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The future of trade and CO2 emissions

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This *Note* is an exploration of the patterns of trade in the coming decade, based upon a literature review. It establishes possible connections with another stream of literature, which points to the contribution of trade to CO_2 emissions. By connecting these two streams, it aims to map out the possible enablers and obstacles that the future of trade could place on the transition towards the Paris Climate Agreement's overarching objectives.

NOTE

November 2023

1. INTRODUCTION

In June 2023, leading financial and trade institutions, and rating agencies warned that trade was slowing sharply, as globalization stalled. The annual growth rate of global import volumes had turned negative already late the year before, and had remained negative in early 2023. A looming threat is deglobalization and fragmentation of trade, the Director-General of the WTO emphasized, calling for an urgent "re-globalization". Looking backward, analysts recalled that In the 10 years to 2020, the average rate of global trade growth fell below that of global GDP growth. It was the first decade since the second world war for which that statement holds true. Among bleak predictions of trade slowdown as an harbinger of a global economic depression, the rise of trade in services emerged as a light of hope. The recede in the volume of world trade in goods is actually partially offset by a recovery in services trade, and in particular, in digitally delivered services. *"It is clear that the future of trade is services. It is digital, it is green and it should be inclusive,"* DG Okonjo-Iweala stated.

How to get to this bright future is the question coming next. We intend in this note to delineate what the future of trade would look like, and whether or not it is set to be "green and inclusive" according to current trends. We do not use a crystal ball for this (sadly, we did not find it) and modestly hinge upon what renowned scholars have conjectured on the topic. Our research leads us to draw into two separate streams–the literature on trade patterns, which leaves aside the climate change problem, and the literature on GHG emissions embedded in trade, which leaves aside the long-term trends in trade patterns. This note is an attempt to bring these two streams closer together and a call for integrating further climate change in the long-term perspective of world trade, and vice and versa. Pending this reciprocal exchange of most needed knowledge, this note points to the risk of conflicting paths between the future of trade and the Paris Agreement and suggest solutions to mitigate this risk.

2. THE EXPANSION OF WORLD MERCHANDISE TRADE HAS COME TO AN END – AGAIN, BUT THIS TIME IT SEEMS SERIOUS

2.1. Trade recessions and expansion: the accordion music of world trade over two centuries

Expressed as a share of world GDP, the pattern of trade since the Industrial Revolution started in the 18th century, displays two consecutives growth periods. The first spans from the late 18th century to the Great depression, with an acceleration of trade in the 1850s, 1860s and 1870s. And the second started in the 1960s, with an acceleration in the 1990s and 2000s (Figure 1). A remarkable and persistent feature is that since the late 2000s, trade in goods seems to be stuck below a peak which occurred somewhere in the first decade of this century. The expansion of world trade has been marked by comparable drops, think about the trade recession in the 1840s and 1850s which coincide with the two opium wars, and the Great depression in the 1930s which triggered the infamous Smooth Hawley tariffs in the US, the "Imperial preference" within the British Empire on the principle of "home producers first, empire producers second, and foreign producers last". What is new in the latest downturn in world merchandise trade is that it is likely to be sparked by endogenous factors and not exogenous shocks such as economic crashes and wars. Trade downturn differs in magnitude among countries. It is particularly high in emerging economies that have opened up most widely and most rapidly at the turn of this century.

Changes in world value added expressed as a share of world output gives another indication of the changing pattern of world merchandise trade. Figure 2 shows that the ratio of value added to gross production for the entire world economy (all sectors) has plateaued since the late 2000s–and so has the expansion of supply chains worldwide.

When production becomes more fragmented across territories, intermediate inputs are sold among firms rather than produced within firms, and the ratio of value creation to sales falls. The ratio is thus an inverse measure of the degree of production fragmentation. The ratio falls when supply chains become longer or more complex. This has been the case in the WTO area–from 1995 until the failure of the 2008 WTO Conference and the financial crisis, which followed. It is no longer the case as reshoring due to wage increases the shift towards inward-looking growth in fast growing emerging economies, in a context of rising trade restrictive measures in the aftermath of the 2008-2009 financial crisis.

Beyond the G20 group, developing countries have embraced import openness for manufactured products, especially machinery and parts that enable them to participate in the international division of labour. But they continue to protect imports of services (World Bank, 2017). By the mid 2010s, countries in East Asia and Pacific had much higher levels of protection than OECD countries. Countries in Latin America and Central Asia are modestly more open but still less open than OECD countries. Countries in Africa and South Asia, home to most of the world's remaining extreme poor, are generally the most closed (id.). For developing countries wishing to participate more in GVCs and to move up the value chain, there is ample room for opening services to import competition and direct foreign investment – and complete what some scholars dub "the second great transformation".

FIGURE 1. World merchandise exports as a share of world GDP. Exports data: Federico-Tena World Trade Historical Database (Federico and Tena, 2019). GDP data: World Bank.

