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NATURE AND TYPE OF COLLABORATIVE RESEARCH AS REFLECTED IN SELECTED THEORETICAL POPULATION GENETICS LITERATURE

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ABSTRACT

Indicates the nature and types of collaborated research as reflected in selected theoretical population genetics literature from 1956 - 80, and studies the role of funding. Highlights the research priorities of few important countries in collaborative research, and the collaboration linkages among various countries in transnational collaborative research. Concludes that with time, the focus of research is slowly shifting from internal collaboration to domestic and international collaboration, supported by increasing funding from government agencies in theoretical population genetics research.

Keywords: Collaboration; Collaborative research; Research priorities; Trans-national collaboration; Theoretical population genetics; Bibliometrics.

INTRODUCTION

Collaboration in research can take a variety of paths, but necessarily takes the form either of cooperation between two researchers or organisations. Cooperation actually takes place between two researchers, but normally in practice we look at this collaboration at other levels; between research groups within a department, between departments within the same institutions, between institutions, between sectors, and between geographical regions, and countries.

Subramanyam (1983) in a review publication has identified the following types of collaboration: (i) teacher-pupil collaboration, (ii) collaboration among colleagues, (iii) supervisor-assistant collaboration, (iv) researcher-consultant collaboration, (v) collaboration beteen organisations, and (vi) international collaboration. Qin ((1994) studied the research publications of *The Philosophical Transactions* from 1901-1991, and simplified the types of collaboration as (i) collaboration in a department within an institution, (ii) collaboaration between two or more departments within an institution, (iii) collaboration between two or more institutions within a country, and (iv) international collaboration. Gupta (1997) studied the types of collaborative research on the pattern of classification suggested by Qin, by taking a sample of publications in the-

oretical population genetics from an international journal *Genetics*, from 1916-80. He noticed a shift in the nature and type of collaborative research over the years. Katz and Martin (1997) points out that besides distinguishing several different levels of collaboration, we also need to recognise that collaboration can occur either between or within different levels. For simplicity they use the prefixes *inter* and *intra* respectively. According to them, the various levels of collaboration, of both the i*nter* and *intra* forms are summarised in Table 1.

Collaboration can also be either homogeneous (i.e. unambiguously either the i*nter* or the *intra* form of collaboration) or heterogeneous (i.e. a mixture of the inter and intra forms of collaboration). Among the types of collaboration explained, international collaboration has been studied most extensively.

DATABASE AND METHODOLOGY

The data for this study is taken from 11 core journals in the area of theoretical population genetics. These core journals were identified on the basis of their contribution and productivity as reflected in the *Bibliography of Theoretical Population Genetics*, compiled by Felsentein (Hicks and Katz, 1995) in 1981. The bibliography provides only references without indicating the addresses of authors. We first identified the sample in the form of references from these 11 core journals as reported in the bibliography, and then physically collected data on addresses and information on the funding support available to each publication covered in the sample.

The duration of the study was from 1956-80. The articles forming our sample, were put in a block of five years and then cumulated, beginning in 1956. Thus, five blocks of data pertaining to the years: 1956-60, 1961-65, 1966-70, 1971-75, and 1976-80 in the sample were obtained. In each time block, the total number of research publications were recorded according to the type of collaboration and the availability of funding. Each publication has been classified first under the following types of classification:

Table 1: Levels of Collaboration and Distinction Between Inter and Intra Forms

	Intra	***Inter***
Individuals	-	Between individuals
Group	Between individuals in the same research group	Between groups (e.g. in the same department)
Department	Between individuals or groups in the same department	Between departments (in the same institutions)
Institution	Between individuals or departments in the same institution	Between institutions
Sector	Between institutions in the same sector	Between institutions in different sectors
Nations	Between the institutions in the same country	Between institutions in different countries

(a) Intra-department collaboration: collaboration within a department (in an organisation or institution);
(b) Inter-departmental collaboration: collaboration between two or more departments(in an organisation or institution);
(c) Inter-institutional collaboration: collaboration between two or more organisations or institutions (located in different cities or in the same city within a country); and
(d) International collaboration: collaboration between two or more organisations or institutions located in more than one country).

For discussion, we have further simplified the above classification of the types of collaboration, and will refer now to generally three types of collaborative relationship: internal collaboration (type a and b taken together), domestic collaboration (type c), and international collaboration (type d).

