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Growing the good and shrinking the bad: Output-emissions elasticities and green industrial policy in commodity-dependent developing countries

Abstract

This paper attempts to answer a series of questions that continue to hamstring the policy space of commodity dependent developing countries (CDDCs), particularly considering commitments made in the context of climate change adaptation and mitigation measures. First, is it possible for CDDCs to meet their development goals while also fulfilling their commitments to climate change mitigation? Is it possible to manage the commodity sector in a way that fosters growth without worsening environmental outcomes? Can CDDCs at their current development stage decouple economic growth and development from increasing emissions, environmental pollution, and resource depletion? While the international community needs to consider the challenges facing CDDCs as they attempt to move towards a low-carbon growth path, CDDCs should embrace green industrial policies to position themselves as viable producers and exporters of green goods. Continued reliance on traditional commodities in an era of green transition may not be a viable long-term option.

Key words: Commodity-dependent developing countries; output-emissions elasticities; green industrial policy

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1. Introduction

In the 2021 edition of the annual World Energy Outlook (IEA, 2021), the International Energy Agency predicts that, as a result of rapid advancement in clean energy technologies, wind turbines and electric vehicles, the global use of fossil fuels will peak by the mid-2020s, with global oil demand declining permanently by the 2030s. However, the agency also points out that the transition away from fossil fuels is not happening fast enough to meet the goal of limiting average global warming to around 1.5 degrees Celsius by 2100, relative to pre-industrial levels. Meeting this goal would require slashing emissions to net zero by 2050 – a move that would involve, among other things, reducing fossil fuel production by roughly 6 per cent per year between 2020 and 2030 (SEI, 2021). Assuming that such a rapid phase-out of fossil fuel production and consumption does occur, the implications for growth and development in developing countries that are currently dependent on exports of fossil fuels will be significant.[1] These outcomes may not be limited only to fossil fuel exporters: climate change itself, together with climate change mitigation efforts in the global economy, pose major challenges to economic and human development in commodity dependent developing countries (CDDCs), more generally.

A country is considered commodity dependent if commodities account for more than 60 per cent of the value of total merchandise exports from that country (Janvier D. Nkurunziza et al., 2017; UNCTAD, 2019a). By this measure, 101 countries were commodity dependent in 2019, up from 93 in 2009 (UNCTAD, 2019a, 2021b). Commodity dependent developing countries are a heterogeneous group: they vary by the type of commodity, by income, and by geographical location (UNCTAD, 2019a). Of the countries that were commodity dependent in 2019, 37.6 per cent were dependent on agricultural commodities, 31.6 per cent on minerals ores and metals; and 30.6 per cent on fuel exports (UNCTAD, 2021b).

Commodity dependence is primarily a developing country phenomenon: almost two out of three developing countries were dependent on commodity exports in 2019, and 86 per cent of commodity dependent countries were developing countries (UNCTAD, 2021b). Between 2009 and 2019, commodity dependence even worsened. The average share of commodities in total merchandise exports increased from 64.1 per cent to 66.3 per cent over the period, while the median commodity share rose from 70.3 per cent to 74 per cent (UNCTAD, 2021b). Africa, which accounts for 44.5 per cent of all CDDCs, has the greatest incidence of commodity dependence, as 45 out of 54 African countries are commodity dependent (UNCTAD, 2021b). Commodity dependence is also strongly correlated with income: 91 per cent of low-income countries are dependent on commodity exports, and the share of commodities in total merchandise exports tends to fall as income rises, even within the group of CDDCs.

CDDCs, especially the poorest among them, are also disproportionately affected by climate change, even though the magnitude of the effect varies across countries depending on their geographical location, the commodities on which they depend, and their financial and technical capacity to adapt to climate change. Of the 40 countries most vulnerable to climate change, 37 are CDDCs; the 10 most vulnerable in this group are all low-income countries (UNCTAD, 2019). The economies of these countries are structured around the extraction and export of commodities, often just one commodity. Current projections for growth in these economies are predicated on their ability to maintain the status quo. However, climate change is likely to have an adverse effect on earnings from commodity exports in CDDCs, through reductions in productivity in key commodity sectors, or through reductions in the demand for their main commodity exports, as a result of climate change mitigation efforts by the world's largest economies. At the micro-level, these adverse impacts on CDDCs will be felt the most by poor, marginal and socially-excluded groups in these countries.

Although CDDCs as a group have contributed much less than more industrialized countries to emissions of greenhouse gases (GHGs), almost all CDDCs have signed on to the Paris Agreement and since 2015, have made significant commitments towards the global climate change mitigation effort (UNCTAD, 2019a). These commitments place them in something of a bind: on one hand, their continued dependence on the extraction of carbon-intensive commodities can make it more difficult to meet their commitments to climate change

[1] The report notes that current estimates project an actual average annual increase in fossil fuel production of 2 per cent (SEI et al.2020).

mitigation targets. On the other hand, honouring their climate change mitigation commitments could make it more difficult for CDDCs to meet their development goals.

The choices facing these countries appear stark: they can continue to rely on the extraction and export of emissions-intensive commodities as the primary source of export revenues and growth, regardless of the implications for climate change. But this strategy exposes them to the very real risk of declining export earnings stemming from falling productivity as the commodity sector is threatened by fluctuations in temperature and precipitation, or from a long-term decline in the demand for these commodities, as their major trading partners move towards greener alternatives (Anzolin and Lebdioui, 2021). Alternatively, CDDCs can meet their commitments to climate change mitigation by voluntarily stranding their resources or waiting for them to be stranded in response to changes in the market valuation of natural resource assets (McGlade and Ekins, 2015; Rempel and Gupta, 2021).[2] But this choice is likely to be politically unpopular, given the devastating economic consequences for these countries of such a drastic reduction in export revenues. There is a third path that would involve a fundamental reorientation of the economic structure of CDDCs through a process of industrialization, thereby diversifying their exports and reducing their dependence on commodity exports. However, industrial production has historically been carbon-intensive, and conventional strategies of industrialization in CDDCs could potentially hasten the pace of global warming (Naudé, 2011).

These challenges can be summed up in a series of questions that continue to hamstring climate talks: is it possible for CDDCs to meet their development goals while also fulfilling their commitments to climate change mitigation? Is it possible to manage the commodity sector in a way that fosters growth without worsening environmental outcomes? Can CDDCs at their current development stage decouple economic growth and development from increasing emissions, environmental pollution and resource depletion?

The answers to these questions require a full understanding of the evolving relationship between output and emissions in CDDCs. With the exception of a few studies, most research on this relationship has focused on developed economies (Cohen et al., 2018). This paper extends this strand of the literature by estimating short-run and long-run output elasticities of emissions for 127 countries, grouped by commodity dependence status over the period 1980 to 2018.[3] Although developed countries have lower output elasticity of emissions than developing countries, elasticity of emissions with respect to output is comparable across CDDCS and diversified developing countries (DDCs). To gain a more nuanced understanding of the relationship between growth and emissions in CDDCs, the CDDC group is disaggregated by type of commodity dependence, by income group, and by region, and estimate output-elasticities of emissions for the sub-groups. Doing so reveals considerable heterogeneity among CDDCs. In addition, to provide context for interpreting these estimates, historical output-elasticities of emissions are estimated for five major developed countries over the period 1800 – 2017. The results are comparable to, and in some cases, higher than the output elasticities of emissions for currently developing countries. The historical analysis highlights the environmental challenges inherent in conventional paths of diversification, industrialization and growth.

Our analysis suggests that although there is a tendency for emissions to increase with output among CDDCs, commodity dependence or export diversification *per se* do not determine the output elasticity of a country's emissions. Hence, there is a role for policy to guide the transition of CDDCs to a low-carbon growth path, one that also provides them with an alternative to commodity dependence. In addition, global policies to slow the pace of climate change by reducing emissions in CDDCs must be attentive to differences among these countries in terms of current levels of emissions and the sensitivity of emissions to output in these countries. Global climate policies that retard output growth in countries with low output-elasticities of emissions will have significant adverse impacts on living standards in those countries but little impact on overall emissions.

Furthermore, the high output-elasticities of emissions among diversified developing countries and among early industrializers in the first century of industrialization makes it clear that conventional patterns of diversification and industrialization are unlikely to be an environmentally sustainable option for CDDCs. This does not mean

[2] Rempel and Gupta (2021) define stranded assets as assets that have suffered from "unanticipated or premature write-downs, devaluations or conversion to liabilities" (p.146) and describe a best-case scenario that involves "equitably managing stranded assets to ensure that the burden falls on rich and capable actors, predominantly from the North."

[3] The sample includes CDDCs, diversified developing countries (DDCs) and developed countries.

that CDDCs must choose between climate change mitigation and development. The reappearance of industrial policy, in the form of green industrial policy (GIP), in mainstream economic analyses and policy discourses, offers the possibility for CDDCs to shape the contours of an alternative low-carbon development path, one in which these countries can accumulate the productive capabilities necessary for the export of green goods and services while also addressing the challenges of employment, technology and energy poverty (Anzolin and Lebdioui, 2021; Azad and Chakraborty, 2021).

While the extant literature has focused mostly on the role of GIP in facilitating the transition to a low-carbon economy in industrialized countries, this paper contends that GIP is especially relevant for CDDCs. GIP can enable CDDCs to shift resources to high productivity sectors while also maximizing the development spillovers from the transition to a low-carbon economy (Anzolin and Lebdioui, 2021). These spillovers include employment creation, expanded access to green energy, the ability to participate in the global economy as producers and innovators of green technologies instead of being merely consumers, and a reduction in the vulnerability of CDDCs to climate change and macroeconomic volatility associated with commodity dependence – vulnerabilities that are likely to worsen as the demand for carbon-intensive commodities declines (Chang and Andreoni, 2021; Pollin, 2015). However, the success of GIP in CDDCs will require complementary policies at the global level to provide access to finance, energy, technology, and a favourable institutional environment.

The structure of the paper is as follows. The next section discusses the various macroeconomic vulnerabilities of CDDCs associated with their dependence on commodities and the challenges that climate change poses for CDDCs. The third section reviews the literature on the relationship between output and environmental pollution, while the fourth section presents the empirical analysis of output elasticities of GHG emissions in CDDCs. The penultimate section explores the potential for green industrial policy in CDDCs, discusses the challenges posed by the current structure of production, trade and investment in the global economy and highlights the need for international policy coordination to ensure that the low-carbon transition is not detrimental to development in these countries. The final section concludes.

2. Commodity dependence, climate change and development

2.1 Commodity dependence and development

Debates over the role of commodity dependence in the process of economic and human development have focused on whether the commodity sector can generate sustained dynamic growth in developing countries, and on the extent to which commodity dependence limits industrial development in CDDCs, hampers their ability to diversify away from commodities or acts as a constraint on human development (Janvier D. Nkurunziza, 2021; Janvier D. Nkurunziza et al., 2017; José Antonio Ocampo, 2017).

The detrimental effects of specialization in commodity exports on economic development are captured in the Prebisch-Singer hypothesis. According to this hypothesis, the long-term downward trend in the net barter terms of trade between primary commodity exports and manufactured exports results in the benefits of trade accruing *primarily* to industrialized countries that specialize in manufactured exports (Prebisch, 1950; Singer, 1950). This hypothesis has spawned an abundant empirical literature which by and large supports the thesis of a long-run decline in the terms of trade of primary commodities relative to manufactured products (Erten and Ocampo, 2013; Grilli and Yang, 1988; Lutz, 1999; Jose Antonio Ocampo and Parra Lancourt, 2004; Sapsford, 1990; Sapsford and Chen, 1999; Sarkar, 2001; Spraos, 1980, 1984). The reasons for this long-run deterioration in the net barter terms of trade for primary commodities include low income and price-elasticities of demand for commodities, as well as the institutional and economic structure of CDDCs (Singer and Gray, 1988).

Commodity dependence is associated with both structural and macroeconomic vulnerabilities, most of which stem from the volatility of commodity prices which are subject to large cyclical movements related to changes in global aggregate demand and to technological innovation (Erten and Ocampo, 2013). This volatility tends to be particularly pronounced in periods of global economic crisis, such as the 2008 financial crisis. More recently, weak global aggregate demand resulting from the COVID-19 pandemic-related collapse of economic activity and global trade in early 2020 contributed to significant downward pressure on commodity prices that year (Tröster, 2020; Tröster and Küblböck, 2020). Economic recovery from the pandemic led to higher demand for commodities, exerting upward pressure on prices.

The military invasion of Ukraine by the Russian Federation in February 2022 has compounded tensions in commodity markets, quickly turning the post-COVID recovery into a full-blown commodity market crisis. Food and fuel prices, as well as those of fertilizers, have increased dramatically owing to the importance of the Russian Federation and Ukraine in supplying those commodities to global markets (UNCTAD, 2022). It is worth adding that the financialization of commodity markets has further exacerbated the volatility of commodity prices (Ederer et al., 2016; Tröster et al., 2019).

The cyclical movements in commodity prices have implications for short-tern macroeconomic stability and economic growth in CDDCs. Cyclical movements in commodity prices lead to pro-cyclical fluctuations in income levels and in aggregate demand as resource-rich countries engage in costly investment programs during periods of booming commodity prices, often abandoning them when commodity prices slump (Nkurunziza et al., 2017). CDDCs also experience strong pro-cyclical patterns in the availability of finance and the cost of financing that follow the cycles of commodity prices (José Antonio Ocampo, 2017). These external factors lead to cyclical patterns in real exchange rates that further enhance fluctuations in aggregate demand. The current account balance is also affected by real exchange rate fluctuations: commodity price booms lead to a real appreciation of the domestic currency, stimulating imports and leading to reductions in exports of non-primary goods, while commodity price slumps can have the opposite effect (José Antonio Ocampo, 2017).

These short-term macroeconomic changes affect the performance of other sectors. For example, the increased spending associated with commodity booms can yield positive impacts in other sectors, but these may be countered by the negative effects of real exchange rate appreciation during commodity booms (José Antonio Ocampo, 2017). Overall, volatility in commodity terms of trade has a negative effect on economic growth, which offsets the positive impacts of commodity booms (Cavalcanti et al., 2011; Van der Ploeg and Poelhekke, 2009). From 2013 to 2017, for example, average commodity price levels fell far below their 2008-2012 levels, leading to economic contractions and recessions in 64 commodity-dependent countries (UNCTAD, 2019b).

CDDCs are also subject to structural vulnerabilities stemming from their dependence on commodity exports. Natural resource exhaustion, long-term changes in consumer demand, increased competition resulting from discovery of resource deposits in other countries and technological innovations that lead to changes in demand for some commodities are all potential causes of structural weaknesses in CDDCs (Chang and Lebdioui, 2020). The strength or weakness of linkages between the commodity sector and other sectors as well as the rate of productivity growth in the commodity sector also have long-term macroeconomic implications for CDDCs, including for their ability to diversify away from commodities (José Antonio Ocampo, 2017; Jose Antonio Ocampo and Parra Lancourt, 2004). Indeed, commodity dependence in developing countries appears to persist over the long-run, leading to what has been described as a commodity trap (Janvier D. Nkurunziza, 2021).

These negative associations between commodity dependence, on the one hand, and macroeconomic stability, long-term economic growth and human development on the other hand, have long provided a strong argument for CDDCs to reduce their dependence on commodity exports. The threat to CDDCs of climate change and the economic consequences of climate-change mitigation policies adopted by other countries provide an added layer of urgency to this argument.

2.2 Commodity dependence and climate change

The relationship between commodity dependence and climate change is multi-faceted, and the contributions of CDDCs to climate change as well as the impacts of climate change on CDDCs vary significantly across countries.

As a group, CDDCs contribute only modestly to climate change: they were responsible for only 21 per cent of the stock of greenhouse gas (GHG) emissions accumulated between 1990 and 2014 (UNCTAD, 2019a, p. 23). This pales in comparison to the 44 per cent attributable to the much smaller group of developed and transition countries, and the 35 per cent attributable to diversified developing countries (UNCTAD, 2019a, p. 23).[4] Average emissions per capita in CDDCs amounted to 5.4 tons of CO2 equivalent (tCO2e) in 2014, significantly lower than the European Union (7.2 tCO2e), China (8.3 tCO2e), Russian Federation (14.1 tCO2e) and the United States (19.9 tCO2e) (UNCTAD, 2019a, p.24).

The contribution of individual commodity sectors to GHG emissions also varies across commodities. The combustion of fossil fuels for energy, heat and transport is the leading source of GHG emissions globally, accounting for nearly half of anthropogenic GHG emissions in 2010 (UNCTAD, 2019a, p.13). This is followed by agriculture, forestry and other land use, which contributed another 24 per cent (IPCC, 2014).[5] There is no reliable data on the contribution of minerals and metals to GHG emissions. However, the mining sector is energy-intensive and contributes to GHG emissions through the use of energy in mining and smelting operations. As global production of key minerals and metals increases, GHG emissions from mining have increased apace (UNCTAD, 2019a, p.17). In addition, as these resources are depleted, mining is expected to become increasingly carbon-intensive as more energy is needed to access deeper deposits and to refine poorer quality ores (UNCTAD, 2019a, p.17).

