

# **Supplementary Information**

## **Rethinking the competition of export trade based on the bipartite network**

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## Appendix A Research Design

Table A.1: HS codes with their industry specifications.

HS Code	Description
HS.01	Animals; live
HS.02	Meat and edible meat offal
HS.03	Fish and crustaceans, molluscs and other aquatic invertebrates
HS.04	Dairy produce; birds' eggs; natural honey; edible products of animal origin, not elsewhere specified or included
HS.05	Animal originated products; not elsewhere specified or included
HS.06	Trees and other plants, live; bulbs, roots and the like; cut flowers and ornamental foliage
HS.07	Vegetables and certain roots and tubers; edible
HS.08	Fruit and nuts, edible; peel of citrus fruit or melons
HS.09	Coffee, tea, mate and spices
HS.10	Cereals
HS.11	Products of the milling industry; malt, starches, inulin, wheat gluten
HS.12	Oil seeds and oleaginous fruits; miscellaneous grains, seeds and fruit, industrial or medicinal plants; straw and fodder
HS.13	Lac; gums, resins and other vegetable saps and extracts
HS.14	Vegetable plaiting materials; vegetable products not elsewhere specified or included
HS.15	Animal, vegetable or microbial fats and oils and their cleavage products; prepared edible fats; animal or vegetable waxes
HS.16	Meat, fish, crustaceans, molluscs or other aquatic invertebrates, or insects; preparations thereof
HS.17	Sugars and sugar confectionery
HS.18	Cocoa and cocoa preparations
HS.19	Preparations of cereals, flour, starch or milk; pastrycooks' products
HS.20	Preparations of vegetables, fruit, nuts or other parts of plants
HS.21	Miscellaneous edible preparations
HS.22	Beverages, spirits and vinegar
HS.23	Food industries, residues and wastes thereof; prepared animal fodder
HS.24	Tobacco and manufactured tobacco substitutes; products, whether or not containing nicotine, intended for inhalation without combustion; other nicotine containing products intended for the intake of nicotine into the human body
HS.25	Salt; sulphur; earths, stone; plastering materials, lime and cement
HS.26	Ores, slag and ash
HS.27	Mineral fuels, mineral oils and products of their distillation; bituminous substances; mineral waxes
HS.28	Inorganic chemicals; organic and inorganic compounds of precious metals; of rare earth metals, of radio-active elements and of isotopes
HS.29	Organic chemicals
HS.30	Pharmaceutical products
HS.31	Fertilizers

HS Code	Description
HS.32	Tanning or dyeing extracts; tannins and their derivatives; dyes, pigments and other colouring matter; paints, varnishes; putty, other mastics; inks
HS.33	Essential oils and resinoids; perfumery, cosmetic or toilet preparations
HS.34	Soap, organic surface-active agents; washing, lubricating, polishing or scouring preparations; artificial or prepared waxes, candles and similar articles, modelling pastes, dental waxes and dental preparations with a basis of plaster
HS.35	Albuminoidal substances; modified starches; glues; enzymes
HS.36	Explosives; pyrotechnic products; matches; pyrophoric alloys; certain combustible preparations
HS.37	Photographic or cinematographic goods
HS.38	Chemical products n.e.c.
HS.39	Plastics and articles thereof
HS.40	Rubber and articles thereof
HS.41	Raw hides and skins (other than furskins) and leather
HS.42	Articles of leather; saddlery and harness; travel goods, handbags and similar containers; articles of animal gut (other than silk-worm gut)
HS.43	Furskins and artificial fur; manufactures thereof
HS.44	Wood and articles of wood; wood charcoal
HS.45	Cork and articles of cork
HS.46	Manufactures of straw, esparto or other plaiting materials; basketware and wickerwork
HS.47	Pulp of wood or other fibrous cellulosic material; recovered (waste and scrap) paper or paperboard
HS.48	Paper and paperboard; articles of paper pulp, of paper or paperboard
HS.49	Printed books, newspapers, pictures and other products of the printing industry; manuscripts, typescripts and plans
HS.50	Silk
HS.51	Wool, fine or coarse animal hair; horsehair yarn and woven fabric
HS.52	Cotton
HS.53	Vegetable textile fibres; paper yarn and woven fabrics of paper yarn
HS.54	Man-made filaments; strip and the like of man-made textile materials
HS.55	Man-made staple fibres
HS.56	Wadding, felt and nonwovens, special yarns; twine, cordage, ropes and cables and articles thereof
HS.57	Carpets and other textile floor coverings
HS.58	Fabrics; special woven fabrics, tufted textile fabrics, lace, tapestries, trimmings, embroidery
HS.59	Textile fabrics; impregnated, coated, covered or laminated; textile articles of a kind suitable for industrial use
HS.60	Fabrics; knitted or crocheted
HS.61	Apparel and clothing accessories; knitted or crocheted
HS.62	Apparel and clothing accessories; not knitted or crocheted
HS.63	Textiles, made up articles; sets; worn clothing and worn textile articles; rags
HS.64	Footwear; gaiters and the like; parts of such articles
HS.65	Headgear and parts thereof

HS Code	Description
HS.66	Umbrellas, sun umbrellas, walking-sticks, seat sticks, whips, riding crops; and parts thereof
HS.67	Feathers and down, prepared; and articles made of feather or of down; artificial flowers; articles of human hair
HS.68	Stone, plaster, cement, asbestos, mica or similar materials; articles thereof
HS.69	Ceramic products
HS.70	Glass and glassware
HS.71	Natural, cultured pearls; precious, semi-precious stones; precious metals, metals clad with precious metal, and articles thereof; imitation jewellery; coin
HS.72	Iron and steel
HS.73	Iron or steel articles
HS.74	Copper and articles thereof
HS.75	Nickel and articles thereof
HS.76	Aluminium and articles thereof
HS.78	Lead and articles thereof
HS.79	Zinc and articles thereof
HS.80	Tin; articles thereof
HS.81	Metals; n.e.c., cermets and articles thereof
HS.82	Tools, implements, cutlery, spoons and forks, of base metal; parts thereof, of base metal
HS.83	Metal; miscellaneous products of base metal
HS.84	Machinery and mechanical appliances, boilers, nuclear reactors; parts thereof
HS.85	Electrical machinery and equipment and parts thereof; sound recorders and reproducers; television image and sound recorders and reproducers, parts and accessories of such articles
HS.86	Railway, tramway locomotives, rolling-stock and parts thereof; railway or tramway track fixtures and fittings and parts thereof; mechanical (including electro-mechanical) traffic signalling equipment of all kinds
HS.87	Vehicles; other than railway or tramway rolling stock, and parts and accessories thereof
HS.88	Aircraft, spacecraft, and parts thereof
HS.89	Ships, boats and floating structures
HS.90	Optical, photographic, cinematographic, measuring, checking, medical or surgical instruments and apparatus; parts and accessories
HS.91	Clocks and watches and parts thereof
HS.92	Musical instruments; parts and accessories of such articles
HS.93	Arms and ammunition; parts and accessories thereof
HS.94	Furniture; bedding, mattresses, mattress supports, cushions and similar stuffed furnishings; lamps and lighting fittings, n.e.c.; illuminated signs, illuminated name-plates and the like; prefabricated buildings
HS.95	Toys, games and sports requisites; parts and accessories thereof
HS.96	Miscellaneous manufactured articles
HS.97	Works of art; collectors' pieces and antiques
HS.99	Commodities not specified according to kind

## Appendix B Full Results of Benchmark Calculation

Table B.1: Full GCP results in 2023.

