

Supplementary information for

Reconstructing emission pathways for developing countries

Developing countries show a narrower distribution in annual average economic growth rates, whereas average emissions change rates are more variable. Over the period 2010-2020, the median annual average economic growth rate for developing countries stood at 2.6%, while emissions saw a median change rate of 2.4%. The annual average median change in carbon intensity was -0.14%. It's clear that annual average economic growth varied from 1.3%-4.1% (IQR), while annual average growth of emissions was 0.035%-4.6% in 2010-2020.

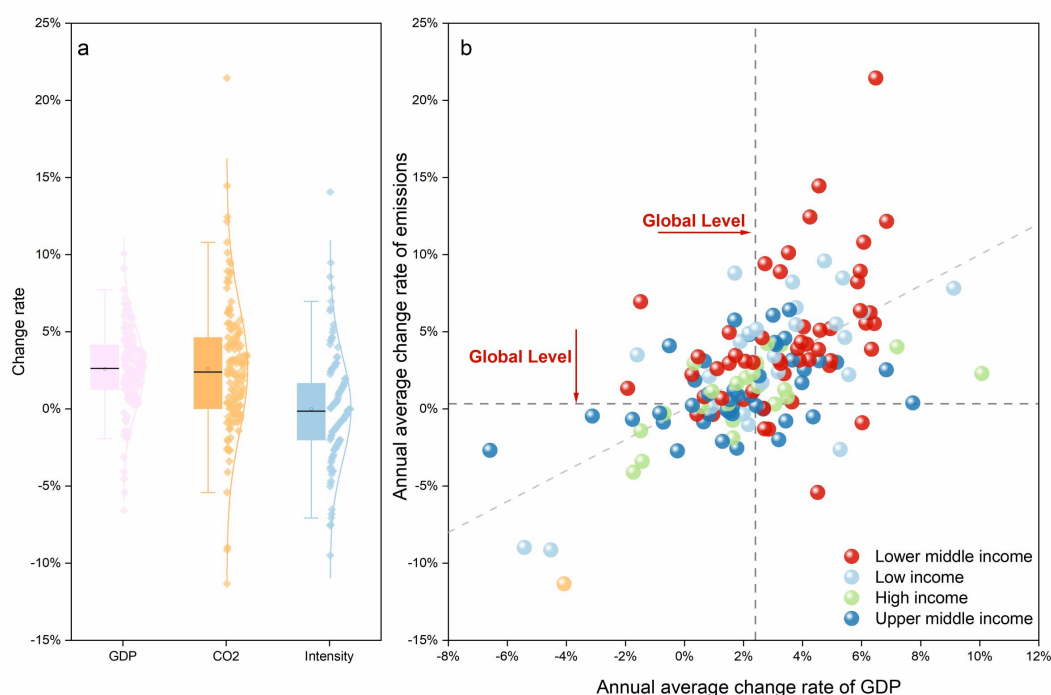
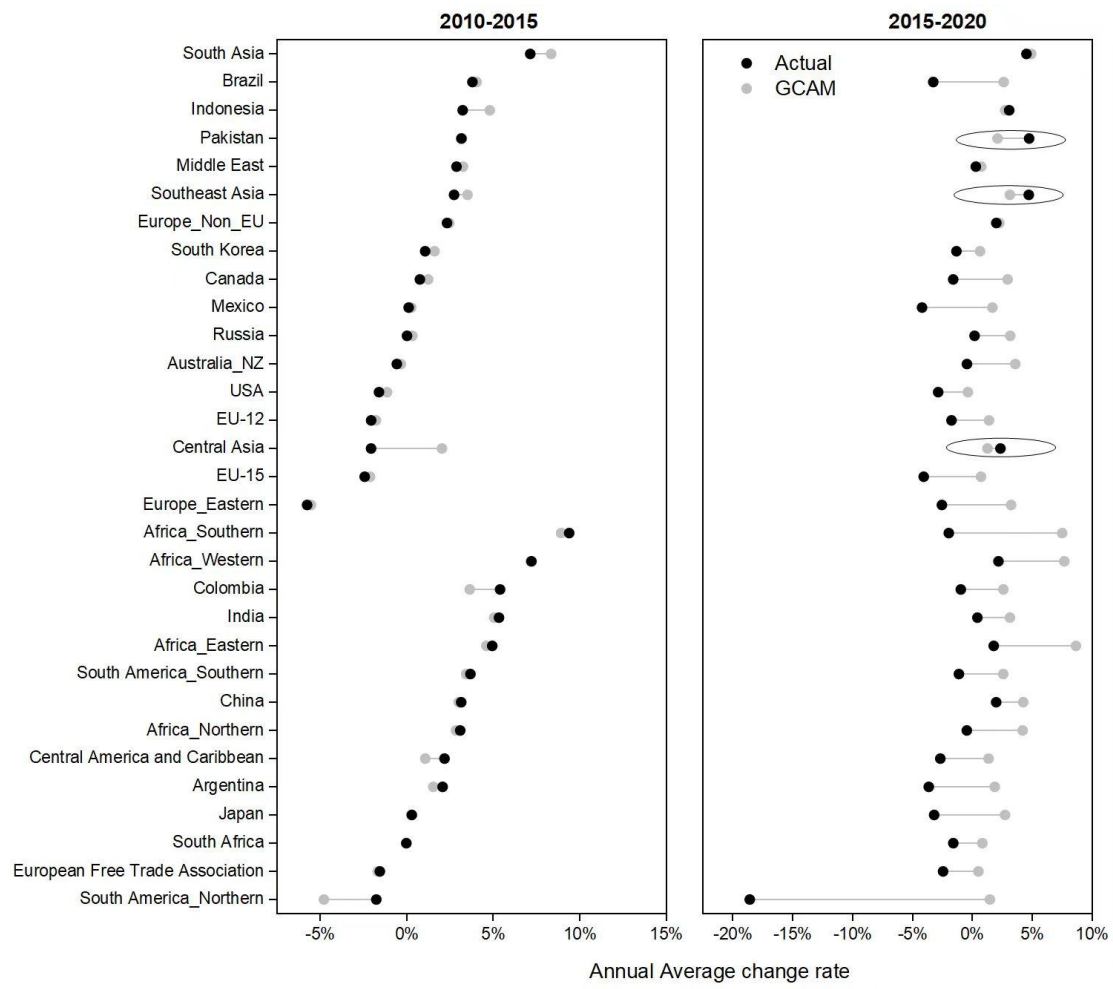