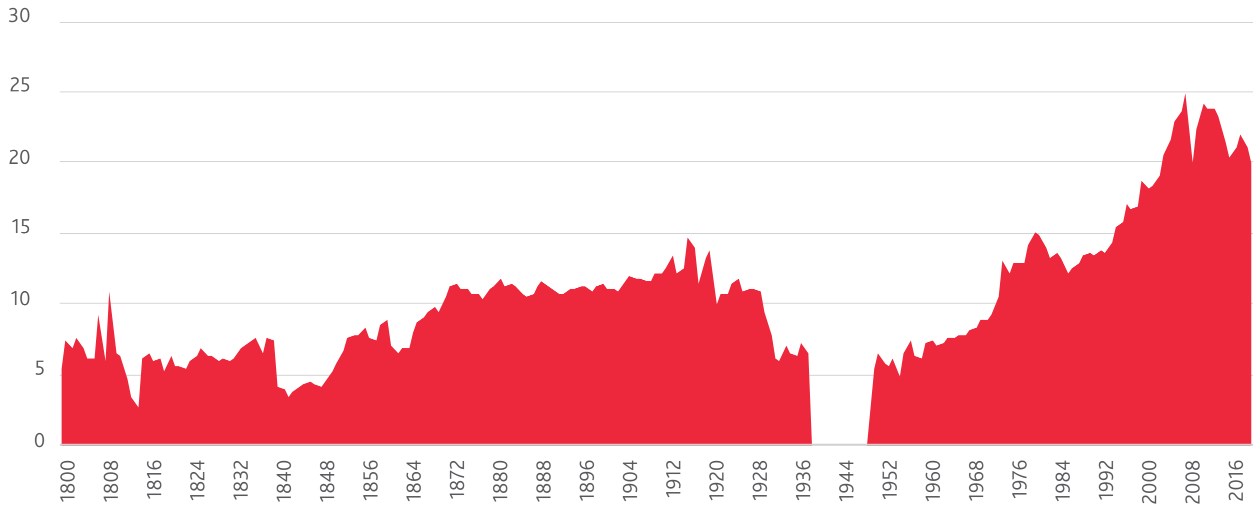
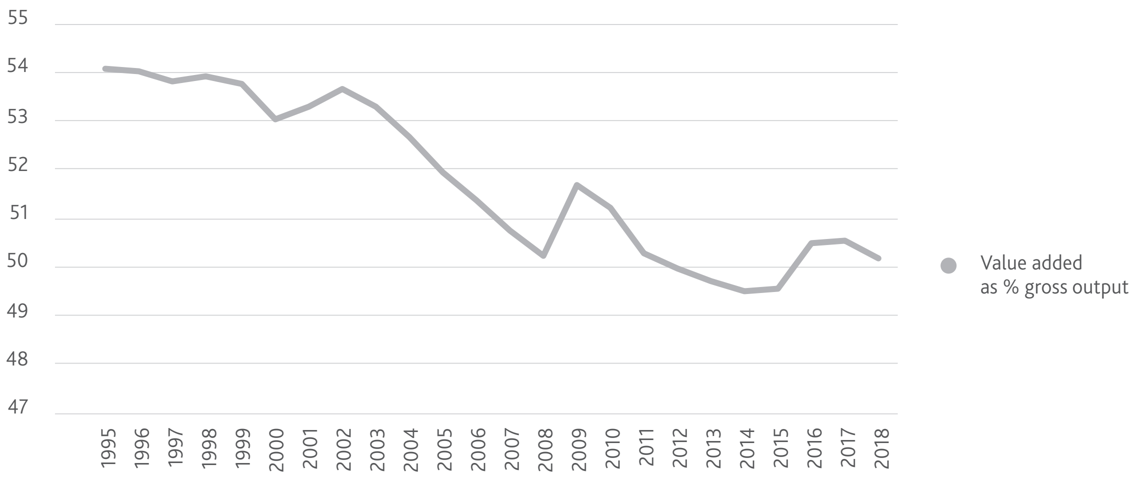


FIGURE 2. **Value added as a share of world gross output (%). Data: OECD. Gross production is the value added of all firms in the world (i.e. GDP) plus the value of all the inputs of goods and services that all firms buy from all other firms (this equals the value of global intermediate inputs).**



2.2. King merchandise trade is dead, long live king service trade

Underpinning the two growth cycles of world merchandise trade displayed in Figure 1 unfolds what Baldwin and other scholars name two "great transformations" in reference to Polanyi's book (Polanyi, 1944). Scholars also concur that we are on the verge of entering a third great transformation (Baldwin, 2019). The basic idea is that globalization is best described as the progressive reduction of three different costs: the cost of moving goods, the cost of moving ideas, and the cost of moving people. And that these costs have fallen–or are falling–but not all at once.

The rise in trade during the first great transformation (1800s to 1960s) materialized, and was supported by, the unbundling of production and consumption. Transport technologies and free(r) trade policies improved in a process that fostered and was fostered by the Industrial Revolution. With easier international shipping, more people can purchase faraway goods. Economies progressively shifted from agriculture to industrial and from rural to urban. But while shipping got cheaper, the costs of moving ideas and people fell much less–and less fast. It was not until the 1990s that the information and communication technology (ICT) revolution radically lowered the cost of moving ideas. This launched globalization's next phase—the "second unbundling", which involves the international separation of factories.

With the second unbundling, factories and not just goods are crossing borders (Baldwin, 2022). Radically better communications, which germinated in the 1970s, made it possible to coordinate complex activities at distance. This marked a shift from industry to services and a rise in intermediate products trade. Then again, technological change (computer-on-a-chip and ICT) and policy reforms (services trade becoming part of the WTO) drove the process. Services trade has been growing way faster than merchandise trade over the last two decades.

Global exports of digitally delivered services alone have almost tripled since 2005, rising by 7.3% per on average per year from 2005 to 2019, outpacing goods exports (+4.7% on a balance-of-payments basis). While goods trade fell in 2020, exports of digitally delivered services rose by 14%, boosted by an increase in remote working, distance learning and home entertainment due to COVID-19 (WTO, 2019). In 2021, world exports of digitally delivered services reached an estimated value of US$3.71 trillion, out of a total of US$5.8 trillion trade in commercial services—and to be compared with US$ 21.6 trillion stagnating trade in goods.

