3. UK NATIONAL OUTPUTS, 1989-2000

3.1 Introduction

UK biomedical research is wide and varied – and constantly evolving. Cities and counties change their production levels. Different sub-fields come to the fore; international collaboration or the numbers of authors on each paper change over time.

This chapter takes a closer look the structure of British biomedical output between 1989 and 2000.

Methodology

Two important points must be noted. Firstly, unlike the last, this chapter describes the UK biomedical output as listed in the Research Output Database, and not directly for the ISI's disks (see the Annex for more details). ROD contains data taken from both the Science Citation Index and the Social Sciences Citation Index. Apart from papers identified by the biomedical address filter, it also includes papers which are from biomedical journals but do not have biomedical addresses. This means that the total number of papers listed for the UK is higher than that used in chapter 2's analysis.

Secondly, when counting papers we used the integer count method, where each paper is attributed as a whole to a country, funder or institution. This means that co-authorship and co-funding can push up the apparent number of papers. If two institutions collaborate to produce one paper, for example, this paper is counted twice, once for each institution.

UK biomedical paper production

In the 12 years between 1989 and the end of 2000, there were a total of 355,188 biomedical papers produced in the UK (as listed in ROD).

The number of papers produced grew on average around 2.3% each year, taking total production levels from 24,141 papers in 1989 to 33,972 in 2000.

The most dynamic growth in British biomedicine paper outputs took place in the early 1990s. After this time growth slowed down, and the numbers of papers actually declined in 1997 (year by year distribution of papers in ROD is shown in Table A3.1.1 in the Appendix).

3.2 Numbers of authors and addresses

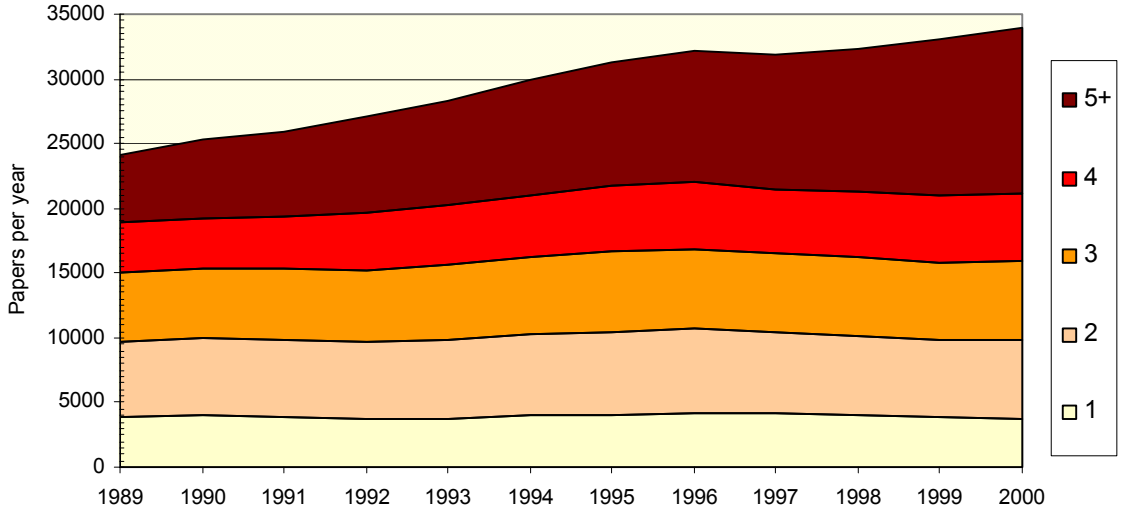

Fig. 3.2.1 Numbers of papers in UK ROD and numbers of authors per paper.

The numbers of authors working on each paper have gone up over time – in particular, papers with five or more authors (figure 3.2.1). In 2000, 38% of papers had at least five authors, compared to only a fifth in 1989.

And the number of papers written by just one author peaked in 1996 and has declined ever since. One-author papers now make up only a tenth of papers in ROD. While in 1989 nearly 16% of ROD papers were written by a single author, by 2000 this percentage dropped to only 11. See tables A3.2.1 in the Appendix for a detailed year-by-year breakdown.