HS Code	GCP Value	GCP Ranking	Trade Value	Trade Ranking
HS.09	1.000000	1	285.7	53
HS.11	0.832038	2	119.5	73
HS.24	0.705231	3	240.7	62
HS.25	0.486100	4	262.5	58
HS.08	0.467206	5	680.1	30
HS.17	0.447477	6	255.7	60
HS.07	0.378841	7	407.1	44
HS.22	0.341480	8	675.8	31
HS.03	0.298979	9	614.3	34
HS.15	0.143621	10	644.6	32
HS.23	0.129377	11	469.9	37
HS.78	0.120373	12	39.0	87
HS.20	0.111197	13	356.3	47
HS.01	0.052594	14	115.8	74
HS.21	0.044991	15	459.0	38
HS.19	0.042598	16	446.6	39
HS.71	0.040027	17	3883.3	5
HS.44	0.038851	18	759.2	25
HS.34	0.033051	19	355.1	48
HS.16	0.031069	20	283.8	54
HS.61	0.025364	21	1133.6	17
HS.41	0.024866	22	85.5	78
HS.12	0.024183	23	625.7	33
HS.14	0.023946	24	7.1	97
HS.06	0.022451	25	123.6	72
HS.18	0.021776	26	262.9	57
HS.31	0.020873	27	375.8	46
HS.52	0.019113	28	278.7	55
HS.26	0.016672	29	1475.8	13
HS.72	0.015491	30	2222.3	10
HS.62	0.013784	31	1060.4	19
HS.13	0.012063	32	45.2	86
HS.76	0.011734	33	1073.4	18
HS.04	0.010051	34	503.6	36
HS.33	0.008240	35	808.8	24
HS.49	0.007808	36	184.3	66
HS.10	0.007775	37	703.4	29
HS.53	0.007712	38	23.3	92
HS.27	0.005696	39	12273.4	2
HS.36	0.005468	40	24.0	91
HS.48	0.005254	41	902.8	22
HS.68	0.005226	42	293.2	52

HS Code	GCP Value	GCP Ranking	Trade Value	Trade Ranking
HS.63	0.004944	43	432.6	41
HS.70	0.004245	44	421.4	43
HS.05	0.004074	45	55.2	84
HS.32	0.003906	46	426.7	42
HS.74	0.003372	47	906.0	21
HS.75	0.002836	48	152.7	69
HS.28	0.002755	49	811.4	23
HS.89	0.002483	50	607.2	35
HS.56	0.001884	51	149.9	70
HS.57	0.001512	52	83.1	79
HS.46	0.001343	53	15.3	94
HS.39	0.001241	54	3504.7	7
HS.73	0.001122	55	1724.2	12
HS.02	0.001109	56	743.2	27
HS.40	0.000703	57	1015.7	20
HS.64	0.000602	58	736.4	28
HS.96	0.000556	59	293.3	51
HS.55	0.000484	60	176.8	67
HS.94	0.000366	61	1456.3	14
HS.79	0.000361	62	88.8	77
HS.38	0.000331	63	1303.8	16
HS.65	0.000296	64	59.1	83
HS.51	0.000271	65	54.7	85
HS.81	0.000239	66	94.3	75
HS.60	0.000233	67	191.0	64
HS.92	0.000222	68	38.2	88
HS.80	0.000219	69	32.9	89
HS.86	0.000195	70	220.5	63
HS.69	0.000189	71	328.9	50
HS.83	0.000133	72	391.3	45
HS.87	0.000131	73	7748.0	4
HS.93	0.000121	74	93.7	76
HS.30	0.000118	75	3702.5	6
HS.58	0.000106	76	60.4	82
HS.91	0.000082	77	267.7	56
HS.54	0.000072	78	260.3	59
HS.67	0.000070	79	64.1	81
HS.42	0.000056	80	444.5	40
HS.90	0.000055	81	3190.7	8
HS.35	0.000038	82	184.7	65
HS.47	0.000035	83	243.6	61
HS.43	0.000031	84	29.3	90
HS.84	0.000029	85	11849.9	3
HS.99	0.000024	86	1915.1	11
HS.85	0.000024	87	15870.0	1
HS.82	0.000015	88	350.2	49

HS Code	GCP Value	GCP Ranking	Trade Value	Trade Ranking
HS.50	0.000014	89	8.5	96
HS.45	0.000012	90	10.5	95
HS.59	0.000010	91	133.4	71
HS.29	0.000009	92	2255.7	9
HS.88	0.000007	93	1339.6	15
HS.95	0.000003	94	747.5	26
HS.97	0.000002	95	154.8	68
HS.66	0.000000	96	19.6	93
HS.37	0.000000	97	74.3	80

NOTE: GCP values have been Max-Min Standardized; trade values are shown in bn\$.

Table B.2: Full GCC results in 2023.

ISO	Country	GCC Value	GCC Ranking	Trade Value	Trade Ranking
VCT	Saint Vincent and the Grenadines	1.0000	1	0.2	160
YEM	Yemen	0.5641	2	0.0	172
GRD	Grenada	0.5335	3	0.2	162
MWI	Malawi	0.3985	4	4.5	140
UGA	Uganda	0.3039	5	21.6	115
RWA	Rwanda	0.2847	6	6.1	133
BDI	Burundi	0.2438	7	0.7	156
KEN	Kenya	0.2257	8	33.1	97
ABW	Aruba	0.2156	9	0.4	158
HND	Honduras	0.1796	10	19.9	118
GTM	Guatemala	0.1563	11	66.8	80
DOM	Dominican Republic (the)	0.1395	12	54.5	83
FJI	Fiji	0.1048	13	4.7	138
BLZ	Belize	0.1018	14	1.3	149
LCA	Saint Lucia	0.0990	15	0.2	163
TZA	Tanzania, the United Republic of	0.0870	16	31.6	99
NIC	Nicaragua	0.0778	17	31.6	98
LAO	Lao People's Democratic Republic (the)	0.0664	18	33.7	96
MDG	Madagascar	0.0615	19	14.5	123
TGO	Togo	0.0612	20	5.9	136
ETH	Ethiopia	0.0584	21	14.2	124
URY	Uruguay	0.0556	22	44.5	91
EGY	Egypt	0.0539	23	198.1	59
CUB	Cuba	0.0505	24	7.9	131
ZWE	Zimbabwe	0.0486	25	28.5	107
PSE	Palestine, State of	0.0445	26	6.6	132
LKA	Sri Lanka	0.0409	27	61.7	82
SRB	Serbia	0.0406	28	124.7	66

ISO	Country	GCC Value	GCC Ranking	Trade Value	Trade Ranking
SLV	El Salvador	0.0385	29	30.7	102
LTU	Lithuania	0.0368	30	195.8	60
JOR	Jordan	0.0362	31	51.0	85
TUR	Turkey	0.0361	32	1085.5	30
SEN	Senegal	0.0326	33	24.3	109
ARM	Armenia	0.0301	34	21.7	114
UZB	Uzbekistan	0.0289	35	78.6	75
BRB	Barbados	0.0277	36	2.1	147
AFG	Afghanistan	0.0272	37	0.9	153
LBN	Lebanon	0.0257	38	20.2	116
WSM	Samoa	0.0254	39	0.2	164
HRV	Croatia	0.0218	40	105.9	67
MUS	Mauritius	0.0215	41	8.8	129
NPL	Nepal	0.0204	42	4.8	137
DMA	Dominica	0.0194	43	0.1	169
DJI	Djibouti	0.0193	44	13.2	125
GRC	Greece	0.0169	45	232.8	54
CUW	Curaçao	0.0167	46	0.2	161
POL	Poland	0.0164	47	1571.5	22
LVA	Latvia	0.0156	48	92.2	71
THA	Thailand	0.0146	49	1322.4	26
CRI	Costa Rica	0.0141	50	70.8	79
ARG	Argentina	0.0138	51	353.2	45
MSR	Montserrat	0.0137	52	0.0	171
COM	Comoros (the)	0.0135	53	0.1	168
PRT	Portugal	0.0128	54	369.9	43
SWZ	Eswatini	0.0124	55	9.9	128
BGR	Bulgaria	0.0118	56	204.9	58
UKR	Ukraine	0.0106	57	245.8	51
GMB	Gambia (the)	0.0105	58	0.2	159
BRA	Brazil	0.0103	59	1385.3	25
ECU	Ecuador	0.0100	60	135.9	63
MOZ	Mozambique	0.0099	61	30.8	101
MAR	Morocco	0.0095	62	178.5	62
GEO	Georgia	0.0091	63	23.1	110
PAK	Pakistan	0.0091	64	134.3	64
ZMB	Zambia	0.0090	65	48.1	89
ESP	Spain	0.0087	66	1885.3	16
MDA	Moldova (the Republic of)	0.0087	67	16.8	120
DNK	Denmark	0.0083	68	592.6	36
COL	Colombia	0.0082	69	218.6	56
MMR	Myanmar	0.0079	70	82.1	74
IND	India	0.0077	71	1877.6	17
BEL	Belgium	0.0076	72	1849.9	18
ALB	Albania	0.0072	73	17.4	119