The third great transformation which is about to expand consists in unbundling the physical (human) presence from face-to-face service provision. Face-to-face costs are expected to plunge thanks to "telemigration"—namely working from home when home is abroad. Telepresence and augmented reality technologies are making remote workers seem less remote. Machine translation, spurred by machine learning, unleashed a "talent tsunami" so that "anyone with a laptop, internet connection, and skills can potentially telecommute to US and European offices" (Baldwin, 2019). This is remote intelligence. But it is not the only factor underpinning the third great transformation and a foreseeable decline in trade costs in different services sectors (Figure 4). The same technology underpins artificial intelligence development and white-collar robots–a new phase of automation where cloned human intelligence become fierce competitors for office jobs, which were previously shielded from automation. Remote intelligence and artificial intelligence are coming for the same services jobs, at the same time, and driven by the same digital technologies: they drive the third unbundling of globalization.

3. THIS IS NO GOOD NEWS YET FOR GHG EMISSIONS EMBODIED IN TRADE

3.1. Trade accountable for about a fourth of total CO2 emissions

The long and seemingly inexorable rise of CO_2 emissions on a hockey stick pattern since 1750 is now sadly familiar. What is much less is how much trade contributed to it. The fact that global trade as a share of GDP itself followed a hockey stick pattern until the mid 2000s gives no indication of a correlation and even less of a causation relationship between the two. Two information sources enable us to disentangle a bit the trade-CO_2 emissions relationship and thereby get a clearer sense of what could happen in the future during the third "great transformation".

Figure 3 compares on the one hand aggregate OECD and aggregate non-OECD production-based emissions, where CO_2 is allocated to the location in which the goods or services are produced, and on the other hand, consumption-based emissions i.e. where CO_2 is allocated to the locations in which consumption occurs. For OECD countries, total production-based and consumption-based emissions have been falling since 2005. There was also a reduction in net imports of CO_2 emissions from fuel combustion by OECD countries from non-OECD economies from 2.1 Gt in 2005 to 1.4 Gt in 2018, with a sharper decline in intermediate goods after 2006 as off-shoring plateaued and China's trade-to-GDP ratio started to decline. Conversely, over the same period, there was a general increase in production-based and consumption-based emissions by non-OECD economies as a whole, as these economies industrialize and catch-up with higher income countries.

The share of CO_2 emitted abroad in total CO_2 embodied in domestic final demand follows the same pattern as the share of trade in world GDP and the magnitude of offshoring. CO_2 emissions abroad, embodied in domestic final demand, reached a peak in the second half of the first decade of this century and then plateaued, making trade accountable for a bit less than a fourth of total CO_2 emissions in the early 2020s.

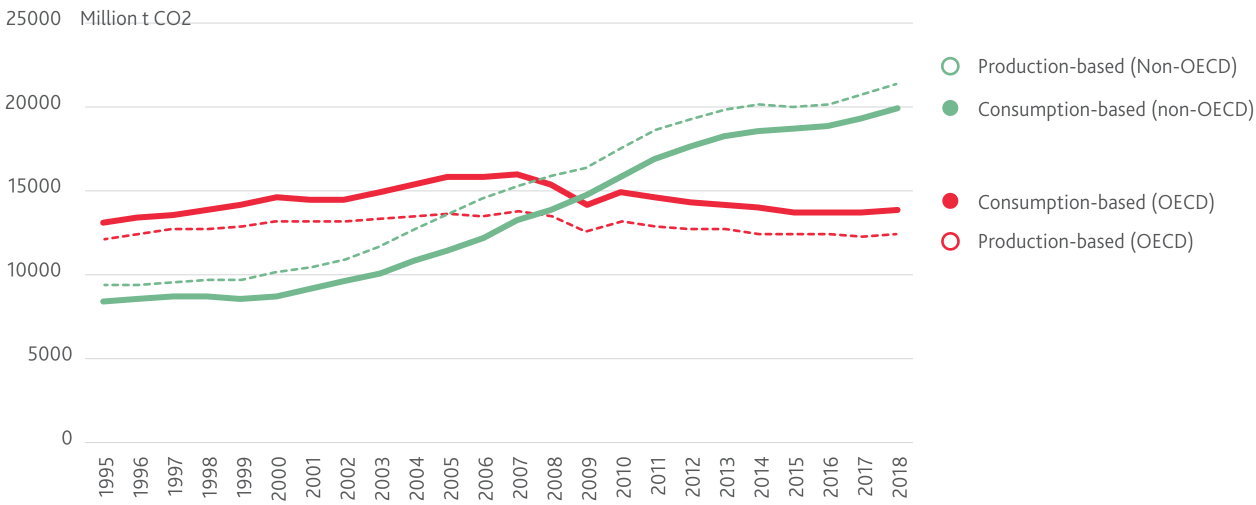
The growth in net imports of embodied emissions into high income countries has been found in numerous studies of CO_2 emissions (see in particular Davis et Caldeira, 2010; Peters *et al.*, 2011) and is also consistent with Copeland, Scott and Taylor (2022) who show a large increase of net imports of embodied air pollutants into high income countries from the late 1990's to 2008.

3.2. It is technique effect, stupid!

Copeland, Scott and Taylor (2022) provide the latest estimates of the effects of trade on various emissions, included, but not limited to, CO_2. They calculate what share of the change in each country's emissions is due to scale, composition, and technique, using a standard method developed by Levinson (2009) based on the Grossman and Krueger (1993) framework. They focus on the second unbundling period.