This tendency towards collaboration also applies to institutions. Currently 37% of papers come from single institutions (as compared to 53% in 1989). And the

yearly proportion of papers with five or more institutional addresses has more than quadrupled since 1989 – from 2% to 9% of the total (figure 3.2.2).

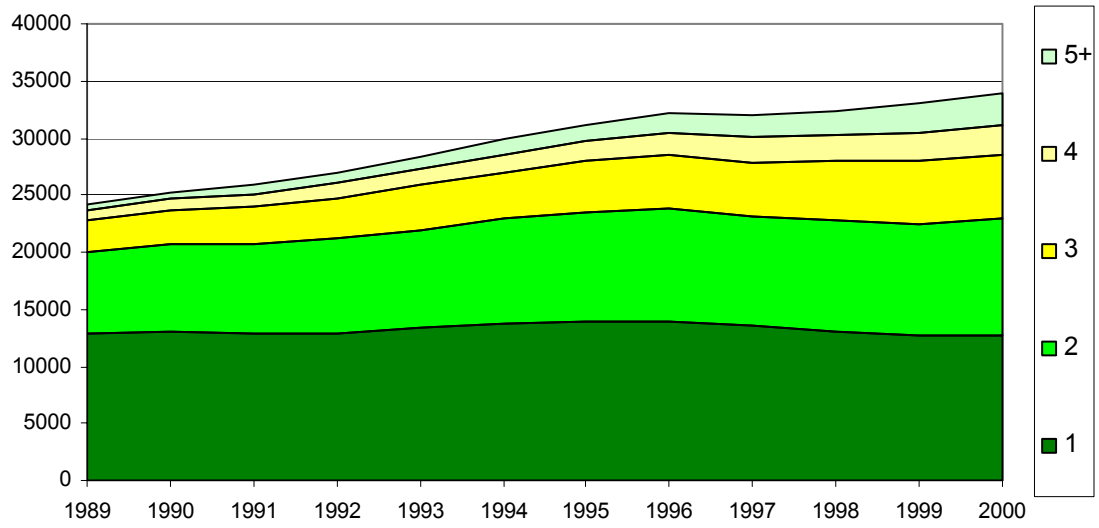

Figure 3.2.2 Numbers of papers in the ROD with given numbers of addresses. See table A3.2.2 for a more detailed breakdown.

One factor that has accompanied this rise in addresses is the rise in non-UK co-authorship of papers (figure 3.2.3). Papers written with a non-UK author doubled over the period – from 16% in 1989 to 32% in 2000.

The USA is still the UK's leading partner in biomedical research (share of co-authored papers more than doubled – from 5 %to nearly 11% between 1989 and 2000), but links with the EU countries are rising even faster. Nearly 16% of all papers produced in the UK in 2000 involved collaboration with one or more of the EU countries, compared to just over 6% in 1989 (for more detailed breakdown see table A3.2.3 in the Appendix).

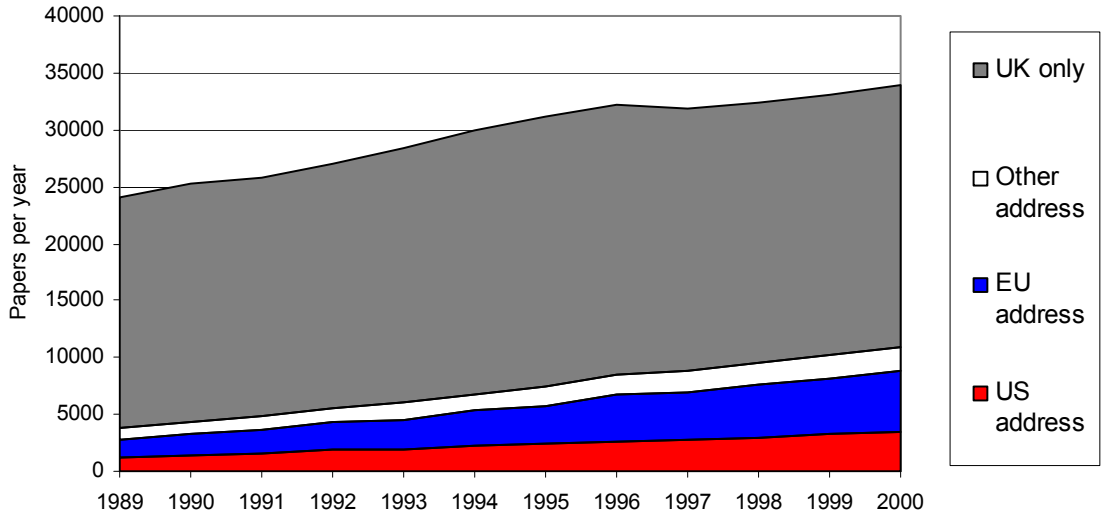

Figure 3.2.3 UK ROD papers with non-UK addresses, 1989-2000.

