometimes go abroad or remain within the country but no longer publish after getting their degree, the productivity of their probabilists and statisticians is among the highest in the world, whether in terms of sheer output or on a per capita basis.

For Canadian readers, it should be mentioned that in Table 6, Canada ranks 16th, with 44.3 PAG*/DIS, 23.9 PAG/DIS, 2.3 ART*/DIS and 1.3 ART/DIS. As there were DIS = 224 Canadian contributors to probability journals over the entire period, Canada would rank 10th when conditioning on DIS $\geq$ 50. In the three sub-periods, Canada ranks 13th, 19th and 9th, respectively.

TABLE 4: Top 15 countries for probability GNP per capita from 1986 to 2000,
inclusively. The ranks are based on variable PAG*/POP.

Rank 86–00	Rank 86–90	Rank 91–95	Rank 96–00	Country	$\frac{\text{PAG}^*}{\text{POP}}$	$\frac{\text{PAG}}{\text{POP}}$	$\frac{\text{ART}^*}{\text{POP}}$	$\frac{\text{ART}}{\text{POP}}$
1	1	1	1	Israel	1502	779	80	43
2	7	4	2	France	558	361	27	17
3	2	9	3	Sweden	511	358	28	20
4	12	3	4	Switzerland	504	321	26	17
5	3	6	7	Netherlands	425	227	25	14
6	5	8	5	Australia	408	232	27	16
7	6	5	10	USA	379	221	20	12
8	8	7	8	Canada	373	201	20	11
9	4	10	6	Denmark	370	241	22	15
10	–	2	16	Iceland	309	269	23	19
11	10	11	12	Norway	279	163	16	10
12	14	12	11	UK	236	149	14	9
13	21	13	9	Singapore	231	136	14	9
14	13	15	13	Germany	221	142	12	8
15	9	16	17	Hungary	213	115	11	6

TABLE 5: Top 15 countries for statistics GNP per capita from 1986 to 2000,
inclusively. The ranks are based on variable PAG*/POP.

Rank 86–00	Rank 86–90	Rank 91–95	Rank 96–00	Country	$\frac{\text{PAG}^*}{\text{POP}}$	$\frac{\text{PAG}}{\text{POP}}$	$\frac{\text{ART}^*}{\text{POP}}$	$\frac{\text{ART}}{\text{POP}}$
1	1	2	1	Australia	1298	683	90	50
2	3	1	2	Canada	1225	663	89	50
3	2	4	6	Denmark	967	577	62	40
4	5	3	4	USA	888	476	59	33
5	4	5	5	Israel	862	449	61	33
6	8	7	3	New Zealand	788	495	60	37
7	6	8	7	Netherlands	761	419	47	27
8	7	6	8	Norway	713	433	47	29
9	10	9	12	UK	478	270	33	20
10	9	11	13	Finland	449	223	30	15
11	14	12	9	Belgium	441	200	26	12
12	11	15	14	Sweden	350	231	25	17
13	21	16	11	Taiwan	348	176	23	12
14	12	13	15	Switzerland	340	198	23	14
15	23	14	16	Singapore	267	146	18	10

TABLE 6: Top 15 countries for probability GNP per national contributor from 1986 to 2000, inclusively. The ranks are based on variable PAG*/DIS.

Rank 86–00	Rank 86–90	Rank 91–95	Rank 96–00	Country	$\frac{\text{PAG}^*}{\text{DIS}}$	$\frac{\text{PAG}}{\text{DIS}}$	$\frac{\text{ART}^*}{\text{DIS}}$	$\frac{\text{ART}}{\text{DIS}}$	DIS
1	–	1	39	Iceland	92.8	80.8	7.0	5.8	1
2	2	5	10	Hungary	66.3	35.7	3.4	1.9	34
3	35	20	1	Chili	60.7	28.9	3.6	1.7	10
4	5	6	4	France	58.4	37.8	2.8	1.8	539
5	7	4	5	USA	57.6	33.5	3.0	1.8	1655
6	11	24	2	Sweden	56.4	39.5	3.1	2.2	77
7	4	10	8	Israel	54.0	28.0	2.9	1.5	128
8	6	3	6	Brazil	53.7	26.4	3.2	1.7	41
9	12	7	3	Switzerland	52.7	33.6	2.7	1.8	64
10	9	15	13	UK	47.9	30.3	2.8	1.9	282
11	18	16	12	Australia	46.5	26.5	3.1	1.8	150
12	29	11	20	Austria	46.2	24.8	3.1	1.8	29
13	16	22	7	Germany	45.1	29.0	2.5	1.6	389
14	1	21	11	Spain	44.8	20.0	2.5	1.1	83
15	3	2	23	Mexico	44.4	21.0	2.2	1.1	17

TABLE 7: Top 15 countries for statistics GNP per national contributor from 1986 to 2000, inclusively. The ranks are based on variable PAG*/DIS.