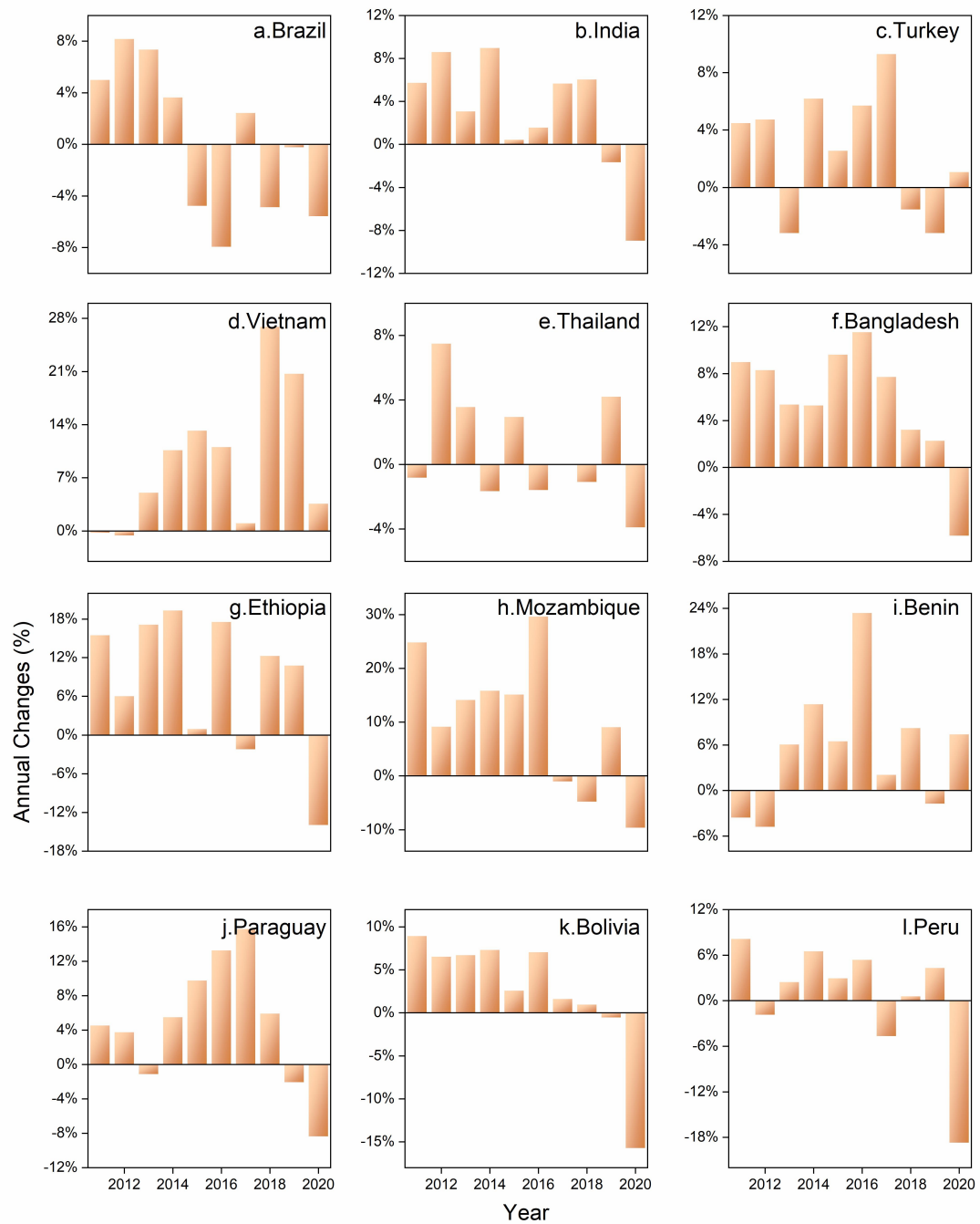
Figure S1 Summary of economic progress and CO₂ emissions from 2010 to 2020 in developing countries. (a) Overall annual average change rate of economic development, emissions and carbon intensity. The GDP, CO₂, and carbon intensity of developing countries are shown in box plots with the quartiles, medians, whiskers, and outliers highlighted. The upper and bottom bounds of the boxes, which span the IQR, correspond to the 25th and 75th percentiles, respectively. The mean and median values are shown as circles and lines inside of boxes. The density and degree of dispersion of the data are shown by the scatter points adjacent to each box. (b) The average annual rate of change in economic growth and emissions for every country. The annual average rate of global economic growth and CO₂ emissions are shown by the horizontal and vertical grey dashed lines, respectively. The tilted gray dashed line signifies that the annual average change rate of emissions and GDP are equal. Various colors mean different income levels.