And although the US and countries in the EU dominate, between 1989 and 2000, the UK co-authored papers (in much smaller numbers) with nearly 190 different countries around the world – from New Zealand to the Vatican City (the leading countries are shown in Table 3.2.1 and in more detail in Table A3.2.4 of the Appendix).

Table 3.2.1 Leading countries with which the UK co-authored biomedical papers in 1989-2000.

COUNTRY	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	% of total
USA	1288	1340	1545	1836	1893	2189	2382	2678	2806	2995	3212	3547	7.80
GERMANY	367	432	456	565	598	764	797	976	1133	1202	1312	1419	2.82
FRANCE	289	400	393	485	583	692	747	889	938	997	1099	1136	2.43
ITALY	239	292	365	431	397	540	571	671	698	826	880	939	1.93
NETHERLANDS	227	260	288	413	439	514	573	625	697	812	851	935	1.87
CANADA	251	241	269	306	373	370	468	510	540	543	607	617	1.43
AUSTRALIA	189	232	290	283	336	380	419	476	490	601	561	646	1.38
SWEDEN	168	221	224	286	255	320	282	416	421	507	551	519	1.17
SWITZERLAND	160	207	210	229	269	318	348	421	402	404	493	457	1.10

SPAIN	87	107	151	236	232	297	322	390	369	480	516	507	1.04
JAPAN	102	133	162	207	228	301	351	379	397	426	440	517	1.03
BELGIUM	108	149	160	204	201	266	293	338	354	389	470	459	0.95
DENMARK	98	120	145	219	206	239	243	285	304	334	376	390	0.83
FINLAND	50	68	74	101	89	109	129	156	207	183	233	282	0.47
IRELAND	56	72	75	93	94	113	138	188	198	193	227	249	0.48
NORWAY	47	66	62	81	80	94	107	137	159	173	166	189	0.38
BRAZIL	41	69	80	85	86	110	109	142	145	161	159	190	0.39
AUSTRIA	40	38	60	62	69	89	94	147	130	171	190	180	0.36
GREECE	53	39	65	76	67	86	81	120	120	128	155	181	0.33
NEW ZEALAND	58	53	66	84	66	79	111	104	102	112	138	188	0.33
ISRAEL	53	58	60	63	89	78	83	99	129	105	126	157	0.31

3.3 Geographical distribution of papers within the UK, and its leading research institutions

We split the UK into its four territories – England, Northern Ireland, Scotland and Wales – to assess if there is a relationship between biomedical outputs and the GDP and population of each region (table 3.3.1).

Table 3.3.1 Outputs of ROD papers from England, Northern Ireland, Scotland and Wales (per year), and comparison with populations and GDP in 1994.

Territory	*Pop (M)*	*GDP, £bn*	*ROD 1989-2000*	*Mean*	*Papers/M*	*Papers/£bn*
England	48.71	483.4	299618	24968	513	51.7
N. Ireland	1.64	13.2	6971	581	354	44.0
Scotland	5.13	50	50264	4189	817	83.8
Wales	2.91	23.8	13562	1130	388	47.5
Total UK	58.39	578.7	355188	29599	507	51.1

We can see that GDP relates more closely to biomedical output than population (in England, Northern Ireland and Wales, at least). But Scotland has a much higher biomedical output than would be expected from either its GDP or its population, compared to other parts of the UK. It has less than 9% of the UK's total GDP, but publishes around 14% of biomedical papers.

For a more detailed breakdown of biomedical production in the UK, we separated the UK into its 124 different post code areas and ranked them in order of the proportion of the total papers they produced (table 3.3.2).

The leading biomedical research institutions that produce the most papers annually in the in the UK are Cambridge, Edinburgh and Oxford universities as well as University College London. The output of each surpasses 10,000 papers in the 12-year period analysed in this report (for more detail on research institutions see Table A3.3.2a (UK institutions) and A3.3.2b (non-UK institutions) in the Appendix.

