

Supporting Information

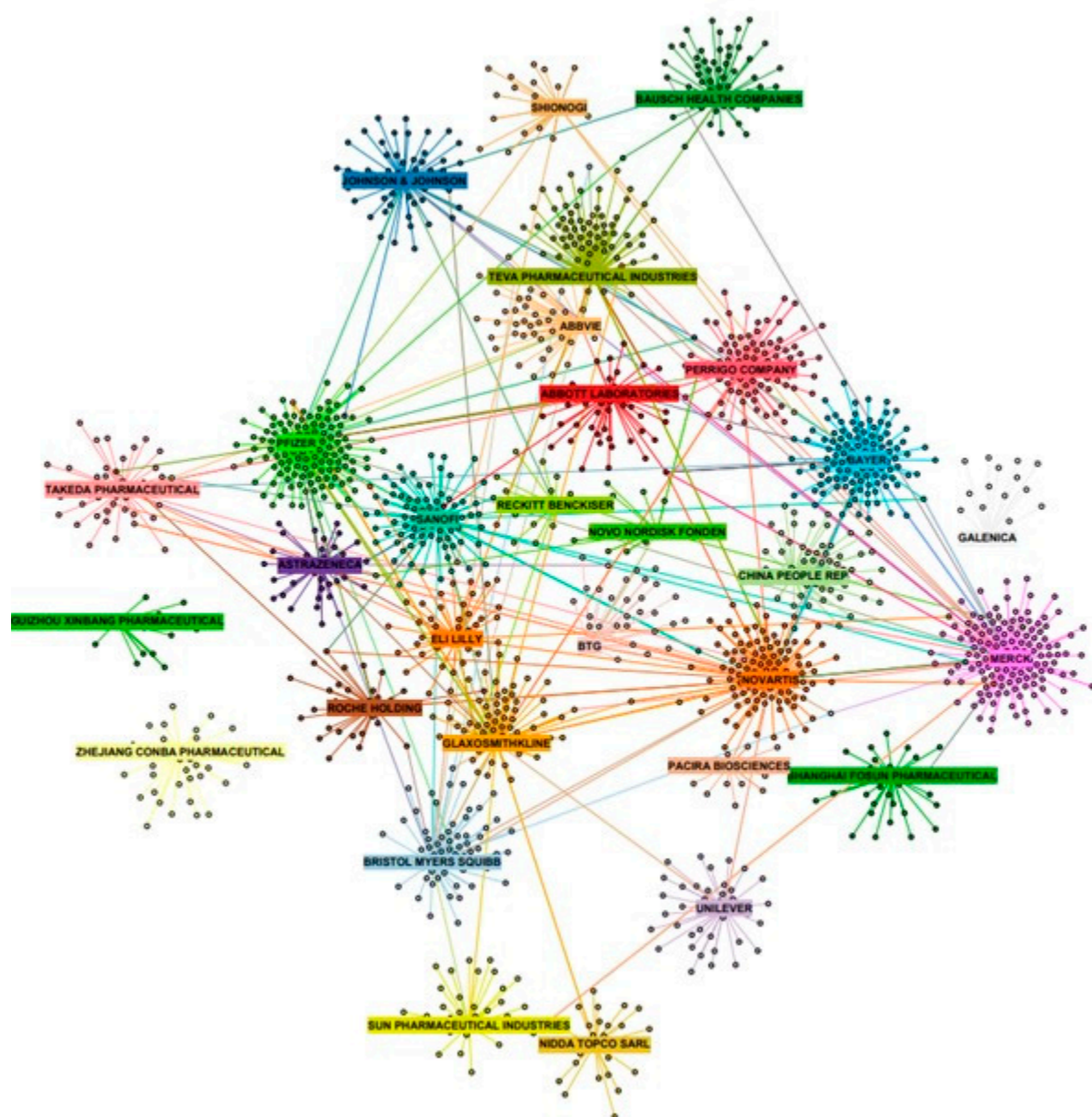


Figure S1 Interactions between 30 major clusters with GUOs as hubs.
A high resolution image is included in the submission material