Rank 86–00	Rank 86–90	Rank 91–95	Rank 96–00	Country	$\frac{\text{PAG}^*}{\text{DIS}}$	$\frac{\text{PAG}}{\text{DIS}}$	$\frac{\text{ART}^*}{\text{DIS}}$	$\frac{\text{ART}}{\text{DIS}}$	DIS
1	1	1	2	Argentina	81.9	38.0	4.5	2.2	14
2	14	2	1	Belgium	56.0	25.3	3.3	1.5	78
3	4	4	4	USA	49.0	26.3	3.3	1.8	4552
4	–	16	3	Uruguay	46.3	21.8	2.8	1.3	4
5	6	8	11	Canada	44.5	24.1	3.2	1.8	732
6	2	5	13	Denmark	44.5	26.5	2.9	1.8	111
7	3	6	8	Australia	44.4	23.4	3.1	1.7	500
8	19	7	7	Czechoslovakia	41.7	22.0	2.5	1.3	20
9	8	10	9	UK	41.6	23.5	2.9	1.7	660
10	13	9	6	Germany	41.1	25.2	2.7	1.6	420
11	7	14	5	Finland	39.4	19.6	2.6	1.3	57
12	11	13	14	Israel	38.9	20.3	2.7	1.5	102
13	18	3	24	Ireland	36.7	20.9	2.6	1.5	18
14	28	12	18	Taiwan	35.6	18.0	2.4	1.3	197
15	9	19	17	Netherlands	34.5	19.0	2.1	1.2	329

4. INSTITUTIONAL RANKINGS

Tables 8 and 9 identify the 15 institutions most prolific in probability and statistics. The rankings are again those induced by variable PAG*. Except for Bell Labs (combined with AT&T), they are all universities or research centres affiliated with universities. Seven institutions, all of them in the US, make both lists: Cornell (2nd in probability, 11th in statistics), Bell Labs (3, 9), the University of California at Berkeley (4, 4), Stanford University (7, 2), the University of Wisconsin at Madison (8, 6), the University of Washington (11, 5), and the University of California at Los Angeles (13, 12).

Among the 16 institutions that are among the 15 most prolific in only one field, seven are non-American (2 French, 1 Australian, 1 Canadian, 1 English, 1 Israeli, 1 Spanish); five of them appear in the probability list, Table 8. The American domination of the statistics scene is further illustrated by the fact that 39 of the 50, or 55 of the 100, most prolific research institutions in that field are US-based. This compares with 29/50 and 45/100 in probability.

In probability, Université de Paris VI has by far the largest number of contributors, and has been the most prolific throughout the survey period. Other institutions won or lost a few positions over time. However, the improvement in the overall production of Columbia University is rather remarkable (32nd in 1986–90, 9th in 1996–2000); the reduced performances of the University of Washington (from 7th to 48th) and of the University of North Carolina (UNC, 9th to 30th) are also noteworthy.

In statistics, Harvard School of Public Health (SPH, Dana Farber Cancer Institute included) is at the top of the heap. Since it shares several researchers with Harvard University, the two should arguably be combined, which would make it first worldwide with 10618 PAG*. Likewise, pooling the data for the Fred Hutchinson Cancer Research Center (27th) and the University of Washington would put them second overall, with 8808 PAG*. Note that the University of Michigan and Texas A&M both gained 16 positions over the recent years, while the contribution to statistics from Bell Labs (-23) declined considerably in volume during the same period. With Stanford and Berkeley ranked among the top seven, both in probability and statistics, the San Francisco Bay area remains the most obvious stronghold of research activity in the statistical sciences between 1986 and 2000.

