



## ANALYSIS

## Open veins: Drain from Latin America through ecologically unequal exchange

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## ABSTRACT

In *Open Veins of Latin America* (1971), Eduardo Galeano argued that colonial interventions in Latin America organised the regional economy around raw material exports and drained the continent of valuable resources and labour, producing conditions of underdevelopment. Scholars have argued that this dynamic continues today, where the suppression of prices and input costs in peripheral regions enables the global North to appropriate resources and value through ‘unequal exchange’. Building on this analysis and grounded in the Marxist tradition of dependency theory, this study empirically assesses Latin America’s position with respect to unequal exchange of natural resources and labour embodied in trade. We use environmentally extended multi-regional input-output (EEMRIO) analysis to measure net flows of embodied materials (biomass, fossil fuels, minerals, and metals), land, and labour between Latin America, the global North, China, and the rest of the global South (1995 to 2020) across seven sectors, along with wage compensation against the labour flows. We find that Latin America has suffered a large drain of all resources to the North over the period. In 2020, the North net-appropriated 935 million tons of materials (including biomass, minerals, metals, and fossil fuels), 4 million km<sup>2</sup> of land, and 53 billion hours of labour (worth €816 billion in Northern wages) from Latin America, mostly consumed as manufactured goods and services. We find that Latin America’s position in the world economy is increasingly ‘peripheral’ in character. It remains a major supplier of primary commodities to the North, experiences a greater per capita drain of biomass, metals, and land than China or the rest of the global South, and disproportionately suffers the ecological damages of Northern consumption.

## 1. Introduction

Latin American dependency theorists have long argued that underdevelopment in the region is in large part a consequence of its unequal integration into the world economy (da Conceição Tavares, 1977; Furtado, 2020; Gunder Frank, 1966; Marini, 2022; Marini, 2015). This school of thought influenced the Uruguayan writer Eduardo Galeano, who in his 1971 book *Open Veins of Latin America* demonstrated how European colonisation and various post-colonial interventions drained the continent of resources and labour, producing and perpetuating underdevelopment (Galeano, 1997). The contemporary form of the pillage described in detail by Galeano has been theorised as ‘unequal exchange’, how the suppression of labour costs in the South compresses prices and enables Northern appropriation of value (Amin, 1976; Amin, 1974;

Emmanuel, 1972).

The Egyptian economist Samir Amin argued that this occurs for two main reasons: because of large wage inequalities between workers in the global North and the global South, to an extent that cannot be explained by productivity differences, and because of unbalanced terms of trade where the prices of Southern exports are compressed relative to the prices of Northern goods (Ajil, 2023; Amin, 1974). This means that Southern states and producers must increase their exports to pay for any given level of imports from the core, leading to net outward transfers of economic value.

Building on these ideas, Stephen G. Bunker emphasised that value appropriation from developing countries through unequal exchange also occurs via drain of environmental resources (Bunker, 1984). This ecological aspect of unequal exchange highlights that value is also

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appropriated by core countries through the undervaluation of natural resources taken from global South countries. As a result, Southern countries are deprived of the full economic value of their labour, exports, and natural resources. These resources, if retained, could contribute to meeting national human needs and development objectives, including through their intrinsic use value (Prasad, 2019). Additionally, the intensification of extraction processes related to trade leads to environmental degradation (Wiedmann and Lenzen, 2018), disrupting local ecosystems and threatening the livelihoods of those dependent on them (Bunker, 1985).

In this study, we explore these dynamics empirically with environmentally extended multiregional input-output (EEMRIO) analysis using EXIOBASE to quantify and analyse patterns of resource appropriation from Latin America through unequal exchange in international trade. We assess flows of embodied materials (biomass, fossil fuels, minerals, and metals), land and labour between four world regions: Latin America, the global North, China, and the rest of the global South. The breadth of our analysis aims at situating Latin America in the context of the broader world economy.

We bridge empirical evidence into dialogue with dependency theory (Bambirra, 2023; dos Santos, 1970; Frank, 1967; Gunder Frank, 1966; Marini, 2022), unequal exchange theory (Amin, 1976; Amin, 1974; Emmanuel, 1972), and ecologically unequal exchange theory (Bunker, 1985; Martinez-Alier, 2003; Ricci, 2023) as the conceptual foundation of this analysis. By doing this, we aim to reassert the relevance of dependency theory as a powerful framework for understanding contemporary development constraints in the global South (Kvangraven, 2021). We argue that unequal exchange, and its ecological dimensions, must be understood as a core mechanism of peripheralisation. Our approach builds on the recognition that understanding the global dynamics of capital accumulation, and particularly their role in reinforcing core-periphery inequalities, is critical for the analysis of sustainable development (Amin, 1992).

Our category for the 'global North' is based on the IMF's list of 'advanced economies', which is primarily comprised of the United States, Canada, Australia, New Zealand, Japan, South Korea, and the wealthy economies of Europe. A full list of the regional aggregations is provided in the Supplementary Table 2. The analysis of labour flows includes both hours worked and wages and is divided by skill levels as defined by the International Labour Organisation (ILO). We also analyse the flows of labour and materials in terms of different sectors of the economy. This work builds on and advances previous studies that have used input-output analysis (IOA) and material flow analysis (MFA) to quantify patterns of resource use and appropriation (Dorninger et al., 2021; Dorninger and Shmelev, 2016; Hickel et al., 2024; Hickel et al., 2022; Infante-Amate et al., 2022; Infante-Amate and Krausmann, 2019; Rivera-Basques et al., 2021; Schaffartzik et al., 2019; Simas et al., 2015).

Previous work by Infante-Amate et al. (2022) assessed net physical exports from Latin America to other world regions. However, this study was limited to material flows and did not assess resource flows embodied in traded goods. Here we assess embodied resource flows, include land and labour flows in addition to materials, provide a full sectoral disaggregation on both the production and consumption side, and apply regional categories consistent with the core-periphery distinction in world-system analysis. While previous work on unequal exchange has tended to focus on the core-periphery relation, we examine Latin America's relationships not only with the core but also with the rest of the world economy for comparative insight. We use exchange ratios and per-capita flows to enable more precise comparisons.