As a result of these differences across commodity sectors, there is considerable heterogeneity in per capita GHG emissions across CDDCs by type of commodity dependence and by income group. In 2014, high-income CDDCs averaged per capita emissions of 22.7 tCO2e, over 10 times the per capita emissions of low-income CDDCs. Among high-income CDDCs, fossil fuel exporters averaged per capita emissions of 31.6 tCO2e, compared to 8.6 tCO2e in other high-income CDDCs that depend on exports of agricultural or mining products (UNCTAD, 2019a, p. 25).

Climate change also reduces productivity in CDDCs. This may be directly through a reduction in yields, for example, or indirectly through the actions taken by CDDCs and by third countries to mitigate and adapt to climate change. CDDCs are vulnerable to the extreme weather patterns associated with climate change: according to the University of Notre-Dame's Global Adaptation Initiative Index, the 10 countries most vulnerable to climate change in 2019 were all low-income CDDCs.[6] Africa features prominently in the list of regions most vulnerable to climate change: 16 out of the 20 most vulnerable countries are in sub-Saharan Africa, and in 2015, four of the 10 countries most affected by extreme weather events associated with climate change were in Africa.[7] While climate change is expected to negatively impact the capacity of CDDCs to produce the commodities on which they depend, there is uncertainty about how exactly specific commodities will be affected. The impact of climate change on different countries will also depend on their geographical location.

The agricultural sector is one of the most exposed to climate change, although the impacts will vary across crops and across countries and regions. The increasing frequency and severity of extreme weather events such as floods and droughts pose a threat to agricultural productivity in the short-run, increasing the risk of crop, livestock and infrastructure losses. The FAO estimates that natural disasters caused $96 billion worth of crop and livestock loss to the agricultural sectors of developing countries over 2005-2016 (FAO, 2018a). Shifts in temperature and precipitation are also likely to cause long-term changes in the production of several crops; coffee yields, for example, are likely to be adversely affected by higher and more variable temperatures, and the global area suitable for cultivation is estimated to decline by up to 50 per cent by 2050 (Bunn et al., 2015).

The impact of climate change on agriculture has a regional dimension. Yields in low-latitude regions are projected to decrease with rising temperatures, while productivity in some high latitude regions may increase (UNCTAD 2019: 15). A large share of agriculture in national output and employment increases a country's vulnerability to climate change (SEI, 2021). Sub-Saharan Africa is especially exposed: 95 per cent of farmed land in the region is rain-fed, and West Africa has been identified as a climate change hotspot with negative impact of climate change on crop yields and production (IPCC, 2019). Climate change is also expected to have

[4] The report does not provide information on the number of developed countries and diversified developing countries used in this calculation.

[5] The biggest sources (63 per cent) of GHG emissions in the agricultural sector is enteric fermentation and manure associated with livestock production (UNCTAD 2019: 15).

[6] https://gain.nd.edu/our-work/country-index/rankings/

[7] The countries were Mozambique (1st), Malawi (3rd), Ghana and Madagascar (joint 8th position). Ninety per cent of the infrastructure was destroyed in Beira, Mozambique, the epicenter of the 2019 Cyclone Idai. Source: https://www.afdb.org/en/cop25/climate-change-africa

permanent adverse effects on freshwater and marine aquaculture in several CDDCs (FAO, 2018b). Small island developing states are some of the most vulnerable to climate change, and they have been among the earliest countries most affected by the risk of rising sea levels and falling revenues from fisheries (UNCTAD, 2019a, p.2).

Other commodity sectors are also vulnerable to climate change. Extreme weather events, rising temperatures, water scarcity and rising sea levels can cause damage to fossil fuel production sites, infrastructure, operations and supply chains (UNCTAD, 2019a, p.14). Although relatively few studies have been done on the potential impact of climate change on mining operations, existing projections of significant changes in climate in mineral-rich regions suggest that climate change may pose a threat to mining infrastructure, operations and transportation routes (UNCTAD, 2019a, p.18). Climate change also threatens forest ecosystems, increasing the susceptibility of forests to fires and altering forest cover, all of which will negatively affect the forestry sector, with adverse impacts on countries that are dependent on forestry-related activities and products, such as Cameroon (UNCTAD, 2019a, p.14).

2.3 Impacts of global climate policy on commodity markets

The mitigation and adaptation measures undertaken by third economies in response to climate change constitute an important source of vulnerability to climate change for CDDCs. Since 2015, the European Union, the United Kingdom, the United States of America, Japan, and the Republic of Korea have adopted net-zero emissions targets for 2050; China and the Russian Federation have pledged to reach this target by 2060, and India by 2070. These measures – especially those undertaken by the largest economies (China, the United States and the European Union) – will have negative implications for CDDCs, because of their impact on the global demand for emissions-intensive commodities (UNCTAD, 2019a, p.35). Mitigation efforts in these economies will increasingly require natural resources to be stranded, either as the direct result of regulatory efforts to combat climate change, or as the result of policy-induced changes in relative prices that reduce the competitiveness of these resources (UNCTAD, 2019a, p.18).

Fossil fuel exporters, in particular, are likely to be disproportionately affected as the global economy moves towards the use of less carbon-intensive sources of energy. At the recent climate summit in Glasgow, 46 countries pledged to phase out domestic coal while another 29 countries committed to ending new public support for fossil fuels and redirect public investment to clean energy. The Beyond Oil and Gas Alliance, led by Costa Rica and Denmark, also pledged to end new licensing rounds for oil and gas exploration. Together, these pledges imply substantial reductions in global fossil fuel use, and fossil fuel reserves are likely to become stranded if these countries succeed in implementing these policies effectively, and if the rapidly falling costs of low-carbon technology induce faster adoption globally (Mercure et al., 2021). This loss of export markets may however not be limited only to fossil fuel exporters: exporters of other commodities could potentially be affected in the long-run, as technological innovations lead to reductions in the demand for their commodity exports. For example, countries that depend on exports of carbon-intensive agricultural commodities will need to adapt to changing trade standards as consumer demand shifts towards more sustainably sourced agricultural products (Anzolin and Lebdioui, 2021).

The resulting falling prices and loss of export revenues and employment will be economically and politically destabilizing for CDDCs, many of which are poorly equipped to cope with these changes (UNCTAD, 2019: 19). More importantly, given the weakness of their bargaining position vis-à-vis the largest economies, CDDCs will have little say in how and when these outcomes materialize. This vulnerability to the outcomes of policy decisions made in third countries is perhaps an even stronger argument for CDDCs to reduce their dependence on commodities. They may be able to implement climate change adaptation and mitigation policies that might help them to stave off the worst effects of rising temperatures. However, without an alternative growth and development path that allows them to create new comparative advantages, CDDCs dependence on commodities for which global demand is declining does not bode well for their long-term economic independence.

2.4 New opportunities for CDDCs and a note of caution

It is worth noting that the growing share of renewable low-carbon energy sources in global energy consumption presents an opportunity for countries that are rich in the resources needed to power these energy sources. The demand for metals such as aluminum, cobalt, copper, lithium, nickel, silver, zinc and other rare earth metals is expected to increase significantly. For example, demand for cobalt is expected to double by 2030, an increase largely driven by the rising demand for electric vehicles globally.[8] Rising demand will generate higher prices that in turn will increase export revenues of countries that are rich in these resources. If used wisely, these windfall resources could contribute to funding economic transformation in these countries, leading to product and export diversification. But these expected benefits will remain largely hypothetical unless the evolution of low-carbon technology fosters the demand for those minerals. Moreover, the policy choices and the regulatory environment both within CDDCs and at the global level will determine the extent to which mineral-rich CDDCs take advantage of this opportunity (UNCTAD, 2019: 38).

However, the window of opportunity offered to some CDDCs such as cobalt-producing Democratic Republic of the Congo or those forming the lithium triangle (Argentina, Chile and the Plurinational State of Bolivia) may be open just temporarily. Technological developments could adversely affect the demand for these commodities if and when cheaper and more widely available substitutes are discovered. For example, ongoing research into the use of more widely available commodities such as nickel instead of cobalt in electric battery production could dampen the demand for the minerals currently considered to be strategic for the energy transition.

To ensure that these structural shifts do not become detrimental to development and ecological sustainability, however, countries that have abundant reserves of these strategic resources will need to manage the environmental impact on their mining sectors and avoid becoming too dependent on the export of these resources (Rempel and Gupta, 2021).

2.5 Solving the problem

Climate change is a global problem, and climate change mitigation is often presented as a classic collective action problem – one in which climate action is costly to individual countries (Aklin and Mildenberger, 2020; Nordhaus, 2015). A few countries – particularly advanced industrialized economies – are responsible for most of the current stock of carbon and other greenhouse gases in the atmosphere. Likewise, the costs of climate change and the costs of taking action to mitigate climate change are not equally distributed across countries. As the previous section makes clear, some populations will suffer more from the consequences of climate change than others, and the cost of climate change mitigation policies will be greater for some populations than for others (Stiglitz, 2015). The populations that will suffer the greatest costs are not the same as those that contributed the most to the problem. At the same time, the benefits of protecting the environment and undertaking actions to mitigate climate change are not constrained by national boundaries. Individual countries therefore have an incentive to take no action and instead count on benefitting from the actions of other countries (Stiglitz, 2015).

Whether this is an accurate characterization of the incentive structure surrounding climate action is up for debate. In a recent paper focused on the fossil-fuel sector, Mercure et al. (2021) argue that this framing overlooks the possibility that falling costs of low-carbon technologies increases the incentives for fossil-fuel importers to invest more in decarbonization technologies and reduce their demand for fossil fuels, while low-cost fossil-fuel exporters have an incentive to increase output so as to capture a greater share of the declining demand for fossil-fuels. In this scenario, high-cost fossil fuel exporters do not benefit from free-riding; instead they suffer the costs associated with shrinking export markets and greater exposure to resource-stranding.

Regardless of how the incentive structures of climate policy are framed, the question of how to distribute the costs and benefits of lowering GHG emissions remains controversial. Who should bear the cost of lowering GHG emissions? Should it be the advanced economies that contributed the most to the existing stock of GHG in the atmosphere, and that have the technological and financial resources to support these costs? Do CDDCs

[8] https://www.spglobal.com/platts/en/market-insights/latest-news/metals/120120-cobalt-demand-set-to-roughly-double-by-2030-roskill

have a right to a greater share of the global carbon budget in pursuit of their right to development (Padilla, 2017; Rempel and Gupta, 2021)?

The landmark Paris Agreement, adopted in 2015, attempts to bring these different and conflicting interests into alignment by establishing a binding commitment for all countries to prepare, communicate and implement nationally determined contributions (NDCs) to reduce GHG emissions, with the goal of keeping the increase in global average temperature to well below 2 degrees Celsius (ideally to 1.5 degrees Celsius) compared to pre-industrial levels (UNCTAD, 2019:3).

Subsequent climate talks, including the most recent one in Glasgow (COP26) have sought to maintain global momentum to decouple output from greenhouse gas emissions and reach net-zero emissions by 2070. Is it possible to achieve the global emission reduction targets without constraining development in CDDCs? The answer to this question hinges on the relationship between growth, development and environmental conditions in these countries. The next section turns to a review of the scholarly debates on this topic.

3. GHG emissions and output growth in CDDCs: A review of the literature

The relationship between growth, development and environmental conditions is a subject of intense debate in the voluminous literature on the role of economic growth on climate change and environmental quality. This review focuses on four strands of this debate, each associated with a different set of policy recommendations that have particular relevance for CDDCs.

The first strand of this literature focuses on identifying the nature of the relationship between economic growth and environmental degradation. In the 1990s, several studies found evidence of an inverted U-relationship (the so-called environmental Kuznets curve) between a variety of environmental pollutants and economic growth and between carbon dioxide emissions and economic growth (Grossman and Krueger, 1995; Panayotou, 1993, 2001). Subsequent empirical analysis has focused on whether there is indeed an inverted U-shaped relationship between economic development and environmental degradation for individual countries, and to identifying the turning point at which increases in income would lead to lower levels of environmental degradation. While most of this work has placed emphasis on behavioural explanations for the improvement in environmental quality as incomes increase and the demand for better environmental quality increases, Panayotou et al. (2000) suggest that it is instead the process of structural change that leads to improvements in environmental quality as incomes rise and countries move to a post-industrial stage of development. If this is the case, the authors argue, then the quantity and intensity of environmental degradation in developing countries and CDDCs (as well as their contributions to climate change) are likely to increase unless "alternative development and energy paths are found that do not constrain their growth prospects" (p.16).[9] The empirical evidence for the environmental Kuznets curve has so far been inconclusive, since individual countries appear to follow different paths, suggesting that instead of simply waiting for environmental quality to improve with growth, appropriate environmental policies can help less developed countries leapfrog over the worst phases of environmental degradation in the process of growth (Padilla, 2017).

A second strand of this literature focuses on the perceived tradeoffs between economic growth and environmental degradation. This relationship is captured in the Kaya Identity, which expresses GHG emissions as the product of population, per capita GDP, energy-intensity of GDP, and carbon-intensity of energy consumed (Anzolin and Lebdioui, 2021). The Kaya Identity emphasizes a presumed tradeoff between economic growth and environmental sustainability; from this perspective, increases in economic growth cannot be achieved without environmental costs; i.e., economic growth is fundamentally incompatible with climate stabilization and ecological and environmental sustainability (Alexander, 2012). The policy implications for CDDCs emanating from this view are clear: if they continue with the current model of resource and carbon-intensive growth, they and the rest of the world will pay the price in terms of rapid climate change; the only

[9] This is due to their position on the upward-sloping portion of the Environmental Kuznets Curve.

policies that will succeed in slowing the pace of climate change are those that forego economic growth in order to reduce overall emissions levels.

There is disagreement about how the costs of lowering GHG emissions should be distributed. One line of argument holds that advanced economies should forego economic growth while allowing developing countries to keep growing (Alexander, 2012; Gough, 2017; Hickel, 2020). Given that advanced economies are largely responsible for most of the current stock of industrially-generated carbon in the atmosphere and have the technological capability and financial resources to bear the cost of mitigating and adapting to climate change, it would make sense that these countries begin to pay immediately for the costs associated with climate change mitigation, thereby allowing "ecological space to permit development-through-growth to proceed for a short time in the Global South" (Gough, 2017, p. 171). The second line of argument calls for the more immediate and deliberate stranding of carbon-intensive resources, especially of fossil fuels (McGlade and Ekins, 2015; Welsby et al., 2021).

In response to the argument that CDDCs' right to development justifies their continued extraction of carbon-intensive resources, Rempel and Gupta (2021, p. 146) argue that these countries would not only exacerbate climate change, they also would expose themselves to significant losses from premature asset stranding as fossil fuels are phased out. Noting that losses from asset stranding are estimated to lie in the range of $16 trillion to $200 trillion, the authors propose that the financial burden of phasing out fossil fuels be allocated to commercial banks, corporations in the fossil fuel industry and institutional shareholders in the global North, who will compensate countries in the global South for leaving their coal, oil and gas reserves in the ground (Rempel and Gupta, 2021, p. 147).

Setting aside the likelihood of this compensation actually occurring in the context of the current global political economy, degrowth may be unlikely to bring the world close to the emissions targets necessary to slow down the pace of climate change. Pollin (2015) notes that global CO2 emissions need to fall to 20 billion tons by 2035. Under a hypothetical degrowth scenario, a global GDP contraction of 10 per cent between 2015-2030 would reduce emissions to 30 billion tons. In other words, a reduction in global GDP four times larger than what was experienced during the Great Recession (2007-09) will not bring the world close to the 2035 emissions target of 20 billion tons (Pollin, 2015: 108). The reduction in growth necessary to bring about the necessary reductions in global CO2 emissions is unlikely to be politically palatable, either in the Global North or the Global South, and is likely to drive further inequality in wealth and income between and within countries (Gough, 2017).

Importantly, other scholars have pointed to a significant limitation of the Kaya Identity. In treating all types of industrialization as being equal in terms of their impact on global GHG emissions, the Kaya Identity overlooks the lower material and energy content of consumption patterns and production methods associated with green technologies, which will reduce the net impact of green industrialization on long-term carbon emissions (Anzolin and Lebdioui, 2020: p. 375).

A third line of argument – the green growth paradigm – focuses on potential synergies between economic development, job creation, and climate change mitigation (Anzolin and Lebdioui, 2021; ILO, 2018; Pollin, 2015, 2021). Based on the view that growth and environmental sustainability can be compatible, the green growth paradigm defines green growth as 'growth that is efficient in its use of natural resources and clean in that it minimizes pollution and environmental impacts' (Anzolin and Lebdioui, 2021: 376). This perspective calls for "huge expansions in energy efficiency, clean renewable energy investments and massive cuts in the use of fossil fuel energy sources….", while at the same time protecting the workers and communities whose livelihoods currently depend on these industries (Pollin, 2015: p.109; p.111). Because of its orientation towards creating employment and increasing social welfare, green growth holds the potential to garner broader political and social support across all income groups, and may be the most pragmatic path towards a low-carbon economy; however, it hinges on the assumption that it is possible to decouple increases in output from GHG emissions.[10]

[10] Gough (2017: 195) notes that green growth forms the centrepiece of the Paris Agreement because, for now, it is the only politically viable strategy for achieving a low-carbon global economy.