The economic growth and emissions across individual developing countries demonstrate a greater degree of heterogeneity in comparison to the overall observed of these countries. Among 143 developing countries, 65 rely on fossil fuels to drive their economic development, accounting for approximately 45% (at the left of the tilted gray dashed line in **Figure 1b**). Of these 65 countries,

26 43 are classified as low and lower-middle-income countries. The remaining developing countries
 27 have experienced economic growth that surpasses their emissions growth, corresponding to a
 28 decrease in carbon intensity. From 2010 to 2020, the global annual average growth rate of
 29 emissions was 0.34%, while the annual average economic growth rate was 2.4%. Most of the
 30 countries located between the vertical grey dashed line and the tilted grey dashed line are low- and
 31 lower-middle-income countries. Compared to the global average annual emissions growth rate,
 32 70.6% of developing countries exceed this level, while 54.5% have an economic growth rate
 33 higher than the global average. For instance, Laos, a lower-middle-income country, recorded a
 34 6.5% annual average economic growth alongside a 21.4% annual average rise in emissions from
 35 2010 to 2020, resulting in the 14.1% annual average increase in carbon intensity. Similarly,
 36 Zambia, also lower-middle-income, achieved 3.5% economic growth with a 10.1% emissions
 37 increase. Burkina Faso, a low-income country, saw 5.4% economic growth and an 8.5% rise in
 38 emissions. In contrast, Guyana, a high-income developing nation, managed 7.2% economic
 39 growth and a 4% increase in emissions, resulting in a -3% change in carbon intensity.
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 42 **Figure S2 Comparison of change rates for historical emission trends and data in GCAM.**



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Figure S3 The actual annual average rates of change in emissions.