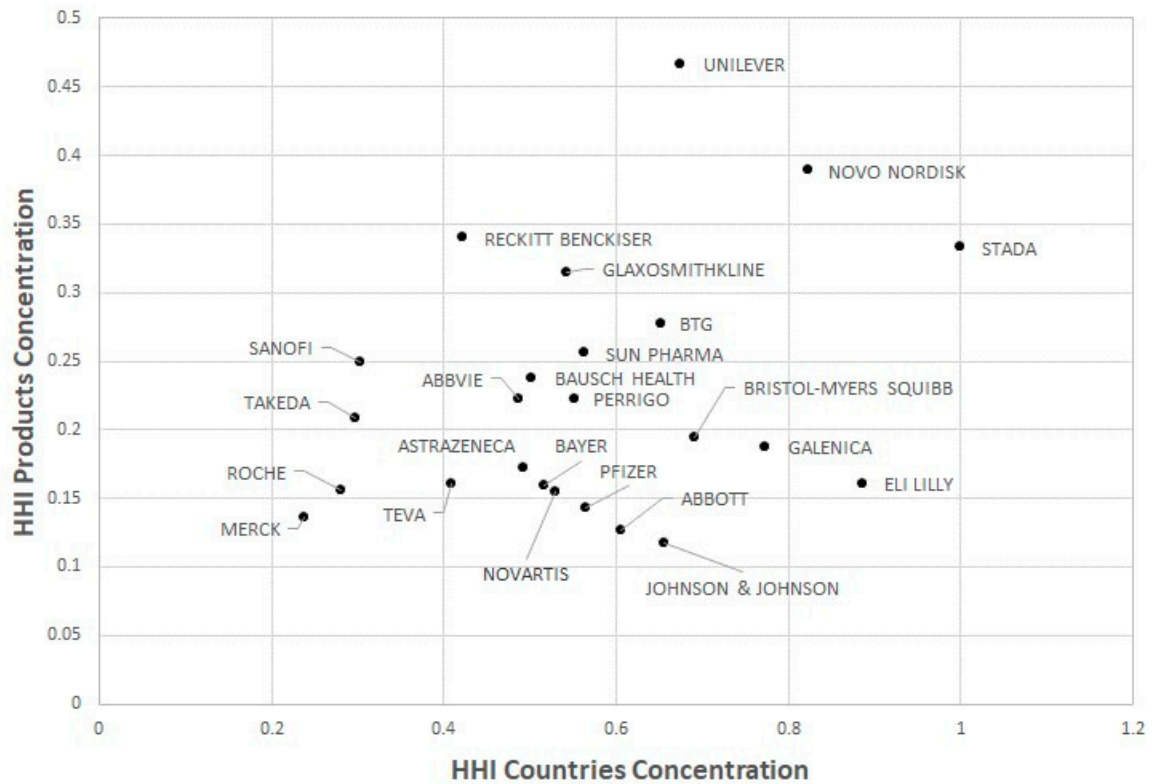


Figure S2 The current structures of the major pharma GUOs
(Products and countries of deal making subsidiaries of the GUOs)