We arrive at several important conclusions. Our findings confirm that Latin America remains a supplier of primary commodities to core economies and a sink for ecological damages outsourced by the core, with little structural change over the past decades. The persistent net appropriation of resources and labour limits the region's capacity for economic development and deepens global inequalities. As the North's high levels of consumption and accumulation rely on these unequal

exchanges, without structural changes in international trade relations Latin America is likely to remain in a subordinate position within the world economy, restricting its prospects for sovereign development.

## 2. Dependency and unequal exchange in Latin America

One of the main concerns of dependency theory is explaining why peripheral countries, particularly Latin America, have remained underdeveloped despite being integrated into the global capitalist system, a condition attributed to a subordinated form of integration (dos Santos, 1970; Kay, 2013, p. 129; Prebisch, 1950, p. 1). It also examines the specific social, political, and economic dynamics of the global South in contrast to those of developed countries, as well as the external and internal mechanisms of domination that characterise it (Kay, 2013).

The centre-periphery framework (Prebisch, 1950) and the idea of declining terms of trade, also known as the *Prebisch-Singer effect* (Prebisch, 1950; Singer, 1950) laid the theoretical foundations for many of the arguments later developed by different strands of dependency theory. Prebisch argued that Latin America's reliance on imports of capital and essential goods, alongside exports of low value-added products, led to consistent dollar scarcity, failing to cover import needs. This external vulnerability deepened during global crises, when contraction in the core reduced imports more than output in the periphery, creating balance-of-payment problems (Prebisch, 1950, pp. 3, 20, 29). The need to service foreign investment and debt in foreign currency further drained external resources (Tavares, 1985).

But dependency is not a unified theory, and its authors and ideas have been grouped into different strands (Bresser-Pereira, 2006; Kay, 2013; Kvangraven, 2023, p. 147; Kvangraven, 2021; Palma, 1978; Vernengo, 2006). Following Kvangraven (2021, 2023), this paper distinguishes between the structuralist and the neoMarxist strands. The structuralist tradition, associated with scholars such as Cardoso and Faletto, Tavares, and Furtado, holds that a form of 'associated dependent development' is possible within capitalism under certain conditions, and is concerned with the historical and financial limitations to industrialisation in the periphery (Cardoso and Faletto, 1979; da Conceição Tavares, 1977; Furtado, 1959). The neoMarxist strand, advanced by Marini, dos Santos, Bambirra, and Frank, in close dialogue with Amin, argues that underdevelopment is structurally produced by capitalism itself, requiring a revolutionary rupture or delinking (Amin, 1976; Bambirra, 2023; dos Santos, 1970; Frank, 1967; Latimer, 2022, p. 27; Marini, 2022).

The neoMarxist tradition bases itself in the concept of monopoly capitalism, where surplus arises not only from production but also via exchange, due to monopoly power. Within dependency, unequal exchange is understood through this lens of surplus extraction and asymmetrical trade relations between core and periphery (Kvangraven, 2021, p. 9). Peripheral economies are positioned primarily as suppliers of raw materials, low-wage labour, and ecological capacity, while depending on the import of capital goods, technology, and manufactured products from core countries. These structural constraints limit the periphery's capacity for autonomous development and subject their internal dynamics, such as wage levels and consumption patterns, to the imperatives of capital in the centre. As a result, the underdevelopment of the periphery is systematically reproduced to sustain this pattern of concentration and growth (Bambirra, 2023; Furtado, 2020; Marini, 2022).

Dependence is defined as a relationship between formally sovereign nations where production relations in the periphery are reorganised to ensure the expanded reproduction of the global system, privileging accumulation in the core (Marini, 2022, p. 7). Or as a situation in which the economy of some countries is conditioned by the expansion of the economy of another country (dos Santos, 1970, p. 231), setting the parameters and limiting the possibilities for social and economic development in the dependent country (Bambirra, 2023, p. 31). This means the specific forms of capitalist development in Latin America are intrinsically connected to the dynamics of capitalism in central countries

(Bambirra, 2023, p. 64), so that ‘the history of Latin America's underdevelopment is the history of the development of the global capitalist system’ (Marini, 2021, p. 47).

Andre Gunder Frank (1967) helped popularise neoMarxist dependency theory, laying the foundations for later contributions by Amin, Emmanuel, and others (Kvangraven, 2021, p. 7). One of Frank's central insights was that prosperity in core nations was predicated on the extraction of surplus from peripheral regions such as Latin America (Noonan, 2010, p. 120). He argued that by denying the peripheral countries access to their own surpluses, core powers actively fabricated and maintained the social, political, and economic dependence that characterised underdeveloped nations (Frank, 1967). Frank also introduced the concept of *potential surplus*, referring to the resources and value that would have been available to peripheral societies had they not been constrained by the monopoly power of core countries (Noonan, 2010, p. 124).

At the core of dependent accumulation is the mechanism of ‘super-exploitation’, when labour is remunerated below its value. Instead of deriving surplus value mainly through productivity growth and technological innovation, accumulation in the periphery relies on the intensification of exploitation: prolonged workdays, increased labour intensity, and the compression of workers' consumption, in some cases to below subsistence (Amin, 1976, p. 196; Marini, 2022, p. 130). Monopolistic control over global markets also lowers the prices of raw materials while raising the prices of industrial goods, facilitating the transfer of surplus created in dependent countries to dominant ones (dos Santos, 1970). These internal mechanisms are directly linked to unequal exchange at the global level.

Building on Emmanuel's (1972) understanding of unequal exchange (EU) as based on wage differentials and the dependency theory view that the core's development produces peripheral underdevelopment, Samir Amin (1976) reconceptualised unequal exchange as the systematic transfer of surplus value from the periphery to the core (Amin, 1976, p. 361). He argued that depressed wages in peripheral economies generate higher surplus value, which is drawn to the centre through international profit equalisation. Peripheral producers are compelled to sell their products at lower prices, effectively transferring a large quantity of their labour to the core economies (Amin, 1976, pp. 140, 178–179). Unequal exchange is actively maintained through economic and extra-economic policies that subordinate peripheral societies into supplying cheap labour (Amin, 1976, p. 192).