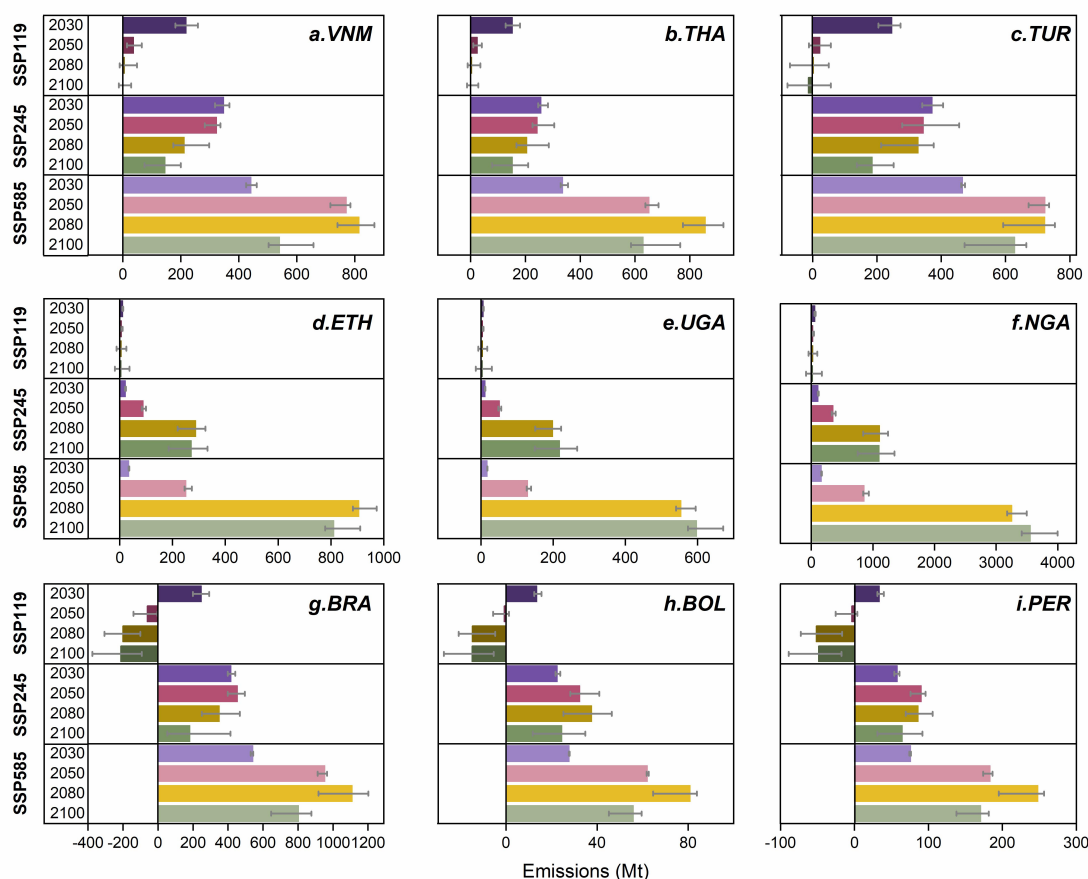


Figure S4 Emission reduction pathways in selective countries under 3 scenarios. a–i, CO₂ emissions from the three scenarios SSP 119, SSP 245, and SSP 585 in the following nine selective countries: Vietnam (a), Thailand (b), Turkey (c), Ethiopia (d), Uganda (e), Nigeria (f), Brazil (g), Bolivia (h) and Peru (i). Countries in the Asian region listed in the first row, followed by the African region, and the South American region. Each plot contains three selective years from the three scenarios. The length of the bars represents the median emissions from models. Error bars denote corresponding emissions from the 25th and 75th percentiles of scenarios across models.

Comparisons of the SSP 119, SSP 245, and SSP 585 scenarios reveals that emission reductions will not occur at a uniform pace across countries, highlighting disparities in the intensity of mitigation efforts. In 2050, emissions under the SSP119 and SSP245 scenarios were -62.2 Mt and 454.3 Mt in Brazil, respectively, with emission reductions of 106.5% and 52.4% relative to the SSP585 scenario (median, Figure 3). Emissions reach to median values of 257.1 Mt, 243.4 Mt and 205.1Mt and for 2030, 2050 and 2080 in Thailand under SSP245 (with interquartile range, IQR, of 245.9~282.1 Mt, 225.4~305.1 Mt and 167.4~285.5 Mt).