ISO	Country	GCC Value	GCC Ranking	Trade Value	Trade Ranking
JAM	Jamaica	0.0070	74	8.3	130
LUX	Luxembourg	0.0064	75	77.6	77
KGZ	Kyrgyzstan	0.0063	76	12.2	126
PER	Peru	0.0062	77	263.7	50
FRA	France	0.0061	78	2888.2	9
TJK	Tajikistan	0.0055	79	6.0	135
NLD	Netherlands (the)	0.0051	80	3327.3	5
IDN	Indonesia	0.0050	81	1113.2	29
VNM	Viet Nam	0.0048	82	1605.8	21
LSO	Lesotho	0.0048	83	4.4	141
ISL	Iceland	0.0045	84	30.0	104
ITA	Italy	0.0042	85	2988.9	7
PRY	Paraguay	0.0040	86	48.9	87
MKD	North Macedonia	0.0040	87	39.7	94
NZL	New Zealand	0.0039	88	209.9	57
CAN	Canada	0.0039	89	2478.0	11
CHL	Chile	0.0037	90	431.0	41
ATG	Antigua and Barbuda	0.0036	91	0.1	165
ZAF	South Africa	0.0035	92	528.2	37
TUN	Tunisia	0.0034	93	84.1	73
CIV	Côte d'Ivoire	0.0034	94	75.3	78
NAM	Namibia	0.0031	95	24.4	108
KAZ	Kazakhstan	0.0030	96	307.9	47
IRN	Iran (Islamic Republic of)	0.0030	97	224.5	55
ROU	Romania	0.0028	98	434.2	40
PAN	Panama	0.0028	99	29.9	105
BLR	Belarus	0.0025	100	102.0	68
AUS	Australia	0.0024	101	1638.9	20
AUT	Austria	0.0023	102	948.3	32
BEN	Benin	0.0022	103	4.7	139
MNE	Montenegro	0.0022	104	2.8	145
BHS	Bahamas (the)	0.0018	105	2.7	146
MDV	Maldives	0.0018	106	0.8	154
BIH	Bosnia and Herzegovina	0.0016	107	40.3	93
PYF	French Polynesia	0.0016	108	0.8	155
NER	Niger (the)	0.0016	109	3.0	144
KIR	Kiribati	0.0015	110	0.0	173
OMN	Oman	0.0015	111	241.9	52
CYM	Cayman Islands (the)	0.0013	112	0.1	167
CYP	Cyprus	0.0012	113	20.1	117
EST	Estonia	0.0012	114	99.7	69
CMR	Cameroon	0.0012	115	22.1	111
BOL	Bolivia (Plurinational State of)	0.0011	116	51.6	84
DEU	Germany	0.0011	117	7936.1	3
CZE	Czechia	0.0011	118	1114.0	28

ISO	Country	GCC Value	GCC Ranking	Trade Value	Trade Ranking
HUN	Hungary	0.0009	119	691.8	35
SVK	Slovakia	0.0008	120	506.7	38
SWE	Sweden	0.0008	121	900.2	33
GHA	Ghana	0.0007	122	65.8	81
SYC	Seychelles	0.0007	123	3.6	143
KHM	Cambodia	0.0007	124	91.7	72
SUR	Suriname	0.0007	125	11.8	127
PHL	Philippines (the)	0.0007	126	362.6	44
MEX	Mexico	0.0006	127	2543.5	10
MRT	Mauritania	0.0005	128	16.2	122
USA	United States of America (the)	0.0004	129	8908.3	2
STP	Sao Tome and Principe	0.0004	130	0.1	170
GBR	United Kingdom	0.0004	131	2390.9	12
TTO	Trinidad and Tobago	0.0004	132	40.7	92
PNG	Papua New Guinea	0.0003	133	30.2	103
RUS	Russian Federation (the)	0.0003	134	1256.1	27
CHN	China	0.0003	135	15377.7	1
BFA	Burkina Faso	0.0003	136	21.7	112
MLT	Malta	0.0003	137	16.8	121
MLI	Mali	0.0003	138	3.6	142
CPV	Cabo Verde	0.0003	139	1.2	150
ARE	United Arab Emirates (the)	0.0002	140	2235.8	13
SVN	Slovenia	0.0002	141	236.6	53
MAC	Macao	0.0002	142	6.0	134
TLS	Timor-Leste	0.0002	143	1.5	148
MYS	Malaysia	0.0002	144	1438.3	24
ISR	Israel	0.0002	145	300.3	48
FIN	Finland	0.0002	146	388.7	42
BMU	Bermuda	0.0002	147	0.1	166
BHR	Bahrain	0.0001	148	78.6	76
MNG	Mongolia	0.0001	149	37.0	95
NOR	Norway	0.0001	150	807.6	34
LBR	Liberia	0.0001	151	1.2	151
KOR	Korea (the Republic of)	0.0001	152	3014.3	6
IRL	Ireland	0.0000	153	984.6	31
CHE	Switzerland	0.0000	154	1832.0	19
AND	Andorra	0.0000	155	1.1	152
GUY	Guyana	0.0000	156	48.8	88
JPN	Japan	0.0000	157	3568.6	4
NGA	Nigeria	0.0000	158	264.3	49
BWA	Botswana	0.0000	159	31.1	100
CAF	Central African Republic (the)	0.0000	160	0.5	157
SGP	Singapore	0.0000	161	2211.4	14
AZE	Azerbaijan	0.0000	162	127.6	65
HKG	Hong Kong	0.0000	163	2943.3	8

ISO	Country	GCC Value	GCC Ranking	Trade Value	Trade Ranking
S19	(other Asia)	0.0000	164	2034.4	15
QAT	Qatar	0.0000	165	440.4	39
GAB	Gabon	0.0000	166	46.3	90
COG	Congo (the)	0.0000	167	21.7	113
SAU	Saudi Arabia	0.0000	168	1442.8	23
COD	Congo (the Democratic Republic of the)	0.0000	169	92.4	70
AGO	Angola	0.0000	170	182.8	61
KWT	Kuwait	0.0000	171	351.5	46
BRN	Brunei Darussalam	0.0000	172	50.2	86
LBY	Libya	0.0000	173	29.3	106

NOTE: GCC values have been Max-Min Standardized; trade values are shown in bn\$.

## Appendix C Research Design of the Synthetic Control Method

The rationale for adopting the Synthetic Control Method (SCM) in this article lies in the fact that Singapore, as a single treated unit, cannot be evaluated using cross-country difference-in-differences models; its GCC experienced a shock in 2008 that lacks a feasible multi-country comparison group. At the same time, Singapore's economic structure, degree of openness, and regional functional role are highly unique, making it difficult to identify a strictly "parallel" control group within conventional empirical frameworks. The strength of the SCM is that it constructs a synthetic Singapore, i.e., a weighted combination of multiple countries whose pre-crisis trends and structural characteristics closely resemble those of Singapore, thereby providing a credible counterfactual against which the post-crisis deviation can be measured. This makes the SCM particularly suitable in settings with a clearly defined treatment timing, a unique treated unit, and no obvious comparison group, which aligns well with the objective of this section.