Their main finding is that in almost every country, the technique effect (which reflects changes in pollution due to changes in the emission intensities of each industry) is much larger than the composition effect (refers to the way that trade liberalization changes the mix of a country's production towards those products where it has a comparative advantage). A broad interpretation of this finding is that under standard versions of comparative advantage theories of international trade, changes in the composition of production across industries due to trade are not the primary driver of environmental change. Stolper-Samuelson and Heckscher-Ohlin theories of international

FIGURE 3. CO2 emissions from fossil-fuel combustion (OECD and non-OECD countries), 1995-2018. Data: TeCO2 (OECD).



trade posit indeed that the main effect of trade on the environment would be to reallocate production across industries. As Copeland, Scott and Taylor (2022) emphasize, to the extent that the main change in pollution is due to decreased emission rates within industries (technique effect), rather than across industries (composition effect), the reallocation across industries due to comparative advantage does not seem to be the main driver of environmental change.

To our knowledge, there is no study on the effect of trade on CO_2 emissions, which covers the latest period of "slowbalization" marked by stagnating trade in goods, the end of offshoring expansion, and the rise of trade in services. A study by Huo *et al.* (2021) provides estimates of how much emissions are embodied in services trade, and comes up with the figure of 30% of total trade emissions between 2010 and 2018–but it does not provide estimates of how much services trade–or trade in total–contributed to CO_2 emissions.

We can infer that due to the plateau of world merchandise trade as a share of GDP that the scale effect of trade is likely to be lower than it was during the expansion phase (1960-2000s). Yet we lack evidence on the magnitude of the composition and technique effects. Reshoring can lead to more or less emission intensity, depending on, inter alia, the stringency of climate regulations in place and the green-technological gap in the new location. A look at the intensity of CO_2 emissions embodied in total gross exports of ICT products would suggest that the slowbalization period was associate with a downward trend of carbon intensity in sectors such as computer, electronic and basic metal, with a trend turning flat in the latter case (Figures 4 and 5).

FIGURE 4. Intensity of CO2 emissions in total gross exports – computer, electronic and electrical equipment, 1995-2018. Data: TeCO2 (OECD).

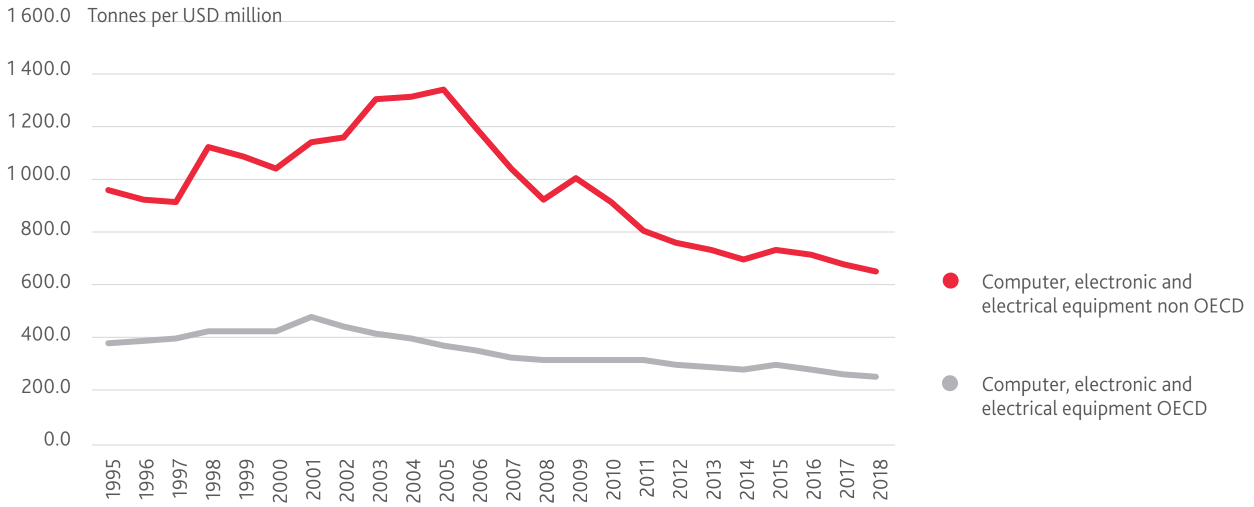
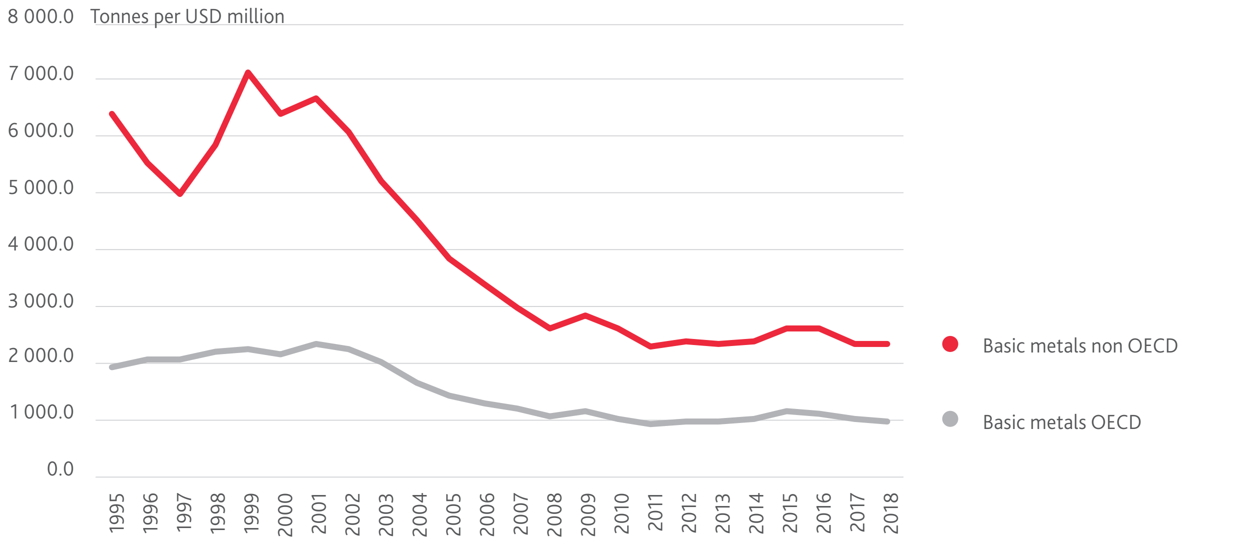


FIGURE 5. Intensity of CO2 emissions in total gross exports – basic metals, 1995-2018. Data: TeCO2 (OECD).