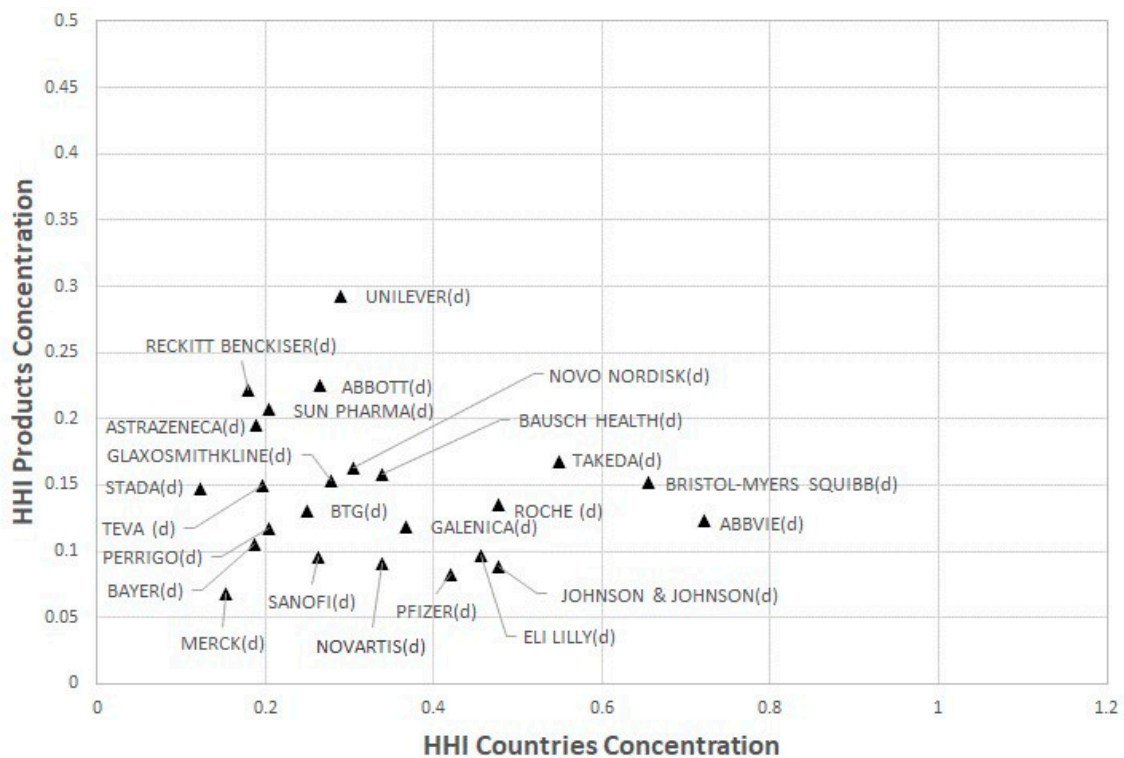


Figure S3 The deals profiles of the major pharma GUOs
(Net products and countries of the GUOs deals as targets and acquirors)

Table S1 Consolidated pharma product (and services) categories derived from Zephyr business categories

No.	Business Offerings Group	No.	Business Offerings Group
1	Animal health products related	18	Drug discovery & development services
2	Biopharma marketing, distributor & wholesaler	19	Generics developer, manufacturer & wholesaler
3	Biopharma product developer and / or manufacturer - diversified or other non-cancer & non-vaccine related	20	Medical instruments, lab material, devices & equipment
4	Biopharma product developer and /or manufacturer - vaccines	21	Other products & services
5	Biopharma product developer and/or manufacturer - cancer related	22	Pharma developer
6	Biopharma services - discovery, development & other	23	Pharma distributor
7	Biotech development services	24	Pharma ingredient, preparation, formulation & chemicals
8	Biotech product or component developer & manufacturer	25	Pharma manufacturer
9	Consumer products - electronics	26	Pharma marketing, retailer & packaging
10	Consumer products - food & nutrition	27	Pharma wholesaler
11	Consumer products - healthcare	28	Platform developer, operator, software & mobile apps
12	Consumer products - household	29	R&D - Biopharma
13	Consumer products - other	30	R&D - Biotech, drug delivery systems & medical devices
14	Cosmetics & skincare	31	R&D - Cancer & vaccines related
15	Dental related	32	R&D - Other
16	Diagnostic & testing related	33	R&D - Pharma
17	Drug delivery systems developer & manufacturer		

Table S2 Characteristics of 30 major hub GUOs (with degrees > 10)