Table 3.3.2 Leading UK postcode areas in terms of production of papers in the ROD from 1989 to 2000 (all post code areas in table A3.3.1 in the Appendix).

Code	Posttown	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	All	%
WC	London WC	2182	2358	2337	2471	2615	2726	2812	3187	3143	3175	3262	3351	33619	7.46
CB	Cambridge	1620	1700	1688	1837	2028	2116	2393	2274	2227	2231	2429	2506	25049	5.56
OX	Oxford	1585	1674	1715	1858	1858	1984	2109	2288	2318	2332	2395	2468	24584	5.46
W	London W	1784	1897	1928	1993	1959	2110	2238	2274	2141	1950	1955	1945	24174	5.36
SE	London SE	1439	1453	1627	1709	1749	1830	1858	1918	1987	1980	2057	2257	21864	4.85
SW	London SW	1286	1435	1502	1588	1609	1677	1683	1720	1750	1782	1863	1885	19780	4.39
EH	Edinburgh	1227	1267	1326	1426	1500	1590	1638	1615	1652	1724	1722	1746	18433	4.09
M	Manchester	1122	1145	1157	1282	1371	1349	1496	1543	1540	1579	1707	1691	16982	3.77
G	Glasgow	1163	1244	1246	1340	1338	1432	1372	1417	1457	1441	1593	1618	16661	3.70
NW	London NW	961	1046	1044	1090	1155	1190	1229	1202	1210	1326	1300	1304	14057	3.12
B	Birmingham	915	970	967	988	1081	1123	1163	1110	1119	1203	1289	1341	13269	2.94
BS	Bristol	675	745	773	858	843	941	1030	1042	1089	1105	1158	1236	11495	2.55
L	Liverpool	744	716	803	794	838	902	977	1022	1008	963	986	1041	10794	2.40
LS	Leeds	676	652	650	672	705	726	832	878	923	968	974	1038	9694	2.15

NE	Newcastle	610	661	687	747	838	811	819	925	828	856	890	988	9660	2.14
NG	Nottingham	597	615	639	652	717	805	824	863	932	914	967	1059	9584	2.13
CF	Cardiff	662	706	671	716	706	772	822	870	896	877	908	953	9559	2.12
LE	Leicester	526	544	577	601	659	821	861	924	837	867	876	1041	9134	2.03
S	Sheffield	487	539	623	665	692	779	761	842	895	880	942	994	9099	2.02

Figure 3.3.1 (map below) shows the areas of greatest growth in the UK of production of biomedical papers between the periods 1989-92 and 1997-2000. Some areas considerably increased the amount of papers they produced.

The output of some postcode areas has grown particularly fast – Telford (TF, x 3.2), for example (although its total output is relatively small) and Stevenage (SG), where the new GlaxoWellcome labs (x 2.4) are located. Four other areas, York (YO), Croydon (CR), Dorchester (DT) and Torquay (TQ)[1], have all more than doubled their proportions of total production. On the other hand, Bromley (BR) where the old Wellcome plc labs were sited (now closed down) has now almost no output. Harrow (HA) has less than half the percentage share it had in 1988-92 because of the closure of the MRC's Clinical Research Centre (see figure 3.3.1).

[1] Croydon owes its increase in published outputs (from 39 to 101) to Mayday Univ. Hospital which increased its output from 12 papers in the earlier time period to 65 in the latter; Dorchester increased its outputs from 22 to 48 papers mainly due to the opening in of a new Centre for Environment, Fisheries and Aquaculture Science (CEFAS) Laboratory in 1995. Torquay's increases are due to increased outputs of the Torbay Hospital and York's - due to the significant expansion of two University of York departments (chemistry and biology).