Tables 10 and 11 show rankings of institutions based on the ratio PAG*/DIS, which provides a measure of the intensity of the research activity (or at least the success at publishing) of researchers claiming a given affiliation. These people are typically faculty members, graduate students, postdoctoral fellows and long-term visitors, but it should be emphasized that they are not necessarily all probabilists or statisticians (e.g., they could be biologists or medical people co-authoring a paper in *Biometrics*), nor are they all based in departments of mathematics or statistics.

To avoid distortions, the results are shown only for those institutions that had at least ten distinct contributors in probability or 15 in statistics in the 15 years spanned by the survey. These conditions make the results roughly comparable between disciplines. In total, 165 institutions meet this criterion for probability, and 202 for statistics.

Interestingly, only two universities (Cornell and Carleton) make the two short lists. In probability, seven institutions are American, two are Canadian, and Australia, France, Germany, Hungary, Spain, and Sweden have one representative each. In statistics, there are 11 US schools, and four other countries have one university each: Australia, Belgium, Canada, and Denmark. Note that in statistics, only two institutions actually have fewer than 20 contributors (Northwestern University and Limburgs Universitair Centrum). Under the stricter condition DIS ≥ 20, the 14th and 15th entries would be the University of Illinois at Urbana-Champaign and Indiana University.

A comparison of Table 11 to Table 9 of Genest (1997), in which DIS ≥ 9, shows a significant overlap of ten entries in the top 15. Although the equivalent of Table 10 was based on DIS ≥ 5 in Genest (1999), ten of the first 15 entries are the same there, too. Looking further down the list, there are 22 US schools among the 50 institutions most productive in probability, and 39

among the top 100. In statistics, the proportions of American institutions are 31/50 and 53/100. By comparison, the ratios for Canada are 6/50 or 13/100 in statistics, but only 2/50 and 5/100 in probability.

TABLE 8: Top 15 world institutions ranked by publication output in probability from 1986 to 2000. The ranks are based on variable PAG*.

Rank 86–00	Rank 86–90	Rank 91–95	Rank 96–00	Institution	PAG*	PAG	ART*	ART	DIS
1	1	1	1	Univ. Paris VI	8333	5664	406	279	116
2	3	2	2	Cornell Univ.	5704	3084	244	133	55
3	2	3	6	Bell Labs	4976	2559	231	121	81
4	4	6	3	U. Cal. Berkeley	4291	2557	234	142	67
5	5	4	5	Technion	3740	1983	177	98	57
6	8	11	4	Univ. Paris XI	3233	2076	136	90	58
7	11	5	17	Stanford Univ.	2886	1624	134	75	49
8	15	7	8	U. Wisc. Madison	2765	1424	122	64	31
9	6	12	18	Univ. Cambridge	2573	1696	148	96	51
10	32	10	9	Columbia Univ.	2399	1367	122	71	49
11	7	8	48	Univ. Washington	2329	1419	101	66	27
12	10	17	16	Purdue Univ.	2278	1404	109	67	41
13	19	15	14	U. Cal. Los Angeles	2242	1387	119	74	38
14	9	16	30	UNC Chapel Hill	2058	1035	105	56	53
15	17	24	15	Univ. Barcelona	1990	901	88	41	18

TABLE 9: Top 15 world institutions, ranked by publication output in statistics from 1986 to 2000. The ranks are based on variable PAG*.

Rank 86–00	Rank 86–90	Rank 91–95	Rank 96–00	Institution	PAG*	PAG	ART*	ART	DIS
1	6	3	1	Harvard SPH	7502	3390	499	236	131
2	1	1	3	Stanford Univ.	7240	4309	395	240	87
3	4	4	4	Austr. Nat. Univ.	6554	3366	424	224	87
4	2	2	8	U. Cal. Berkeley	6522	3900	386	243	89
5	14	5	2	Univ. Washington	5998	3076	347	191	102
6	3	9	7	U. Wisc. Madison	5769	2843	393	207	117
7	9	7	12	Univ. Chicago	4695	2862	274	177	70
8	10	10	14	Univ. Waterloo	4541	2404	330	187	78
9	5	13	28	Bell Labs	4470	2237	278	155	100
10	21	19	5	Univ. Michigan	4371	2370	278	156	117
11	11	14	15	Cornell Univ.	4305	2225	274	143	61
12	20	15	10	U. Cal. Los Angeles	4075	2124	258	142	74
13	16	6	27	Univ. Minnesota	4017	2419	282	177	66
14	26	8	16	Penn State Univ.	3994	2135	270	146	61
15	27	16	11	Texas A&M Univ.	3782	1819	238	121	50

TABLE 10: Top 15 world institutions ranked by publication output in probability from 1986 to 2000.
The ranks are based on variable PAG*, conditional on DIS ≥ 10.