The extent to which different economies have actually succeeded in decoupling output growth and improvements in living standards from GHG emissions is the subject of the fourth strand of this literature, which focuses on the estimation of long-run emissions-output elasticities for different countries or groups of countries. Most of this literature has been focused on advanced economies, and only a few studies have focused on the relationship between growth and emissions in commodity dependent countries. One of the earliest studies to focus on developing countries is Narayan and Narayan (2010) who use a panel co-integration model to estimate long and short-run elasticities of carbon dioxide emissions with respect to output in 43 developing countries between 1980-2004. The authors find that for 15 out of the 43 countries in their sample (about 35 per cent of their sample), the long-run elasticity of emissions with respect to income is lower than the short-run elasticity, suggesting that in these countries at least, increases in income are associated with lower carbon dioxide emissions.[11] However, the long-run income elasticity of carbon dioxide emissions was positive for all but six countries (Iraq, the United Arab Emirates, Yemen, the Congo, Kenya and Nigeria) indicating that the majority of countries in the sample still need to do more to foster decoupling of long-run income growth from carbon dioxide emissions.[12]

Noting that changes in emissions associated with the booms or downturns in the business cycle can obscure structural changes that make the economy more or less emissions-dependent, other studies decompose growth in emissions and real GDP into their trend and cyclical components before estimating the respective elasticities. Cohen et al. (2018) apply this approach to the top 20 emitters (a group that includes four commodity exporters) over the period 1990-2014. They find that trend elasticities decline with per capita incomes, so that advanced economies have lower trend output elasticities of emissions than emerging market economies.[13] Advanced economies have an average trend emissions-output elasticity of 0, while countries with large shares of agriculture and industry relative to services in value added have trend elasticities that range from 0.6 to 1 (Cohen et al., 2018: p.21). They also find evidence that trend elasticities have fallen over time, with higher trend elasticities in the post WW2 period (an average of 1.11 for countries that have adequate data) and lower trend elasticities since the 1980s (an average of 0.66).

In an extension of this approach to a sample of 46 commodity exporting countries over the period 1990-2014, Jalles and Ge (2020) estimate average long-term output-emissions elasticities of about 0.7, compared to 0.1 in advanced countries. For most countries in their sample, trend elasticities of emissions with respect to output are less than one, which they argue is evidence of 'relative decoupling' of GDP growth from emissions. They also find that among the top 20 commodity exporting emitters, trend elasticities are larger than cyclical elasticities, suggesting that emissions in these countries are more structural than cyclical in nature (p.5). Some countries also have negative elasticities (Ecuador and Paraguay), an indication that these countries have succeeded in decoupling their trend emissions from trend GDP and managed to transition to a low-carbon path (p.12). In the next section, we apply this approach to estimate trend and cyclical elasticities of emissions with respect to output in a larger sample of countries (186) and over a longer period (1980-2018).

[11] The countries were Iraq, Jordan, Kuwait, Yemen, Qatar, the United Arab Emirates, Argentina, Mexico, the Bolivarian Republic of Venezuela, Algeria, Kenya, Nigeria, the Congo, Ghana and South Africa (p.662). Note that almost all of these are CDDCs, with the exception of Jordan, Mexico and South Africa.

[12] Their estimates range from -0.94 for the Congo to 4.23 for Guatemala.

[13] One reason for this is the fact that advanced industrialized countries are able to outsource much of their most carbon-intensive production to less industrialized countries (Gough, 2017; Jalles and Ge, 2020).

4. Empirical analysis of output-elasticities of emissions in CDDCs

4.1 Framework and estimation methodology

Following Cohen et al. (2018) and Jalles and Ge (2020), we use the Hodrick-Prescott (HP) Filter to decompose real GDP per capita and greenhouse gas (GHG) emissions series into their trend and cyclical components.[14] The cyclical component reflects the short-run relationship between output and emissions, and the trend component captures the long-run relationship between output and emissions.[15]

For comparison purposes, we carry out these decompositions for 186 CDDCs, DDCs and developed countries over the period 1980-2018. These countries are further disaggregated by type of commodity dependence (for CDDCs), by region and by income group.[16] The list of countries is provided in the Appendix, Table A1.

The second part of our analysis is limited to countries that have complete data for the period 1980 – 2018. We estimate the cyclical and trend output-elasticities for 63 CDDCs, 40 DDCs and 24 developed countries and for CDDCs disaggregated by region, per capita income and type of commodity export (Appendix, Table A2). For the cyclical relationship between emissions and output, we estimate the following fixed effects specification:

$$e_{ti}^{c} = \beta^{c}\, y_{ti}^{c} + \gamma_i + \epsilon_{ti}^{c} \qquad (1)$$

where e_{ti}^{c} and y_{ti}^{c} are respectively the cyclical components of the log of emissions and log of real output for each country in the group, β^{c} is the estimated cyclical elasticity of emissions with respect to output, γ_i captures country fixed effects and ϵ_{ti}^{c} is a random error term. The trend elasticity is estimated as follows:

$$e_{ti}^{\tau} = \beta_0 + \beta^{\tau}\, y_{ti}^{\tau} + \gamma_i + \epsilon_{ti}^{\tau} \qquad (2)$$

Where e_{ti}^{τ} and y_{ti}^{τ} are the trend components of the log of emissions and the log of real output, β^{τ} is the estimated trend elasticity of emissions with respect to output and ϵ_{ti}^{τ} is a random error term. We include an intercept to account for differing initial levels of output and emissions.

In both specifications, γ_i are the country-specific fixed effects and ϵ_{t}^{c} and ϵ_{ti}^{τ} are the error terms.

Finally, for individual countries, the cyclical and trend output elasticity of emissions are estimated using OLS regressions as follows:

$$e_{t}^{c} = \beta^{c} y_{t}^{c} + \epsilon_{t}^{c} \qquad (3)$$
$$e_{t}^{\tau} = \beta^{0} + \beta^{\tau} y_{t}^{\tau} + \epsilon_{t}^{\tau} \qquad (4)$$

where e_{t}^{c} and e_{t}^{τ} are the cyclical and trend components of the log emissions series for each country, y_{t}^{c} and y_{t}^{τ} are the cyclical and trend component of log GDP, and β^{c} and β^{τ} are the trend and cyclical elasticities.

A statistically significant elasticity between 0 and 1 would indicate that a 1 per cent increase in output is associated with a less than proportionate increase in emissions. An elasticity of zero or less means that growth in output is not associated with additional emissions, while an elasticity greater than 1 would indicate that output growth is associated with a more than proportionate increase in emissions.

[14] The Hodrick-Prescott Filter is a data-smoothing technique that minimizes the function $\min_{\tau}(\sum_{t=1}^{T}(y_t - \tau_t)^2 + \lambda\sum_{t=2}^{T-1}[(\tau_{t+1} - \tau_t) - (\tau_t - \tau_{t-1})]^2)$ where $y_t = \tau_t + c_t + \epsilon_t$ is a given series, τ_t is the trend component, c_t is the cyclical component, and ϵ_t is the error component (Hodrick and Prescott, 1997). Following Cohen et al. (2019) and Jalles and Ge (2019), the smoothing parameter $\lambda = 100$.

[15] The values for the aggregate series are initially calculated by using the unweighted mean. For robustness, we also aggregate the series using population weights. This second set of plots are provided upon request.

[16] Countries are identified as CDDCs, DDCs and DCs based on the designations in UNCTAD (2019a). UNCTAD (2019a) also provides information about the type of commodity dependence (agricultural, fuel, mineral and metal), income level (we adopt the UNCTAD (2019) categories of low, lower-middle, upper-middle, and high-income countries), as well as geographic information. Some countries have missing data.

Second, to provide context for interpreting our estimates and compare the output-elasticity of emissions in CDDCs to the evolution of the output-elasticities of emissions of the developed countries during the first century of their industrialization, we conduct the same decompositions and estimations for a much longer time periods – starting from the mid-18th or mid-19th centuries – for five of the major developed countries: the United States, the United Kingdom, Germany, France, and Japan. We then divide these decomposed series into 30-year periods for each country and estimate the elasticities on these shorter periods in order to trace out the evolution of output-elasticities of emissions for these countries at different stages of their industrial development.

4.2 Unit root and cointegration tests

We examine the time series properties of the data for the original series of log GDP and GHG emissions, and for the trend components of these series. We do this by group and for individual countries.

For each country group (e.g., Agricultural CDDCs, High Income Fuel CDDCs, etc.) the Im-Pesaran-Shin panel unit root tests were conducted to test for unit roots within each country group panel, with the maximum number of lags chosen according to the Akaike Information Criterion (AIC). These tests are conducted for log GDP, and log total GHG emissions up to the first differences for the level values.

Pedroni panel cointegration tests were used to test log GDP and total GHG emissions for cointegration, for both the level and trend series. The Modified Phillips-Perron t-statistic was used to compute the p-value for these tests. According to these tests, log GDP and log GHG are cointegrated in levels for the groups of fuel CDDCs and mineral CDDCs, and their trends are cointegrated for the groups of agricultural CDDCs, mineral as well as CDDCs and DDCs as a whole. Neither the level nor trend series are cointegrated for the DC group as a whole.

When disaggregated by commodity dependence status, region, and income level, the trend series are cointegrated for CDDCs, with low middle and upper middle income CDDCs, and CDDCs in East Asia and the Pacific, Latin America and the Caribbean, and in Sub-Saharan Africa exhibiting trend cointegration (Appendix, Table A2).

For each country with adequate data, Augmented Dicky-Fuller tests were conducted to test for the presence of a unit root of the individual series. These tests are reported for the level and trend series of log GDP and log GHG emissions (cyclical components are stationary by construction). A test for cointegration between log GDP and total GHG emissions was performed for both the level and trend components. The levels of real GDP and GHG (in logarithm) are cointegrated for only 15 countries, or 12 per cent of the sample. These series are cointegrated in about 16 per cent of the CDDCs, and they are not cointegrated in any of the DDCs.

The trend components of real GDP and GHG, however, are cointegrated in a larger number of countries: 30 countries (24 per cent of the sample), including France, Germany and the United Kingdom for which we examine a longer time period, 32 per cent of DDC countries, and 25 per cent of CDDC countries (Full data available upon request).

Note that results of apparent order of integration higher than I(2) suggest that the series may contain structural breaks and/or outliers in certain years or periods. Typically, the tests are expected to show integration of order 1 or less once these features are incorporated into the unit root and cointegration tests. This would need to be explored on a country-by-country basis, which is beyond the scope of this study. Therefore, elasticity estimates by country need to be taken with caution for countries that either exhibit apparent high levels of order of integration of the series or absence of cointegration. The focus of the paper is on the analysis by commodity dependence categories, and we provide country-level elasticities to illustrate the heterogeneity among CDDCs.

4.3 Data and stylized facts

For the primary analysis, we use data on real output per capita (in 2010 US$) taken from the World Bank's World Development Indicators. Data on greenhouse gas emissions come from the Emissions Database for Global Atmospheric Research (EDGAR) which contains data sets covering the three direct greenhouse gases –

carbon dioxide, nitrous oxide and methane aggregated by country and by sector, using the IPCC 2006 sector designations.[17]

For the historical analysis focusing on the five major industrialized economies, data for real GDP per capita is from the Maddison Project, and data for historical carbon dioxide emissions is from the Carbon Dioxide Information and Analysis Center (CDIAC).[18] Total CO2 emissions is the sum of fossil fuel emissions for solid, liquid, and gas fuels, as well as gas flaring and cement production. Combined GDP and CO2 emissions data for each country is available as follows: United States (1800 - 2017), United Kingdom (1751 – 2017), Germany (1850 – 2017), France (1820 – 2017), and Japan (1870 – 2017).

Table 1 presents some stylized facts about income and emissions for the sample. In 2018, CDDCs had the lowest average GDP per capita as well as the lowest levels of emissions, relative to DDCs and developed countries. Emissions were lowest in sub-Saharan Africa and among low-income countries, and highest in North America. Among CDDCs, fuel exporters emitted the most, although their emissions were substantially less than those generated by North America. Emissions in DDCs and upper-middle income countries in 2018 were higher than those of developed countries and high-income countries. The top emitters in each of the three categories – CDDCs, non CDDCs, and developed countries – are listed in Table 2.

Table 1. Summary statistics

Group	Average GDP (in millions of 2015 US$)	Average CO2 emissions	Average Greenhouse Gas emissions
CDDC Status			
CDDC	99 530.3	90 625.4	92 149.4
DDC	479 519.8	436 640.1	440 073.1
DC	1 257 598.3	332 915.6	334 622.3
CDDC Type			
Agricultural CDDC	91 161.1	65 651.8	67 046.5
Fuel CDDC	178 541.1	186 131.2	188 776.9
Mineral CDDC	32 638.4	26 396.4	26 980.9
CDDCs by region			
East Asia and Pacific	836 530.8	604 463.5	608 522.5
Europe and Central Asia	455 144.1	159 638.6	160 860.4
Latin America and the Caribbean	163 974.0	91 145.5	92 748.4
Middle East and North Africa	172 692.4	138 910.7	140 765.2
North America	10 605 611.4	3 159 749.2	3 175 319.9
South Asia	412 373.7	544 152.7	550 193.2
Sub-Saharan Africa	38 702.6	47 105.9	48 029.2

[17] The IPCC sectors are defined as follows: energy Industries comprises emissions from fuels combusted by the fuel extraction or energy-producing industries; manufacturing industries are emissions from combustion of fuels in industry, and includes combustion for the generation of electricity and heat for own use in these industries; transportation sector refers to emissions from the combustion and evaporation of fuel for all transport activity (excluding military transport); manufacturing (non-energy) covers emissions from industrial processes and product use, excluding those related to energy combustion. Please see the IPCC guidelines for further details.

[18] This dataset provides country-level time-series estimates of carbon dioxide (CO2) emissions from fossil fuel combustion and cement manufacture going back to 1751, and include emissions from solid fuel consumption, liquid fuel consumption, gas fuel consumption, cement production, and gas flaring (https://data.ess-dive.lbl.gov/view/doi:10.15485/1712447)

Group	Average GDP (in millions of 2015 US$)	Average CO2 emissions	Average Greenhouse Gas emissions
Income			
High	921 396.8	264 144.3	265 685.4
Low	17 510.0	27 449.2	28 161.1
Low middle	151 436.7	175 408.2	177 784.2
Upper middle	436 648.4	383 338.0	386 605.5

Note: All values reported for 2018

Table 2. Top emitters

Country	GDP (millions of 2010 US$)	Total CO2 emission (ktons)	Total GHG emissions (ktons)
CDDCs			
Russian Federation	1 430 115	1 823 398	1 840 037
Brazil	1 797 739	1 201 539	1 224 978
Islamic Republic of Iran	425 620.3	666 693.1	675 341.1
Nigeria	492 074.9	591 952.3	600 732.5
Saudi Arabia	676 339.5	593 814.9	598 189.7
DDCs			
China	13 493 418	11 852 621	11 919 523
India	2 590 899	3 642 851	3 674 494
Indonesia	999 178.6	991 355.3	1 006 355
Republic of Korea	1 601 904	696 868.2	698 605.1
Mexico	1 255 065	581 186	588 184.6
Developed Countries			
United States	19 551 981	5 651 108	5 677 674
Japan	4 578 914	1 225 865	1 228 035
Germany	3 561 302	853 765.3	856 453.8
Canada	1 659 241	668 390	672 966.2
Australia	1 463 016	478 237.7	482 964.4
Agricultural CDDCs			
Brazil	1 797 739	1 201 539	1 224 978
Argentina	583 429.8	27 6514.2	281 884
Ethiopia	82 721.2	188 687.3	192 593.4
Myanmar	72 421.9	108 173.4	111 847.6
Uganda	37 238.7	72 737.2	73 943.9
Fuel CDDCs			
Russian Federation	1 430 115	1823 398	1 840 037
Islamic Republic of Iran	425 620.3	666 693.1	675 341.1
Nigeria	492 074.9	591 952.3	600 732.5
Saudi Arabia	676 339.5	593 814.9	598 189.7
Kazakhstan	202 016.2	284 797	287 525.6

Country	GDP (millions of 2010 US$)	Total CO2 emission (ktons)	Total GHG emissions (ktons)
Mineral CDDCs			
Chile	260 354.5	129 783.3	130 712.8
Democratic Republic of the Congo	42 619.0	95 171.6	96 704.7
Uzbekistan	95 650.0	93 779.9	96 501.9
Peru	210 307.6	73 978.4	75 188.9
United Republic of Tanzania	57 011.9	72 985.9	74 863.1

Note: All values reported for 2018

Decomposing emissions and real GDP series into their cyclical and trend components allows us to assess how the relationship between emissions and output has evolved over time. While emissions and output cycles mirror each other closely in developed countries, they diverge in both CDDCs and DDCs, suggesting that the cyclical relationship between growth and emissions is weaker in developing countries than in developed countries. The trends in emissions and output for CDDCs and non-CDDCs are relatively similar, with emissions and GDP per capita increasing gradually over the course of the past several decades (Figure 1). Overall, the decompositions suggest that emissions in CDDCs have increased at least as fast, or faster than GDP, although for most CDDCs, emissions have increased from very low initial levels.