Cluster	Hub firm of cluster	Hub Parent Country	Firms in cluster	No. of subsidiaries	Hub Degrees	Total deals	Countries of operation	Product categories
1	MERCK	US	134	291	154	171	33	191
2	PFIZER	US	121	220	141	158	39	166
4	NOVARTIS	DE	111	260	120	138	24	171
3	BAYER	CH	105	191	128	149	27	192
5	PERRIGO COMPANY	IE	89	67	94	97	12	86
6	SANOFI	FR	85	181	94	108	31	73
8	GLAXOSMITHKLINE	IE	69	127	79	100	22	92
7	TEVA PHARMACEUTICAL	GB	68	198	81	108	36	102
9	BRISTOL MYERS SQUIBB	US	67	106	75	89	21	65
10	JOHNSON & JOHNSON	US	59	291	64	67	24	107
11	CHINA NATIONAL/RESOURCES ^{1,2}	CN	57	102	56	63	4	53
12	BAUSCH HEALTH COMPANIES	CA	55	105	55	60	10	68
13	TAKEDA PHARMACEUTICAL	JP	48	108	53	54	23	63
14	ABBOTT LABORATORIES	US	47	184	49	53	23	70
15	ABBVIE	US	45	93	47	54	14	115
16	ELI LILLY	US	43	73	47	51	13	97
18	ASTRAZENECA	IN	42	19	43	44	12	66
17	UNILEVER	GB	40	70	45	53	24	43
19	ZHEJIANG CONBA PHARMA ²	CN	37	13	36	62	1	57
20	ROCHE HOLDING	CH	34	109	35	39	18	35
21	SHANGHAI FOSUN PHARMA ²	CN	33	17	32	41	2	62
22	SUN PHARMACEUTICAL	IN	31	39	32	37	10	40
23	BTG	US	30	8	31	39	6	40
24	STADA ³	DE	29	20	29	32	11	19
25	SHIONOGI ²	JP	24	15	23	30	4	19
26	GALENICA	CH	16	9	15	16	5	29
27	RECKITT BENCKISER	GB	14	22	15	15	12	18
28	NOVO NORDISK FONDEN	DK	14	53	14	21	13	26
29	GUIZHOU XINBANG PHARMA ²	CN	12	1	11	16	1	23

Cluster	Hub firm of cluster	Hub Parent Country	Firms in cluster	No. of subsidiaries	Hub Degrees	Total deals	Countries of operation	Product categories
30	PACIRA BIOSCIENCES ²	US	12	5	12	17	2	11
TOTAL		n/a	1,571	2,997	n/a	1,982	n/a	n/a

¹The cluster of firms having “China People Rep” as the GUO registered in the database could not be validated with other sources. An analysis of the major deal making firms grouped under this GUO concluded that this cluster consists of two major independent Chinese corporations, namely, China National Pharmaceutical Group Corporation and China Resources (Holdings) Co., Ltd. For reporting ease, we renamed this cluster as “China National / Resources”.

²The hub firms were China National / Resources, Zhejiang Conba Pharmaceutical, Shanghai Fosun Pharmaceutical, Shinogi, Guizhou Xinbang Pharmaceutical and Pacira Biosciences were eliminated from this study as outliers due to being disconnected with the network of the other 24 and having operations in less than 5 countries.

³The cluster having “Nidda Topco SARL” as the GUO name could not be validated with other sources with the exception of a minor mention in an annual report of STADA Arzneimittel AG. As STADA Arzneimittel AG was the most frequently occurring deal maker in this cluster and a major German pharmaceutical firm with no other mentioned holding firm, we renamed the GUO as STADA in further analyses.

Table S3 Major countries concentration of head offices of subsidiaries of hub firms operating in more than 5 countries

Country	TOTAL	MERCK	PFIZER	BAYER	NOVARTIS	PERRIGO	SANOFI	TEVA	GSK ¹	BMS ²	J&J ³	BAUSCH	TAKEDA	ABBOTT ⁵	ABBVIE	ELI LILLY	UNILEVER	ASTRAZENECA	ROCHE ⁶	SUN PHARMA ⁷	BTG	STADA	GALENICA	RECKITT ⁸	NOVO NORDISK ⁹
USA	216	19	28	12	7	8	4	12	6	18	17	11	12	14	17	13	1	6	2	7	1	0	0	1	0
Germany	53	14	4	26	1	0	1	0	0	0	2	0	2	1	0	1	0	0	0	0	0	1	0	0	0
France	47	6	2	4	5	0	21	1	2	2	0	0	0	0	0	0	1	1	1	0	1	0	0	0	0
UK	43	2	1	1	1	0	2	0	14	1	0	0	3	1	0	0	4	6	0	0	2	0	0	5	0
India	37	4	5	3	6	0	3	0	3	0	0	0	0	1	0	2	2	1	0	6	0	0	0	1	0
Switzerland	24	2	1	0	15	0	0	0	0	0	1	0	0	0	0	0	0	0	3	0	0	0	2	0	0
Japan	20	1	0	2	2	0	4	0	0	0	0	0	10	0	0	0	0	0	1	0	0	0	0	0	0
Spain	19	3	1	3	2	0	1	1	1	0	1	0	0	2	0	0	1	0	2	0	0	0	1	0	0
Italy	13	3	4	0	2	0	0	0	0	2	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0
Australia	12	2	2	0	0	0	1	2	2	1	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0
Netherlands	10	3	0	1	0	0	1	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0
Canada	10	0	1	0	2	0	1	1	0	0	2	3	0	0	0	0	0	0	0	0	0	0	0	0	0
China	10	0	0	1	3	0	1	0	1	0	2	0	1	0	0	0	0	1	0	0	0	0	0	0	0
Ireland	9	0	3	0	1	1	0	1	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
Sweden	8	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0