As OECD (2019) emphasises, the growing share of services in the economy will slow down the growth in materials use, as the materials intensity of services is lower than that of agriculture or industry. A plausible hypothesis is that as the material basis of trade stabilizes as a share of global GDP, and as services trade is expanding and global supply chains are reshoring, the share of CO_2 emissions embodied in trade could plateau or recede, and the net effect on CO_2 emissions improve. Similarly to what happened with SO2 in the 1970s, 1980s and 1990s with the progressive reshoring of factories from labour-well endowed and lax regulation countries to richer and more environmentally-friendly jurisdictions (Antweiler, Copeland and Taylor, 2001).

3.3. How much emissions embodied in telepresence and white-collar robots?

In the third unbundling, remote and artificial intelligences (RI and IA) combine to replace an unprecedented range of office and professional workers, previously shielded from globalization. Automation and globalisation in services–what Baldwin (2019) refers to as "globotics"–has not been thought of, designed or spurred by any climate or energy saving motive. It is a common feature with the first two unbundlings. It is about to radically shape trade and our economies, yet in total autonomy from the climate question. How much emissions are embodied in globotics and what is the contribution of this new form of trade in services to CO_2 emissions thus remain unresolved questions. The energy (electricity) content of globotics itself, let alone its carbon footprint, has not been explored yet as this third unbundling is still in its infancy both in the real economy and in the literature.

Intuitively, as the material basis of trade narrows (as a share of total trade and global GDP) and offshoring is receding, one can guess that the technique effect will be critical–as much and even more than during the previous unbundling. And that this technique effect entangles different technological bundles. The globotics technologies–the ICT required for RI and IA to perform at massive scale. This for the trade driver part. And the long-run technological change upon which the RI and IA add up, which is characterised by the substitution of energy with human capital (Box 1). This for the climate/energy driver part.

If look back at the last two centuries, human capital accumulation has contributed to technological change, enabling switching to more energy-efficient technology, which has eventually reduced energy consumption in industrialized countries (Awaworyi Churchill *et al.*, 2023). Could this negative technique effect (negative in the sense of reducing emissions) associated with human capital net out the climate effect of RI and IA should the latter be positive–and which also heavily rely on human capital - remains speculative at this stage, yet a critical question.

BOX 1. HUMAN CAPITAL AS A DRIVER OF CO_2 EMISSIONS

Exploring the relationship between human capital and CO_2 emissions, Awaworyi Churchill *et al.* (2023) find that over five centuries in the UK:

1. Human capital has a negative effect on energy consumption, such that a unit increase in years of schooling reduces energy consumption in the long run in the range 4–9%. This result is consistent with the findings in previous studies that have used data over more recent shorter periods that there is a negative relationship between human capital and energy consumption;

2. Human capital is an important factor of energy transition, alongside factors such as access to capital, infrastructure, institutions and technology;

3. Their results are consistent with a story in which, over five centuries, human capital accumulation has contributed to technological progress, enabling switching to more energy-efficient technology, which has reduced energy consumption;

4. Their results suggest that investment in education is likely to generate externalities for reducing carbon emissions and facilitating the transition to renewables. In the same vein, Shahbaz *et al.* (2022) and Yao *et al.* (2019) find that while investment in human capital has a negative effect on overall energy consumption and dirty energy consumption, it promotes clean energy consumption. Thus, in terms of facilitating transition to renewables, investment in human capital is likely to generate a double dividend;

5. Their findings are also consistent with human capital and energy being substitutes in production in the long run, particularly as economies transition to services, so investment in human capital has the potential to offset reductions in energy consumption in maintaining economic growth (Akram *et al.*, 2020). This is also confirmed by Hondroyiannis *et al.* (2022) in the broader case of environmental pollution.

Their findings add to a growing consensus that in the long run the relationship between human capital and energy consumption is negative, although the relationship might be positive for shorter periods or specific periods of rapid industrialization, such as the period between the First Industrial Revolution and the energy transition to coal in Britain. Human-capital induced technique effect compensates the negative income (or scale) effect of economic growth. Henriques *et al.* (2017) show that as income levels increase, scale effects become dominant. Technological change proves to be the main offsetting factor in the long run. Particularly in the last decades, technological change and fuel switching have become important contributors to the decrease in emissions in Europe.

Source: Based on Awaworyi Churchill *et al.* (2023)

4. MITIGATING THE RISK OF DIVERGENCE BETWEEN TRADE AND DECARBONISATION PATTERNS

Common and distinct trends shape the future of trade and the transition to net-zero. The common trend lies in human capital accumulation, which over the long run reinforces the share of services in global GDP and trade. The shift from things to thoughts is a key feature of the second transformation–or unbundling–as we have just seen. And thoughts or ideas take an even more prominent role in the third great transformation. Human capital drives this third great transformation and the pattern of trade associated with it–the "slowbalization" of trade in goods and the rise of trade in RI and IA-based services. The good news is that it altogether substitutes–at least partly–to energy consumption.