Figure 1. Trend and cycle decomposition of GDP and GHG for CDDCs, DDCs and developed countries

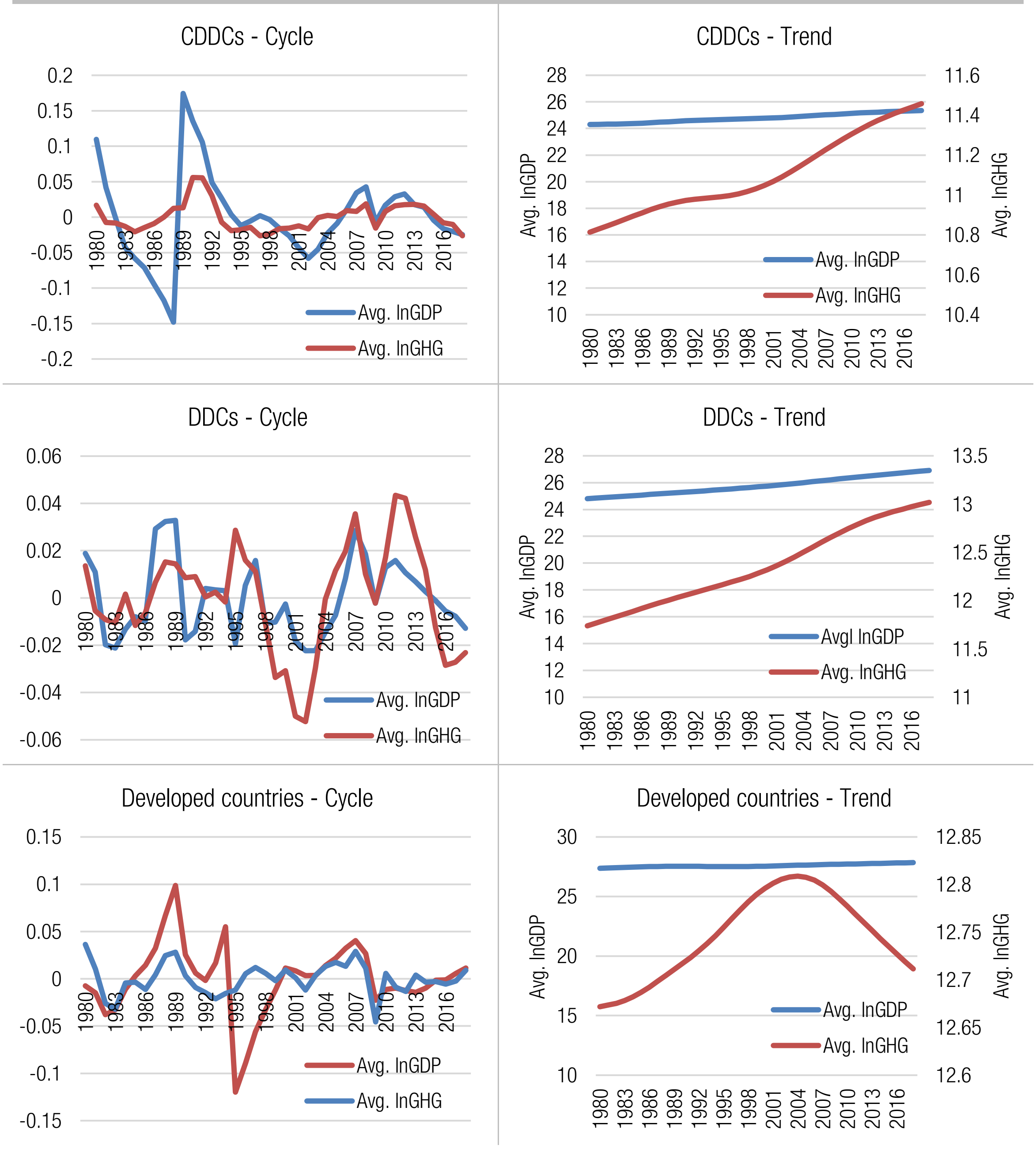


Figure 2 breaks down the CDDC category by type of commodity dependence: agricultural, mineral, and fuel. The cyclical relationship between emissions and growth is stronger in agricultural and mineral CDDCs than in fuel CDDCs; however, the trend components of emissions and growth for the different CDDC categories suggest that over time emissions have tended to rise with GDP growth in all CDDCs.

Figure 2. Trend and cycle decompositions for CDDCs by commodity type

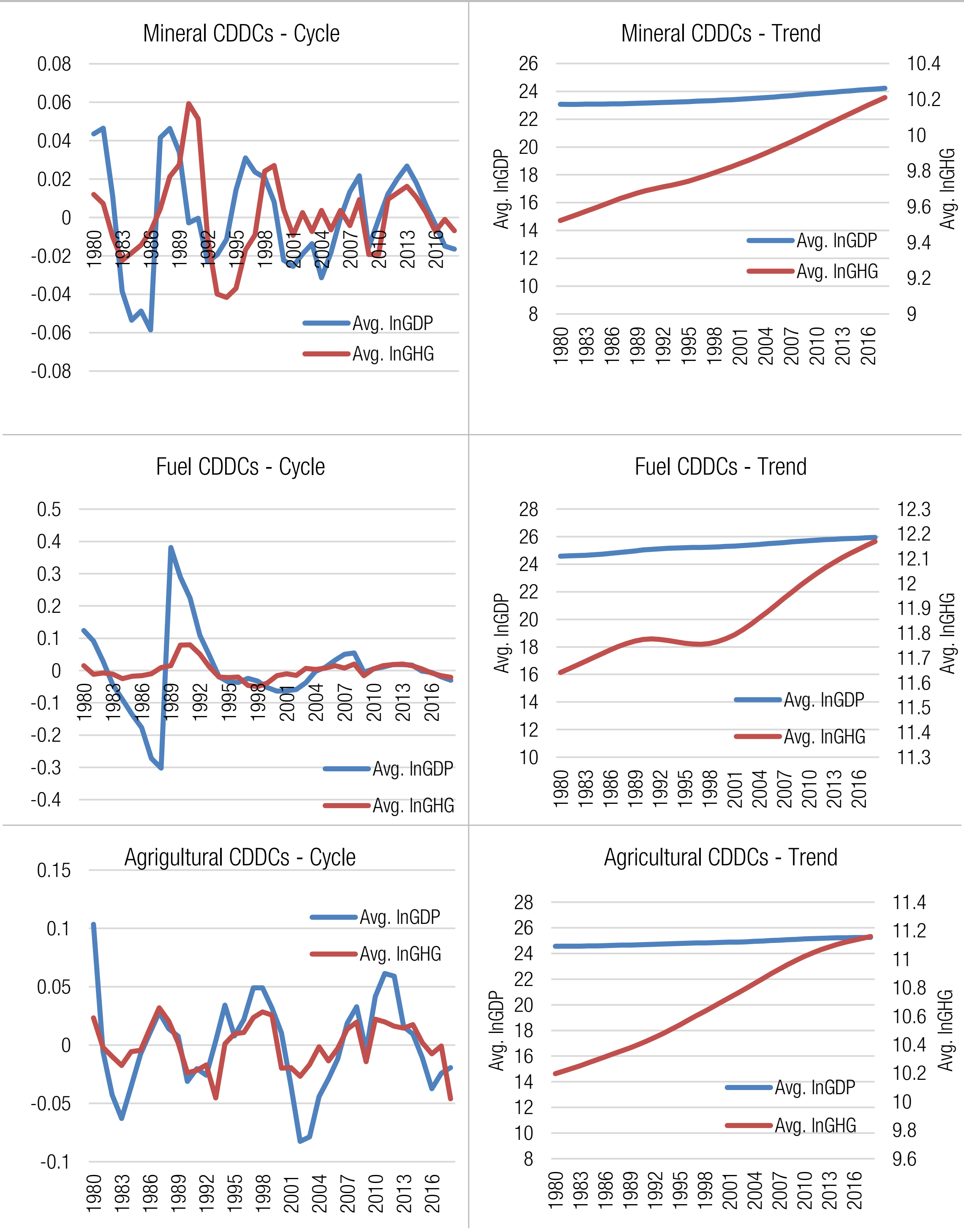
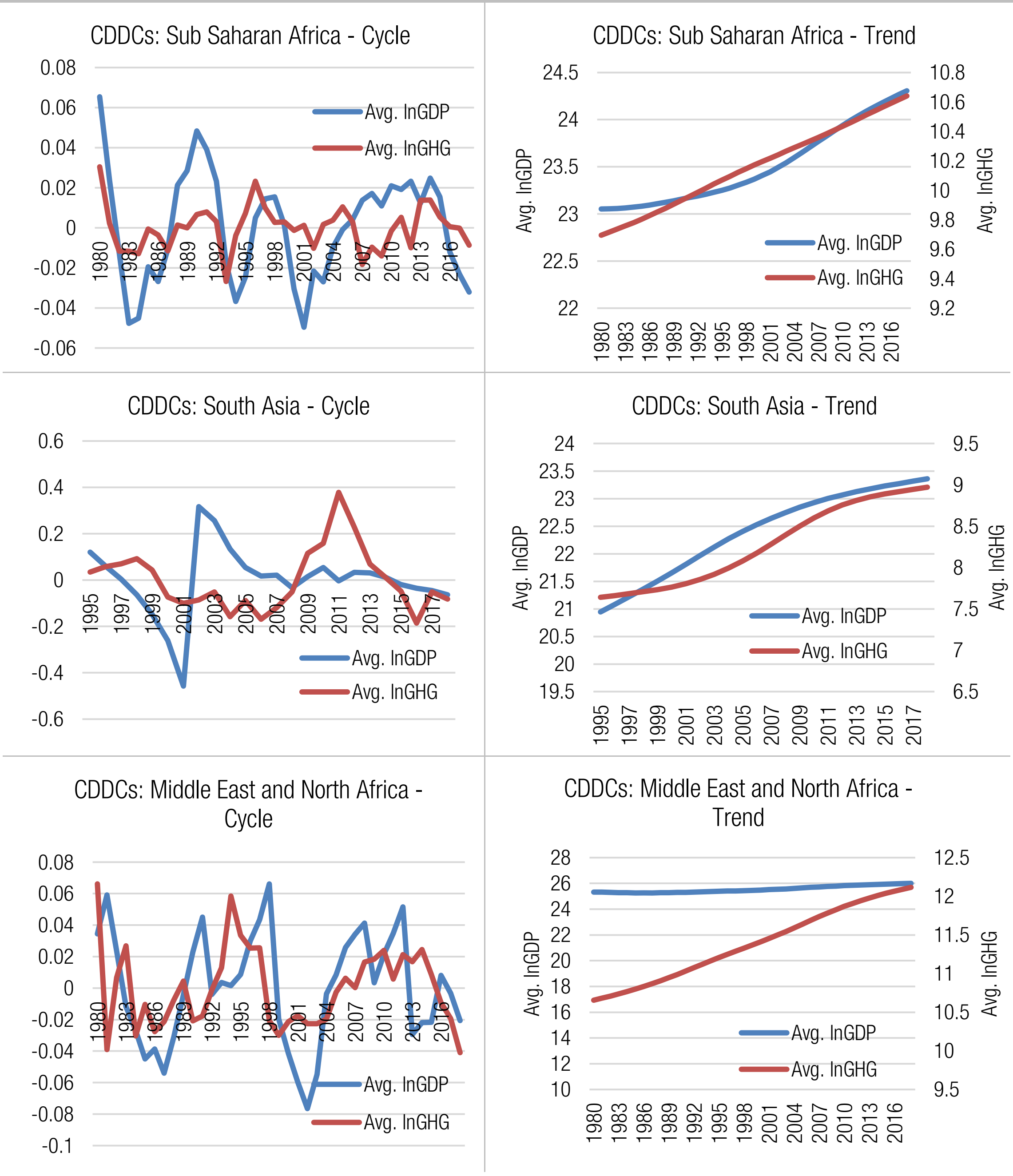


Figure 3 shows trend and cycle decompositions for CDDCs by region. There are striking differences in the long-run relationship between emissions and growth across regions. CDDCs in East Asia and the Pacific experienced the fastest increases in GDP and emissions. Emissions growth in CDDCs in Europe and Central Asia has levelled off in the recent decades, while income growth has continued. Emissions and GDP trends for Latin America and the Caribbean as well as Sub-Saharan Africa have followed a moderate upward trend since 1980. In the Middle East and North Africa, GDP has levelled out and decreased slightly in the last decade, while emissions have continued to increase steeply. CDDCs in South Asia show a more erratic pattern, with emissions increasing sharply and output decreasing, then levelling out.[19]

Figure 3. Trend and cycle decompositions for CDDCs by region



[19] However, note that only the Maldives and Afghanistan in this sample are included for CDDCs in South Asia. Trend decompositions for non-CDDCs are presented in the Appendix.