For Latin American dependency theory, unequal exchange is a core constraint to peripheral development (Kvangraven, 2021; Ricci, 2025). The need for peripheral countries to increase the scale and intensity of resource extraction to maintain export revenues leads to an outward transfer of not only labour and value but also natural resources whose environmental costs are largely externalised to the periphery (Dorninger et al., 2021; Ricci, 2023). These ecological transfers represent a form of what would later be conceptualised as ‘ecologically unequal exchange,’ (EUE) in which the biophysical basis of development in the core is sustained by environmental degradation and resource depletion in the periphery (Hornborg, 2009a; Rice, 2007).

Stephen G. Bunker, defined as part of the ‘ecological dependency tradition’, made the explicit connection between the unequal exchange theories of the 1960s and 1970s and environmental impacts (Brolin, 2006, p. 302, 304). He noted that in order to understand the process that created and maintained the underdevelopment of the Amazon, it was necessary to consider how both natural and human environments were affected by modes of extraction (Bunker, 1985). Bunker argued that development theories had largely failed to account for how resource extraction reshapes the material conditions of the environments from which those resources are removed, constraining their future development potential (Bunker, 1984).

In his analysis of the Brazilian Amazon, Bunker observed that while increasing flows of materials and energy enable productive economies to expand internally, they impose structural constraints on the regions

from which they are extracted. These constraints reproduce underdevelopment as a relational outcome of both internal economic arrangements and externally imposed trade dynamics (Bunker, 1984). He argued that while additional value is generated when labour transforms raw materials, this value is typically realised in the industrial core, not in the periphery where extraction occurs. The periphery is left with unstable external demand, depleted resources, lost energy not reinvested locally, and increased vulnerability (Bunker, 1985, p. 45).

After Bunker's early contribution, the concept of ecologically unequal exchange (EUE) was formalised by several scholars. One approach defines EUE as the net physical transfer of productive potential in the form of labour time, energy, and other material resources, with no reference to economic value (Hornborg, 1998, 2003, 2009b). Joan Martinez-Alier, by contrast, emphasises the political and distributive implications of EUE within the broader concept of ‘ecological debt’—the debt owed by industrialised nations to peripheral countries due to resource plundering, unfair trade, environmental damage, and the free occupation of environmental space (Brolin, 2006, p. 104). He argues that environmental values are incommensurable and shaped by social-political struggles and decision-making, rather than reducible to a single metric, whether monetary or physical (Martinez-Alier, 2003, Martinez-Alier, 2002, p. 45). Ricci, in turn, draws on an eco-Marxist interpretation that sees EUE as part of capitalism's broader logic of value extraction to argue that UE and EUE are best understood as a unified phenomenon rooted in the international law of value. In his view, market prices systematically misrepresent the ecological content of goods, enabling the appropriation of nature's productivity without monetary compensation (Ricci, 2023).

This paper follows an understanding of unequal exchange as a central mechanism driving uneven development or the ‘development of underdevelopment’ (Gunder Frank, 1966). The analysis that follows draws on the neoMarxist strand of dependency theory to assess Latin America's position in the world economy and adopts Amin's and Ricci's theorisations of unequal and ecologically unequal exchange, respectively. It seeks to quantify these unequal flows to clarify how global production structures constrain peripheral development. It adopts the view that these constraints cannot be understood as mere deficiencies or incomplete stages of development but must be situated within the overall structure of the global capitalist system. This aligns with Marini's view that the specific dynamics of Latin American economies can only be grasped through their integration into international capitalism (Marini, 2022, p. 114).

### 3. Methods

#### 3.1. Environmentally extended multi-regional input output (EEMRIO) analysis

Environmentally extended multiregional input-output (EEMRIO) analysis uses multi-regional Input-output (MRIO) tables to assess both socioeconomic and environmental impacts that occur throughout global supply chains until the final consumer (Kitzes, 2013). We performed EEMRIO analysis using data from the MRIO database EXIOBASE v.3.9.6 (Stadler et al., 2025).

The standard input–output identity is:

$$\mathbf{x} = \mathbf{A}\mathbf{x} + \mathbf{f}$$

where:

- $\mathbf{x}$  is the vector of total output by sector,
- $\mathbf{A}$  is the matrix of direct input coefficients ( $a_{ij} = z_{ij}/x_j$ ),
- $\mathbf{f}$  is the vector of final demand by sector and region.

Solving for total output:

$$\mathbf{x} = (\mathbf{I} - \mathbf{A})^{-1} \mathbf{f} = \mathbf{L} \mathbf{f}$$

where  $\mathbf{L}$  is the Leontief inverse, representing the total (direct and indirect) production requirements to satisfy one unit of final demand.

Multiplying  $\mathbf{L}$  by the final demand  $\mathbf{f}$  provides the total upstream inputs needed to produce the goods and services consumed by households and governments,  $\mathbf{x}$ , in monetary terms.

Environmental or socio-economic coefficients  $\mathbf{e}$  store non-monetary intensities per unit of total output. We determine the resources from sector  $i$  of producer country  $p$  embodied in country  $c$  final demand, or the ‘footprint’, by multiplying  $\mathbf{e}$  with the total output from that same country and sector required to meet final demand in consumer country  $c$  ( $\mathbf{X}$ ). This can be expressed as:

$$\mathbf{Q} = \widehat{\mathbf{e}} \mathbf{L} \mathbf{f}$$

here, ‘hat’ ( $\widehat{\phantom{x}}$ ) represents the diagonalized vector.

We determined final demand requirements for five material resources: land, biomass, minerals, metals, and fossil fuels; and for labour in terms of labour time (represented in hours) and labour compensation (represented in constant 2005 euros). The period examined extends from 1995, the earliest obtainable year in this version of EXIOBASE, to 2020, the latest with non-nowcasted data.