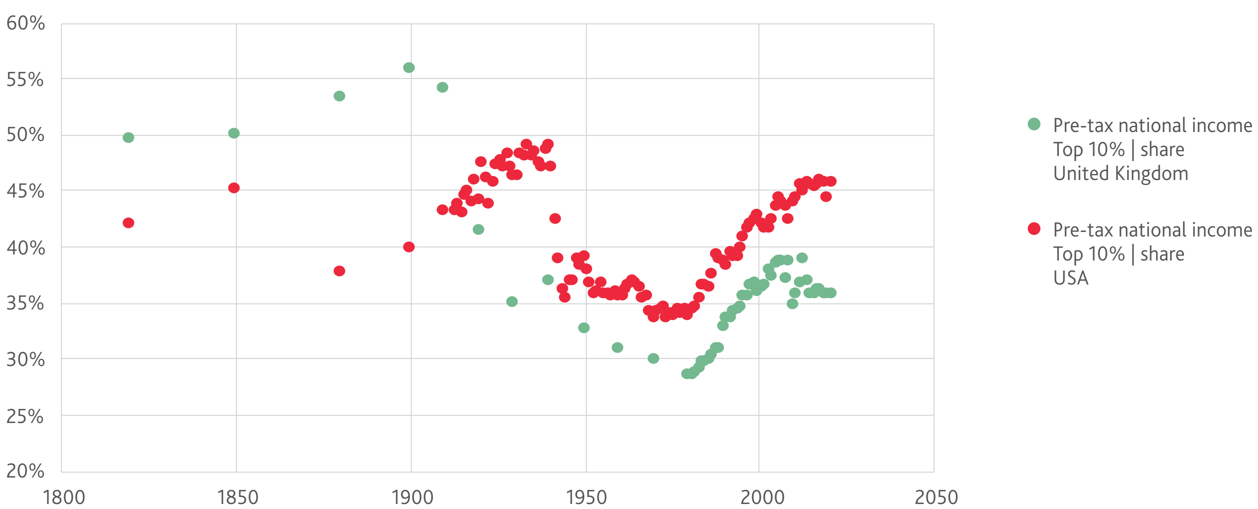
However, diverging trends could place trade and GHG emissions on incompatible pathways. We pick two of them. The first lies in the upheaval and backlash that the third great transformation – the "globotics" as Baldwin names it–is set to spark. As more and more white-collar jobs are being displaced and occupations eliminated, economic inequalities are set to widen, making this third transformation "unbelievably unfair" (Baldwin, 2019). Transitioning to a net-zero economy while inequalities increase looks like a daunting challenge for budget-constrained modern welfare states. In an unprecedented move, yellow-vests and white-collars could join and rail against it, creating an unstable mixture - the type of combination that has in the past exploded (id.). Two transitions at the same time could be one too many.

The second diverging factor is to be found on the material basis of trade and net-zero transition. OECD (2019) forecasts an increase in material resource use to 2060, even though at a lower pace than during the second unbundling. The increasing share of services in manufacturing and demand by households and government, combined with other trends such as digitalisation and an increase in R&D, is expected to enhance the share of the services sectors in the economy. This means that global materials intensity is projected to decrease due to the relatively low materials intensity of services compared to agriculture and industry. Despite this projected relative decoupling, materials-intensive sectors would continue to grow until 2060 according to OECD projections, leading to a substantial increase in overall materials use. For instance, the OECD report emphasizes, global demand for food and agricultural goods is projected to increase by about 65% by 2060 over 2017 levels (id.). These forecasts convey the simple reminder that even though less energy- and material-intensive, the shift towards services in the second and upcoming third great transformation superimposes rather that substitute the two first great transformations, as countries catch up across the board.

4.1. Upheaval and backlash against globotics could hamper the transition to net-zero

History shows that the two great transformation have been associated with a rapid increase in value creation and concentration, and subsequently, with rounds of upheavals, backlashes and shelterism by an evolving welfare state. Individuals and countries embraced fascism and communism as part of the backlash against the first great transformation, Baldwin (2019) recalls. The globotics upheaval, he warns, could spread very quicly since low-wage telemigrants and zero-wage white-collar robots are a worldwide challenge. Due to the logic of workplace competition, he adds, telemigrants and cognitive robots will undermine workplace protections, benefits and wages. In a context of economic inequalities moving close to their pre-World War I highest level

FIGURE 6. Income inequality in the UK and USA, 1820-2021, measured as the share of top 10% in pre-tax national income. Data: wid.world\data



in many countries, estimates of job displacement from telemigrants and robots range from big to enormous, binding further upward the inequality U curve (Figure 6). A key concern is not absolute job displacement, but the mismatch between the speed of job displacement and job replacement. The third transformation is specific on this matter. Globalization during the great (1st) transformation started one century after automation started. Globalization during the services transformation started two decades after automation. Now globalization and automation are taking off at the same time, increasing dramatically the net displacement figure.