The total sample consists of 2,502 publications, out of which 1,474 research publications are single-authored (468 publications of which are funded) and 1,028 research publications (667 publications of which are funded) are multi-authored. A chronological breakdown of the total sample indicates that 34.61% (866 publications) pertain to the time block 1976-80. For other time blocks, the percentage contribution in the total sample were: 29.05% (727 publications) for 1971-75; 20.58% (515 publications) for 1966-70; 10.47% (262 publications) for 1961-65; and 5.27% (132 publications) for 1956-60.

In terms of geographical distribution, the largest number of publications originated from United States, contributing 52.96% (1325 publications) to the total sample. The next important group of countries in terms of contributions are: United Kingdom (507 publications), Australia (205 publications), Japan (96 publications), Canada (72 publications), Israel (46 publications), Germany (39 publications), and France (37 publications), contributing 20.26%, 8.19%, 3.83%, 2.87%, 1.83%, 1.55%, and 1.47% each, respectively to the total sample. Rest of the contributions have come from 35 other countries.

For simplification in the analysis, we have divided the total sample in two groups: A and B. In Group A, we have included only United States, as it is the major contributor in the total output. In Group B, we have included all other 42 countries, which together have contributed 47.04% to the total output.

This paper will briefly study the nature and type of collaborative research as reflected though addresses in research publications of theoretical population genetics speciality. The research publications are desegregated under three types: internal collaboration, domestic collaboration, and international collaboration. Of the total 1028 collaborated publications, 543 publications reflect internal collaboration (56.35% of which are funded), 257 publications domestic collaboration (71.20% of which are funded), and the rest 228 publications inter-national collaboration (78.07% of which are funded).

The total number of collaborating publications in Group A and Group B are 623 and 405, respectively. Of the total 623 collaborative publications in Group A, 347 publications (67.72% of which are

funded) reflect internal collaboration, 181 publications (81.76% of which are funded) domestic collaboration, and the rest 95 publications (92.63% of which are funded) international collaboration. Similarly in Group B, out of total 405 collaborative publications, 196 publications (36.22% of which are funded) reflect internal collaboration, 76 publications (46.05% of which are funded) domestic collaboration, and the rest 133 publications (67.67% of which are funded) international collaboration.

The number of countries who have written 10 or more collaborative publications in the total sample is shown in Table 2, along with the number and type of collaborative publications contributed by them.

NATURE AND TYPE OF COLLABORATION

Internal Collaboration

Out of the total 543 internal collaborated publications, 347 publications (63.90%) are contributed by United States, 95 publications (17.49%) by United Kingdom, 29 publications (5.34%) by Japan, 20 publications (3.68%) by Australia, and 11 publications (2.02%) by Canada, and the rest of the countries have contributed less than 2% to the total internal collaborative publications.

Internal collaborative publications occupy a major percentage share in total collaborative publications of some of the significant countries. Its percentage contribution in total collaborative publications lies between: 71%-80% in Germany and Japan, 51%-60% in United States, United Kingdom, and India, 41%-50% in Australia, 31-40% in Canada, Italy, and France, and 11%-20% in Israel. The reason why this collaboration is dominant because it requires the least resources to collaborate.

Domestic Collaboration

Compared to other types of collaboration, priority to domestic collaborative publications is given only in few countries. Out of total 257 domestic collaborative publications, 181 publications (70.43%) are contributed by United States, 31 publications

Table 2: Type of Collaborative Publications Contributed by Selected Countries

Country	Number of Publications by Types of Collaboration			Total Publications
	Internal	Domestic	International	
USA	347	181	95	623
UK	95	31	37	163
Australia	20	11	17	48
Japan	29	4	6	39
Canada	11	7	13	31
Israel	4	8	11	23
Italy	4	3	6	13
India	7	0	6	13
France	4	3	5	12
New Zealand	4	1	7	12
Germany	8	0	2	10

(12.06%) by United Kingdom, 11 publications (4.28%) by Australia, 8 publications (3.11%) by Israel, 7 publications (2.72%) by Canada, and rest of the countries below this percentage.

In individual countries, the priority to this type of collaborative publications is not very high. Its percent contribution in total collaborative publications lies between: 31%-40% in Israel, 21%-30% in United States, Italy, Canada, France, and Australia, 11%-20% in United Kingdom and Japan, 1%-10% in New Zealand, and 0% in Germany and India.

In recent years, science and technology policies of many countries are focusing on the need to do active collaborative work of this type to economise on resources, facilities, and human resources, and also encouraging increasing domestic collaboration, with same or different objectives. The United Kingdom , for example, encourages universities and research institutions to work more closely with industry to generate applications of research efforts carried out in the country. The European Union, on the other hand, suggests and encourages collaboration between institutions and organisations located in more- and less- favoured regions in the research efforts it support (Hicks and Katz, 1995).