Regarding the choice of donor countries, this article selects India, Indonesia, Bangladesh, Brunei, Thailand, Myanmar, the Philippines, and Malaysia to construct the counterfactual for Singapore. These countries belong to South and Southeast Asia, share exposure to the global financial crisis, and operate within a broadly similar macroeconomic environment. All have been WTO members since 1995 and experienced no major "institutional breaks" during the pre-treatment window, helping to ensure that the estimates are not confounded by unrelated policy shocks. Their export structures exhibit both similarities and differences: some economies have middle-to-high-tech manufacturing bases (e.g., Malaysia, Thailand), others are labor-intensive (e.g., Bangladesh, Indonesia), and some are resource-based (e.g., Brunei). This structural diversity allows the weighting procedure to fit Singapore's pre-crisis competition trend with greater precision. Since the dataset begins in 2001, the pre-treatment window spans 2001–2007. Although relatively short, the high degree of business-cycle synchronization within Southeast Asia and the stability of Singapore's GCC before the crisis make this window adequate for capturing reliable pre-treatment dynamics.

In implementation, we first construct a balanced panel for Singapore and the donor countries from 2001 to 2023, removing any country with missing values in GCC or GCC ranking to ensure the feasibility of the SCM. We then minimize the pre-treatment Root Mean Squared Error (RMSE)

between actual Singapore and synthetic Singapore, allowing the model to endogenously assign optimal weights to donor countries and construct the counterfactual. Here, the optimal weights can be expressed as:

$$\begin{cases} W^* = \arg_W \min \|X_1 - X_0 W\| = \arg_W \min (X_1 - X_0 W)' V (X_1 - X_0 W) \\ V^* = \arg_V \min (Z_1 - Z_0 W^*)' (Z_1 - Z_0 W^*) \end{cases} \quad (\text{C.I})$$

Where,  $X_1$  denotes the vector consisting of the values of the pre-treatment covariates for the treated unit,  $X_0$  denotes the matrix consisting of the corresponding pre-treatment covariates for the control units;  $V$  denotes the positive semi-definite symmetric matrix whose diagonal elements reflect the relative importance of the covariates;  $Z_1$  denotes the vector of pre-treatment outcomes for the treated unit, and  $Z_0$  denotes the matrix of pre-treatment outcomes for the control units. Then, the post-2008 divergence between actual and synthetic Singapore is interpreted as the net effect of the global financial crisis.

To ensure a high-quality pre-treatment fit, we include not only the time series of GCC or GCC ranking itself but also a set of structural predictors that capture long-term economic characteristics. These variables reflect the economic size, income level, and degree of openness of Singapore and the donor countries, thereby strengthening the explanatory power of the synthetic control for pre-crisis competition patterns.

First, we include GCCs and GCC rankings in 2001, 2003, and 2006 as special predictors to capture the dynamic profile of competitive pressure. These years cover the early, middle, and late stages of the pre-crisis window, allowing the algorithm to match not only initial levels but also intermediate fluctuations and the most recent pre-crisis state.

Second, GDP (current USD\$) is incorporated to capture differences in economic scale. Economic size affects trade capacity and a country's position in regional supply chains, making it an essential structural predictor in constructing the counterfactual. In addition, GDP per capita (current USD\$) is included to represent income level and development stage. This is particularly important because Singapore, as a high-income economy dominated by high-value-added industries, differs substantially from most donor countries in terms of industrial structure. Finally, exports of goods and services (BoP basis, current USD\$) are used to capture the degree of global economic integration and the outward-oriented nature of each economy. This variable reflects a country's engagement in international markets and constitutes an important channel through which competitive pressure emerges. Including it ensures that the synthetic control matches Singapore's pre-crisis level of openness and trade dependence. Taken together, these predictors enable the model to match Singapore along three key dimensions, i.e., economic structure, development level, and openness, thus producing a synthetic control that closely approximates the real Singapore and significantly improving the pre-treatment fit.

## Appendix D Discussion on Algorithm

Table D.1: Correlation between GCC and trade volume.

Year	$\beta$	p value	$R^2$ (adj.)
2001	0.077**	[0.016]	0.0332
2002	0.089**	[0.012]	0.0350
2003	0.055**	[0.041]	0.0230
2004	-0.003	[0.918]	0.0001
2005	-0.001	[0.968]	0.0000
2006	-0.001	[0.982]	0.0000
2007	-0.001	[0.960]	0.0000
2008	0.043*	[0.086]	0.0160
2009	0.048*	[0.091]	0.0156
2010	0.050*	[0.086]	0.0160
2011	0.021	[0.464]	0.0029
2012	0.014	[0.603]	0.0015
2013	0.052**	[0.049]	0.0208
2014	0.029	[0.316]	0.0055
2015	0.115***	[0.003]	0.0470
2016	0.103***	[0.001]	0.0573
2017	0.088***	[0.001]	0.0584
2018	0.075***	[0.003]	0.0488
2019	0.098***	[0.000]	0.0735
2020	0.012	[0.696]	0.0009
2021	0.054*	[0.091]	0.0159
2022	0.026	[0.392]	0.0041
2023	0.052	[0.115]	0.0145

“\*\*\*”, “\*\*”, and “\*” denote  $p < 0.01$ ,  $< 0.05$  and  $< 0.1$ .

Table D.2: Correlation between GCP and trade volume.

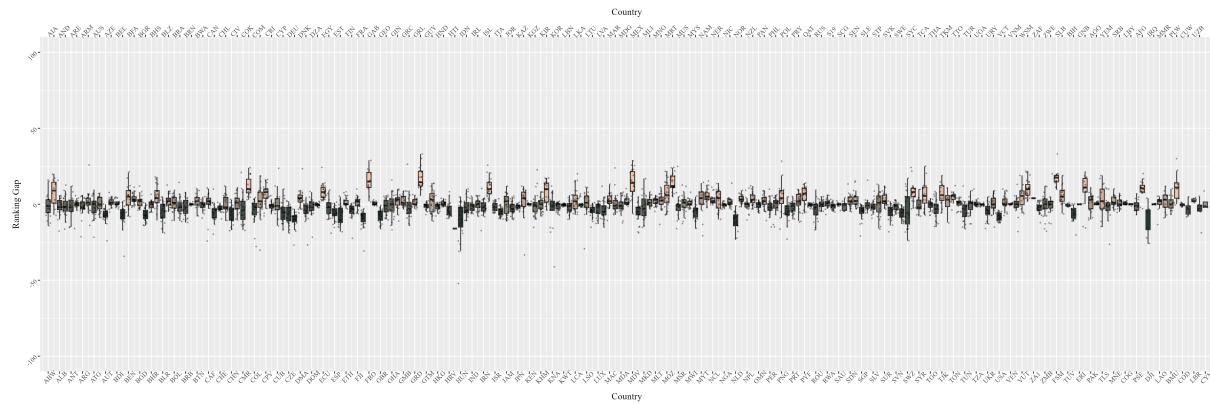
Year	$\beta$	p value	$R^2$ (adj.)
2001	-0.078	[0.445]	0.0062
2002	-0.064	[0.532]	0.0041
2003	-0.083	[0.416]	0.0070
2004	-0.070	[0.495]	0.0049
2005	-0.046	[0.657]	0.0021
2006	-0.035	[0.737]	0.0012
2007	-0.049	[0.631]	0.0024
2008	0.024	[0.813]	0.0006
2009	0.017	[0.866]	0.0003
2010	0.002	[0.986]	0.0000
2011	0.029	[0.774]	0.0009
2012	0.047	[0.650]	0.0022
2013	0.068	[0.511]	0.0046
2014	0.063	[0.538]	0.0040
2015	0.069	[0.499]	0.0048
2016	0.079	[0.443]	0.0062
2017	0.079	[0.444]	0.0062
2018	0.052	[0.616]	0.0027
2019	0.060	[0.560]	0.0036
2020	0.096	[0.348]	0.0093
2021	0.109	[0.287]	0.0119
2022	0.091	[0.374]	0.0083
2023	0.089	[0.384]	0.0080

“\*\*\*”, “\*\*”, and “\*” denote  $p < 0.01$ ,  $< 0.05$  and  $< 0.1$ .