Table S4 Major pharma product (and services) categories concentration of subsidiaries of hub firms operating in more than 5 countries

Product Categories	TOTAL	MERCK	PFIZER	BAYER	NOVARTIS	PERRIGO	SANOFI	TEVA	GSK ¹	BMS ²	J&J ³	BAUSCH	TAKEDA	ABBOTT ⁵	ABBVIE	ELI LILLY	UNILEVER	ASTRAZENECA	ROCHE ⁶	SUN PHARMA ⁷	BTG	STADA	GALENICA	RECKITT ⁸	NOVO NORDISK ⁹
Pharma manufacturer	250	26	26	16	16	4	29	9	24	14	10	8	13	6	12	6	1	11	3	8	2	1	0	2	3
Biopharma developer (a)	54	5	12	2	1	0	5	3	0	4	2	1	4	0	1	3	0	9	1	1	0	0	0	0	0
R&D – pharma	51	2	4	1	1	0	2	2	7	5	3	3	5	3	3	1	0	3	0	2	0	1	0	1	2
Pharma developer	42	5	6	0	2	0	0	5	4	1	2	5	1	3	1	1	0	4	0	1	1	0	0	0	0
Consumer products (a)	38	2	3	0	2	1	1	0	4	0	0	0	2	0	0	0	22	0	1	0	0	0	0	0	0
Pharma wholesaler	37	8	6	5	1	1	2	1	1	2	1	1	1	1	3	1	0	0	0	0	0	0	2	0	0
Animal health products	35	6	10	6	4	2	0	3	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0
Consumer products (b)	33	2	3	4	3	2	4	0	0	0	5	0	0	2	0	0	1	2	2	0	0	0	0	2	1
Diagnostic & testing	30	4	1	7	4	1	2	0	0	0	1	0	0	4	0	1	0	0	3	2	0	0	0	0	0
Cosmetics & skincare	25	1	1	0	0	0	4	0	1	3	5	2	0	0	4	0	2	2	0	0	0	0	0	0	0
Pharma components ¹⁰	24	2	4	2	2	0	0	2	0	0	0	0	1	0	0	0	0	3	0	7	0	0	1	0	0
Medical instruments ¹¹	16	1	2	2	0	0	2	0	0	0	3	0	0	5	1	0	0	0	0	0	0	0	0	0	0
Consumer products (c)	13	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	5	0

Table S5 Major countries concentration of head offices of connections of hub firms operating in more than 5 countries