International Collaboration

International collaboration is increasingly becoming more frequent over a period of time, and playing an important role in the production of scientific knowledge across the world. There are many factors both, internal and external, to the scientific enterprise, that stimulate international collaboration. The internal factors are cognitive and social, while external factors are economic and political. International collaboration is motivated by many intra-scientific factors, such as the desire to increase knowledge, exchange skills and data, and enhance professional development. It is further facilitated by decreasing cost of communication (travel, fax, and e-mail). Besides government support for international contacts and facilities, bilateral and multilateral agreements between countries, and initiatives on the part of international agencies have further encouraged collaboration of this type (Nagpal and Sharma, 1994).

The number of internationally collaborated publications world-wide has grown from 7 publications during 1956-60 (14.58% of the total) to 83 publications (21.22% of the total), with an annual growth rate of 117.04%.

United States

The United States contributed 41.66% to the world's total international co-authored publications. It is among the countries with a significant percentage of co-authorship (47.02%), but it ranks in the low end in terms of overall percentage of publications involving international collaboration (11.53% during 1956-60 to 15.81% during 1976-80). This occurred solely as a result of its large publication base. The United Kingdom contributed 16.23% to the world's international co-authored publications. It is among the countries with 32.15% of its total publications appearing as co-authored publications, but it ranks in lower end in terms of

its overall percentage of publications involving international collaboration(6.25% during 1956-60 to 24.13% during 1976-80). Australia contributed 7.45% to the world's total international co-authored publications. Its percentage of co-authored publications are 23.41%, but its contribution in terms of publications involving international collaboration have decreased (from 50% during 1956-60 to 33.33% during 1976-80). Japan contributed 2.19% to the world's total international co-authored publications and its percentage of co-authored publications is 39.58%. Canada contributed 13.59% to the world's total co-authored publications, and its percentage of co-authored publications is 43.05%.

Scientific collaboration as measured by international co-authorship, centres to a remarkable degree on United States (National Science Board, 1996). In 41.66% (95 publications) of all international co-authored publications, US authors collaborated with authors from 15 countries. The largest number of international co-authored publications of United States involve collaboration with: Japan (22 publications out of 95), United Kingdom (15 publications), Israel (14 publications), Australia (8 publications), New Zealand (7 publications), Canada (6 publications), Italy (5 publications), Denmark (4 publications), so on.

Authors participating in nearly 32.89% of all international co-authored publications from other countries collaborate with US authors. From the total international co-authored publications combined from 1956-60 to 1976-80, United States authors participated and collaborated in: 100% of all international co-authored publications of Japan, in 90.90% of Israel, in 85.71% of New Zealand, in 66.66% of Italy, in 64.70% of Australia, in 54.05% of United Kingdom, in 50% of India and Denmark, in 38.46% of Canada, and in 20% of France, as shown in Table 3 and 4.

Other Countries

Out of the total collaborated publications, the number of international co-authored publications are: 37 publications (16.22%) of United Kingdom, 17 publications (7.45%) of Australia, 13 publications (5.70%) of Canada, and 11 publications (4.82%) of Israel, as shown in Table 3. This means that authors from other countries collaborated with these countries' authors in these publications.

Similarly scientists from other countries collaborated with scientists from UK in 35 (15.35%), Japan in 24 (10.25%), Australia and Israel each in 16 (7.01%), Canada in 13 (5.70%) and New Zealand in 11 (8.82%) publications (Table 4).

From the total sample of collaborated publications from 1956-60 to 1976-80 taken together, UK authors collaborated in: 15.78% (15 out of 95) of all international co-authored publications of United States, in 17.64% (3 out of 17) of Australia, in 30.76% (4 out of 13) of Canada, in 9.09% (1 out of 11) of Israel, in 16.66% (1 out of 6) of Italy, in 20% (1 out of 5) of France, and 100% (2 out of 2) of Federal Republic of Germany (Table 4). Similarly, Australian authors collaborated in 8.51% (8 out of 95) of all international co-authored publications of United States, in 13.51% (5 out of 37) of United Kingdom, and in 14.28% (1 out of 7) of New Zealand. Canadian authors,

similarly, collaborated in 9.57% (9 out of 95) and 5.40% (2 out of 37) of all international co-authored publications of United States and United Kingdom. Japanese and Israeli authors, similarly, collaborated in 23.40% (22 out of 95) and 15.95% (15 out of 95) of all internationally co-authored publications of United States.