Figure 3. Trend and cycle decompositions for CDDCs by region *(cont.)*

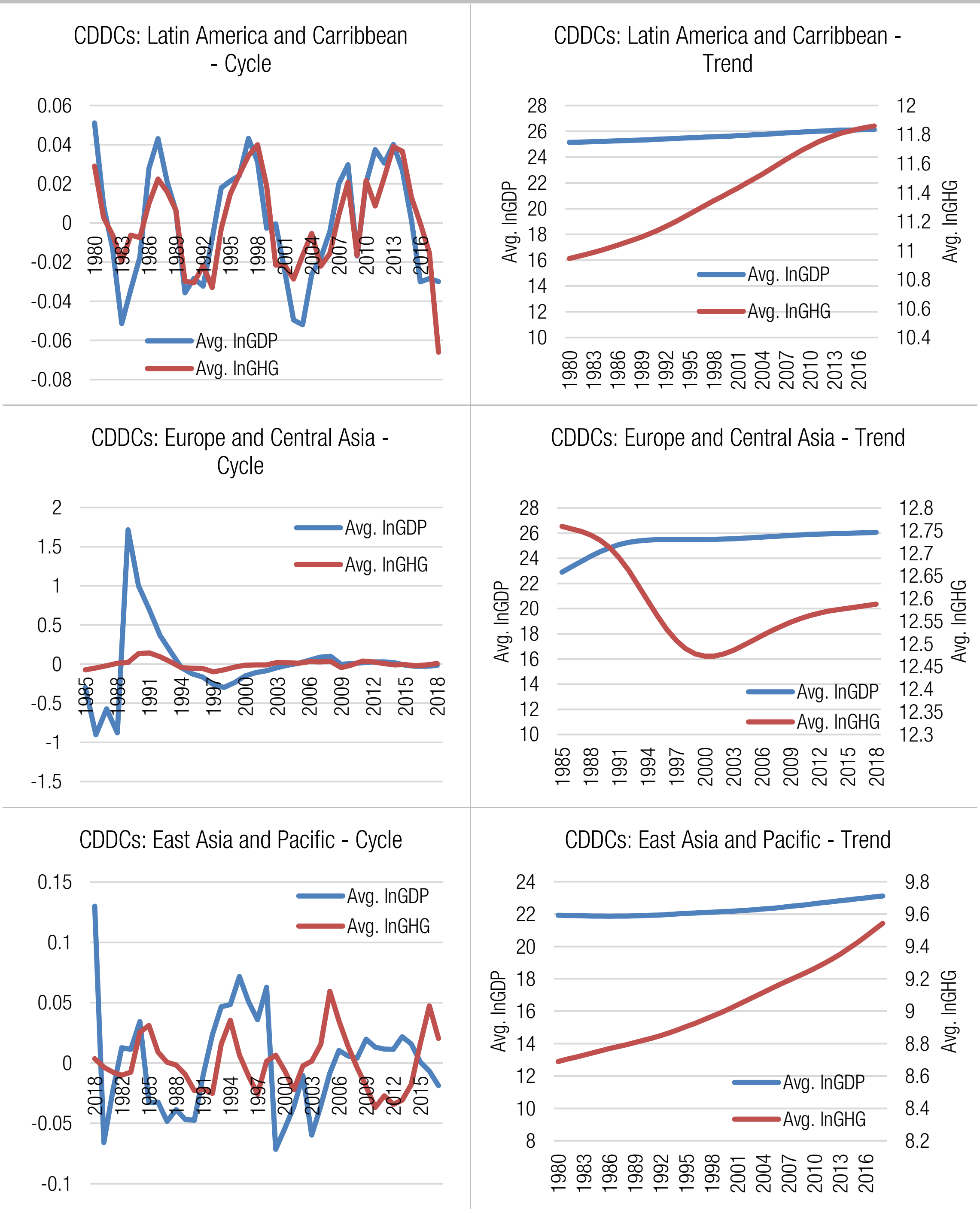
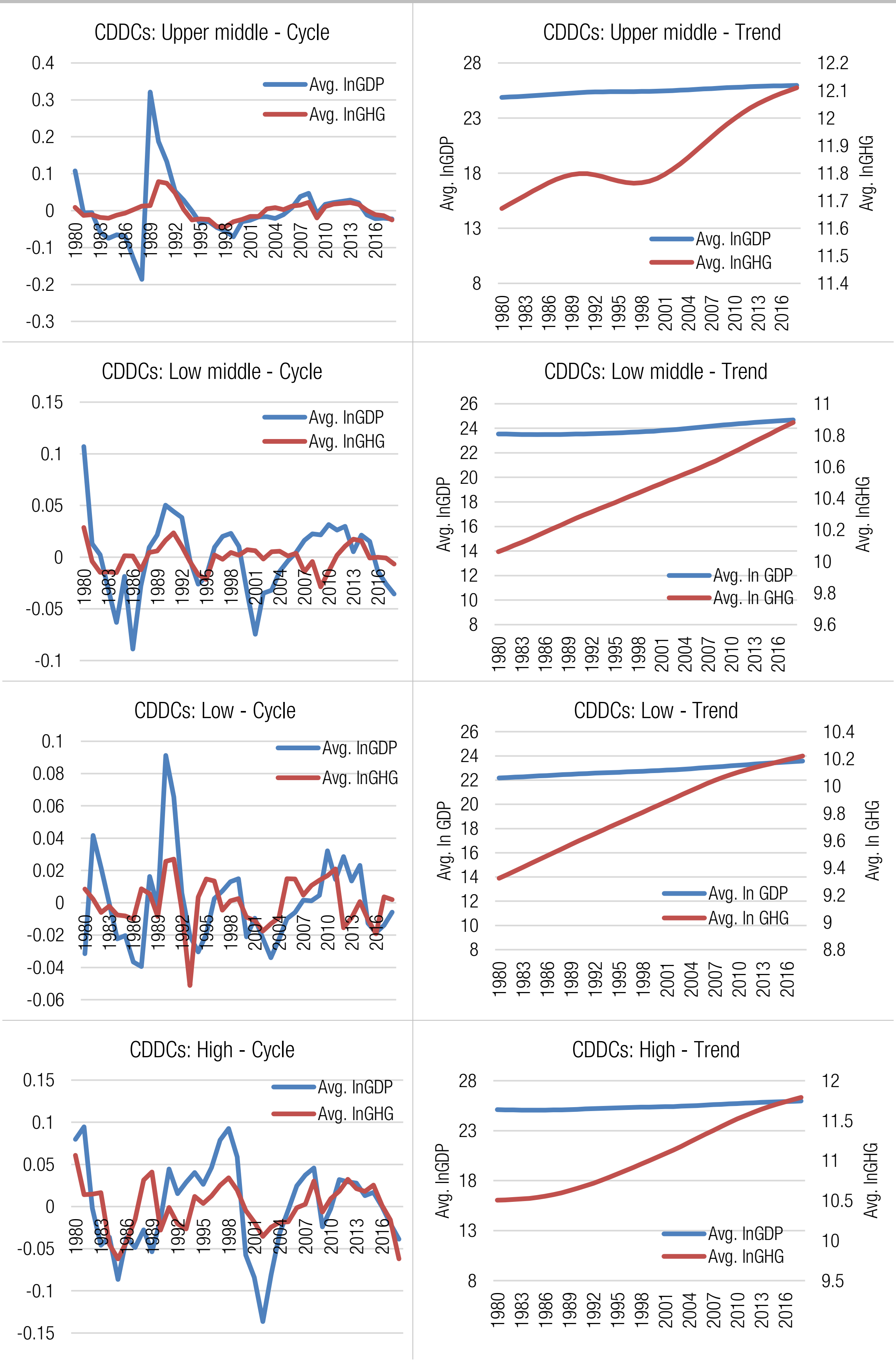


Figure 4 shows trend decompositions for CDDCs by income level. For high-income CDDCs (Bahrain, Saudi Arabia, and other oil exporters), emissions growth is rapid while GDP per capita is growing slowly or is steady. Growth in emissions has been much more moderate in middle-income and low-income CDDCs, while low-income CDDCs have seen very little growth in output.

Figure 4. Trend and cycle decompositions for CDDCs by income



In general, for both CDDCs and DDCs, emissions growth seems to be increasing at the same rate as, or faster than GDP per capita. The next section presents the estimates of cycle and trend elasticities for the different country groups.

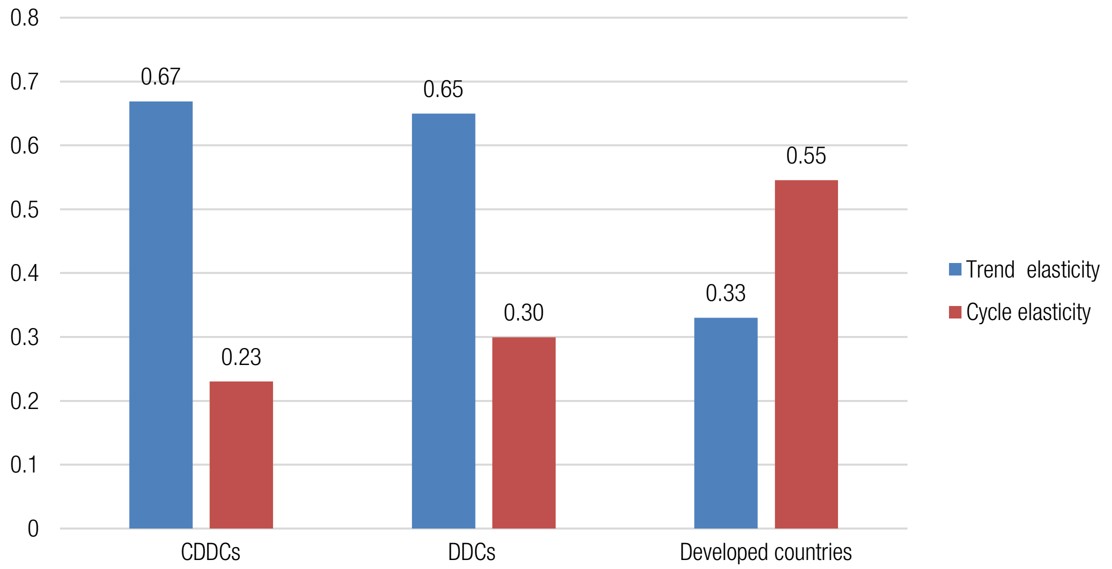
4.4 Estimated output elasticities of emissions

Table 3 and Figure 5 show the cyclical and trend elasticities for CDDCs, DDCs and developed countries. In general, these results are similar to the results obtained for individual countries by Cohen et al. (2018) and Jalles and Ge (2020). Compared to emissions in developed countries, emissions in CDDCs and DDCs are less procyclical; however, the higher trend elasticities for both CDDCs and DDCs suggest that emissions are more sensitive to changes in output in the long run than in the short run. Estimates of elasticities for individual countries are presented in Table A3 of the Appendix.

Table 3. Trend and cycle elasticities by country status (fixed-effects estimates)

Country category	Trend elasticity	Trend p-value	Cycle elasticity	Cycle p-value
CDDC	0.67	0.00	0.23	0.00
DDC	0.65	0.00	0.39	0.00
Developed country	0.30	0.00	0.63	0.00

Figure 5. Trend and cyclical elasticities for CDDCs, DDCs and developed dountries

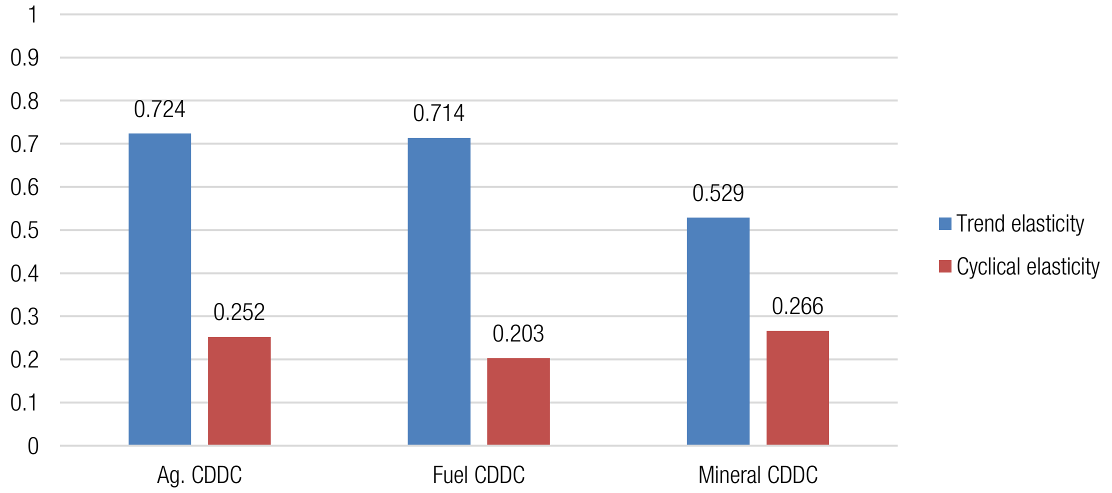


Disaggregating the group of CDDCs by type of commodity dependence reveals some heterogeneity within the group: trend elasticities are higher for CDDCs that depend on agricultural and fuel exports than among mineral exporters (Table 4 and Figure 6). Analysis at the country-level reveals even more heterogeneity within these groups (see Appendix Table A3).

Table 4. Trend and cycle elasticities for CDDCs by type of commodity export

Country category	Trend elasticity	Trend SE	Trend p value	Cycle coefficient	Cycle SE	Cycle p value
Agricultural CDDC	0.72	0.03	0.00	0.25	0.05	0.00
Fuel CDDC	0.71	0.02	0.00	0.20	0.08	0.01
Mineral CDDC	0.53	0.02	0.00	0.27	0.07	0.00

Figure 6. Trend and cyclical elasticities for CDDCs by type of commodity export



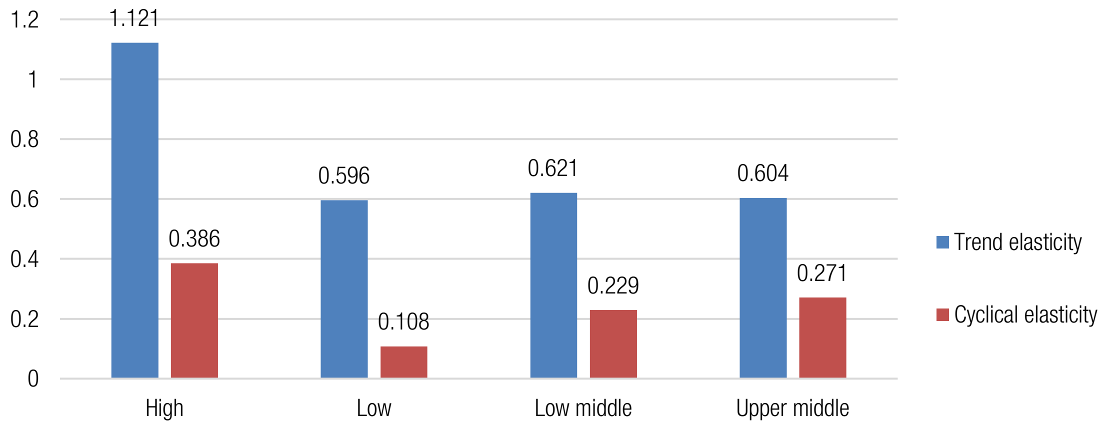
The differences among CDDCs are more striking when the elasticities are analyzed by income (Table 5). How rich or poor a CDDC is clearly has some bearing on the sensitivity of emissions to output in that country: the output-elasticity of emissions in low-income CDDCs is 0.5, compared to 0.6 in middle-income countries and 1.1 among high-income CDDCs (Figure 7). Again, elasticity estimates at the country-level reveal considerable heterogeneity within these income groups (Appendix Table A3).

Table 5. Trend and cycle elasticities by income group (fixed-effects estimates)

Country category	Income level (World Bank classification)	Trend coefficient	Trend p-value	Cycle coefficient	Cycle p-value
CDDC	High	1.12	0.00	0.39	0.00
CDDC	Low	0.60	0.00	0.11	0.00
CDDC	Lower middle	0.62	0.00	0.23	0.00
CDDC	Upper middle	0.60	0.00	0.27	0.01

Note: see income group thresholds in footnote 19

Figure 7. Elasticities by income group

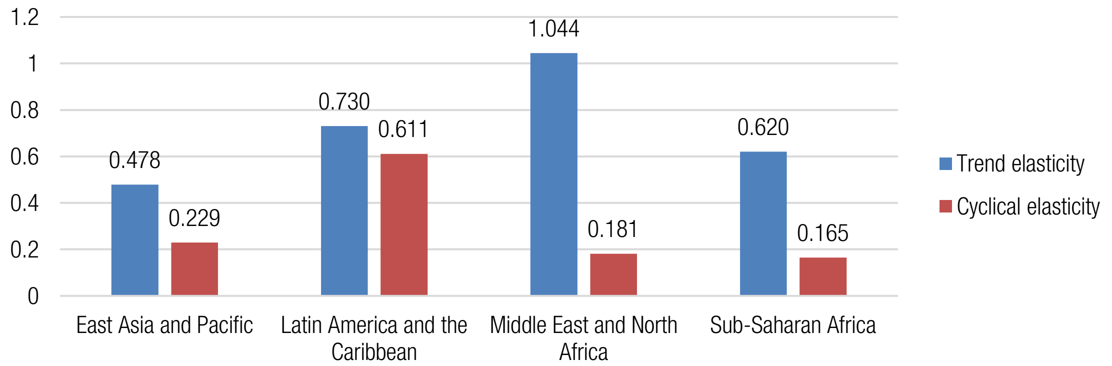


A regional analysis also reveals important differences among CDDCs (Table 6 and Figure 8). The long-run output-elasticity of emissions is highest in the Middle East and North Africa (MENA) region, and considerably lower in East Asia and Pacific (EAP) and Sub-Saharan Africa (SSA). Emissions are also least pro-cyclical in SSA and more procyclical in Latin America and the Caribbean (LAC). These regional differences are likely due to differences in types of commodity dependence and production processes across regions. Within each region, there is again considerable heterogeneity among countries (Table A10).