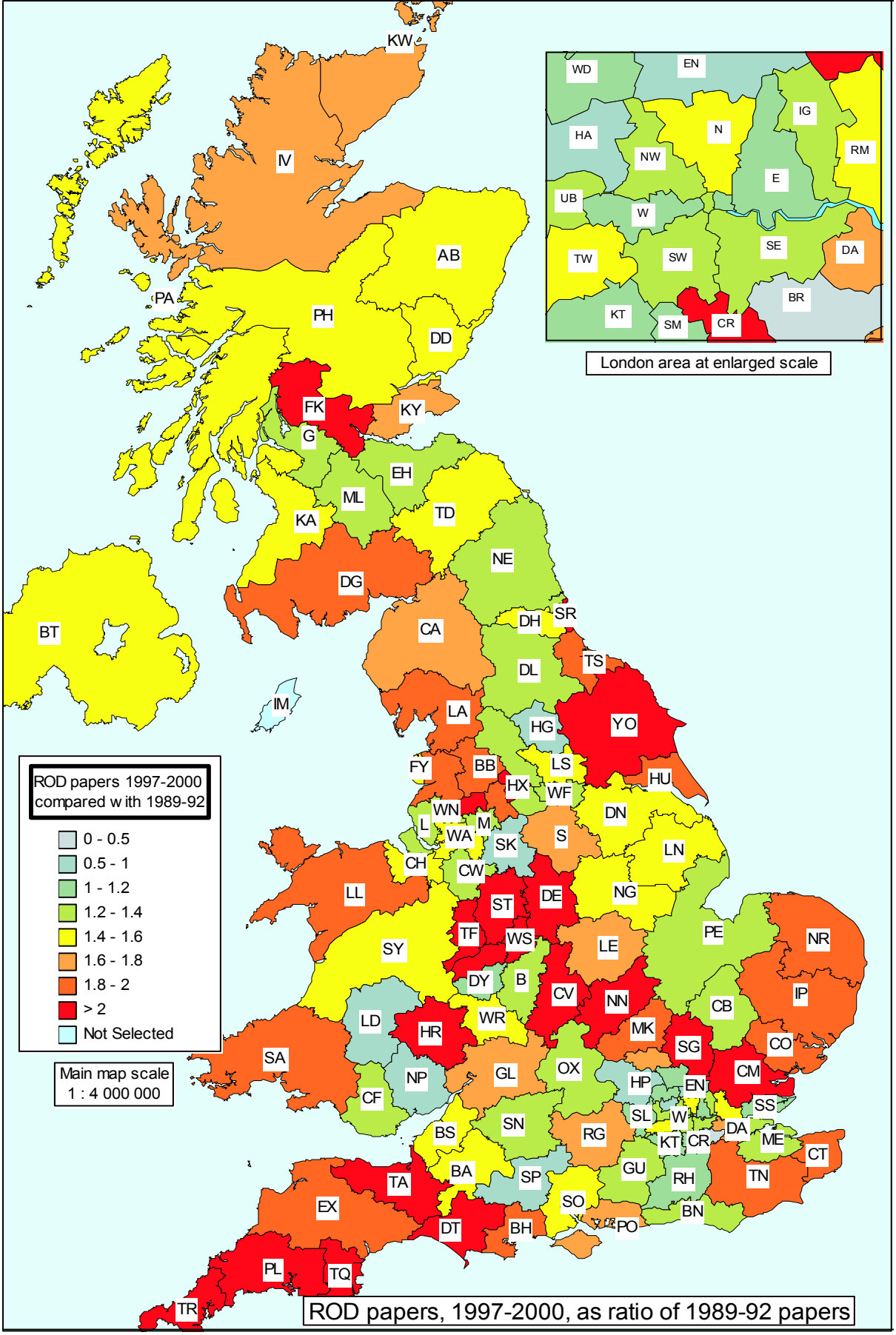

Figure 3.3.1 Map of the UK showing changes in percentage of ROD papers in each postcode-area from 1989-92 to 1997-2000 (expressed as a ratio)

Inter-city collaboration

Inter-city collaboration in the UK has been rising steadily over the past 12 years. We can measure its level with the difference between the total number of papers produced by all postcode areas in the UK – as one paper produced by at least two areas is counted twice – and the number of papers listed in ROD. When we divide this difference by the number of ROD papers, we have a percentage figure for collaboration level (table 3.3.3).

Table 3.3.3 Inter-city collaboration on ROD papers, from 1989 to 2000.

Period:	*1989-92*	*1993-96*	*1997-2000*
Total ROD papers	103246	121578	131264
Sum of pc areas	125509	153775	171364
Difference	22263	32197	40100
M*, %	21.56%	26.48%	30.55%

* M is an indicator of collaboration

International collaboration

We noted earlier that, along with inter-city collaboration, the phenomenon of international collaboration has grown throughout the UK. But actual levels vary with each region (Figure 3.3.2).