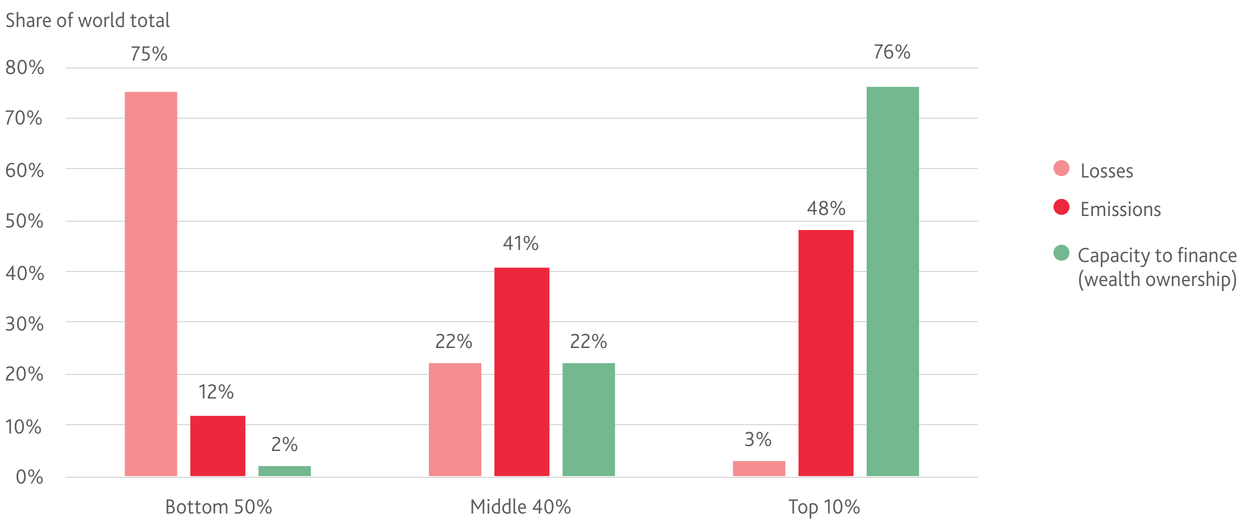
The possible increase of economic inequality while the globotics transformation unfolds could add another layer of constraints to the transition to net-zero emissions. The strain on public budget as telemigrants and robots do not pay taxes and the fact that displaced workers are entitled compensations would narrow the public policy space for supporting low-carbon innovation and workers transition to low-carbon jobs and occupations. A simple instrument such as the carbon tax has proved incredibly complex to implement in situations where the distributional impacts of the carbon tax add to inequalities already deemed unfair. Andersson and Atkinson (2020) results indicate that carbon taxation will be regressive in high-income countries with relatively high levels of inequality, but closer to proportional in middle- and low-income countries and in countries with low levels of income inequality (see also Fremstad and Paul, 2019; Chen, 2022; Zhao ***et al.***, 2022). The capacity to raise taxes and finance trade and climate change losers is bi-dimensional, as inequalities not only arise at domestic level, but also among countries. A global approach to economic and climate inequalities seems inevitable, yet hampered by many difficulties as coordination of tax policies among countries is in its infancy. In their report on climate inequalities, Chancel ***et al.*** (2023a) compare climate-induced losses, GHG emissions and wealth ownership across different world population percentiles (Figure 7). They come to the conclusion that profound transformations of international and national tax regimes will be necessary to increase the overall progressivity and returns of taxes and ensure that mitigation and adaptation efforts are shared equitably across the population–the business-as-usual scenario (no cooperation) meaning that climate and economic inequalities would reinforce one another.

Note: The graph shows that the bottom 50% of the world population contributes to 12% of global emissions but is exposed to 75% of relative income losses due to climate change. Emissions inequality data based on the World Inequality Database for 2019. Losses can be measured in many different ways. In this simple representation, Chancel ***et al.*** (2023) use country-level GDP losses (in 2030 and relative to a world without climate change) from Burke, Hsiang, and Miguel (2015). They give each emitter group within each country a per capita percentage income loss score. They assume that the bottom 40% of the distribution is 20% more exposed to losses than the average population in a given country, a conservative estimate based on recent studies (see Hallegatte and Rozenberg, 2017). The sum of these loss scores, weighted by population, gives a total global relative income loss burden, which is distributed across groups of emitters. These estimates of the global inequality in income losses should be interpreted with great care given the stylized approach taken to construct them. They nonetheless provide a useful representation of the large global inequality in climate change impacts found in the literature. Source: Chancel ***et al.*** (2023a).

4.2. Anticipating a great transformations crush

The idea of great transformations succeeding one to the other in a sequential manner is obviously a simplification of history. The pattern of a first unbundling being followed by a second then a third is an acceptable simplification of the changes underpinning the continuous transformation of our economies

FIGURE 7. Global carbon inequality: losses vs. emissions vs. capacity to finance.



over more than two centuries. It masks (like all simplifications and models) some changes occurring at the interstices of this sequential change. The pace of transition within each transformation differs among countries, which makes inevitable that some embrace, say, the first unbundling, while others are in the midst of the second unbundling and a few others are heading at full steam towards globotics. The great transformations partly overlap, and this overlap is made possible by international trade.

International trade not only links countries to each other, it also makes possible the great transformations to unfold at different pace in different places. Wine-against-clothe trade in Ricardo's time could enhance the first great transformation in England and the surge in manufactures in GDP, while making Portugal an agrarian country for decades. The same holds for Spain. Thomas and McCloskey (1981, p.102) describe Portugal, and Spain, as the "giants" of the sixteenth century, especially in comparison with Britain, the "inconsiderable little island of the sixteenth century, a mere dwarf". In the same vein, Bairoch (1976) considered Portugal one of Europe's five richest countries as late as 1800, and Bairoch ***et al.*** (1980) placed Lisbon as one of Europe's four most populous cities (after Naples, Paris and London). Despite this promising start, Portugal became one of Europe's poorest countries during the second half of the nineteenth century during the first great transformation. Its convergence only started with the emergence of modern economic growth in the 1950s, about two decades before the UK embarked into the second great transformation (Palma and Reis, 2018).