Rank	Institution	$\frac{\text{PAG}^\star}{\text{DIS}}$	$\frac{\text{PAG}}{\text{DIS}}$	$\frac{\text{ART}^\star}{\text{DIS}}$	$\frac{\text{ART}}{\text{DIS}}$	DIS
7	City Univ. New York	131.0	67.2	4.6	2.5	15
12	Univ. Barcelona	110.5	50.0	4.9	2.3	18
14	Cornell Univ.	103.7	56.1	4.4	2.4	55
15	Weierstrass Inst.	100.6	49.9	3.7	1.9	10
17	Univ. Utah	99.6	65.9	4.9	3.3	14
21	Univ. Provence	94.5	51.5	4.3	2.4	10
22	Indiana Univ.	92.5	59.9	4.9	3.2	14
24	U. Wisc. Madison	89.2	46.0	3.9	2.1	31
26	Univ. Washington	86.3	52.5	3.7	2.5	27
28	Univ. Western Australia	86.1	52.1	4.3	2.7	14
32	Colorado State Univ.	82.2	43.2	4.0	2.1	13
34	Univ. British Columbia	81.8	44.3	3.0	1.8	21
38	Hungarian Acad. Sci.	79.2	46.1	4.1	2.4	16
40	Carleton Univ.	76.7	36.4	3.3	1.6	23
44	Chalmers Univ.	74.8	54.2	4.1	3.0	19

TABLE 11: Top 15 world institutions ranked by publication output in statistics from 1986 to 2000.
The ranks are based on variable PAG*, conditional on DIS ≥ 15.

Rank	Institution	$\frac{\text{PAG}^\star}{\text{DIS}}$	$\frac{\text{PAG}}{\text{DIS}}$	$\frac{\text{ART}^\star}{\text{DIS}}$	$\frac{\text{ART}}{\text{DIS}}$	DIS
15	Stanford Univ.	83.2	49.5	4.5	2.8	87
18	Rutgers Univ.	79.5	40.6	5.7	3.0	40
20	Carleton Univ.	78.4	40.3	5.2	2.7	21
21	U. Cal. Davis	77.3	42.3	4.8	2.6	42
23	Texas A&M Univ.	75.6	36.4	4.8	2.4	50
24	Austr. Nat. Univ.	75.3	38.7	4.9	2.6	87
27	Northwestern Univ.	74.3	48.8	4.7	3.2	18
29	Univ. Aarhus	74.1	50.0	5.0	3.5	20
30	U. Cal. Berkeley	73.3	43.8	4.3	2.7	89
32	Iowa State Univ.	72.6	40.1	4.6	2.6	42
34	Cornell Univ.	70.6	36.5	4.5	2.3	61
35	Carnegie Mellon Univ.	69.9	40.0	4.4	2.7	54
41	Univ. Chicago	67.1	40.9	3.9	2.5	70
42	Limburgs Univ. Centrum	66.1	29.4	4.1	1.9	16
44	Penn. State Univ.	65.5	35.0	4.4	2.4	61

5. CANADIANA

The data presented in Section 3 clearly show Canada's strength as a producer of new methodology in the statistical sciences between 1986 and 2000. In probability, it ranks 5th worldwide for gross national production, 8th when corrected for its population, and Canadian probabilists stand 16th in terms of productivity. Canada's performance in statistics is even more impressive: second in GNP and per capita, as well as second or third for productivity of its researchers among countries with sizable research groups.

To gain further insight into this performance, provincial rankings based on variables PAG*, PAG*/POP and PAG*/DIS are given in Table 12. As in earlier studies, Ranking I (based on GNP) is in general agreement with population size. Ontario claims some 55% of the Canadian PAG* total in each discipline, and adding Québec and British Columbia brings the ratio over 85% in both cases. Ranking II corrects for demography on the basis of the 1996 census figures. It illustrates, in particular, the sad state of underdevelopment of research in probability and statistics in French Canada. On the positive side, note that Nova Scotia and Newfoundland are better represented in statistics than one might expect from their size, as is Manitoba in probability theory.