In EXIOBASE, labour data is disaggregated in different skill levels according to the International Standard Classification of Occupations (ISCO) by the International Labour Organisation (ILO) (ILO, 2008). The disaggregation of the data into seven different economic sectors followed the sectoral aggregation recommended by the EXIOBASE authors (<https://ntnu.app.box.com/v/EXIOBASEconcordances/file/282982479518>). The full concordance table with the sectoral composition is available in the Supplementary Information.

### 3.2. Regional aggregations

Detailed country classifications can be found in Supplementary Table 2. We approximated the ‘global North’ category using the IMF’s list of ‘advanced economies,’ which includes Australia, Austria, Belgium, Canada, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Japan, Latvia, Luxembourg, Malta, Netherlands, Norway, Portugal, Slovakia, Slovenia, South Korea, Spain, Sweden, Switzerland, Taiwan, United Kingdom, and the USA.

The ‘Latin America’ category includes Brazil, Mexico, and the aggregated category ‘Rest of the World America.’ The ‘China’ category refers specifically to data from mainland China. The ‘global South’ comprises all other countries classified as ‘emerging and developing’ by the IMF. Due to limitations in EXIOBASE, some IMF ‘advanced economies’ are aggregated into broader regions such as ‘Rest of the World Europe’ or ‘Rest of World Asia.’ Consequently, we included these countries in our global South category. However, the impact on the results is minimal due to the small size of these countries.

### 3.3. Sectors

We categorised the EXIOBASE production data into seven sectors—agriculture, manufacturing, mining, services, electricity and utilities, construction, and transport—following the suggested sectoral aggregation from the product tables (accessible at <https://ntnu.app.box.com/v/EXIOBASEconcordances/file/282981183372>). Further details regarding the sectoral composition can be found in Supplementary Data 1.

### 3.4. Calculations

We collected data on the resources and labour embodied in traded goods and services exchanged between regions: from the global North to peripheral regions (Latin America, the global South, and China), from

peripheral regions to the North, between peripheral regions, and among Northern countries. These calculations were done for seven sectoral aggregates. For labour, we also obtained data by skill level, along with compensation paid for labour in these trade flows. Additionally, we gathered data on resources and labour by sector for domestic production and consumption within both the global North and peripheral regions (Latin America, China, and the global South), which includes the resources and labour used in non-traded goods. Compensation for labour in these domestic activities was also obtained.

In this study, Northern appropriation is conceptualised as the net transfer of resources—exports minus imports—from Latin America to Northern regions through international trade, particularly due to the systematic undervaluation of Latin America’s exports relative to its imports. To quantify the net appropriation by the North, we subtracted the North’s exports to Latin America, China, and the global South from the imports it received from these regions.

For each resource or labour type  $r$ , we calculated net appropriation from peripheral region  $g$  as the difference between imports from and exports to such region:

$$A_t^{g,r} = I_t^{g,r} - E_t^{g,r}$$

where:

$A_t^{g,r}$  is the net Northern appropriation of resource  $r$  from region  $g$  in year  $t$ .

$I_t^{g,r}$  denotes total embodied imports of resource  $r$  by the North from region  $g$  in year  $t$ .

$E_t^{g,r}$  denotes total embodied exports of resource  $r$  by the North from region  $g$  in year  $t$ .

For total Northern consumption, we added up the flows from peripheral regions to the North, the intra-North trade, and the production and consumption of non-traded goods within the North. Finally, wages (in euros per hour) for each region were calculated by dividing the total compensation received for labour exports by the total labour exported (in hours).

### 3.5. Limitations

Several limitations of our work should be acknowledged. First, our analysis is based on EXIOBASE data, which inherits uncertainties from input-output modelling, sectoral aggregation, and reporting inconsistencies. These uncertainties apply particularly to the case of peripheral regions, such as Latin America, since EXIOBASE’s country resolution is limited to 49 individual nations, mostly from the core, complemented by five Rest of the World (Row) categories (full country disaggregation can be found in Supplementary Table 2). While other MRIO databases such as GTAP and GLORIA offer higher country resolution, GTAP only contains data for reference years and has limited socio-economic and environmental extensions (Aguilar et al., 2022), and GLORIA’s coverage does not include wage extensions for labour accounts (Lenzen et al., 2017, 2022).

## 4. Results

### 4.1. Drain from Latin America to the global North

Building on this paper’s concern with core-periphery dynamics, we begin by analysing Latin America’s trade balance with the global North. We find that Latin America consistently exports larger quantities of all resources to the global North than it imports, indicating a persistent pattern of unequal exchange. Fig. 1 shows Latin America’s exports and imports of embodied resources over 1995–2020. In 2020, Latin America exported 8 times more embodied land to the global North than it imported, 2.3 times more materials (combining biomass, minerals, metals, and fossil fuels), and 6.9 times more labour. On average throughout 1995–2020, Latin America exported 4.5 times more land, 2.2 times more