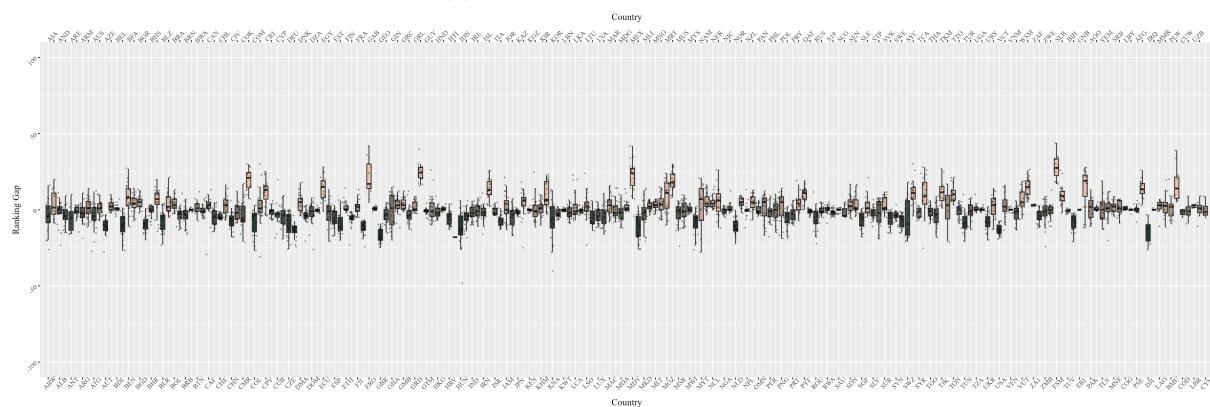
## Appendix E Result for Robustness Check

## Appendix F Result for Sensitivity Analysis

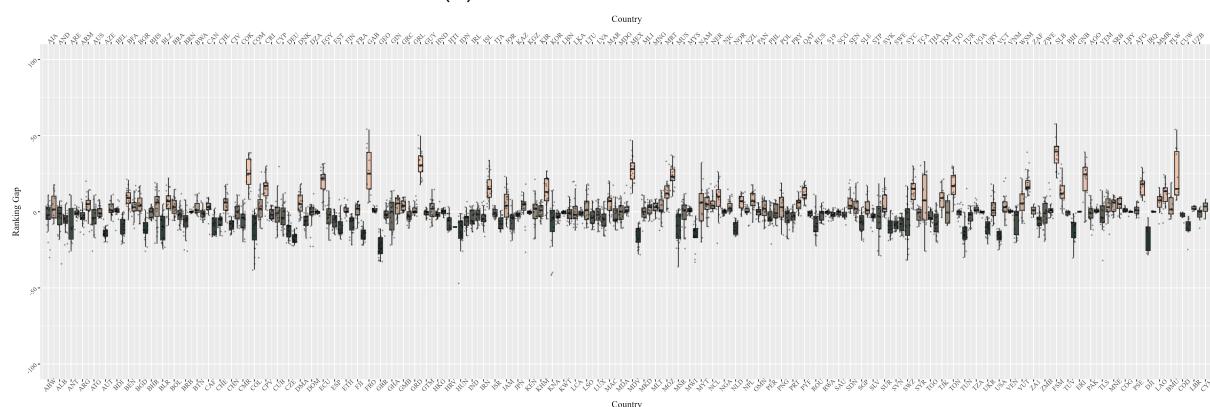
## References



(a) Results under  $RCA \geq 0.8$

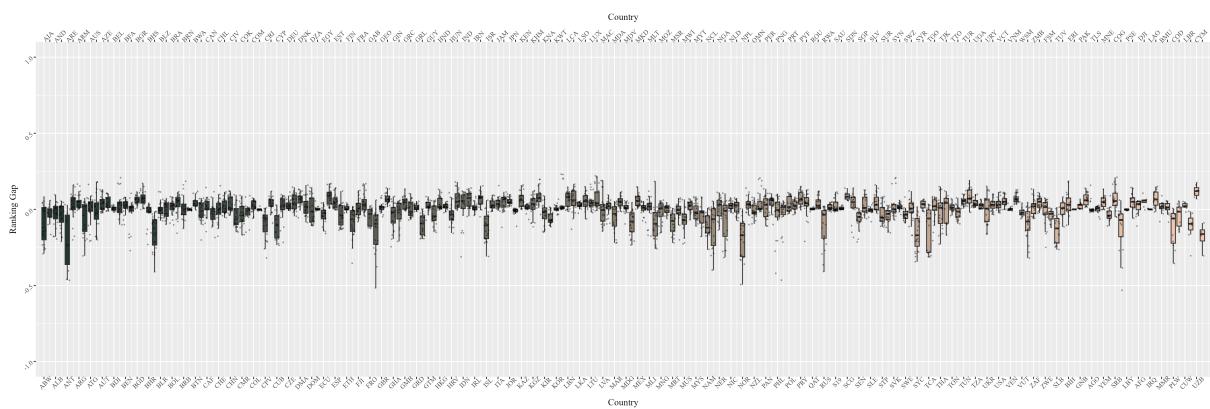


(b) Results under  $RCA \geq 0.7$

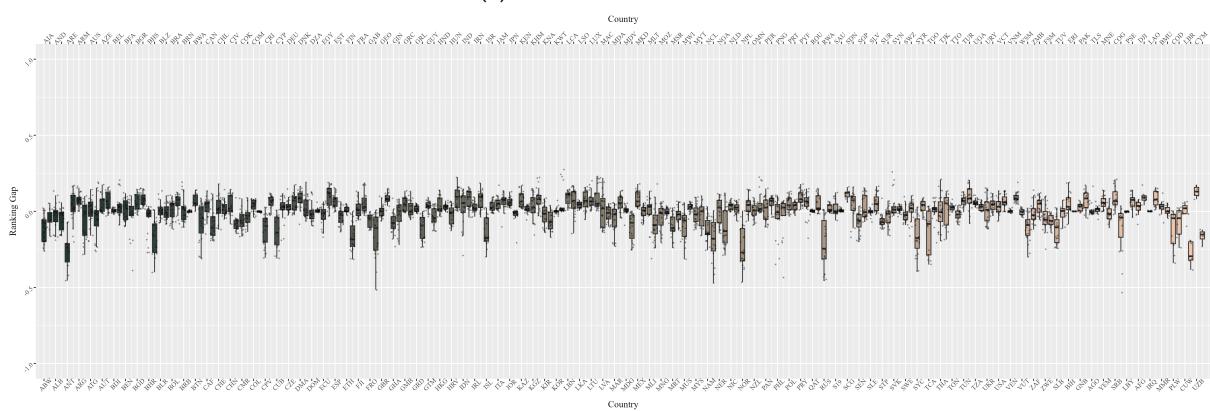


(c) Results under  $RCA \geq 0.6$

Figure E.1: Robustness check results under different RCA threshold in 2023.



(a) Results under  $s = 3$



(b) Results under  $s = 4$

Figure E.2: Robustness check results under different “ $s$ ” in 2023.