Table 6. Elasticities by region (fixed-effects estimates)

Commodity dependent developing country status	Region	Trend coefficient	Trend p-value	Cycle coefficient	Cycle p-value
CDDC	East Asia and Pacific	0.48	0.00	0.23	0.09
CDDC	Latin America and the Caribbean	0.73	0.00	0.61	0.00
CDDC	Middle East and North Africa	1.04	0.00	0.18	0.08
CDDC	Sub-Saharan Africa	0.62	0.00	0.16	0.01

Figure 8. Elasticity by region



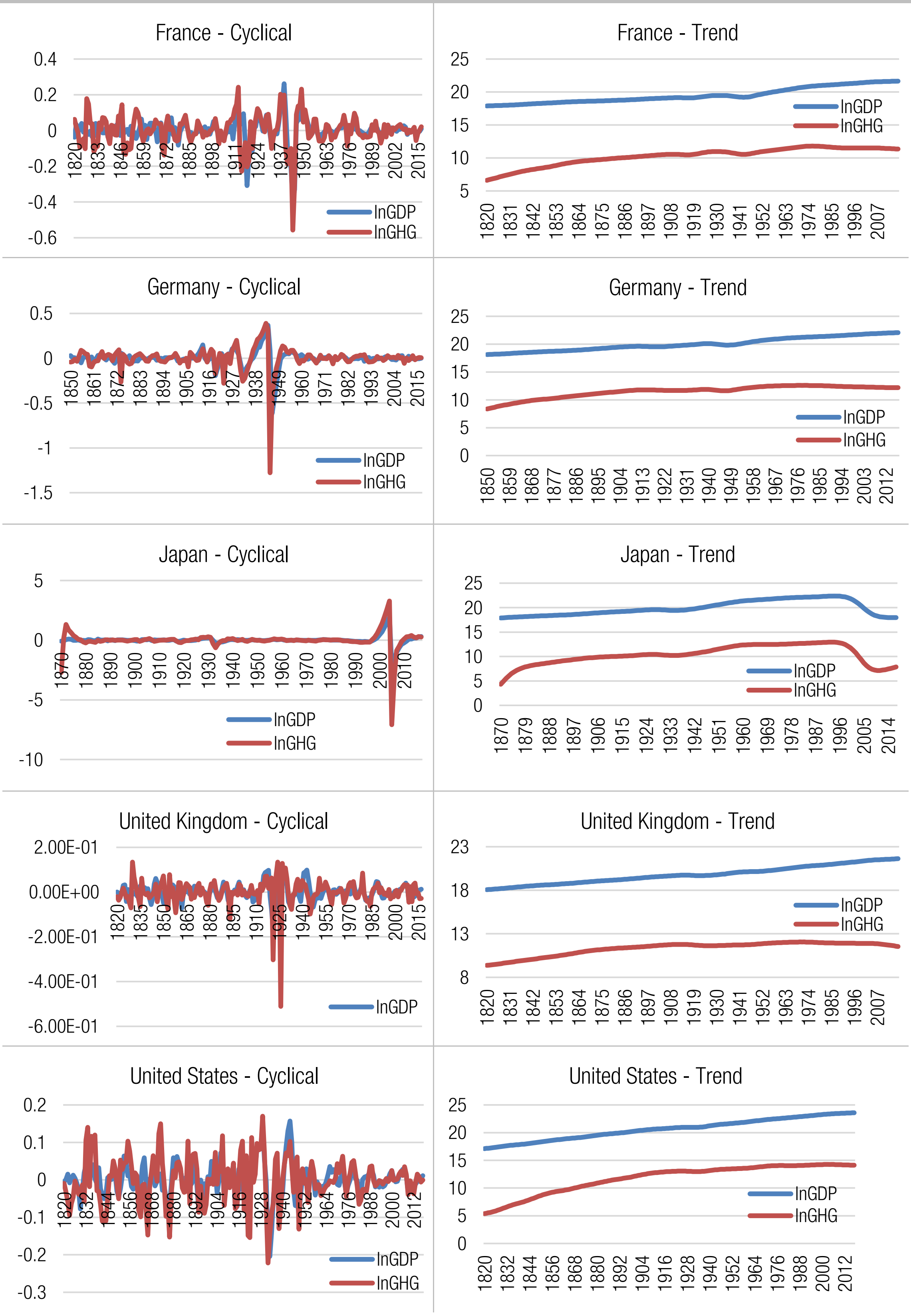
4.5. Long-run elasticities for early industrializers

How do these output emissions elasticity estimates compare with historical elasticities for more developed countries? To provide some historical context for interpreting our estimates of elasticities for CDDCs, we examine the trend growth-emissions elasticities for the five major developed economies since the middle of the 18th century to identify historical links between greenhouse emissions and economic growth in the early stages of industrial development. An argument that is frequently made is that since today's developed countries are responsible for the significant majority of accumulated stock of GHG emissions, and currently have higher per capita emissions than developing countries, the latter should be allowed a greater share of the global carbon budget. Critics of this view argue that emissions in developing countries are rising at a faster pace than they are in the now developed countries, and will continue to do as these countries develop. A comparison of the output-elasticity of emissions in CDDCs and non-CDDCs to those of developed countries when they were at a similar stage of development can help to provide some clarity about the relationship between conventional paths of industrialization and diversification and perhaps also provide some guidance for policy. Note that this analysis focuses only on CO2 emissions. Data limitations prevent an examination of other greenhouse gas emissions from early industrialization.

The trend-cycle decompositions for these five countries over the entire timespan available for each country are provided in Figure 9. Overall, most of the major industrialized economies appear to have followed a highly carbon-intensive industrial growth path, with a levelling-out of emissions growth in the late 20th century, and ending with some modest attempts to reduce emissions. Next, we examine the pattern of carbon-intensive growth in more detail. First, the full time series of the five major economies are split up into 30-year periods.

This results in 9 periods for the United Kingdom, 8 periods for the United States, 7 for France, 6 for Germany, and 5 for Japan.

Figure 9. Long-run trend and cycle decompositions for early industrializers



The trend and cyclical elasticity equations are estimated on each of these 30-year sub-periods. The results are plotted in Figures 10 and 11. Emissions in Japan are strongly pro-cyclical over all periods but less so in the other countries (Figure 10). However, output growth in the early periods of industrialization led to more than proportionate increases in emissions, with trend elasticities greater than 2 in the mid to late 19th century for all the countries (Figure 11). Each subsequent period generally witnesses a decline in the output-elasticity of emissions. In their final period they are at or near zero elasticity, suggesting most early industrializers have reached a state of relative de-coupling.[20] However, none of these countries saw output-elasticities of emissions lower than 1 until well past a century of industrialization (Appendix Table A3).

Figure 10. Long-term cyclical elasticities for early industrializers

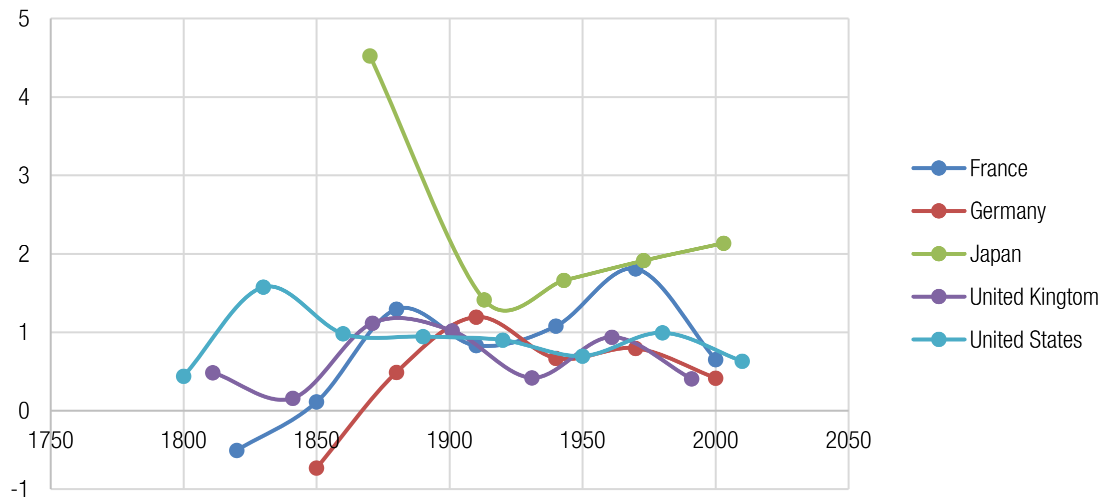
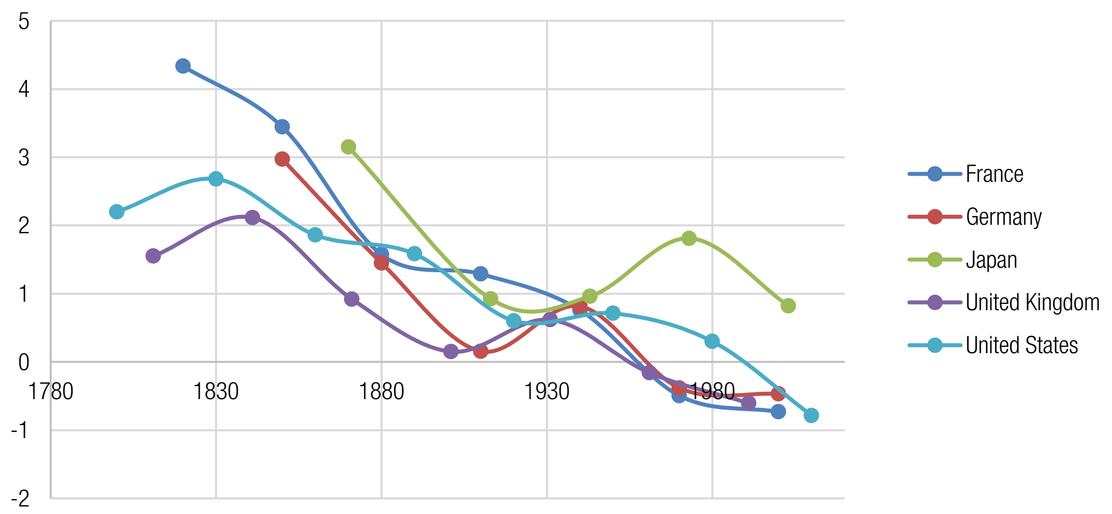


Figure 11. Long-term trend elasticities for early industrializers



It is important to note that generally, the currently developing countries – both CDDCs and DDCs – have output-elasticities of emissions comparable to (and in several cases, less than) those of the early industrializers when the latter were mostly well past a century of industrialization. Elasticities of several currently developing countries (CDDCs and DDCs) are at about the levels that the early industrializers reached in the mid-20th century.

[20] Note that some authors have argued that is due to the ability of Europe and the United States to outsource their most polluting productive activities to East Asia, so that consumption in these countries embodies substantially more emissions than production (see Jalles and Ge, 2020; Gough, 2017: 73).

4.6 Discussion of the results

Do the empirical results in this study mean that CDDCs should be permitted to follow a similar trend in growth and emissions, especially given the currently low level of emissions being generated by these countries? Should they see developed countries' historical high output-elasticities of emissions as benchmarks – a necessary price to be paid for economic progress? Or should these high-elasticities in the early period of industrialization be seen as a warning of what lies ahead, in terms of the impact on climate change, if CDDCs follow a similar industrialization path?

Before we turn to these questions, there is an important caveat to be made. The heterogeneity among CDDCs in terms of the growth elasticity of their emissions makes it difficult to generalize about the evolution of the relationship between growth and emissions in CDDCs. What is clear, however, is that commodity-dependence *per se* is not the only determinant of the elasticity of a country's emissions to growth: other factors play a role. For this reason, policies to decouple growth from emissions in CDDCs must be attentive to country differences – in particular, the current level of emissions, the sensitivity of emissions to changes in output industrial structure, as well as existing productive capabilities. Low-income CDDCs, for example, have some of the lowest levels of emissions, as well as lower output-elasticities of demand than other CDDCs; an exclusive focus on cutting emissions may be costly to development in these countries without generating significant benefits in terms of reductions in emissions. For low-income CDDCs, it may well be that, at least in the short-run, focusing instead on sustainable management of the commodity sector can promote growth without worsening environmental outcomes.

In the long run, however, continued dependence on commodities appears to be an increasingly risky strategy for CDDCs as a group. Lower demand and falling prices for GHG-intensive commodities are becoming ever more likely as the global economy responds to growing pressures to slow down the pace of climate change. Maintaining their current dependence on commodities exposes CDDCs to the macroeconomic shocks associated with these market trends. For this reason alone, there is a strong case to be made for CDDCs to diversify away from commodity exports. Furthermore, our analysis indicates that diversified developing countries have higher output elasticities of emissions, suggesting that diversification alone will not be enough to decouple growth from emissions. This is borne out by the historical high output elasticities of emissions of today's industrialized countries during the first century of their industrial process.

Despite the benefits of diversification and industrialization for CDDCs, conventional strategies of industrialization and structural change are not a sustainable option, because of the implications of such a path for environmental degradation. Reducing output-elasticities of emissions in high-emitting CDDCs, laying the foundation for a less carbon-intensive development path in all CDDCs, while also reducing poverty, generating employment and improving living standards requires a different development strategy – one that can ensure that industrialization and export diversification are environmentally sustainable. In the next section, we explore the role that green industrial policy can play in shaping the contours of this development strategy in CDDCs.

5. Growing the good and reducing the bad: a path forward for CDDCs?

So far, we have argued that climate change adds another layer of risk for countries already struggling to cope with the challenges of commodity dependence (UNCTAD, 2019a; UNCTAD and FAO, 2017). The possibility of future declines in demand for carbon-intensive commodities, as well as the threats to productivity in the commodity sector from climate change provides a more urgent imperative for CDDCs to reorient the structure of their economies away from the current state of dependence on primary commodity exports.

The challenge that CDDCs face today – that of meeting their development priorities, while also achieving the declines in GHG emissions necessary to keep global temperatures in check – requires a transformation of their productive capabilities within the context of fundamental changes in the energy and transportation systems that have fueled industrial development in the past. Bringing about such transformations will require industrial policies that will alter economic structures in ways that can increase productivity and prosperity while simultaneously accelerating the shift towards a low-carbon, resource-efficient economy – in other words, green industrial policy (Altenburg and Assmann, 2017). Given that most resource-rich countries are also rich in labour, these policies will need to be attentive to the need to create employment for their growing populations.

Green industrial policy has been defined as 'including any government measure aimed to accelerate the structural transformation towards a low-carbon, resource efficient economy in ways that also enable productivity enhancements in the economy" (Altenburg and Rodrik, 2017: p.11). While there are many similarities between steering an economy in the direction of conventional industrial development and steering investment in a green economy, there are some important differences between green industrial policy and traditional notions of industrial policy. These include the focus on environmental externalities as an important market failure; the promotion of technologies and patterns of consumer behaviour that are desirable because of their environmental impacts; the short time-frame within which structural change must be achieved; and the potential for positive spillovers that extend beyond the boundaries of the domestic economy (Altenburg and Rodrik, 2017: 11-16).

The next section presents the case for greening industrial policy in CDDCs and highlights the challenges that CDDCs will need to overcome. The section begins with a brief discussion of the debates over industrial policy and its recent resurgence in the literature.

5.1 Industrial policy and development: history and debates

After three decades of what Chang and Andreoni (2021, p. 324) describe as "ideologically motivated willful neglect", there has been a resurgence in interest in industrial policy among mainstream economists and policy makers in the developing and developed world. This is due to several factors: recognition that industrialization achieved through proactive industrial policy is central to economic transformation, and an acceptance of the limits of market fundamentalism in generating employment and human development in the face of challenges posed by globalization, disruptive technological change and financial crises (Ferrannini et al., 2021, p.3; Aiginger and Rodrik, 2020).

The recent literature on industrial policy highlights some of the shortcomings of traditional industrial policy, and proposes changes that would bring industrial policy into the 21st century. First, instead of the traditional focus on manufacturing, industrial policy should extend to all sectors of the economy, including agriculture, mining and services (Altenburg and Rodrik, 2017; Ferrannini et al., 2021). Second, instead of the traditional focus on correcting market failures and enhancing competitiveness, industrial policy should be driven by societal goals, including climate, health, poverty reduction, decent job creation and reduction of inequality (Aiginger and Rodrik, 2020; Ferrannini et al., 2021; Mazzucato, 2018). Third, in place of top-down policy making that targets pre-selected sectors with a standard list of subsidies and incentives and that operates in isolation from other policies, industrial policy should consist of a sustained collaboration between public and private sector to determine the appropriate government policies and firm strategies, and create the appropriate institutional environment for these to succeed (Aiginger and Rodrik, 2020:192). Finally, instead of the traditional focus on labour saving strategies to increase labour productivity, industrial policy should steer technological change in directions that are both pro-environment and pro-labour (Aiginger and Rodrik, 2020: 192).

5.2 Why do commodity dependent developing countries need a green industrial policy?

The case for green industrial policy in commodity dependent countries rests on several arguments. The first is an old one: commodity dependence renders these countries vulnerable to the macroeconomic shocks associated with price volatility in commodity markets, and the long-term decline in commodity prices does not bode well for development in these countries. There is a well-established empirical link between income growth and greater diversification of production and employment via industrial development (Chang, 2011; Chang and Andreoni, 2021; Imbs and Wacziarg, 2003). The inability of markets to coordinate this kind of industrial development and structural change by themselves is a classic argument for industrial policy that does not need to be repeated here.

Our empirical analysis of output-elasticities of emissions adds another layer of complexity to the classic argument for industrial policy in CDDCs. Traditionally, industrial policy has focused on manufacturing – a sector that is highly carbon-intensive. We have shown that today's industrialized countries, all of which successfully deployed industrial policy in the past, also had very high growth-elasticities of emissions. A major challenge for CDDCs therefore is how to diversify away from commodities without further increases in emissions. A successful transition to a low-carbon economy in developing countries implies changes in consumption patterns, living environments, and transportation systems, that in turn require a fundamental transformation in production and in production systems – not just in manufacturing, but also in other sectors (Anzolin and Lebdioui, 2021; Chang and Andreoni, 2021). This kind of transformation can only be achieved with large coordinated investments in energy systems, infrastructure, and technological innovation (Anzolin and Lebdioui, 2021; Chang and Andreoni, 2021; Okereke et al., 2019). In the short-term, these coordinated investments can help to reduce emissions associated with expansions in the commodity sector. A case in point is Ecuador's Optimization of Power Generation and Energy Efficiency Program (OGE-EE). This program, implemented in 2008 by the state-owned oil company PetroAmazonas, succeeded in reducing the flaring of gas and the use of diesel for electricity generation in the oil sector, making it possible to lower emissions by 848,500 tCO2e between 2009-2015 (Anzolin and Lebdioui, 2021). There are as yet other unexplored possibilities: for example, countries like the Democratic Republic of the Congo and Chile can use their cobalt and lithium to attract strategic investments in the manufacture of electric batteries; not only would this cut emissions associated with the transportation of ore to produce batteries in Asia and Europe, but these countries would begin to develop the capabilities necessary to become producers of green technology. In the longer-term, green industrial policy can bring about the necessary transformation of production in CDDCs, reducing the long-run sensitivity of emissions to growth in these countries and placing them on a sustainable, low-carbon development path.