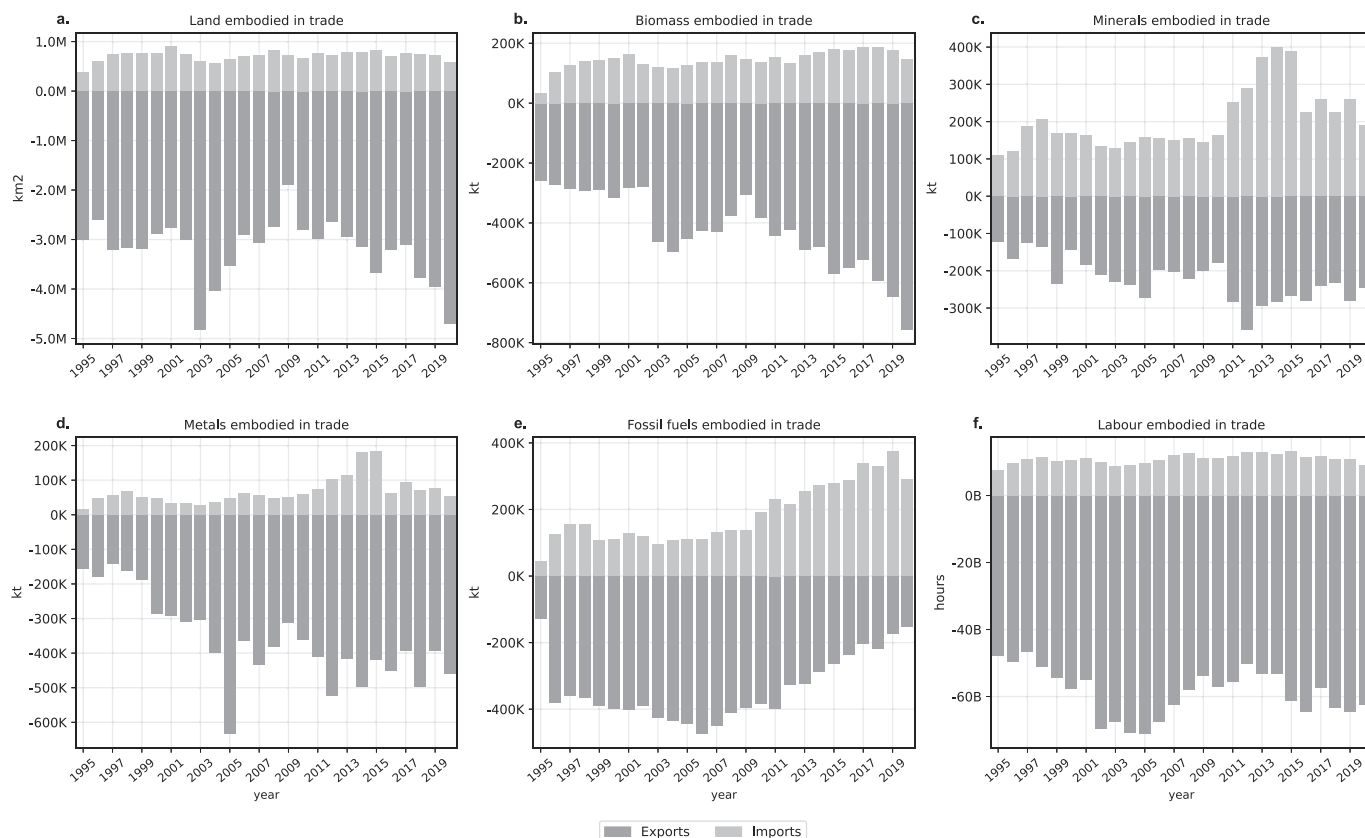


Fig. 1. Latin America's trade balance with the global North. Exports and imports from Latin America's perspective, 1995–2020. (a) land, (b) biomass, (c) minerals, (d) metals, (e) fossil fuels, and (f) labour.

materials, and 5.3 times more labour than it imported from the North. The pattern by which peripheral regions export more to the core than they import reflects a subordinate integration into the global economy. These net outflows of resources and labour from Latin America to the global North can be characterised as Northern appropriation from the continent. We find that Northern net-appropriation from Latin America has occurred across all resources, and all skill levels of labour, during the period studied.

Table 1 shows the cumulative Northern net-appropriation from Latin America for the period 1995–2020, as well as Northern net-appropriation from the rest of the global South. We see Latin America provides a particularly large share of the North's total net-appropriation of land (36%), biomass (27%), and metals (70%), dramatically in excess of Latin America's share of the Southern population. In the case of minerals, fossil fuels and labour, the North relies more on the rest of the global South (see Supplementary Table 1 for detailed data).

Table 1 also shows the extent to which Northern consumption relies on appropriation from Latin America and the rest of the South, underscoring its enduring structural dependence on Southern land, resources, and labour. We see that Northern appropriation from Latin America comprises, on average (for all resources, across 1995–2020), 5.1% of Northern consumption; in other words, without this appropriation,

consumption in the global North would have been 5.1% lower, all else being equal.

Fig. 2 shows Northern net-appropriation from Latin America in each year, disaggregated by sector of consumption for natural resources, and sector of production for labour. This considers that a resource, such as cotton, can be exported as an agricultural product but consumed as a manufactured good, like a garment. This analysis reveals how appropriation is driven by the final demand of different sectors. In the case of materials, sectors of production often overlap with the type of resource (e.g., biomass with agriculture, minerals and metals with mining).

Our findings show that Northern net appropriation of land, biomass, and metals from Latin America has generally increased over the study period. The majority of these resources are ultimately consumed in the form of manufactured goods, followed by services, construction, and agriculture. This pattern underscores how the North relies on the appropriation of Latin American resources to sustain the production of the secondary and tertiary products it consumes. These results suggest that the manufactured items and services consumed in the North are highly material-intensive and directly benefit from the ongoing resource drain from Latin America. In sum, while the North enjoys the benefits of industrial and service-based affluence, the ecological burdens are externalised to Latin America.

Table 1 Northern net-appropriation from Latin America, 1995–2020.

	Land	Biomass	Minerals	Metals	Fossil fuels	Labour
Northern net-appropriation from LatAM	65.22 million km <sup>2</sup>	7.34 million kt	0.51 million kt	7.61 million kt	3.98 million kt	1.24 billion hours
Northern net-appropriation from all of GS	183.36 million km <sup>2</sup>	27.39 million kt	67.06 million kt	10.95 million kt	57.14 million kt	15.90 billion hours
LatAm as % of total Northern net-appropriation	35.5%	26.8%	0.76%	69.5%	6.9%	7.8%
LatAm as % of Northern consumption	7.1%	4.7%	0.17%	13.5%	2.5%	3.1%



Fig. 2. Net appropriation of resources by the global North from Latin America by sector of consumption (natural resources) and production (labour), 1995–2020. (a) land, (b) biomass, (c) minerals, (d) metals, (e) fossil fuels, and (f) labour.

Some of the sectoral results are striking. In 2020, 206 km<sup>2</sup> of land appropriated from Latin America were embodied in agriculture consumed by the North, 283km<sup>2</sup> in construction, 833 km<sup>2</sup> in services, and 2.7 million km<sup>2</sup> in manufacturing. The total area is equivalent to twice the combined size of Spain, France, Germany, the UK, and Italy. These results suggest that most of Latin America's land-based exports are not food but inputs for industrial production.