For example, 37% of all papers published in Warrington are international, as its Daresbury Synchrotron attracts many non-UK scientists, Enfield (home to the National Institute for Biological Standards as well as a Cancer Research UK lab) has the second highest level.

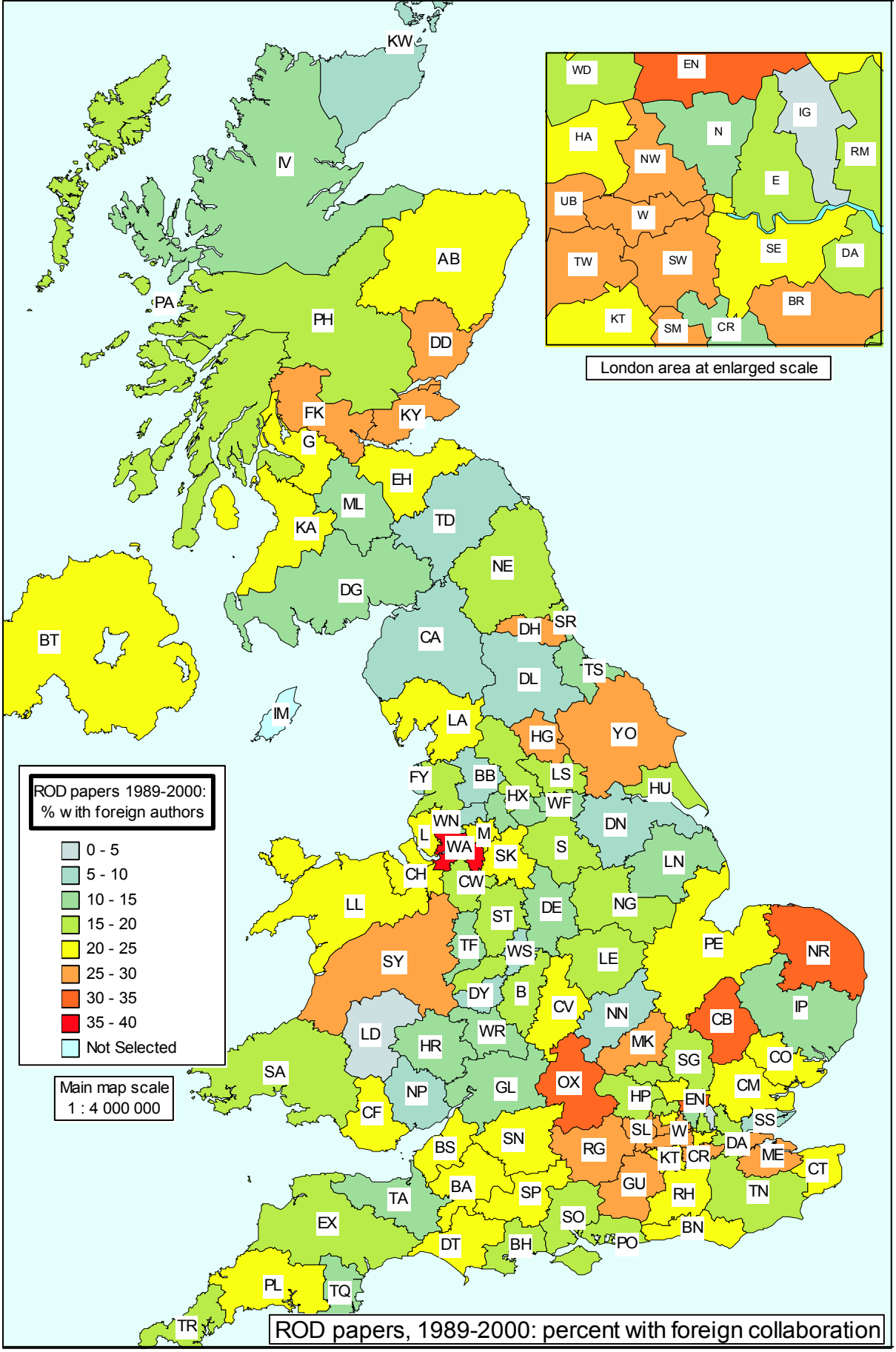

Fig. 3.3.2 Map showing % of ROD papers with foreign collaboration, 1989-2000.