The early 21st century can be described as the transition from the second to the third great transformation, yet this sequential reading masks different transition patterns. High and middle-income countries (using World Bank definition) are on a clear pattern of transitioning away from manufacture to services, while the low-income group seems to erratically embrace manufacturing. In this group, the shift to services, which has prevailed between the mid 2000s until the mid 2010s, has stalled. During the slowbalisation period, trade has stabilised or continued to expand as a share of GDP in high-income countries, but it receded in middle and low-income countries. Mirroring the transformation of globotics in the coming year–mostly in human capital well-endowed high and middle-income countries–trade will continue to entail a substantial part of great transformation 1 and 2-type of goods, as low-income countries catch-up and industrialize at scale as Portugal did in the 1950s–apologies to the reader for this Rostovian vision of economic convergence.

In this crush of three great transformations, trade is set to expand in goods, services and globotics along different income group lines, and in turn, different welfare states regimes. As some countries and territories industrialize while others move to globotics through different layers of specialization patterns, the amount of emissions embodied in and permitted by trade might not follow the seemingly plateau displayed in Figure 3. The pollution haven hypothesis, which for three decades has been constantly rejected in the literature, could find a late confirmation through the rise of South-South industry–2nd unbundling type of–trade.

5. CONCLUSION: TWEAKING CLIMATE & TRADE AGREEMENTS TO MAXIMISE TECHNIQUE EFFECTS AND MITIGATE DIVERGENCE RISKS

5.1 Boost the technique effect

Literature shows that the technique effect reflects the principal avenue through which trade opening can help mitigate climate change. On this premise, diplomatic efforts have focused at the WTO on increasing access to the best available low-carbon technologies–without much success as no agreement on such goods and related services could be concluded thus far. On their side, free trade agreements (FTAs) to date have not been crafted from this particular perspective either. Moreover, it is worth reminding that increasing the availability of goods, services and technologies that are likely to be important in mitigating GHG emissions is not just about the liberalisation of environmental goods and services. Investing in the production of the much needed goods and technologies for decarbonisation, creating lead markets to make a business case of technologies not matured yet, are also of critical importance. In its 2022 report, Working Group III of the United Nations' Intergovernmental Panel on Climate Change (IPCC) expressed concern that much of international governance still promotes fossil fuels and highlighted the role of investment treaties and investor-state dispute settlement. Hitherto, investment law and climate change law have stood side by side, van Aaken and Broude (2022) acknowledged, leaving the potential of technique effect largely untapped. The conclusion is that climate investment provisions, chapters and treaties seem the missing pieces of the trade and climate governance puzzle.

5.2 Level up cooperation on corporate and private wealth taxation

The thorny issues of taxing corporate profits and transparency over the rates being paid by large multinationals should be included in the transatlantic trade agreement currently being negotiated, Thomas Piketty argued about ten years ago. As rising wealth inequalities are set to become an obstacle to the financing and implementation of low-carbon policies, taxing the beneficiaries of globalization seems like common sense. In October 2021, G-20 leaders finalized a new global tax deal aimed at curbing tax avoidance by large multinational enterprises (MNEs). The deal, brokered by the Organization for Economic Cooperation and Development (OECD) and endorsed now by 140 countries and jurisdictions, focused on reforming international and national tax systems to address tax avoidance and enhance tax cooperation. Current discussions on the apportionment of multinationals profits show that this global corporate tax could lead to additional government revenues of the order of US$110-160 billion (under so-called Pillars 1 and 2) for both high income and low-income countries. However, the proposal has been criticized by developing countries and some experts for the rather low level of corporate tax rate (15%) it has come up with, and for allocating relatively few taxing rights to low and middle income countries. As the Independent Commission for the Reform of International Corporate Taxation (ICRICT) stresses, the global minimum tax *"proposals as currently formulated are fundamentally inequitable, in that they give the prior right to apply a top-up tax (to the agreed global minimum) to undertaxed profits to the home countries of multinational enterprises (MNEs), while host countries would have only a secondary, back-up right. This would be a direct transfer of revenue from developing countries, which are generally only hosts to foreign MNEs, to the rich home countries."* (ICRICT, 2020). Therefore Thomas Piketty's diagnosis still holds. Collective action, including binding provisions to tackle tax avoidance, automatic transmission of fiscal and banking information and the establishment of a common registry of financial assets are the other missing pieces of the trade and climate governance puzzle.

5.3 Avoid a catastrophic great transformation crush

The great transformations partly overlap, and this overlap is made possible by international trade, which makes possible the great transformations to unfold at different pace in different places. A diverging factor seems to be found in the material basis of trade and net-zero transition. The pollution haven hypothesis, which for three decades has been constantly rejected in the literature, could find a late confirmation through the rise of South-South industry–2nd unbundling type of–trade. How much gas should a low income country tap and burn? How much can it afford if this gas is taxed for its GHG content? The same questions arise for cement, steel, fertilisers. To turn the question on its head, scholars have asked how much should Global South countries that have kept within their carbon limits be rewarded for their efforts? Fanning and Hickel (2023) proposed that countries in the Global South, which have not overshot their carbon allocations, should be entitled to a total of $192 trillion in climate compensation by 2050—this is calculated based on a carbon price of $200/ton and counting emissions since 1960 only 24. If this compensation were to be paid between 2020 and 2050, an annual compensation of around US$6.4 trillion from the over-emitters would thus be required to support the countries that have kept within their carbon budget. Translated into practical terms, Chancel *et al.* (2023b) find that this compensation mirrors a 2% yearly tax on the total assets held by the Global North (equivalent to 12% of their national income) across three decades. Alternatively, this amount could be sourced through a 3.5% yearly wealth tax targeting the richest 10% in the Global North, sparing the rest of the population. Tweaking rates within this top echelon could distribute the burden more fairly. These figures might appear staggering, especially when contrasted against current climate finance flows. However, these metrics proxy the sheer magnitude of climate finance needed to make the great transformation crush compatible with the Paris Agreement.

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