Over the full studied period, most labour drained from Latin America was provided by the services, agriculture, and manufacturing sectors, in that order. In 2020, 21 billion hours labour were appropriated through agriculture, 18 billion hours from services, and 12 billion hours from manufacturing. In the case of agriculture, this means a 55% increase from 1995, and 87% in the case of manufacturing. See Supplementary Fig. 3 for detailed labour data by sector and skill level.

The monetary value of labour is an artefact of power dynamics in political economy. Wages in the global South are kept low in large part due to interventions by Northern states and firms to cheapen labour, both at the national level (e.g., through structural adjustment programmes that reduce labour standards), and through monopoly and monopsony power in global commodity chains (Suwandi, 2019). Scholars of unequal exchange have argued that the net appropriation of embodied labour from the global South can be represented in terms of

prevailing Northern prices (Amin, 1976; Kohler, 1998). Following this precedent, we represent the wage value of labour net-appropriated by the North in terms of prevailing Northern wages, differentiated by skill level and sector.

Our results, represented in Fig. 3, show that the wage value of Northern appropriation of high-skilled labour from Latin America was €168 billion in 2020, primarily through the services and manufacturing sectors. Appropriated medium-skilled labour was worth €521 billion, and low-skilled at €127 billion. The total value of labour appropriation from Latin America in that year was €816 billion, having increased by 208% since 1995. From 1995 to 2020, the cumulative wage value of net-appropriated labour reached €13 trillion, with 46% drained via services, 31% via manufacturing, 12% via agriculture, and 6% via electricity and utilities, construction, and transport. The average annual drain amounted to €517 billion.

#### 4.2. Latin America's position in global patterns of exchange

Next, we situate Latin America within the broader global economy. Unequal exchange theory holds that peripheral countries may experience unequal exchange not only with core economies but also with other peripheral regions with relatively higher price levels. In our analysis, we

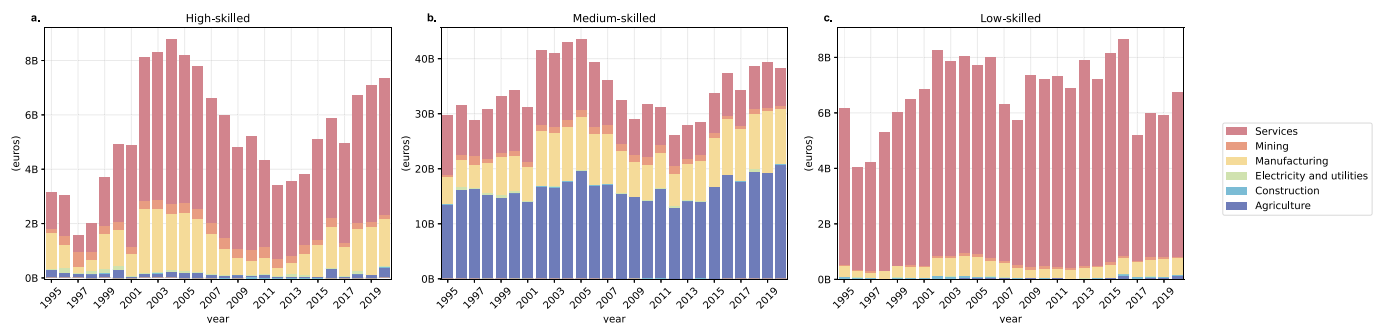


Fig. 3. The wage value of labour appropriation from Latin America by the global North, represented in Northern wages, by sector and skill level, 1995–2020. (a) high-skilled, (b) medium-skilled, (c) low-skilled.

distinguish these intra-peripheral flows from appropriation per se, as they typically reflect a passive consequence of global price hierarchies shaped by core economies—rather than deliberate efforts by peripheral states to suppress prices or restructure production in other peripheral countries.

Fig. 4 presents total net outflows of resources from Latin America over time, disaggregated by recipient region: the global North, China, and the rest of the global South. Net outflows of embodied land, biomass, and metals from Latin America to the rest of the world have increased consistently over the period. However, Latin America has generally been a net importer of minerals, and more recently, a similar trend has emerged with fossil fuels.

We find that most of Latin America's net outflows have been directed toward the global North: this is true in the case of land, minerals, metals, fossil fuels and labour. In 2020, the global North net-appropriated 4 million km<sup>2</sup> of land and 935 thousand kt of materials from the region. Net outflows of embodied labour from Latin America to the global North amounted to 53 billion hours, equivalent to 25 million workers working 40 h a week. This is slightly more than the combined working-age population of Chile, Bolivia, and Uruguay in that year. While some net outflows of land, metals, and biomass also go to China and the rest of the global South (in the case of biomass, this represents the majority of outflows) it is important to note that these flows are largely offset by Latin America's net imports of minerals and fossil fuels from those regions. Some changes have occurred in recent years, with China becoming a net importer of fossil fuels from Latin America, although the volumes remain relatively small. Fig. 4 shows these flows in absolute terms. In per capita terms, outflows to China and the rest of the South are considerably smaller than those to the North, because the former have much larger populations.

Finally, we turn to comparing the global North's net-appropriation from Latin America to its net-appropriation from China and the rest of

the global South. We know that, in absolute terms, the North relies more heavily on appropriation from the Rest of South group than from Latin America and China, for biomass, fossil fuels, and labour (see Supplementary Fig. 1). This is partly because the rest of South is larger in terms of landmass and population. To correct for this, we assess the question in per capita terms.