Table S1 Illustrative of classification of emissions scenarios and CMIP6 scenarios.

Classification of emissions scenarios into warming levels: C1-C8	CMIP6 scenarios
C8 exceeding warming of 4°C ($\geq 50\%$)	SSP5-8.5
C7 limit warming to 4°C ($> 50\%$)	SSP3-7.0
C6 limit warming to 3°C ($> 50\%$)	SSP2-4.5

C5 limit warming to 2.5°C (>50%)	SSP4-3.7
C4 limit warming to 2°C (>50%)	
C3 limit warming to 2°C (>67%)	SSP2-2.6
C2 return warming to 1.5°C (>50%) after a high overshoot	
C1 limit warming to 1.5°C (>50%) with no or limited overshoot	SSP1-1.9

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64 **Table S2 Classification of countries.**

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Regions	Countries	ISO3	Income level	Sub-region	Region	Developed
Asian countries except Japan (R5ASIA)	China	CHN	Upper middle income	Eastern Asia	Asia	Developing
	China Hong Kong SAR	HKG	High income	Eastern Asia	Asia	Developing
	China Macao SAR	MAC	High income	Eastern Asia	Asia	Developing
	Mongolia	MNG	Upper middle income	Eastern Asia	Asia	Developing
	Taiwan					
	Afghanistan	AFG	Low income	Southern Asia	Asia	Developing
	Bangladesh	BGD	Lower middle income	Southern Asia	Asia	Developing
	Bhutan	BTN	Lower middle income	Southern Asia	Asia	Developing
	India	IND	Lower middle income	Southern Asia	Asia	Developing
	Maldives	MDV	Upper middle income	Southern Asia	Asia	Developing
	Nepal	NPL	Lower middle income	Southern Asia	Asia	Developing
	Pakistan	PAK	Lower middle income	Southern Asia	Asia	Developing
	Sri Lanka	LKA	Lower	Southern	Asia	Developing

			middle income	Asia		
	Brunei Darussalam	BRN	High income	South-eastern Asia	Asia	Developing
	Cambodia	KHM	Lower middle income	South-eastern Asia	Asia	Developing
	Democratic People's Republic of Korea	PRK	Low income	Eastern Asia	Asia	Developing
	East Timor	TLS	Lower middle income	South-eastern Asia	Asia	Developing
	Indonesia	IDN	Upper middle income	South-eastern Asia	Asia	Developing
	Lao People's Democratic Republic	LAO	Lower middle income	South-eastern Asia	Asia	Developing
	Malaysia	MYS	Upper middle income	South-eastern Asia	Asia	Developing
	Myanmar	MMR	Lower middle income	South-eastern Asia	Asia	Developing
	Papua New Guinea	PNG	Lower middle income	Melanesia	Oceania	Developing
	Philippines	PHL	Lower middle income	South-eastern Asia	Asia	Developing
	Republic of Korea	KOR	High income	Eastern Asia	Asia	Developed
	Singapore	SGP	High income	South-eastern Asia	Asia	Developing
	Thailand	THA	Upper middle income	South-eastern Asia	Asia	Developing
	Viet Nam	VNM	Lower middle income	South-eastern Asia	Asia	Developing
Countries of the Middle East and	Bahrain	BHR	High income	Western Asia	Asia	Developing
	Iran (Islamic)	IRN	Upper	Southern	Asia	Developing