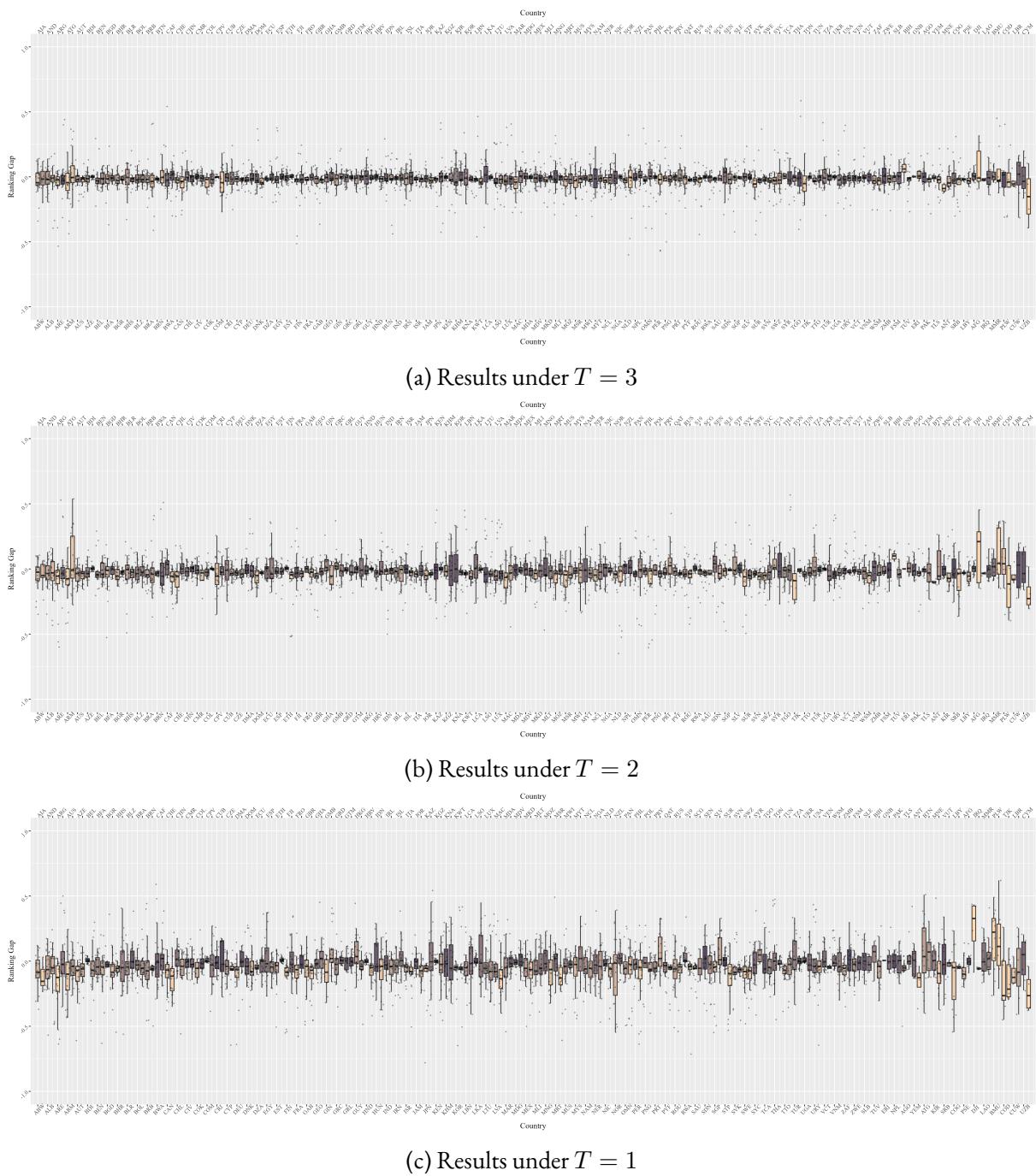


Figure E.3: Robustness check results under different statistical windows in 2023.

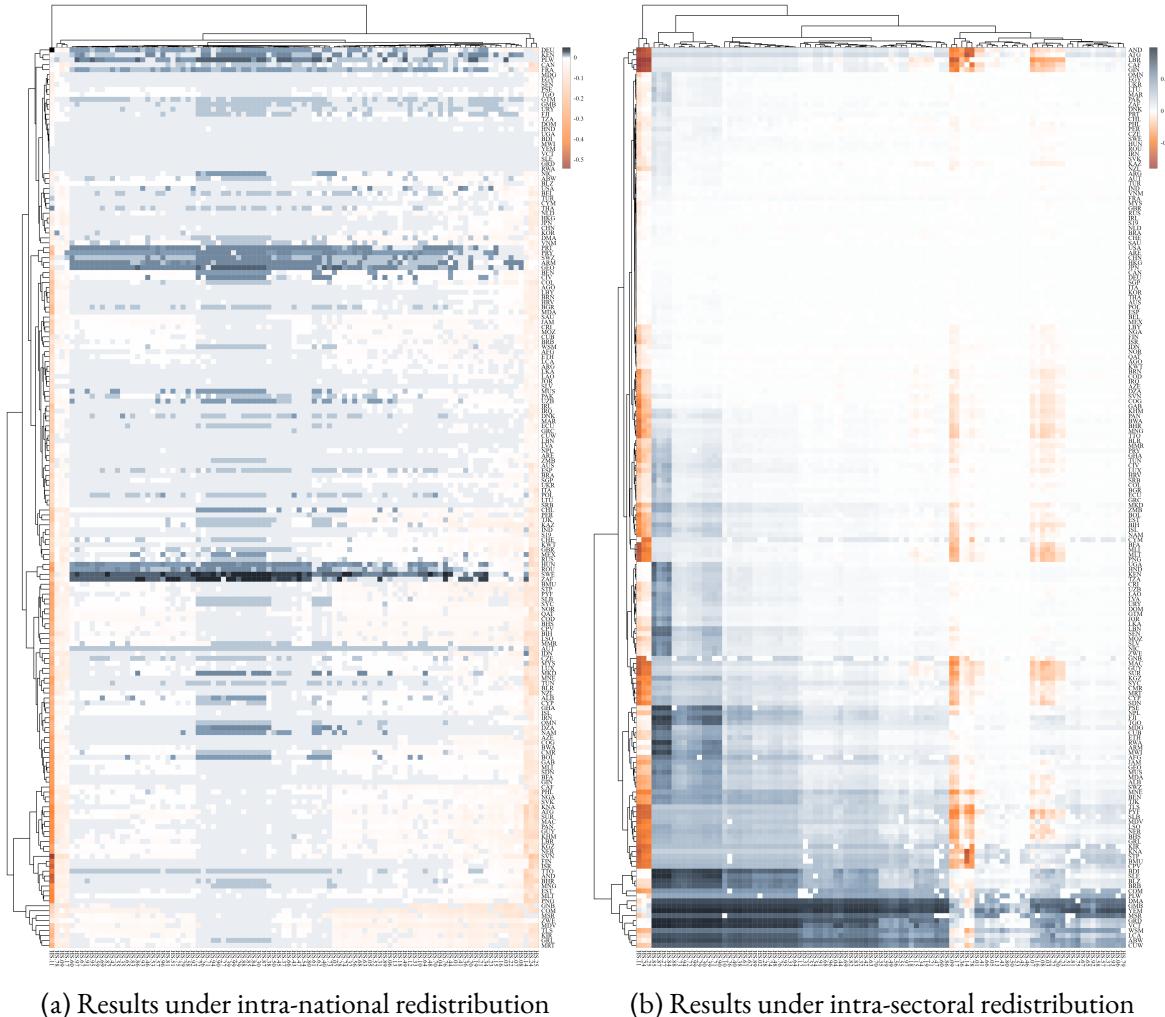


Figure F.1: Sensitivity analysis results based on 1% as the redistribution magnitude.