Table 3 : Collaboration Linkages Made with Other Countries

Source Country	NICP	Collaborating Countries
USA	95	JPN(22),ISR(15),UK(15),CAN(9),AUS(8),NZL(8) ITA(4),DNK(4),BRA(2),MEX(2),FRG(2),etc.
UK	37	USA(20),AUS(5),CAN(2),NOR(2),JPN(1),NLD(1), POL(1),IND(1),NGR(1),SDN(1),MEX(1),SAFR(1)
AUST	17	USA(11),UK(3),ISR(1),NZL(1),NGR(1)
CAN	13	USA(5),UK(4),NZL(2),FRG(1),FRA(1)
ISR	11	USA(10),UK(1)
NZL	7	USA(6),AUS(1)
IND	6	USA(3),GDR(2),SWITZ(1)
JPN	6	USA(6)
ITA	6	USA(4),UK(1),NLD(1)
FR	5	USA(1),UK(1),BEL(3)
FRG	2	UK(2)

NICP = Number of international co-authored publications or linkages

Table 4: Collaboration Linkages Received from Other Countries

Collaborating country	NCL	Source Country
USA	75	UK(20), AUS(11), ISR(10), JPN(6), ITA(4), CAN(5),NZL(4), IND(3), etc.
UK	35	USA(15), AUS(3), CAN(4), FRG(2), SWED(2), NOR(1), ITL(1), FRA(1), ISR(1), SPN(1), MEX(1)
JPN	24	USA(22), UK(1),SRILANK(1)
AUS	16	USA(8),UK(5),NZL(1),SWE(1)
ISR	16	USA(15), AUS(1)
CAN	13	USA(9), UK(4),SGP(1), GRC(1)
NZL	11	USA(8), CAN(2), AUS(1)
DNK	4	USA(4)
ITL	4	USA(4)

NCL = Number of collaboration linkages received

Priorities Accorded to Different Types of Collaborative Publications

From the data presented in Table 5, it is clear that although there is an increase in the number of internal collaborated publications from 30 publications (62.59% of the total) during 1956-60 to 202 publications (51.66% of the total) during 1976-80, but in terms of percentage contribution, there is a decrease from 62.59% to 51.66% from 1956-60 to 1976-80. In contrast, the number of domestic and international collaborated publications have increased from 11 publications (22.91% of the total) and 7 publications (14.58% of the total) during 1956-60 to 106 publications (27.10%) and 83 publications (21.22% of the total) during 1976-80, showing an increasing trend in the percentage share in both the cases.

Studying the financial support available to different types of collaborative publications, we observe that it is increasing with time in all types of collaborative publications as shown in Table 6. In internal collaboration, the funded publications have increased from 36.66% during 1956-60 to 62.37% during 1976-80. In domestic and international collaboration, the funded publications have increased from 18.18% and 57.14% during 1956-60 to 77.35% and 86.74% during 1976-80. The largest funding support is available to international collaborative publications from the beginning.

Table 5: Change in Different Types of Collaborative Publications with Time

Period	NCP	Types of Collaboration		
		Internal	Domestic	International
		---------- in percentage ----------		
1956-60	48	62.50	22.91	14.58
1961-65	72	56.94	27.77	15.27
1966-70	204	56.37	19.60	24.01
1971-75	313	49.52	25.55	24.92
1976-80	391	51.66	27.10	21.22

NCP = Number of collaborated publications

Table 6: Funded Support Available to Different Types of Collaborative Publications

Period	NCP	Types of Collaboration		
		Internal	Domestic	International
		----percentage of publications funded---		
1956-60	48	36.66	18.18	57.14
1961-65	72	56.09	50.00	72.72
1966-70	204	56.52	72.50	71.42
1971-75	313	52.25	75.00	75.64
1976-80	391	62.37	77.35	86.74

NCP = Number of collaborated publications

The changing priorities accorded to different type of collaborative publications in Group A and Group B is also studied. Based on the data presented in Table 7 and 8, the following observations are made:

(a) internal collaborative publications occupy a significant percentage of total collaborative publications in both groups. In Group A, on the one hand, its contribution has consistently decreased from 69.23% during 1956-60 to 53.35% during 1976-80, and on the other hand, its contribution fluctuated between 37.50% to 54.54% during the same period in Group B;

(b) domestic collaborative publications, on the one hand, have consistently increased their percentage contribution from 19.23% during 1956-60 to 30.83% during 1976-80 in Group A, and on the other hand, its percentage contributions have decreased from 27.27% during 1956-60 to 20.28% during 1976-80, with the exception of one block year 1961-65; and

(c) the percentage of international collaborated publications have shown an increasing trend in both groups. In Group A, its percentage contribution have increased from 11.53% during 1956-60 to 15.81% during 1976-80, while in Group B, the increase for the same period was from 18.18% to 31.15%., a marginal increase in Group A.