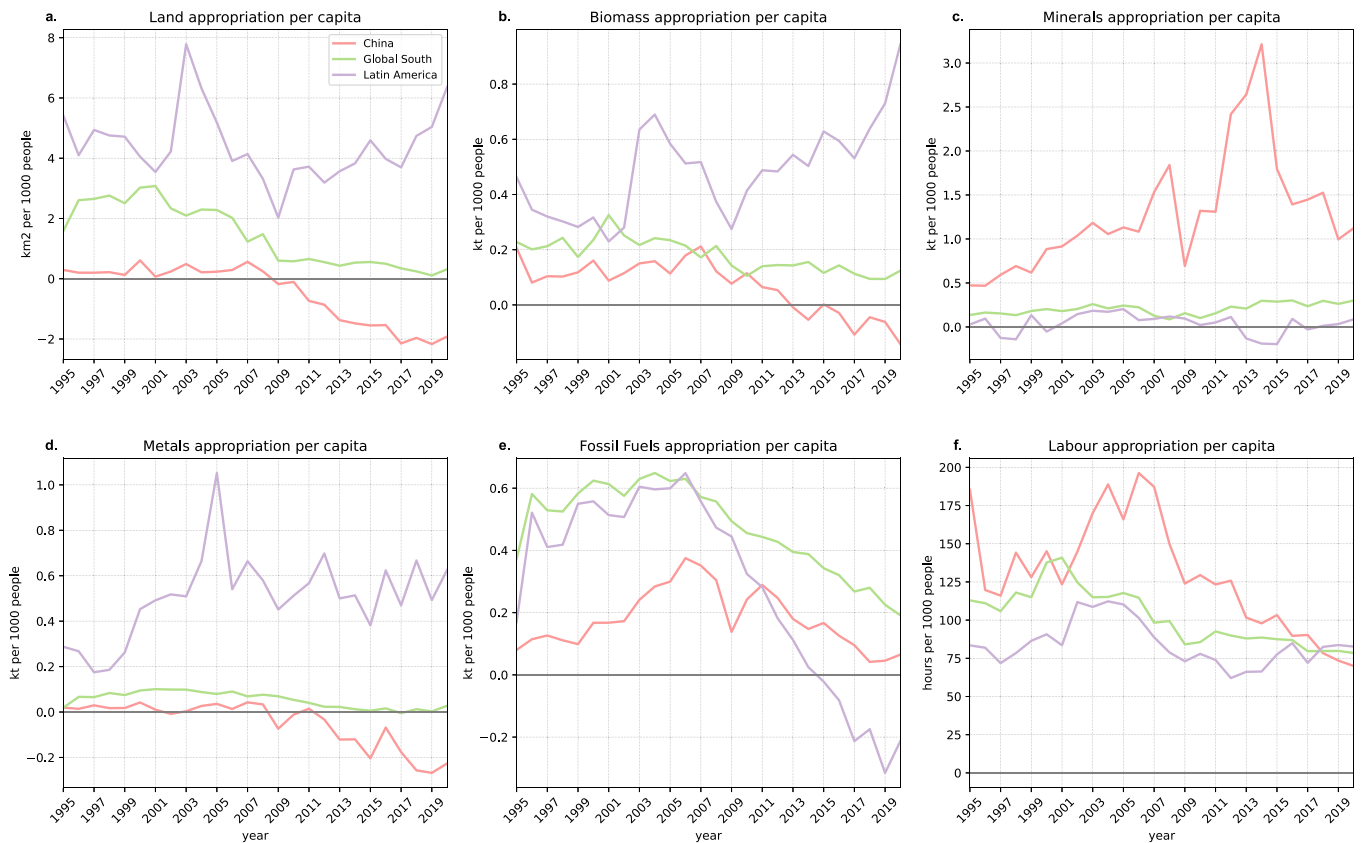
In per capita terms, we find that appropriation by the North from Latin America did not significantly exceed that from other global South regions in the early years of the studied period. However, in recent years this has changed. Latin America is currently more heavily drained of land, biomass, and metals than both China and the rest of the global South. This is demonstrated in Fig. 5. As of 2020, Northern appropriation from Latin America in per capita terms is 1909% higher than from the rest of the global South for land, for biomass it is 660% higher, for metals it is 2164% higher. For land, biomass, and metals, Northern appropriation per capita from Latin America has been increasing whereas for China and the rest of the South it has declined since 1995.

These figures suggest that the Latin American region remains largely a supplier of primary commodities to the core, specifically metals and agricultural commodities, even despite its semi-peripheral position in the world economy. In fact, Latin America's position is increasingly 'peripheral' in character, taking the role of supplier of land-based goods as other parts of the global South, such as China, assume more of a semi-peripheral position. Indeed, the data on land and biomass suggests that Latin America and China are trading places in terms of their relative positions vis-à-vis the core.

Latin America's peripheral status is further confirmed when we analyse the sectoral composition of production associated with the drained resources. Rather than focusing solely on the sector of consumption, that is, the sector to which a product or service belongs when consumed in the global North, we shift attention to the sector of production in Latin America, identifying the sector in which the resource



Fig. 4. Net outflows from Latin America to the rest of the world by year, 1995–2020, segmented by recipient region. (a) land, (b) biomass, (c) minerals, (d) metals, (e) fossil fuels, and (f) labour.



**Fig. 5.** Northern appropriation of resources and labour from Latin America, China and the rest of the global South in per capita terms, 1995 vs 2020. (a) land, (b) biomass, (c) minerals, (d) metals, (e) fossil fuels, and (f) labour.

was originally embodied before being transformed into a final consumption good. In 2020, over half (52%) of the land appropriated by the global North from Latin America was embodied in cattle production, followed by forestry, logging, and related services (29%), mining (6.45%), and vegetables, fruits, and nuts (5%). By contrast, only a small fraction was associated with services (0.54%) and manufacturing (0.50%). For biomass, 53% was drained in the form of cattle, 17% as vegetables, fruits, and nuts, and 15% as sugar cane and sugar beet. In the case of metals, another resource showing high and rising levels of per capita appropriation, 42% was embodied in copper ores and concentrates, 37% in precious metal ores, and 10% in iron ores.

China comprises a relatively larger share of Northern appropriation in terms of embodied minerals, labour, and fossil fuels, respectively, suggesting that China is largely a supplier of more industrialised goods to the core. Fossil fuel and labour drain from the rest of the global South are particularly striking, with, in the case of labour, 374 billion hours drained in 2020, equivalent to around 180 million workers working 40 h a week for a full year (see Supplementary Fig. 1).