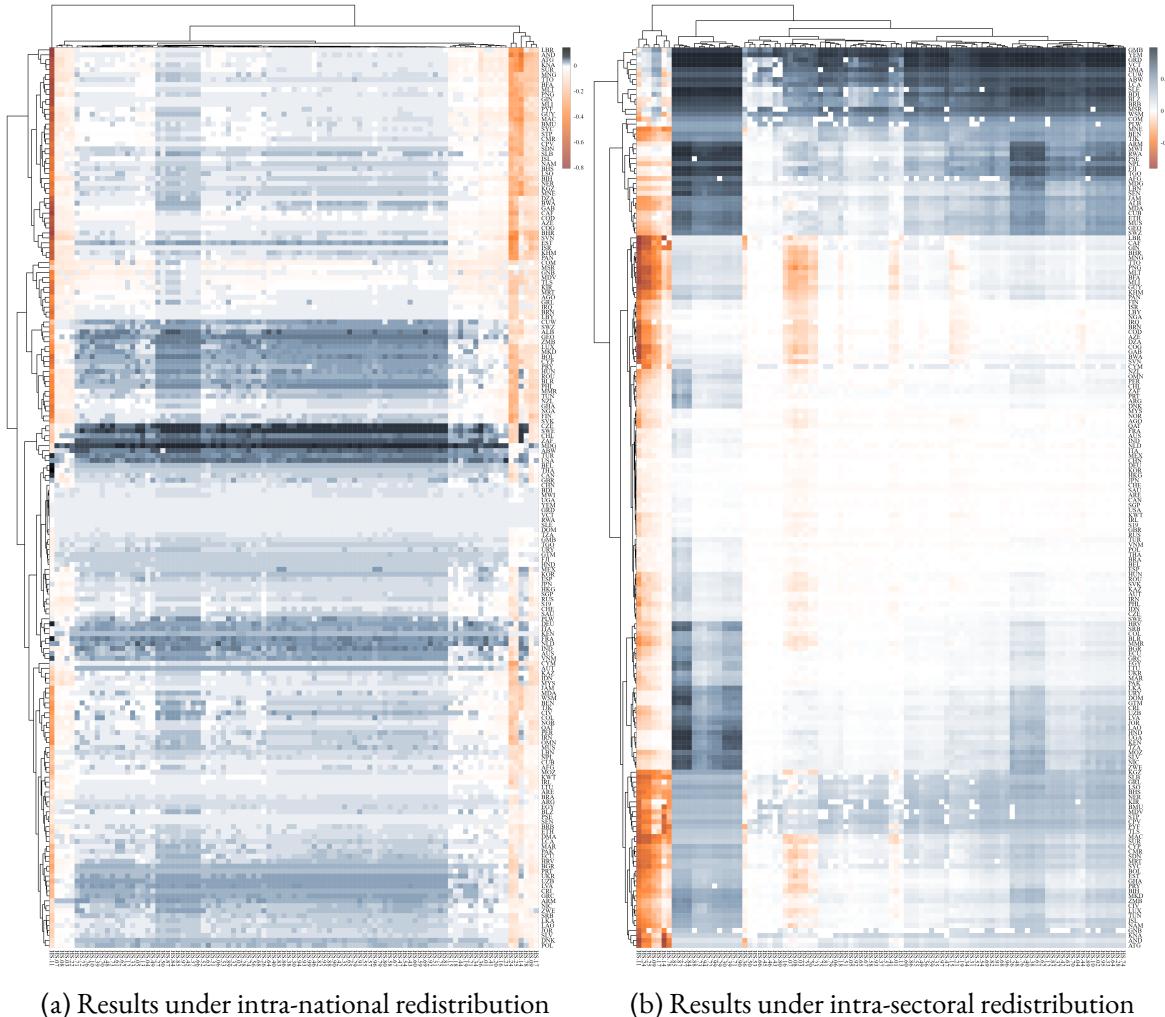


Figure F.2: Sensitivity analysis results based on 5% as the redistribution magnitude.

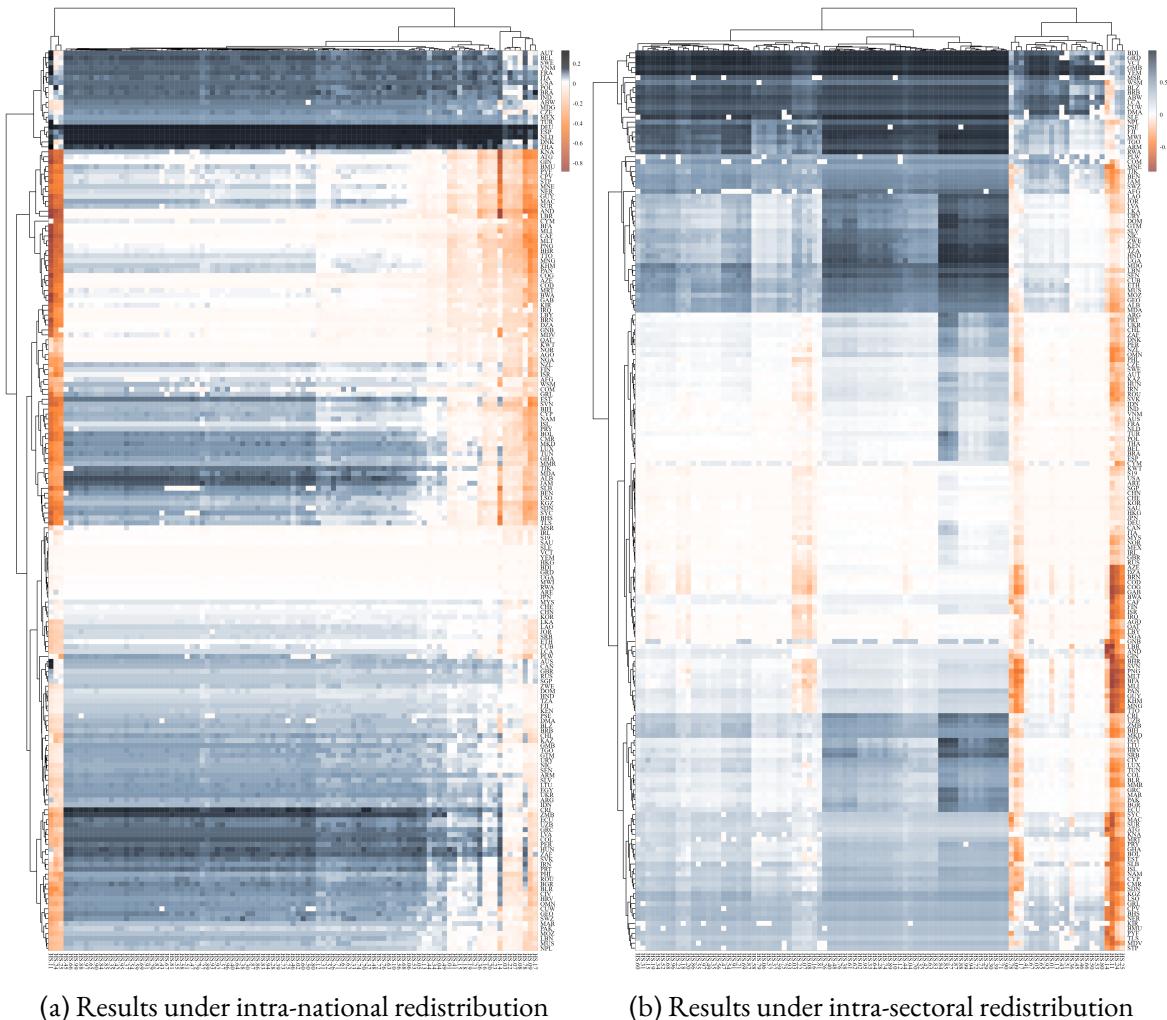


Figure F.3: Sensitivity analysis results based on 20% as the redistribution magnitude.