Ranking III, based on PAG*/DIS, shows that it is in British Columbia that probabilists and statisticians have been most productive in research during the study period. In both disciplines, Ontario and Québec rank second and fourth, respectively.

TABLE 12: Canadian provinces ranked by research output in probability (top) and statistics (bottom) from 1986 to 2000, as measured by PAG* (I), PAG*/POP (II) and PAG*/DIS (III).

I	II	III	Province	PAG*	PAG	ART*	ART	DIS
1	1	2	Ontario	5429	2839	275	150	114
2	2	1	British Columbia	1747	948	69	41	27
3	4	4	Québec	1555	919	94	58	48
4	5	5	Alberta	496	288	36	21	22
5	3	3	Manitoba	409	176	22	9	9
6	6	6	Nova Scotia	131	74	7	4	6
7	7	7	Saskatchewan	125	91	10	7	6
8	8	8	New Brunswick	32	16	5	3	3
9	9	9	Newfoundland	9	5	1	1	1
10	10	10	Prince Edward Island	0	0	0	0	0
1	1	2	Ontario	18133	9724	1319	725	401
2	5	4	Québec	5557	2992	398	227	140
3	3	1	British Columbia	4033	2183	276	155	86
4	6	6	Alberta	1890	1152	144	88	54
5	2	3	Nova Scotia	1109	555	74	40	26
6	7	9	Manitoba	748	407	62	34	27
7	4	5	Newfoundland	526	332	39	26	15
8	8	8	New Brunswick	344	166	25	13	12
9	10	7	Saskatchewan	203	112	16	9	6
10	9	10	Prince Edward Island	38	19	2	1	2

TABLE 13: Top 15 Canadian institutions ranked by publication output in probability from 1986 to 2000. The left-most column gives their worldwide ranks, as measured by variable PAG*; the right-most column gives their ranks based on PAG*/DIS, conditional on DIS $\geq$ 10.

Rank	Institution	PAG*	PAG	ART*	ART	DIS	Rank$_{DIS}$
18	Carleton Univ.	1765	838	75	37	23	14
19	Univ. British Columbia	1717	931	64	38	21	12
78	Univ. Toronto	823	365	44	21	27	138
109	Univ. Ottawa	608	322	33	17	13	68
121	York Univ.	535	343	29	19	12	77
128	McGill Univ.	518	335	24	17	11	67
147	McMaster Univ.	458	242	22	12	8	–
174	Univ. Alberta	394	209	27	15	17	160
181	Univ. Waterloo	389	279	27	20	13	141
240	Univ. Manitoba	230	107	12	6	6	–
264	Univ. Laval	196	74	10	4	7	–
278	Univ. Western Ontario	181	106	10	6	6	–
280	Univ. Winnipeg	179	69	10	4	3	–
292	Concordia Univ.	166	85	15	8	8	–
299	École Polytechnique	157	137	14	12	5	–

TABLE 14: Top 15 Canadian institutions ranked by publication output in statistics from 1986 to 2000. The left-most column gives their worldwide ranks, as measured by variable PAG*; the right-most column gives their world rank, based on PAG*/DIS, conditional on DIS $\geq$ 15.

Rank	Institution	PAG*	PAG	ART*	ART	DIS	Rank$_{DIS}$
8	Univ. Waterloo	4541	2404	330	187	78	27
22	Univ. Toronto	3118	1701	226	125	60	44
36	Univ. British Columbia	2444	1387	155	93	43	31
52	Carleton Univ.	1647	846	109	56	21	3
55	McGill Univ.	1514	810	104	58	29	43
59	Univ. Alberta	1469	898	109	67	33	71
62	Univ. Montréal	1410	790	103	63	34	80
63	Univ. Western Ontario	1385	875	104	65	36	94
66	Statistics Canada	1354	629	89	44	50	157
78	Simon Fraser Univ.	1187	590	91	46	28	78
92	York Univ.	1030	615	76	47	19	36
95	Univ. Laval	985	533	69	39	17	29
98	McMaster Univ.	960	504	85	45	32	140
110	Univ. Ottawa	877	549	50	33	13	–
118	Univ. Windsor	805	385	58	28	20	85

Additional details are provided by Tables 13 and 14, where the top 15 Canadian institutions are listed, with their overall rank in the two disciplines. Three of them are in the top

100 worldwide in probability (Carleton University, The University of British Columbia, University of Toronto), the first two among the best 20. As for Canada's excellence in statistics, it translates into no fewer than 13 of its institutions ranking in the top 100: six from Ontario (University of Waterloo, University of Toronto, Carleton University, The University of Western Ontario, York University, McMaster University), three from Québec (McGill University, Université de Montréal, Université Laval), two from British Columbia (The University of British Columbia, Simon Fraser University), one from Alberta (University of Alberta), and the federal agency Statistics Canada.