Just as collaboration levels vary according to the research institutions in an area, levels of paper production link to the locations of pharmaceutical industry laboratories.

The leading laboratories are SmithKline Beecham plc and the Merck Neuroscience Centre in Chelmsford (CM), AstraZeneca plc in Stockport (SK), and GlaxoWellcome plc in Stevenage (SG) – all of which push up production in those areas. Table A3.3.2a lists two other major pharmaceutical labs: the former Wellcome plc lab in Bromley (BR) and Pfizer in Canterbury (CT).

3.4 The research level of biomedical papers

All biomedical research can be placed on a spectrum from basic to clinical. It is important that each national system achieves an appropriate balance of research. One way of monitoring what this balance is, is to classify each biomedical paper published into an appropriate category.

One method of looking at the balance of research is to examine the publications in any given journal and then to categorise the journal according to the predominant type of research it carries. The journal classification used in this report has been devised by CHI Research Inc.[2] All journals are assigned a research level based on a four-point scale: RL1 – clinical observation, RL2 – clinical mix, RL3 – clinical investigation and RL4 – basic research. Table 3.4.1 also shows the classification of ROD papers for the three four-year periods studied.

[2] Narin,F., Pinski, G. and H.H. Gee (1976) Structure of the biomedical literature. *JASIS*, 27, pp. 25-45.

Table 3.4.1 Four research levels of biomedical journals, as defined by CHI Research Inc., and the numbers and percentages of ROD papers at each level, 1989-2000.

	n.a.	1	2	3	4	
RL	(not assigned)	Clinical observation	Clinical mix	Clinical investigation	Basic research	TOTAL
1989	233	5158	6386	5576	6787	24140
1990	259	5221	6783	5763	7269	25295
1991	299	5504	6607	6025	7431	25866
1992	333	5514	7002	6500	7693	27042
% 89-92	1.1	20.9	26.2	23.3	28.5	
1993	382	5918	6975	6824	8222	28321
1994	439	6266	7330	6982	8886	29903
1995	583	6207	7618	7164	9635	31207
1996	627	6915	7429	7421	9755	32147
% 93-96	1.7	20.8	24.1	23.4	30.0	
1997	625	6710	7786	7062	9755	31938
1998	558	6783	7819	7281	9890	32331
1999	725	6961	8074	7322	9939	33021
2000	847	7303	8138	7509	10175	33972
% 97-00	2.1	21.1	24.2	22.2	30.3	

There has been a modest shift over the 14-year period from clinical mix and clinical investigation to basic research.

The balance of research varies around the country. Of the postcode areas that published at least 200 papers per year, Norwich (NR), the site of the BBSRC's John Innes Centre and the University of East Anglia, had the highest level of basic research (63%).

London EC (the location of St Bartholomew's Hospital; 13%) and London SE (home of King's, Guy's and St Thomas's; 14%) had the lowest proportions of basic research (see table A3.4.1 in the appendix for a list of the major producers and the percentages of their output published in basic research journals (RL4) and in clinical journals (RL1)).

The analysis of the research levels of the various subfields that make up British biomedicine is shown in Figure. Overall, the UK research in 32 selected subfields for the period tended towards more applied research, although it included a fair proportion of basic papers.

Altogether, there were 13 more basic subfields, with at least half of their papers published in RL3 or RL4 journals. Predictably, neuroscience and genetics were by far the most basic disciplines. Both had over 60% of papers published in basic journals (RL4). On the other hand, surgery, mental health research and otorhinolaryngology were the most clinical. Each subfield had over 50% of papers published in RL1 journals.