The third argument for green industrial policy in CDDCs is directly related to the particular challenge that the climate change response in the world's largest economies poses for CDDCs. The increasingly widespread adoption of decarbonization policies and low-carbon technologies in the European Union, the United States, and China is already increasing the risk of significant downward revaluation of carbon assets, and by implication, of the natural resources underlying these assets (Altenburg and Rodrik, 2017, p. 6). Market-driven economic stranding of natural resource assets poses significant threats to CDDCs whose economies remain dependent on the resources at greatest risk of economic stranding – in particular, fuel and mineral dependent countries. Green industrial policy in CDDCs can bring about a successful transition to a low-carbon economy in these countries while also reducing their commodity dependence and avoiding the costly economic losses associated with market-driven resource stranding. The Namibian government, for example, has recently placed the production of green hydrogen at the centre of its strategy for becoming a global leader in alternative energy markets. If this strategy is successful, the country will be able to move away from its traditional dependence on mineral and agricultural exports.

The final argument for green industrial policy lies in the significant benefits that will accrue to CDDCs that successfully transition to a low-emissions development path. These benefits arise from the synergies between development and climate change mitigation, and include obvious benefits such as improvements in human health and the potential for sustainable future growth, productivity and resource efficiency that results from a successful transition to a low-emissions growth path (Padilla, 2017). Although these policies may have significant short-term opportunity costs, CDDCs stand to gain from undertaking this transition now when these costs are relatively low, rather than at a later stage of development, when the costs of greening the economy may be too high due to infrastructure, sectoral and technological lock-in (Padilla, 2017). Instead of merely being consumers of green energy, relying on imports of green technology, CDDCs that successfully implement green industrial policy can develop new productive capabilities and dynamic comparative advantages in green products and technologies (Anzolin and Lebdioui, 2021; Padilla, 2017).

5.3 What would Green Industrial Policy in CDDCs look like in practice?

Green industrial Policy has several dimensions: changing consumer behaviour; increasing resource efficiency at the firm level, and development of green technology. Of these, the development of green technology is likely to be the most effective at achieving the goals of green development in the long-run (Anzolin and Lebdioui, 2021). The actual policies that each CDDC can adopt will differ depending on several factors, not least the array of productive capabilities already in existence. Policy choices should be guided by a few principles, however.

The first principle relates to the development of productive capabilities themselves and the decision about which productive capabilities to develop. Innovation in green technology (or any form of technology, for that matter) is path-dependent, and requires the prior existence of an array of capabilities. Most CDDCS may initially have a limited set of productive capabilities that are relevant to green technology innovation so they need to "jump" from their current position to a point where they acquire the capabilities required (UNCTAD, 2021). Hence, states have an important role to play in supporting the development of these capabilities through support for research and development and the provision of long-term patient capital (Anzolin and Lebdioui, 2021, p. 388). Furthermore, while the emergence of new technologies in the Fourth Industrial Revolution has created opportunities for leapfrogging in developing countries, these technologies have also created new challenges. One challenge is that contemporary technological change often involves the fusion of several different technologies, requiring developing countries to develop what (Chang and Andreoni, 2021) describe as 'foundational capabilities' that will allow them to learn these new technical solutions and be able to apply them in new and innovative ways, rather than acquiring the productive capabilities that are specific to a particular technology.

To this end, the promotion of learning in production, i.e., the process of developing and accumulating productive capabilities, will be essential to the development of green technology innovations in CDDCs. This will require policies that create an environment within which firms can stay in business, expand and improve upon their production processes (Chang and Andreoni, 2021). These policies will include a combination of domestic policies to reduce business uncertainty, encourage investment and steer innovation; export-related policies to take advantage of dynamic comparative advantage and ensure the eventual upgrading of industrial structure and macroeconomic policies focused on the management of aggregate demand, which has implications for the conduct of industrial policy (Chang and Andreoni, 2021).

Green industrial policy in CDDCs will also benefit from attention to the political economy dimensions and distributional effects of altering the structure of the economy in such fundamental ways. Given the low rates of employment that are typical of CDDCs, employment creation will need to be an important goal of industrial policy. At the same time, managing conflicts between losers and winners will be essential to the success of green industrial policy, and may require either temporary protection and subsidies to particular sectors that are adversely affected, or supporting more radical restructuring within sectors (Chang and Andreoni, 2021, p. 336).

Finally, it is also important for policy makers to consider the role of GIP in contributing to gender equality. Empirical evidence suggests that the links between gender inequality and industrial policy are complex. On the one hand, industrial policy can help to create jobs and increase women's access to employment opportunities; on the other hand, countries might take advantage of pre-existing gender inequalities in wages to enhance export competitiveness and growth without reducing these inequalities (Berik et al., 2009; Seguino, 2000a, 2000b). Attention to the gendered dimensions of green industrial policy will be important in ensuring that gender equality is not sacrificed for environmental sustainability and green growth.

Instead of trying to follow a policy template or simply copying more advanced economies, it is important that CDDCs identify policy approaches that are best suited to the level of development and focus on new priorities such as supporting vulnerable groups, enhancing gender equality, reducing use of fossil fuel energy and developing green technology for new types of agriculture, housing and transport. Above all, they should adopt a pragmatic approach to industrial policy, targeting policies to overcome specific bottlenecks and meet their strategic objectives (Aiginger and Rodrik, 2020; Chang and Zach, 2018).

5.4 What are the challenges to the successful adoption of Green Industrial Policy in CDDCs?

Much of the recent literature on green industrial policy has been focused towards developed countries; with a few exceptions, developing countries have been mostly ignored in this literature (Altenburg and Pegels, 2012). There is little doubt that many CDDCs will face an uphill battle in their efforts to transition to a green industrial economy. As Chang and Andreoni (2021) note, the institutionalization of neoliberal trade policies in developing countries since the 1980s has impeded the development of productive capabilities in these countries, resulting in 'premature de-industrialization' among middle-income countries, 'pre-industrial premature de-industrialization' in several least developed countries, and the continued dependence on commodity exports (Chang and Andreoni, 2021, p. 169).

CDDCs trying to implement green industrial policies today will be doing so in the context of a global economy that poses new challenges. One such challenge is the expansion of global value chains (GVCs) and the dominance of transnational corporations (MNEs) within these value chains. Although participation in GVCs can provide opportunities for emerging economies to enter technology-intensive industries and capture value from advanced manufacturing technologies, concerns about the mobility of transnational capital may also be a barrier to the successful implementation of green industrial policy in CDDCs. More importantly, research on commodity-based and low-tech manufacturing GVCs shows that transnational companies may use their market power in these global value chains to create entry barriers, enabling them to capture the bulk of the value generated in these value chains and limiting the scope for learning in developing countries (Chang and Andreoni, 2021, p. 338). If CDDCs commit resources only to basic processing and assembly in the early stages of green industrial development, they can become stuck at the lower levels of the green industrial ladder, relying for their growth on cheap labour and natural resources and specializing in products with low income elasticities of demand (Aiginger and Rodrik, 2020, p. 201).

These challenges, however, do not preclude the successful implementation of green industrial policy in these countries. Chang (2011:101) notes that the mobility of transnational corporations varies across industries and across countries, so that the feasibility of green industrial policy depends to a large extent on the industry and the country. In addition, industrial policies are not as important an influence on FDI location decisions as other factors such as market conditions, infrastructure and the quality of the labour force, all of which can benefit from coordinated industrial policy. Most importantly, if strategically deployed, green industrial policy can help developing countries avoid getting stuck in a low-productivity, low-value added green production cycle (Chang and Andreoni, 2021: 170; Chang and Andreoni, 2020).

Changes in the rules that govern trade and investment in the global economy also pose another challenge to the implementation of green industrial policy in developing countries. The policy options available to CDDCs today are limited by the fact that many of the classic tools of industrial policy such as tariffs, quotas and export subsidies are banned or circumscribed by the rules of the World Trade Organization (Chang, 2011). However, many countries still have considerable amount of leeway to maneuver around these restrictions. For example, industrial policy measures that are domestic in nature are not subject to international agreements, which means that CDDCs have the ability to make targeted investments in infrastructure, research and development (Chang, 2011; Chang and Andreoni, 2020). Furthermore, the structure and ambiguities of WTO rules also gives countries considerable policy space; developing countries are also able to take advantage of the special and differentiated treatment provided for in most WTO rules. For example, many developing countries that have not met the upper limits on tariffs still have room to increase tariffs; they are also able to regulate some aspects of foreign direct investment and make use of provisions for emergency tariff increases, over which they have considerable discretion (Chang, 2011; Chang and Andreoni, 2021).

A third challenge to the success of green industrial policy in CDDCs is related to the financialization of the global economy. The dominance of financial interests over economic activity at different levels – corporate, national, global – can render industrial policy ineffective through its impact on industrial development (Chang and Andreoni, 2020: 341). As a result of corporate financialization, the investment decisions of large transnational corporations (TNCs) are captured by financial interests that are oriented to the short-term, leading to declining investments and missed opportunities for innovation in host countries (Chang and Andreoni, 2020: 347). In Ghana, for example, the financialization of TNCs in the cocoa and chocolate sectors has constrained the ability of Ghanaian producers to move up the cocoa-chocolate global value chain and upgrade their productive capabilities in cocoa production (van Huellen and Abubakar, 2021). At the national and global levels, countries are exposed to volatility of financial flows and to macroeconomic shocks associated with this volatility (Chang and Andreoni, 2020). The need to manage these shocks, as well as the lack of global regulation and increased opportunities for tax avoidance and evasion by TNCs reduces the capacity of governments to maintain favorable macroeconomic conditions and finance the infrastructure investments that are necessary for effective green industrial policy.

5.5 What would be necessary for green industrial policy to succeed in CDDCs?

These challenges suggest that if they are to be successful, efforts to green industrial policies in CDDCs will require complementary polices at the national and global levels to change the rules of trade and investment and counter the effects of financialization in developing countries. These policies should include, among others, greater regulation of transnational capital flows, as well as international collaboration to reduce tax avoidance and evasion and direct the global financial system towards financing productive investment (Chang and Andreoni, 2020).

More immediately, CDDCs will benefit from efforts to tackle the increasing financialization of commodity markets and stabilize commodity prices through the creation of price stabilization mechanisms (Tröster and Küblböck, 2020; Tröster et al., 2019). Rules to limit speculation in commodity markets may be necessary, as would cooperation between regional and international development financing institutions and governments to provide counter-cyclical financing facilities that can help to mitigate shocks from commodity price movements (Tröster, 2020). South-south cooperation among CDDCs to increase their bargaining power vis-à-vis international commodity buyers, reinstate stabilization funds and negotiate for more favorable rules governing global trade and investment will help to create policy space for industrial policy, while the greater stability of export revenues resulting from commodity price stabilization can increase the fiscal capacity of CDDCs governments to implement appropriate industrial policy.

Equally important is the issue of technology transfer to CDDCs and to the Global South more generally. For CDDCs to successfully transition to a low-carbon development path, they will need to be able to access existing green technologies and, when necessary, adapt them to local contexts. Currently, green technologies are developed in the North, and most low-income and middle-income CDDCs have limited means to acquire these technologies on their own. Within the framework of the Trade Related Investment Measures (TRIMs) agreement, countries can still impose conditions on foreign investors regarding technology transfer and hiring local labour as a way of creating technological spillover effects; they may also be able to be strategic about attracting FDI into targeted industries (Chang, 2011). This, however, is not enough. Current practices with respect to technology transfer – in particular, rules governing the protection of intellectual property – severely limit access of CDDCs to technology, and there is a need for an international framework along the lines of the Technology Mechanism in the Paris Agreement to ensure the transfer of green technology to CDDCs (UNCTAD, 2021a).

The preceding discussion should make it clear that international financial institutions, donor governments and aid agencies all have a role to play in supporting CDDCs in their transition to a green growth path. Green industrial policy in CDDCs will require a significant commitment of financial resources, and the support of these institutions in designing and financing the implementation of these policies and assuring access to technology can help to ensure their success. In line with this idea of greater international cooperation in support of CDDCs efforts, Aiginger and Rodrik (2020) propose an annual international forum to guide industrial policy and take advantage of the spillovers between countries and possibilities for mutual learning (p.203).

6. Conclusion

Ultimately, measures and transformations needed to achieve a green transition in CDDCs will require strong political commitment and leadership, both in CDDCs and in developed countries. As the discussion above has illustrated, even though the main issues relating to a green transition in CDDCs are similar across countries in the group, each country needs to chart a path that fits its specific circumstances. CDDCs that are currently reliant on fossil fuels, for example, may not face the same needs as those relying on the agriculture sector. Therefore, each country will need to undertake an assessment of where it is and make a realistic choice of where it would like to be in the medium and long terms. This assessment will in most cases require external assistance given the capacity constraints facing CDDCs and the particularly high uncertainty associated with the commodities economy in the future. Moreover, strong leadership will be needed at the international level, particularly from developed countries, to ensure that CDDCs have all the support they need to embark on a successful but realistic process of economic greening that at the same time responds to the multiple development challenges they face. Indeed, a new greener growth and development model will be adopted by CDDCs if they have an incentive to do so; for example, if the new model helps them to address better their structural problems, including poverty and inequality.

In the 1950s, the Prebisch-Singer hypothesis provided a theoretical argument for CDDCs to reduce their dependence on commodities. Since then, much has been written about the need for CDDCs to diversify their exports. Only a few countries have succeeded in bringing about the structural transformation necessary to achieve this diversification. Most CDDCS seem to be trapped in a state of commodity dependence (Nkurunziza, 2021). In many CDDCs, commodity dependence has deepened and become even more prevalent than it was in the 1950s. Much of this has been due to changes in the global economic system that have kept these countries dependent on commodities (Chang, 2011).

The future of international trade based on current competitive advantage in commodities is inextricably linked to climate change for CDDCs. For the majority of these countries, productivity in key commodity sectors is threatened by extreme weather events associated with climate change. More worryingly, natural resource assets are at risk of market-driven stranding as decarbonization policies and green trade standards become more widespread among the world's major economies. Now, more than ever, developing productive capabilities for the export of green goods and services should be an important objective especially for countries that currently have few preexisting productive capabilities upon which to build a green manufacturing sector (Anzolin and Lebdioui, 2021: 396).

Can CDDCs navigate the necessary challenges as the world transitions away from fossil fuels and other GHG intensive growth paths? The historical experience suggests that the answer is a qualified 'yes'. Several countries have successfully navigated similar transitions. For example, prior to the 1990s, Indonesia was a major exporter of both coal and oil. Between 2001 and 2010, its fossil fuel export revenues as a share of GDP fell by 35 per cent; however overall GDP continued to grow at healthy rates, pointing to the country's capacity to adjust to the fall in oil exports (Pollin, 2015: 106; UNCTAD 2021). Currently, although Indonesia generates per capita carbon emissions that are a tenth of those of the United States, it aims for growth in the range of 6-7 per cent annually over the next 20 years and projects a more than five-fold increase in emissions over this period, if growth is fueled by oil, coal and gas. However, if Indonesia invests 1.5 per cent of GDP in energy efficiency and clean energy infrastructure every year for the next twenty years, emissions per capita would stabilize at the current low level while the economy grows at around 6 per cent per year, with substantial expansion in employment opportunities (Pollin, 2015: 118).

However, it would be unrealistic to imagine that CDDCs, especially the poorest among them, can achieve these kinds of transformations entirely on their own, without adequate financial support and technology transfer from richer countries. Until recently, the benefits of industrial policy and economic diversification appeared to accrue primarily to individual CDDCs, and there was little incentive for other countries to support this transition. Climate change has shifted that calculus: not only CDDCs, but the global economy as a whole, stand to benefit if CDDCs succeed in diversifying away from a carbon-intensive development path dependent on commodity extraction to a low-carbon development path. Simply calling for these countries to 'leave the resources in the ground' is a political and economic dead-end: in the absence of a viable alternative for CDDCs, this approach will not succeed in achieving the necessary reductions in emissions required to slow down the pace of climate change.

Green Industrial Policy, with its potential for employment generation as well as environmental sustainability, offers a viable alternative. Its implementation will allow for an orderly transition from a high-carbon growth path while also mitigating the destabilizing impact that will result from a more disorderly transition. Mercure et al., (2021) suggest that given the current incentive structure surrounding the transition to low-carbon economy, commodity exporters may benefit from increasing their extraction of fossil fuels and flooding markets in an effort to capture a greater share of shrinking export markets. If this happens, the impact on the global stock of emissions and on the pace of climate warming may well cancel out any positive impacts of decarbonization policies elsewhere. This time around, therefore, it is in the interest of all countries to support a green transition in CDDCs: one that will allow them to achieve their development goals without sacrificing the environment. If countries in the Global North can provide real and meaningful support for this transition in CDDCs, the outcome would be a win-win all around.