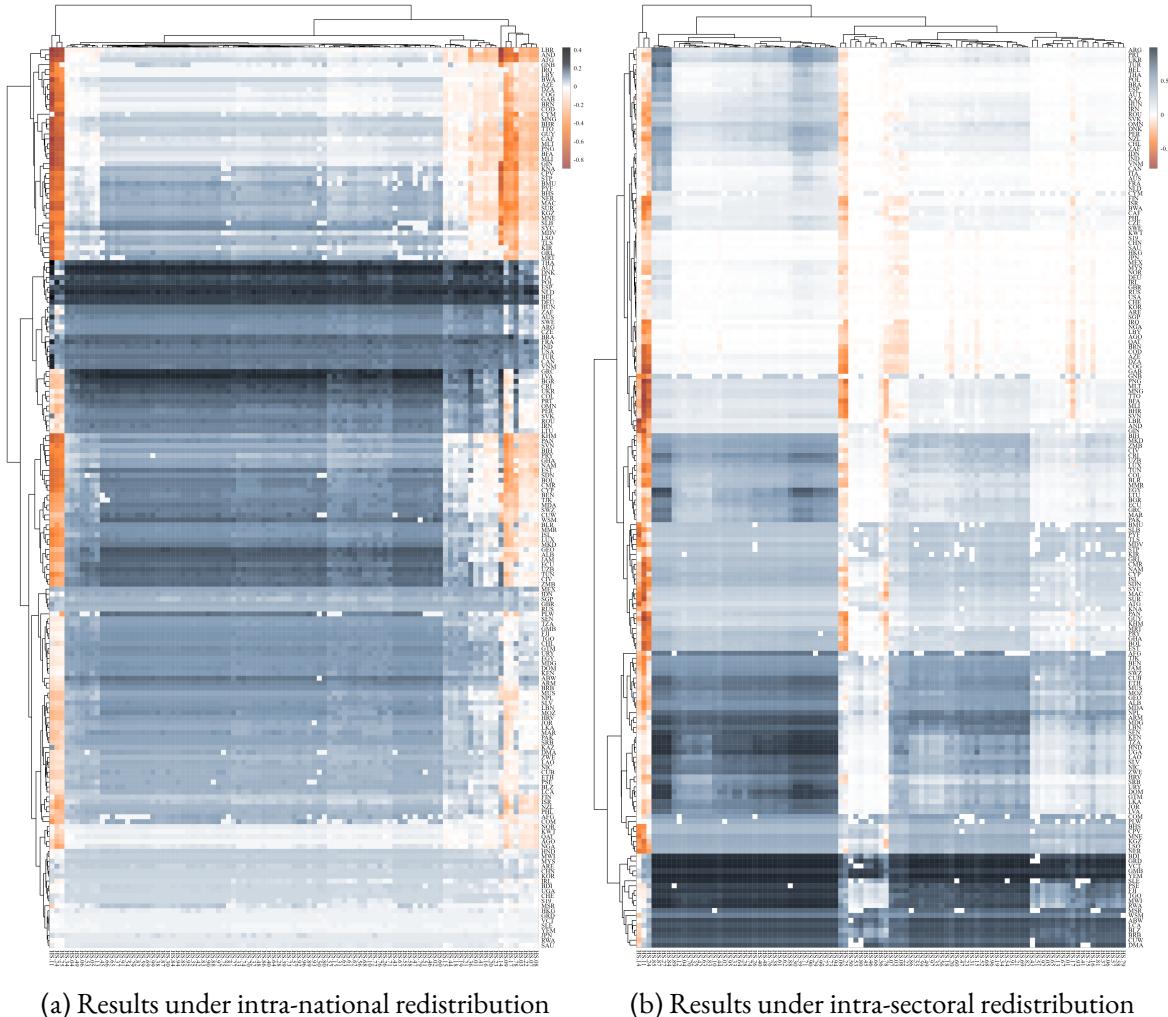
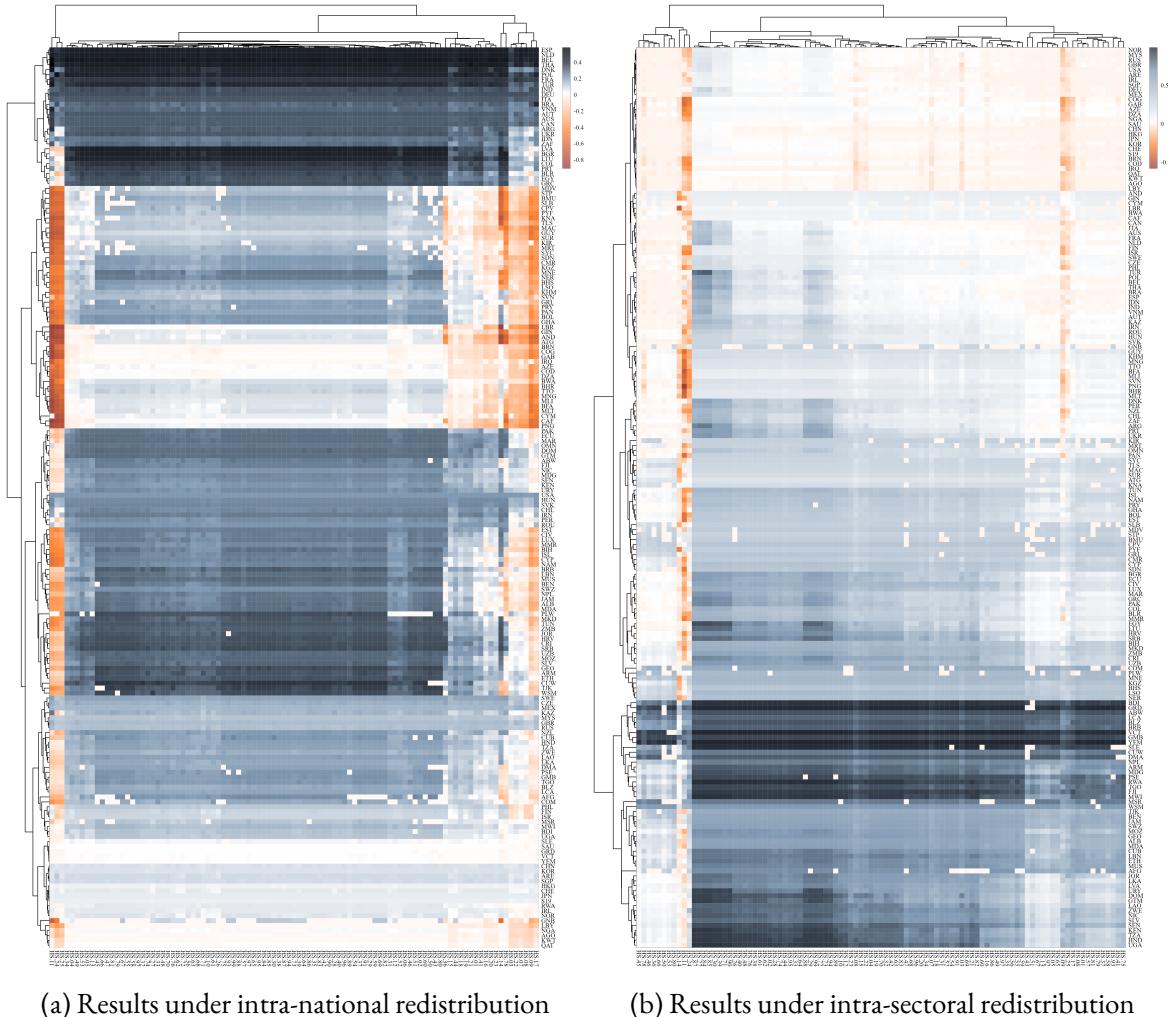


Figure F.4: Sensitivity analysis results based on 30% as the redistribution magnitude.



(a) Results under intra-national redistribution

(b) Results under intra-sectoral redistribution

Figure F.5: Sensitivity analysis results based on 50% as the redistribution magnitude.