Country	TOTAL	MERCK	PFIZER	BAYER	NOVARTIS	PERRIGO	SANOFI	TEVA	GSK ¹	BMS ²	J&J ³	BAUSCH	TAKEDA	ABBOTT ⁵	ABBVIE	ELI LILLY	UNILEVER	ASTRAZENECA	ROCHE ⁶	SUN PHARMA ⁷	BTG	STADA	GALENICA	RECKITT ⁸	NOVO NORDISK ⁹
USA	712	54	85	41	57	15	42	33	41	56	40	30	25	28	38	31	18	21	17	12	12	1	1	4	10
Germany	132	8	10	7	18	8	7	2	14	7	1	0	2	2	4	4	7	9	0	0	9	7	1	3	2
France	102	23	6	26	10	4	5	1	3	1	1	1	3	2	3	2	0	2	0	0	0	4	0	2	3
UK	71	9	4	2	4	7	14	5	3	3	2	0	1	1	3	0	4	3	1	1	1	0	1	1	1
India	64	9	0	1	4	0	10	7	2	1	3	0	11	3	0	0	0	1	7	5	0	0	0	0	0
Switzerland	61	1	3	1	3	35	3	1	4	0	2	0	1	0	0	4	0	1	0	0	1	0	0	1	0
Japan	56	6	2	3	9	0	0	1	5	4	2	1	4	0	1	1	0	3	3	1	0	1	9	0	0
Spain	52	8	5	9	0	14	3	5	2	1	0	0	0	3	0	0	0	0	1	0	1	0	0	0	0
Italy	49	2	9	5	7	1	4	0	4	0	2	0	0	2	0	0	0	2	0	10	1	0	0	0	0
Australia	45	6	2	5	3	2	0	21	0	1	2	0	0	1	0	0	0	0	1	1	0	0	0	0	0
Netherlands	40	0	6	3	6	1	1	2	1	2	0	8	1	0	0	2	0	1	0	1	3	0	0	0	2
Canada	33	3	1	2	7	1	3	2	2	1	1	0	0	2	0	0	1	2	2	0	1	1	1	0	0
China	30	5	4	2	2	1	2	2	1	2	0	3	2	0	0	0	1	2	0	1	0	0	0	0	0
Ireland	29	9	1	0	5	2	0	3	0	1	0	1	0	2	1	0	0	1	0	0	0	3	0	0	0
Sweden	27	3	2	1	2	1	2	0	1	2	1	0	2	1	0	0	2	3	0	0	0	1	3	0	0
Argentina	25	3	2	2	1	0	0	1	2	0	1	0	0	0	0	1	1	0	1	0	8	1	0	0	1

Table S6 Major pharma product (and services) categories concentration of connections of hub firms (categories with counts >than 5)

Product Categories	TOTAL	MERCK	PFIZER	BAYER	NOVARTIS	PERRIGO	SANOFI	TEVA	GSK ¹	BMS ²	J&J ³	BAUSCH	TAKEDA	ABBOTT ⁵	ABBVIE	ELI LILLY	UNILEVER	ASTRAZENECA	ROCHE ⁶	SUN PHARMA ⁷	BTG	STADA	GALENICA	RECKITT ⁸	NOVO NORDISK ⁹
Pharma manufacturer	494	48	39	14	47	28	42	43	43	20	11	30	18	14	18	11	2	17	11	16	6	11	2	3	0
Biopharma developer (a)	179	14	16	7	13	0	18	17	10	17	8	1	13	0	8	4	0	21	2	2	0	2	0	0	6
R&D - pharma	141	9	13	3	17	3	6	8	10	5	4	9	7	1	13	2	1	5	5	9	7	1	1	0	2
R&D - biopharma	107	8	15	3	12	0	16	2	18	8	1	4	5	0	3	6	0	2	2	0	1	0	0	0	1
Medical devices ¹¹	98	9	3	3	5	5	3	5	0	0	17	10	0	12	9	1	1	2	3	0	8	0	0	0	2
Pharma developer	96	6	12	2	8	3	6	15	5	9	3	1	4	1	8	4	0	2	2	2	0	1	2	0	0
Pharma wholesaler	93	11	12	3	2	9	10	7	10	2	1	6	1	4	3	0	0	1	1	0	0	5	4	1	0
Cosmetics & skincare	73	5	4	8	0	9	3	0	6	0	3	7	0	0	2	1	18	1	0	5	0	0	1	0	0
Consumer products (b)	64	5	7	3	10	5	4	1	7	0	4	2	0	0	1	0	8	2	0	0	0	0	1	4	0
Animal health products	63	19	5	11	5	6	3	3	0	0	0	0	0	0	0	9	1	1	0	0	0	0	0	0	0
R&D – biotech	60	6	8	1	4	0	8	1	3	2	2	1	1	7	0	3	0	6	0	1	3	0	0	0	3
Platform & software	59	8	5	6	3	10	4	0	2	2	4	0	0	5	0	0	2	1	5	0	0	1	1	0	0
Consumer products (a)	57	4	6	2	4	5	1	0	4	0	3	3	4	3	1	0	12	1	0	0	0	3	0	1	0