The right-most column of Tables 13 and 14 also gives the world rank of Canadian institutions as a function of their number of distinct contributors to probability and statistics between 1986 and 2000. Identified there are the five groups of Canadian probabilists who are among the 100 most productive in the world, on a per capita basis. Researchers at The University of British Columbia and at Carleton University are particularly strong, ranking 12th and 14th worldwide.

Canada can also take pride in the fact that 13 statistics groups across the nation rank among the 100 most productive in the world. Carleton University is impressive in third position, followed by Waterloo (27th) and Laval (29th). In addition to institutions listed in Table 14, Dalhousie University ranks 90th on a per capita basis, although based on variable PAG*, it is only 142nd worldwide.

TABLE 15: Break-down of the 100 most prolific probabilists and statisticians by country, based on the location of the institution where they did most of their work in the period 1986–2000.

Country	Ranks among 100 most prolific probabilists	Ranks among 100 most prolific statisticians
Argentina		68
Australia	22, 59, 75, 78	1, 93
Austria	66	
Belgium	56, 60, 85	30, 69, 75
Brazil	35, 50, 61	
Canada	8, 11, 16	7, 18, 34, 52, 81
China	34	100
Denmark	25	70
France	1, 10, 13, 19, 24, 26, 42, 57, 87, 89, 93	64
Germany	14, 18, 45, 62, 65, 81, 83, 86, 95	8, 20, 41
Israel	12, 15, 40, 41	
Italy	96	
Japan	72	
Netherlands	73	59, 80
Spain	3	
Sweden	90	
Switzerland	48, 82	
Taiwan		44
United Kingdom	33, 94	24, 26, 60, 67, 86 87, 99
United States	50 other ranks	73 other ranks
USSR	92	

6. A FEW WORDS ABOUT INDIVIDUAL PERFORMANCE

Several arguments were given by Genest (1997, 1999) that speak against the production of individual rankings. This policy is continued here, despite the existence of precedents (e.g., Phillips, Choi & Sochet 1988, Baltagi 1998 or Cribari-Neto, Jensen & Novo 1999) and numerous requests for nominative statistics and individual comparisons that the first author's earlier work generated. For the purpose of NSERC's Reallocations Exercise, however, it is worth mentioning that three Canadian probabilists rank 8th, 11th and 16th among the 100 most prolific authors in their field. Similar information for other countries is given in Table 15, where the US (50 authors), France (11) and Germany (9) count the largest contingents in that select group.

Summary data for statistics can also be found in Table 15. The US (73 authors), the United Kingdom (7) and Canada (5) are best represented, but five statisticians (12th, 37th, 58th, 60th) are in fact people who were educated in Canada or started their careers in this country and later moved to the United States. In addition, two of the Canadians (7th, 81st) recently left for the US. These facts provide a vivid illustration of the "brain drain" that has been depriving Canada of some of its best elements in recent years, especially in statistics.

Other countries have long suffered from the same phenomenon. Among the 100 most prolific statisticians, for example, 17 US authors have typical Chinese names, and seven are Indian. By comparison, there are only four Chinese and one Indian among the 100 most prolific probabilists; again, all of them are US-based. Given this information, Table 15 also gives a fair linguistic breakdown of the most active authors in both disciplines. As might have been expected, there are 12 francophones among the top 100 probabilists (11 French and 1 Belgian, who is 85th), and only two in statistics (a Belgian, 30th; a Frenchman, 64th); the first French Canadian is 102nd. And on the gender front, there is no woman in the probability group and there are only two (the 52nd, the 69th) in statistics.

In closing, the authors wish to emphasize that despite their best efforts, the results reported herein are subject to some (hopefully small) degree of data-entry error, in addition to the aforementioned dependence on the choice of journal and survey period.

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