Table 7: Change in Different Types of Collaborative Publications Group A with Time

Period	NCP	Types of Collaboration		
		Internal	Domestic	International
		---------- in percentage ----------		
1956-60	26	69.23	19.23	11.53
1961-65	48	66.66	18.75	14.58
1966-70	116	57.76	23.27	18.96
1971-75	180	52.77	34.44	12.77
1976-80	253	53.35	30.83	15.81

NCP = Number of collaborated publications

Table 8: Change in Different Types of Collaborative Publications Group B with Time

Period	NCP	Types of Collaboration		
		Internal	Domestic	International
		-------- in percentage ---------		
1956-60	22	54.54	27.27	18.18
1961-65	24	37.50	45.83	16.16
1966-70	88	67.04	14.77	30.68
1971-75	133	45.11	13.53	41.35
1976-80	138	48.50	20.28	31.15

NCP = Number of collaborated publications

The funding support available to different type of collaborative publications in Group A and B is also studied. From the data presented in Tables 9 and 10, we observe the funded publications have shown an increasing trend in both the groups from 1956-60 to 1976-80. The findings can be summarised as below:

(a) In internal collaborative publications, the percentage of funded publications have increased from 50% to 72.59% Group A and from 16.16% to 41.79% in Group B.
(b) The percentage of funded publications in domestic collaborative publications, have increased from 40% to 89.74% in Group A, and from 0% to 42.85% in Group B. The systematic increase in funded publications is observed only in Group A, but in Group B there are fluctuations in the growth.
(c) a comparative higher percentage of funded publications are noticed in international collaborative publications. The percentage of funded publications has increased from 33.33% to 100% in Group A from 1956-60 to 1976-80, while in Group B, the percentage contribution has first declined and then came back to the same position for the same period.

Table 9: Financial Support Available to Different Types of Collaborative Publications in Group A with Time

Period	NCP	Types of Collaboration		
		Internal	Domestic	International
		-percentage of publications funded-		
1956-60	26	50.00	40.00	33.33
1961-65	48	65.62	66.66	85.71
1966-70	116	68.65	74.07	81.81
1971-75	180	65.26	80.64	95.65
1976-80	253	72.59	89.74	100.00

NCP = Number of collaborated publications

Table 10: Financial Support Available to Different Types of Collaborative Publications in Group B with Time

Period	NCP	Type of Collaboration		
		Internal	Domestic	International
		-Percentage of Publications Funded-		
1956-60	22	16.16	00.00	75.00
1961-65	24	22.22	36.36	50.00
1966-70	88	41.66	69.23	62.96
1971-75	133	31.66	55.55	67.27
1976-80	138	41.79	42.85	74.21

NCP = Number of collaborated publications

CONCLUSION

Of the total sample, 41.88% and 39.76% publications are observed to be funded and collaborated. The percentage of collaborated papers is not very high because the field is theoretical in nature . Among the single-authored and multi-authored publications, 33.64% and 64.88% publications are observed to be funded. This indicates that funding agencies are encouraging collaborative research.

Among the countries involved in theoretical population genetics collaborative research, United States is the largest contributor with maximum number of research publications, followed by United Kingdom, Australia, Japan, etc.

Internal collaborated publications occupy a major share in collaborative publications of important countries. In contrast, comparatively less priority is given to domestic collaborative publications in most of the countries. In recent years science and technology policies of many countries are encouraging scientists to undertake this type of collaborative work. Domestic collaboration, in particular, has been observed and is found to be encouraged maximum in United States, and is seen as a important policy instrument for regional development and for innovative research in the field. International collaboration continues to be important and is becoming more frequent with the passage of time.

Scientific collaboration, as measured by international co-authorship, centres to a remarkable degree on United States. On the one hand, we observe that 41.66% (95 out of 228) of all internationally collaborated publications are from United States, and these publications involve collaboration with authors from 15 countries. Important and significant collaborated partners of the US as reflected in co-authorship are Japan, UK, Israel, Australia, etc. On the other hand, US authors attract collaboration in 56.39% (75 out of 133) of all internationally collaborated publications of other countries. US authors collaborated in 70% of all internationally collaborated publications of Japan, Israel, and New Zealand.

The analysis also clearly brings forth the changes taking place in the nature of collaborative research over the years. A distinctive shift is observed to be taking place from internal collaborative publications to domestic and international collaborative publications, supported by provision of increasing funds from government agencies.

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