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Appendix

Table A1. Country list for decompositions

Agriculture CDDC	Fuel CDDC	Mineral CDDC	Diversified Developing Countries (DDC)	Developed Countries (DC)
Total: 35	Total: 30	Total: 32	Total: 52	Total: 37
Afghanistan*	Algeria	Armenia*	Albania	Australia
Argentina	Angola	Botswana	Antigua and Barbuda	Austria
Belize	Azerbaijan*	Burkina Faso	Bangladesh	Belgium
Benin	Bahrain	Burundi	Barbados	Bulgaria
Brazil	Bolivia (Plurinational State of)	Chile	Belarus*	Canada*
Central African Republic	Brunei Darussalam	Democratic Republic of the Congo	Bhutan	Croatia*
Comoros	Cameroon	Eritrea*	Bosnia and Herzegovina*	Cyprus
Cote d'Ivoire	Chad	Ghana	Cabo Verde	Czechia*
Djibouti*	Colombia	Guinea*	Cambodia*	Denmark
Ecuador	Equatorial Guinea	Guyana	China	Estonia*
Ethiopia*	Gabon	Jamaica	Costa Rica	Finland
Fiji	Iraq	Kyrgyzstan*	Dominica	France
Guatemala	Islamic Republic of Iran	Lao People's Democratic Republic (the)*	Dominican Republic	Germany
Guinea-Bissau	Kazakhstan*	Liberia*	Egypt	Greece
Kenya	Kuwait*	Mali	El Salvador	Hungary
Kiribati	Libya*	Mauritania	Eswatini	Iceland*
Madagascar	Nigeria	Mongolia*	Georgia	Ireland
Malawi	Oman	Montenegro*	Grenada	Israel*
Maldives*	Qatar	Mozambique	Haiti	Italy
Micronesia (Federated States of)*	Republic of Congo	Namibia*	Honduras	Japan
Myanmar*	Russian Federation (the)*	Nauru*	India	Latvia*
Palau*	Saudi Arabia	Niger	Indonesia	Lithuania*
Paraguay	Saint Lucia	Papua New Guinea	Jordan	Luxembourg
Sao Tome and Principe*	Sudan	Peru	Republic of Korea (the)	Malta
Senegal	Timor-Leste*	Rwanda	Lebanon*	Netherlands
Seychelles	Trinidad and Tobago	Sierra Leone	Lesotho	New Zealand
Solomon Islands	Turkmenistan*	Suriname	Malaysia	Norway
Somalia*	United Arab Emirates	Tajikistan*	Marshall Islands*	Poland*
Syrian Arab Republic (the)*	Venezuela (Bolivarian Republic of)*	United Republic of Tanzania (the)*	Mauritius	Portugal
The Gambia	Yemen	Togo	Mexico	Romania*
Tonga*		Uzbekistan*	Republic of Moldova (the)*	Slovakia*
Uganda*		Zambia	Morocco	Slovenia*
Uruguay			Nepal	Spain
Vanuatu			Nicaragua	Sweden
Zimbabwe			North Macedonia*	Switzerland
			Pakistan	United Kingdom
			Panama	United States
			Philippines	
			Samoa*	
			Serbia*	
			Singapore	
			South Africa	
			Sri Lanka	
			Saint Kitts and Nevis	

Agriculture CDDC	Fuel CDDC	Mineral CDDC	Diversified Developing Countries (DDC)	Developed Countries (DC)
			Saint Vincent and the Grenadines	
			Thailand	
			The Bahamas	
			Tunisia	
			Turkey	
			Tuvalu*	
			Ukraine*	
			Viet Nam*	

* Indicates country is dropped from elasticity estimates due to missing data

Table A2. Cointegration groups

Commodity dependent developing country status	Ln GDP order of integration	Ln GHG order of integration	Trend GDP order of integration	Trend GHG order of integration	Logs cointegrated	Trends cointegrated	Ln GDP IPS p value	D1 Ln GDP IPS p value	Ln GHG IPS p value	D1 Ln GHG IPS p value	Trend GDP IPS p value	D1 trend GDP IPS p value	Trend GHG IPS p value	D1 trend GHG IPS p value	MPP p value for logs	MPP p value for trends
CDDC	1	1	1	1	0	1	1	0	1	0	1	0	0.9975	0.0001	0.1851	0
DC	1	1	1	0	1	0	1	0	0	0	0	0	0	1	0	0
DDC	1	1	1	0	0	0	1	0	1	0	1	0	0	0	0	0
Type of commodity dependency	Ln GDP order of integration	Ln GHG order of integration	Trend GDP order of integration	Trend GHG order of integration	Logs cointegrated	Trends cointegrated	Ln GDP IPS p value	D1 Ln GDP IPS p value	Ln GHG IPS p value	D1 Ln GHG IPS p value	Trend GDP IPS p value	D1 trend GDP IPS p value	Trend GHG IPS p value	D1 trend GHG IPS p value	MPP p value for logs	MPP p value for trends
Agricultural CDDC	1	1	1	1	0	1	1	0	1	0	1	0.0004	0.9458	0.0157	0.1279	0
Fuel CDDC	1	1	1	2	1	0	1	0	1	0	1	0	0.9937	0.0584	0.0074	0.0034
Mineral CDDC	1	1	1	1	1	1	1	0	0.9995	0	1	0.0142	0.7753	0.0044	0.0417	0

Commodity dependent developing country status	Region	Ln GDP order of integration	Ln GHG order of integration	Trend GDP order of integration	Trend GHG order of integration	Logs cointegrated	Trends cointegrated	Ln GDP IPS p value	D1 Ln GDP IPS p value	Ln GHG IPS p value	D1 Ln GHG IPS p value	Trend GDP IPS p value	D1 trend GDP IPS p value	Trend GHG IPS p value	D1 trend GHG IPS p value	MPP p value for logs	MPP p value for trends
CDDC	East Asia and Pacific	1	1	1	1	0	1	1	0	0.986	0	1	0.009	0.056	0.019	0.145	0.006
CDDC	Latin America and the Caribbean	1	1	1	1	0	1	1	0	1	0	1	0	0.75	0	0.112	0
CDDC	Middle East and North Africa	1	1	1	2	0	0	1	0	0.998	0	0.66	0	0.955	0.617	0.133	0.175
CDDC	Sub-Saharan Africa	1	1	1	1	0	1	1	0	1	0	1	0.001	1	0.03	0.201	0
Commodity dependent developing country status	Income level	Ln GDP order of integration	Ln GHG order of integration	Trend GDP order of integration	Trend GHG order of integration	Logs cointegrated	Trends cointegrated	Ln GDP IPS p value	D1 Ln GDP IPS p value	Ln GHG IPS p value	D1 Ln GHG IPS p value	Trend GDP IPS p value	D1 trend GDP IPS p value	Trend GHG IPS p value	D1 trend GHG IPS p value	MPP p value for logs	MPP p value for trends
CDDC	High	1	1	1	0	1	0	1	0	0.995	0	0.7	0	0.013	0.32	0.027	0.056
CDDC	Low	1	1	1	2	0	0	1	0	1	0	1	0.009	0.698	0.212	0.271	0
CDDC	Low middle	1	1	1	1	0	1	1	0	1	0	1	0.01	1	0.002	0.255	0
CDDC	Upper middle	1	1	1	1	0	1	0.999	0	0.999	0	1	0	0.95	0.002	0.235	0

Table A3. Elasticities by type of commodity dependence and income level

Country Name	Region	Commodity dependent developing country status	Type of commodity dependency	Income level	Trend OLS coefficient	Trend OLS SE	Trend OLS p value	Cycle OLS coefficient	Cycle OLS SE	Cycle OLS p value
Argentina	Latin America and the Caribbean	CDDC	Agricultural CDDC	High	0.912	0.01	0	0.416	0.065	0
Belize	Latin America and the Caribbean	CDDC	Agricultural CDDC	Upper middle	0.269	0.03	0	-0.036	0.182	0.843
Benin	Sub-Saharan Africa	CDDC	Agricultural CDDC	Low	0.735	0.016	0	-0.06	0.289	0.837
Brazil	Latin America and the Caribbean	CDDC	Agricultural CDDC	Upper middle	1.174	0.014	0	0.645	0.086	0
Central African Republic	Sub-Saharan Africa	CDDC	Agricultural CDDC	Low	-0.098	0.082	0.237	0.049	0.038	0.202
Comoros	Sub-Saharan Africa	CDDC	Agricultural CDDC	Low	1.731	0.049	0	0.077	0.305	0.803
Côte d'Ivoire	Sub-Saharan Africa	CDDC	Agricultural CDDC	Low middle	1.537	0.12	0	0.059	0.188	0.756
Ecuador	Latin America and the Caribbean	CDDC	Agricultural CDDC	Upper middle	0.762	0.008	0	1.009	0.197	0
Fiji	East Asia and Pacific	CDDC	Agricultural CDDC	Upper middle	-0.592	0.058	0	2.514	0.721	0.001
Guatemala	Latin America and the Caribbean	CDDC	Agricultural CDDC	Upper middle	0.699	0.017	0	-0.208	0.652	0.751
Guinea-Bissau	Sub-Saharan Africa	CDDC	Agricultural CDDC	Low	1.069	0.041	0	0	0.08	0.996
Kenya	Sub-Saharan Africa	CDDC	Agricultural CDDC	Low middle	0.75	0.009	0	0.373	0.121	0.004
Kiribati	East Asia and Pacific	CDDC	Agricultural CDDC	Low middle	2.944	0.214	0	-0.288	0.921	0.756
Madagascar	Sub-Saharan Africa	CDDC	Agricultural CDDC	Low	1.39	0.066	0	0.229	0.144	0.12
Malawi	Sub-Saharan Africa	CDDC	Agricultural CDDC	Low	0.484	0.024	0	-0.133	0.145	0.365
Myanmar	East Asia and Pacific	CDDC	Agricultural CDDC	Low middle	0.273	0.007	0	0.321	0.071	0
Paraguay	Latin America and the Caribbean	CDDC	Agricultural CDDC	Upper middle	0.696	0.016	0	0.805	0.186	0
Senegal	Sub-Saharan Africa	CDDC	Agricultural CDDC	Low	1.213	0.024	0	0.207	0.22	0.353
Seychelles	Sub-Saharan Africa	CDDC	Agricultural CDDC	High	1.567	0.087	0	-0.345	0.661	0.604
Solomon Islands	East Asia and Pacific	CDDC	Agricultural CDDC	Low middle	0.719	0.026	0	0.266	0.13	0.049
The Gambia	Sub-Saharan Africa	CDDC	Agricultural CDDC	Low	1.174	0.012	0	0.642	0.202	0.003
Uruguay	Latin America and the Caribbean	CDDC	Agricultural CDDC	High	1.107	0.066	0	1.113	0.127	0
Vanuatu	East Asia and Pacific	CDDC	Agricultural CDDC	Low middle	0.881	0.098	0	-1.137	0.544	0.043
Zimbabwe	Sub-Saharan Africa	CDDC	Agricultural CDDC	Low	0.575	0.055	0	0.318	0.04	0
Algeria	Middle East and North Africa	CDDC	Fuel CDDC	Upper middle	0.989	0.025	0	0.378	0.293	0.205
Angola	Sub-Saharan Africa	CDDC	Fuel CDDC	Low middle	0.491	0.015	0	0.193	0.093	0.046
Bahrain	Middle East and North Africa	CDDC	Fuel CDDC	High	0.869	0.016	0	0.255	0.199	0.207
Bolivia (Plurinational State of)	Latin America and the Caribbean	CDDC	Fuel CDDC	Low middle	0.999	0.008	0	0.643	0.303	0.041
Brunei Darussalam	East Asia and Pacific	CDDC	Fuel CDDC	High	2.203	0.054	0	0.995	0.216	0
Cameroon	Sub-Saharan Africa	CDDC	Fuel CDDC	Low middle	0.568	0.05	0	0.3	0.071	0
Chad	Sub-Saharan Africa	CDDC	Fuel CDDC	Low	0.547	0.01	0	-0.019	0.051	0.711

Country Name	Region	Commodity dependent developing country status	Type of commodity dependency	Income level	Trend OLS coefficient	Trend OLS SE	Trend OLS p value	Cycle OLS coefficient	Cycle OLS SE	Cycle OLS p value
Colombia	Latin America and the Caribbean	CDDC	Fuel CDDC	Upper middle	0.334	0.033	0	0.965	0.39	0.018
Equatorial Guinea	Sub-Saharan Africa	CDDC	Fuel CDDC	Upper middle	0.577	0.011	0	0.161	0.254	0.53
Gabon	Sub-Saharan Africa	CDDC	Fuel CDDC	Upper middle	1.512	0.077	0	0.397	0.214	0.072
Iraq	Middle East and North Africa	CDDC	Fuel CDDC	Upper middle	0.621	0.051	0	0.123	0.161	0.45
Islamic Republic of Iran	Middle East and North Africa	CDDC	Fuel CDDC	Upper middle	1.593	0.042	0	0.611	0.05	0
Nigeria	Sub-Saharan Africa	CDDC	Fuel CDDC	Low middle	0.529	0.023	0	0.176	0.059	0.005
Oman	Middle East and North Africa	CDDC	Fuel CDDC	High	1.27	0.109	0	-0.589	0.393	0.142
Republic of Congo	Sub-Saharan Africa	CDDC	Fuel CDDC	Low middle	1.276	0.042	0	0.464	0.098	0
Saudi Arabia	Middle East and North Africa	CDDC	Fuel CDDC	High	1.482	0.021	0	0.43	0.115	0.001
Saint Lucia	Latin America and the Caribbean	CDDC	Fuel CDDC	Upper middle	1.234	0.038	0	0.033	0.468	0.943
Sudan	Sub-Saharan Africa	CDDC	Fuel CDDC	Low middle	0.629	0.007	0	-0.083	0.159	0.602
Trinidad and Tobago	Latin America and the Caribbean	CDDC	Fuel CDDC	High	1.059	0.039	0	0.59	0.204	0.006
United Arab Emirates	Middle East and North Africa	CDDC	Fuel CDDC	High	1.189	0.035	0	0.07	0.133	0.605
Botswana	Sub-Saharan Africa	CDDC	Mineral CDDC	Upper middle	0.523	0.016	0	0.51	0.215	0.023
Burkina Faso	Sub-Saharan Africa	CDDC	Mineral CDDC	Low	0.525	0.013	0	-0.416	0.509	0.419
Burundi	Sub-Saharan Africa	CDDC	Mineral CDDC	Low	0.849	0.189	0	-0.202	0.284	0.48
Chile	Latin America and the Caribbean	CDDC	Mineral CDDC	High	0.828	0.01	0	0.904	0.195	0
Democratic Republic of the Congo	Sub-Saharan Africa	CDDC	Mineral CDDC	Low	0.141	0.186	0.453	0.052	0.05	0.31
Ghana	Sub-Saharan Africa	CDDC	Mineral CDDC	Low middle	0.36	0.019	0	0.792	0.171	0
Guyana	Latin America and the Caribbean	CDDC	Mineral CDDC	Upper middle	0.289	0.05	0	0.305	0.19	0.117
Jamaica	Latin America and the Caribbean	CDDC	Mineral CDDC	Upper middle	0.506	0.085	0	1.81	0.335	0
Mali	Sub-Saharan Africa	CDDC	Mineral CDDC	Low	0.791	0.009	0	0.011	0.085	0.899
Mauritania	Sub-Saharan Africa	CDDC	Mineral CDDC	Low middle	1.207	0.089	0	0.949	0.455	0.044
Mozambique	Sub-Saharan Africa	CDDC	Mineral CDDC	Low	0.128	0.014	0	0.174	0.118	0.149
Niger	Sub-Saharan Africa	CDDC	Mineral CDDC	Low	0.602	0.056	0	0.515	0.328	0.125
Papua New Guinea	East Asia and Pacific	CDDC	Mineral CDDC	Low middle	0.901	0.043	0	0.014	0.257	0.958
Peru	Latin America and the Caribbean	CDDC	Mineral CDDC	Upper middle	0.585	0.011	0	0.541	0.08	0
Rwanda	Sub-Saharan Africa	CDDC	Mineral CDDC	Low	0.089	0.027	0.002	0.04	0.102	0.701
Sierra Leone	Sub-Saharan Africa	CDDC	Mineral CDDC	Low	0.49	0.03	0	0.167	0.054	0.004
Suriname	Latin America and the Caribbean	CDDC	Mineral CDDC	Upper middle	0.451	0.029	0	0.854	0.331	0.014
Togo	Sub-Saharan Africa	CDDC	Mineral CDDC	Low	1.31	0.054	0	0.314	0.122	0.014
Zambia	Sub-Saharan Africa	CDDC	Mineral CDDC	Low middle	0.689	0.017	0	0.407	0.116	0.001