Africa (R5MAF)	Republic of)		middle income	Asia		
	Iraq	IRQ	Upper middle income	Western Asia	Asia	Developing
	Israel	ISR	High income	Western Asia	Asia	Developed
	Jordan	JOR	Lower middle income	Western Asia	Asia	Developing
	Kuwait	KWT	High income	Western Asia	Asia	Developing
	Lebanon	LBN	Lower middle income	Western Asia	Asia	Developing
	Oman	OMN	High income	Western Asia	Asia	Developing
	Qatar	QAT	High income	Western Asia	Asia	Developing
	Saudi Arabia	SAU	High income	Western Asia	Asia	Developing
	Syrian Arab Republic	SYR	Low income	Western Asia	Asia	Developing
	United Arab Emirates	ARE	High income	Western Asia	Asia	Developing
	Yemen	YEM	Low income	Western Asia	Asia	Developing
	Algeria	DZA	Upper middle income	Northern Africa	Africa	Developing
	Angola	AGO	Lower middle income	Sub-Sahara n Africa	Africa	Developing
	Benin	BEN	Lower middle income	Sub-Sahara n Africa	Africa	Developing
	Botswana	BWA	Upper middle income	Sub-Sahara n Africa	Africa	Developing
	Burkina Faso	BFA	Low income	Sub-Sahara n Africa	Africa	Developing
	Burundi	BDI	Low income	Sub-Sahara n Africa	Africa	Developing
	Cote d'Ivoire	CIV	Lower	Sub-Sahara	Africa	Developing

			middle income	n Africa		
	Cameroon	CMR	Lower middle income	Sub-Saharan Africa	Africa	Developing
	Cape Verde	CPV	Lower middle income	Sub-Saharan Africa	Africa	Developing
	Central African Republic	CAF	Low income	Sub-Saharan Africa	Africa	Developing
	Chad	TCD	Low income	Sub-Saharan Africa	Africa	Developing
	Comoros	COM	Lower middle income	Sub-Saharan Africa	Africa	Developing
	Congo	COG	Lower middle income	Sub-Saharan Africa	Africa	Developing
	Democratic Republic of the Congo	COD	Low income	Sub-Saharan Africa	Africa	Developing
	Djibouti	DJI	Lower middle income	Sub-Saharan Africa	Africa	Developing
	Egypt	EGY	Lower middle income	Northern Africa	Africa	Developing
	Equatorial Guinea	GNQ	Upper middle income	Sub-Saharan Africa	Africa	Developing
	Eritrea	ERI	Low income	Sub-Saharan Africa	Africa	Developing
	Ethiopia	ETH	Low income	Sub-Saharan Africa	Africa	Developing
	Gabon	GAB	Upper middle income	Sub-Saharan Africa	Africa	Developing
	Gambia	GMB	Low income	Sub-Saharan Africa	Africa	Developing
	Ghana	GHA	Lower middle income	Sub-Saharan Africa	Africa	Developing
	Guinea	GIN	Lower middle	Sub-Saharan Africa	Africa	Developing

			income			
	Guinea-Bissau	GNB	Low income	Sub-Saharan Africa	Africa	Developing
	Kenya	KEN	Lower middle income	Sub-Saharan Africa	Africa	Developing
	Lesotho	LSO	Lower middle income	Sub-Saharan Africa	Africa	Developing
	Liberia	LBR	Low income	Sub-Saharan Africa	Africa	Developing
	Libyan Arab Jamahiriya	LBY	Upper middle income	Northern Africa	Africa	Developing
	Madagascar	MDG	Low income	Sub-Saharan Africa	Africa	Developing
	Malawi	MWI	Low income	Sub-Saharan Africa	Africa	Developing
	Mali	MLI	Low income	Sub-Saharan Africa	Africa	Developing
	Mauritania	MRT	Lower middle income	Sub-Saharan Africa	Africa	Developing
	Mauritius	MUS	Upper middle income	Sub-Saharan Africa	Africa	Developing
	Morocco	MAR	Lower middle income	Northern Africa	Africa	Developing
	Mozambique	MOZ	Low income	Sub-Saharan Africa	Africa	Developing
	Namibia	NAM	Upper middle income	Sub-Saharan Africa	Africa	Developing
	Niger	NER	Low income	Sub-Saharan Africa	Africa	Developing
	Nigeria	NGA	Lower middle income	Sub-Saharan Africa	Africa	Developing
	Reunion	REU		Sub-Saharan Africa	Africa	Developing
	Rwanda	RWA	Low income	Sub-Saharan Africa	Africa	Developing
	Senegal	SEN	Lower	Sub-Saharan	Africa	Developing