Product Categories	TOTAL	MERCK	PFIZER	BAYER	NOVARTIS	PERRIGO	SANOFI	TEVA	GSK ¹	BMS ²	J&J ³	BAUSCH	TAKEDA	ABBOTT ⁵	ABBVIE	ELI LILLY	UNILEVER	ASTRAZENECA	ROCHE ⁶	SUN PHARMA ⁷	BTG	STADA	GALENICA	RECKITT ⁸	NOVO NORDISK ⁹
Pharma components ¹⁰	54	6	6	5	1	3	2	5	3	2	1	3	1	1	3	1	2	0	1	6	0	1	1	0	0
Diagnostic & testing	54	3	4	9	10	0	5	2	1	6	1	1	2	4	0	0	0	0	2	0	2	2	0	0	0
Biotech developer ¹⁴	44	8	3	3	3	0	5	0	0	0	4	0	1	9	0	3	0	0	1	0	4	0	0	0	0
R&D - cancer & vaccines	44	5	5	2	5	0	0	3	7	5	0	0	1	0	1	3	0	0	4	0	2	1	0	0	0
Biopharma developer (b)	40	6	2	0	6	0	0	4	1	9	1	1	1	0	1	0	0	0	4	0	1	1	0	0	2
R&D – other	35	2	5	2	0	1	1	1	3	2	0	1	0	1	3	2	0	3	3	1	1	0	0	0	3
Consumer products (c)	30	2	1	1	2	2	1	0	1	0	4	0	0	0	0	0	11	0	0	0	0	0	0	5	0
Drug discovery ¹⁵	30	1	4	2	3	0	1	2	0	3	4	1	2	0	2	1	0	1	1	0	2	0	0	0	0
Pharma marketing	28	3	3	2	1	5	2	0	0	1	0	3	1	1	0	0	0	1	0	0	0	2	3	0	0
Generics manufacturer	26	2	3	0	3	2	0	8	2	0	0	0	0	1	0	0	0	0	0	3	0	2	0	0	0
Biopharma developer (c)	25	6	7	2	3	0	1	0	5	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Other products	23	1	1	1	2	1	2	3	1	1	1	1	1	0	0	0	1	4	0	0	1	0	1	0	0
Consumer products (d)	18	6	0	8	0	1	0	0	0	0	2	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Pharma distributor	18	1	1	1	2	5	2	1	0	0	0	0	0	0	0	0	0	1	0	0	0	2	2	0	0
Dental related	11	0	0	0	1	9	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0

¹GSK = GlaxoSmithKline; ²BMS = Bristol-Myers Squibb; ³J&J = Johnson & Johnson; ⁴Bausch = Bausch Health; ⁵Abbott = Abbott Laboratories;

⁶Roche = Roche Holding; ⁷Sun Pharma= Sun Pharmaceutical; ⁸Reckitt = Reckitt Benckiser; ⁹Novo Nordisk = Novo Nordisk Fonden

Biopharma developer (a) = biopharma product developer and/or manufacturer - diversified or other non-cancer & non-vaccine related

Biopharma developer (b) = Biopharma product developer and/or manufacturer - cancer related

Biopharma developer (c) = Biopharma product developer and/or manufacturer - vaccines

Consumer products (a) = Consumer products - food & nutrition

Consumer products (b) = Consumer products – healthcare

Consumer products (c) = Consumer products – household

Consumer products (d) = Consumer products – electronics

¹⁰Pharma components = Pharma ingredient, preparation, formulation & chemicals

¹¹Medical devices = Medical instruments, lab material, devices & equipment

¹²R&D - Biotech = R&D - biotech, drug delivery systems & medical devices

¹³Platform & Software = Platform developer, operator, software & mobile apps

¹⁴Biotech developer = Biotech product or component developer & manufacturer

¹⁵Drug discovery = Drug discovery & development services

¹⁶Pharma marketing = Pharma marketing, retailer & packaging

¹⁷Generics manufacturer = Generics developer, manufacturer & wholesaler

¹⁸Other products = Other products & services