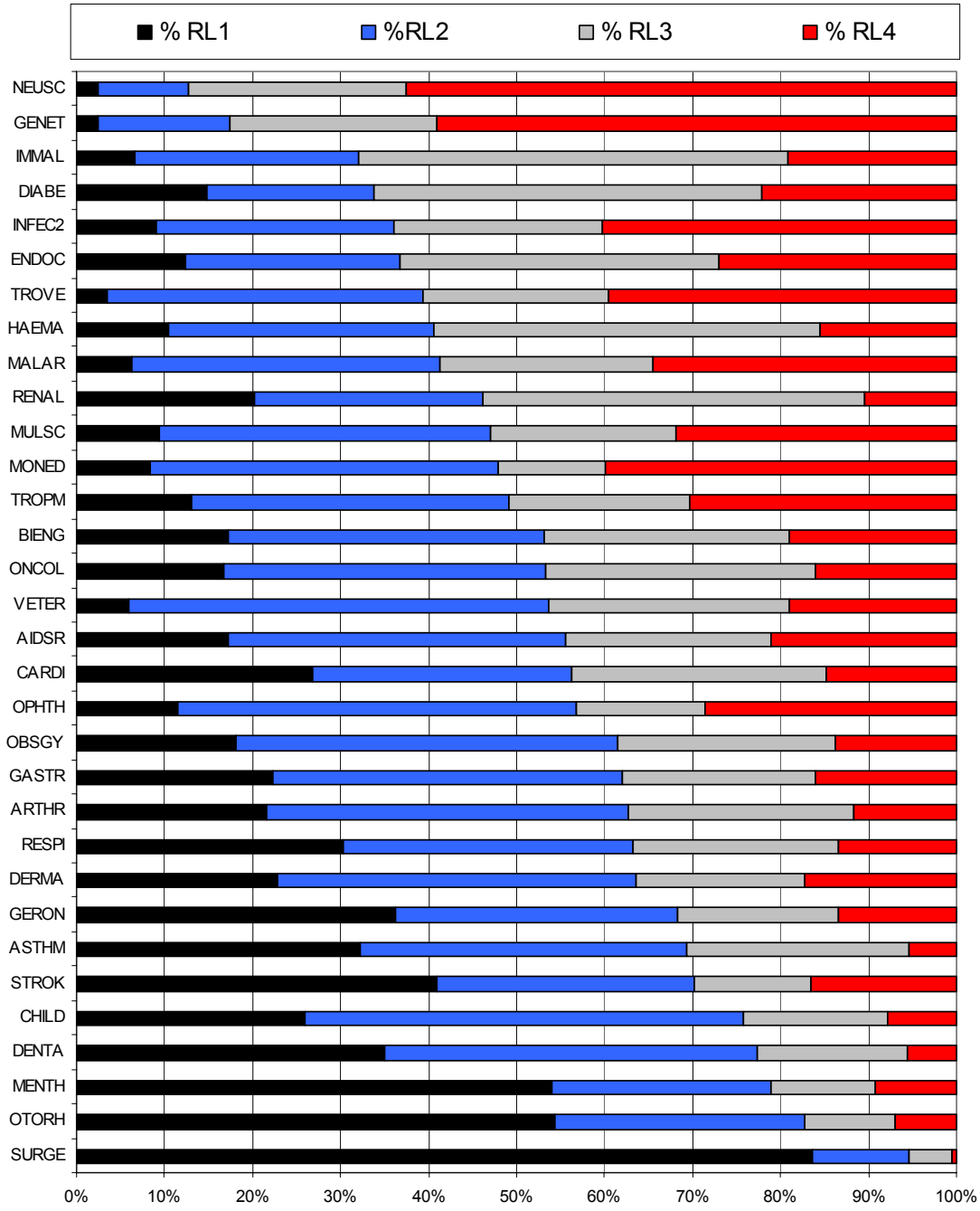

Figure 3.4.1 Distribution of UK ROD papers by research level (RL), 1989-2000.

Key Findings

- The most dynamic growth in British biomedicine took place in the early 1990s. After this time growth slowed down, and the numbers of papers declined in 1997
- Number of authors and institution addresses have been steadily increasing – 38% of papers now have at least five authors, and the yearly proportion of papers with five or more addresses (9%) has more than quadrupled since 1989
- International collaboration is also rising, led by the United States but also with a rapid increase in the EU, which is now involved with 16% of UK biomedical papers
- Scotland is responsible for a relatively high proportion of British biomedical output (14%), compared to its share of GDP (9%)
- The UK biomedical portfolio tends towards more applied clinical research rather than basic theoretical research, although there has been a modest shift in the other direction
- As expected, neuroscience and genetics were by far the most basic biomedical subfields, while surgery, mental health research and otorhinolaryngology were the most clinical