			middle income	n Africa		
	Sierra Leone	SLE	Low income	Sub-Saharan Africa	Africa	Developing
	Somalia	SOM	Low income	Sub-Saharan Africa	Africa	Developing
	South Africa	ZAF	Upper middle income	Sub-Saharan Africa	Africa	Developing
	Sudan	SDN	Low income	Northern Africa	Africa	Developing
	Swaziland	SWZ	Lower middle income	Sub-Saharan Africa	Africa	Developing
	Togo	TGO	Low income	Sub-Saharan Africa	Africa	Developing
	Tunisia	TUN	Lower middle income	Northern Africa	Africa	Developing
	Uganda	UGA	Low income	Sub-Saharan Africa	Africa	Developing
	United Republic of Tanzania	TZA	Lower middle income	Sub-Saharan Africa	Africa	Developing
	Western Sahara	ESH		Northern Africa	Africa	Developing
	Zambia	ZMB	Lower middle income	Sub-Saharan Africa	Africa	Developing
	Zimbabwe	ZWE	Lower middle income	Sub-Saharan Africa	Africa	Developing
Latin American countries (R5LAM)	Argentina	ARG	Upper middle income	Latin America and the Caribbean	Americas	Developing
	Bahamas	BHS	High income	Latin America and the Caribbean	Americas	Developing
	Barbados	BRB	High income	Latin America and the Caribbean	Americas	Developing

	Belize	BLZ	Upper middle income	Latin America and the Caribbean	Americas	Developing
	Bolivia	BOL	Lower middle income	Latin America and the Caribbean	Americas	Developing
	Brazil	BRA	Upper middle income	Latin America and the Caribbean	Americas	Developing
	Chile	CHL	High income	Latin America and the Caribbean	Americas	Developing
	Colombia	COL	Upper middle income	Latin America and the Caribbean	Americas	Developing
	Costa Rica	CRI	Upper middle income	Latin America and the Caribbean	Americas	Developing
	Cuba	CUB	Upper middle income	Latin America and the Caribbean	Americas	Developing
	Dominican Republic	DOM	Upper middle income	Latin America and the Caribbean	Americas	Developing
	Ecuador	ECU	Upper middle income	Latin America and the Caribbean	Americas	Developing
	El Salvador	SLV	Upper middle income	Latin America and the Caribbean	Americas	Developing
	Guadeloupe	GLP		Latin America and the Caribbean	Americas	Developing

	Guatemala	GTM	Upper middle income	Latin America and the Caribbean	Americas	Developing
	Guyana	GUY	High income	Latin America and the Caribbean	Americas	Developing
	Haiti	HTI	Lower middle income	Latin America and the Caribbean	Americas	Developing
	Honduras	HND	Lower middle income	Latin America and the Caribbean	Americas	Developing
	Jamaica	JAM	Upper middle income	Latin America and the Caribbean	Americas	Developing
	Martinique	MTQ		Latin America and the Caribbean	Americas	Developing
	Mexico	MEX	Upper middle income	Latin America and the Caribbean	Americas	Developing
	Netherlands Antilles	CUW	High income	Latin America and the Caribbean	Americas	Developing
	Nicaragua	NIC	Lower middle income	Latin America and the Caribbean	Americas	Developing
	Panama	PAN	High income	Latin America and the Caribbean	Americas	Developing
	Paraguay	PRY	Upper middle income	Latin America and the Caribbean	Americas	Developing

	Peru	PER	Upper middle income	Latin America and the Caribbean	Americas	Developing
	Puerto Rico	PRI	High income	Latin America and the Caribbean	Americas	Developing
	Suriname	SUR	Upper middle income	Latin America and the Caribbean	Americas	Developing
	Trinidad and Tobago	TTO	High income	Latin America and the Caribbean	Americas	Developing
	Uruguay	URY	High income	Latin America and the Caribbean	Americas	Developing
	Venezuela	VEN	0	Latin America and the Caribbean	Americas	Developing
OECD90 and EU (and EU candidate) countries (R5OECD90 +EU)	Albania	ALB	Upper middle income	Southern Europe	Europe	Developed
	Austria	AUT	High income	Western Europe	Europe	Developed
	Belgium	BEL	High income	Western Europe	Europe	Developed
	Bosnia and Herzegovina	BIH	Upper middle income	Southern Europe	Europe	Developed
	Bulgaria	BGR	High income	Eastern Europe	Europe	Developed
	Croatia	HRV	High income	Southern Europe	Europe	Developed
	Cyprus	CYP	High income	Western Asia	Asia	Developed
	Czech Republic	CZE	High income	Eastern Europe	Europe	Developed
	Denmark	DNK	High income	Northern Europe	Europe	Developed

	Estonia	EST	High income	Northern Europe	Europe	Developed
	Finland	FIN	High income	Northern Europe	Europe	Developed
	France	FRA	High income	Western Europe	Europe	Developed
	Germany	DEU	High income	Western Europe	Europe	Developed
	Greece	GRC	High income	Southern Europe	Europe	Developed
	Hungary	HUN	High income	Eastern Europe	Europe	Developed
	Iceland	ISL	High income	Northern Europe	Europe	Developed
	Ireland	IRL	High income	Northern Europe	Europe	Developed
	Italy	ITA	High income	Southern Europe	Europe	Developed
	Latvia	LVA	High income	Northern Europe	Europe	Developed
	Lithuania	LTU	High income	Northern Europe	Europe	Developed
	Luxembourg	LUX	High income	Western Europe	Europe	Developed
	Macedonia	MKD	Upper middle income	Southern Europe	Europe	Developed
	Malta	MLT	High income	Southern Europe	Europe	Developed
	Montenegro	MNE	Upper middle income	Southern Europe	Europe	Developed
	Netherlands	NLD	High income	Western Europe	Europe	Developed
	Norway	NOR	High income	Northern Europe	Europe	Developed
	Poland	POL	High income	Eastern Europe	Europe	Developed
	Portugal	PRT	High income	Southern Europe	Europe	Developed
	Spain	ESP	High income	Southern Europe	Europe	Developed
	Sweden	SWE	High income	Northern Europe	Europe	Developed

	Switzerland	CHE	High income	Western Europe	Europe	Developed
	Turkey	TUR	Upper middle income	Western Asia	Asia	Developing
	United Kingdom	GBR	High income	Northern Europe	Europe	Developed
	Canada	CAN	High income	Northern America	Americas	Developed
	United States of America	USA	High income	Northern America	Americas	Developed
	Australia	AUS	High income	Australia and New Zealand	Oceania	Developed
	Fiji	FJI	Upper middle income	Melanesia	Oceania	Developing
	French Polynesia	PYF	High income	Polynesia	Oceania	Developing
	Guam	GUM	High income	Micronesia	Oceania	Developing
	Japan	JPN	High income	Eastern Asia	Asia	Developed
	New Caledonia	NCL	High income	Melanesia	Oceania	Developing
	New Zealand	NZL	High income	Australia and New Zealand	Oceania	Developed
	Romania	ROU	High income	Eastern Europe	Europe	Developed
	Samoa	WSM	Lower middle income	Polynesia	Oceania	Developing
	Serbia	SRB	Upper middle income	Southern Europe	Europe	Developed
	Slovakia	SVK	High income	Eastern Europe	Europe	Developed
	Slovenia	SVN	High income	Southern Europe	Europe	Developed
	Solomon Islands	SLB	Lower middle income	Melanesia	Oceania	Developing
	Vanuatu	VUT	Lower	Melanesia	Oceania	Developing

			middle income			
Countries from the Reforming Economies of the Former Soviet Union (R5REF)	Armenia	ARM	Upper middle income	Western Asia	Asia	Developing
	Azerbaijan	AZE	Upper middle income	Western Asia	Asia	Developing
	Belarus	BLR	Upper middle income	Eastern Europe	Europe	Developed
	Georgia	GEO	Upper middle income	Western Asia	Asia	Developing
	Kazakhstan	KAZ	Upper middle income	Central Asia	Asia	Developing
	Kyrgyzstan	KGZ	Lower middle income	Central Asia	Asia	Developing
	Republic of Moldova	MDA	Upper middle income	Eastern Europe	Europe	Developed
	Russian Federation	RUS	High income	Eastern Europe	Europe	Developed
	Tajikistan	TJK	Lower middle income	Central Asia	Asia	Developing
	Turkmenistan	TKM	Upper middle income	Central Asia	Asia	Developing
	Ukraine	UKR	Upper middle income	Eastern Europe	Europe	Developed
	Uzbekistan	UZB	Lower middle income	Central Asia	Asia	Developing