Recent increases in Northern appropriation of land, biomass and metals from Latin America are largely explained by a rise in the United States' appropriation from the continent. Fig. 6 shows per capita appropriation from Latin America by the United States (US) and Europe, calculated as the net flows from Latin America to each Northern region in a given year, divided by that region's population in the same year. Here, Europe refers to the 27 countries of the European Union plus Norway, Switzerland, and the United Kingdom.

The results indicate that appropriation by Europe remained relatively stable throughout the period in comparison to appropriation by the US. For most resources, US appropriation peaked around the early 2000s and again after the 2008 financial crisis, with high levels sustained until recent years. The 2000s commodity boom and rising global demand for raw material led Latin American countries to expand

exports. In turn, the 2008 financial crisis decreased demand for imports, dragging commodity prices down. Despite the now unfavourable conditions, Latin American economies intensified resource extraction to compensate for lost revenue. As a result, net outflows of resources rose after 2008, even as their market value declined, reinforcing the region's dependence on primary commodity exports and exposing the vulnerabilities of this economic model. In the specific case of minerals, the decline in US appropriation from Latin America after 2008 was accompanied by an equivalent increase in appropriation of minerals from China.

Exchange ratios normalise flows by correcting for the volume of trade, allowing for direct comparisons between regions. Fig. 7 displays the exchange ratios (exports divided by imports) for all three global South regions with the global North. An exchange ratio higher than one indicates that the region exports more than it imports and suffers a net outflow to the global North. The higher the exchange ratio, the larger the net-outflows. We display the exchange ratios for land and materials (biomass, metals, minerals, and fossil fuels), and labour. Our main finding here is that China is the only region to achieve a substantial improvement in its exchange with the North over time—apart from an improvement in the case of fossil fuels in Latin America. For Latin America and the rest of the global South, their overall structural position vis-à-vis the North has changed very little over the period (generally worsening during the structural adjustment years, improving after 2005, and then worsening again in recent years). For these two regions, there are no signs of convergence with the North.

## 5. Discussion

Our results reveal consistent patterns of resource and labour appropriation from the global South by the global North over 1995–2020. Northern economies benefited from 183 million km<sup>2</sup> of land, 163

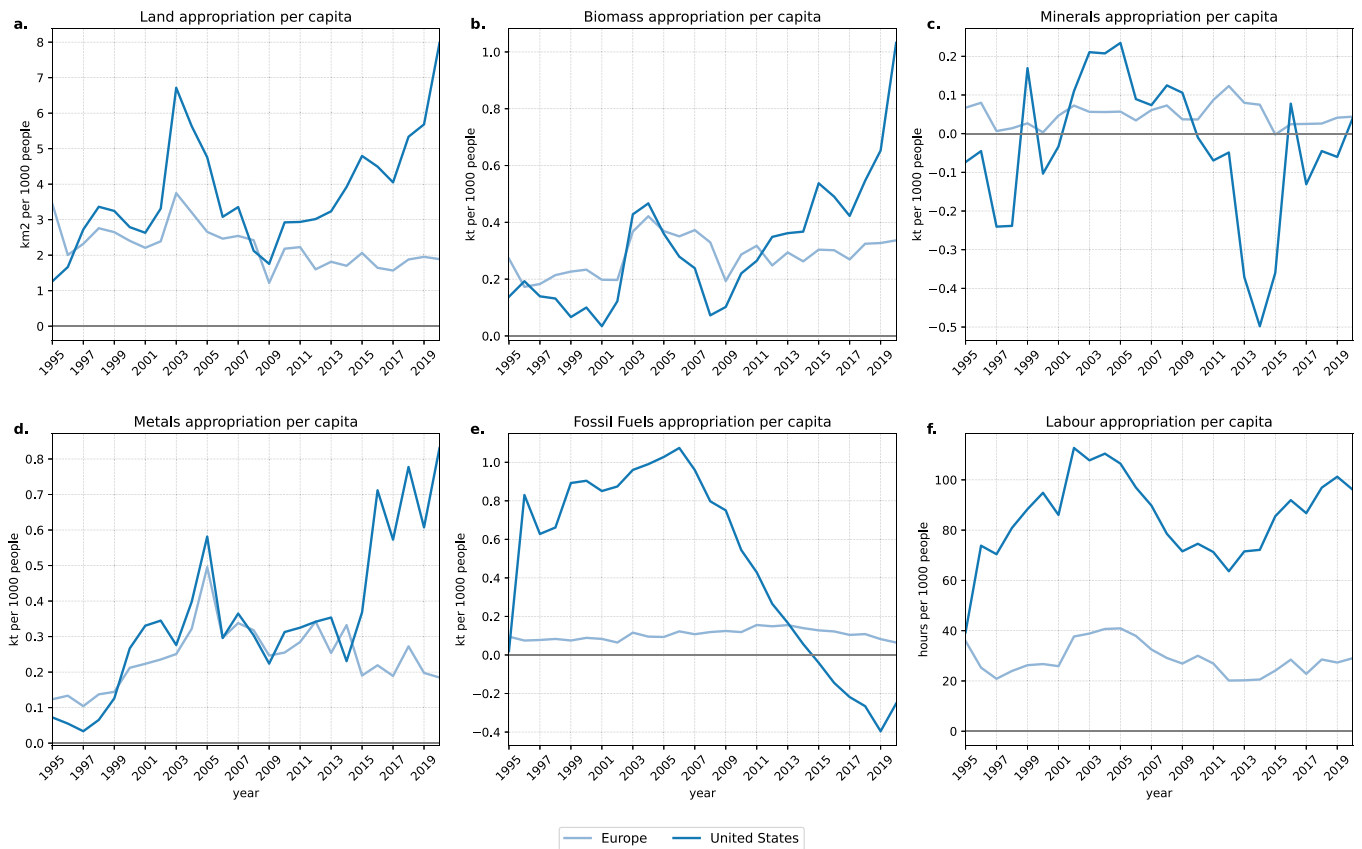


Fig. 6. Europe and US net-appropriation of resources and labour from Latin America in per capita terms (1995 vs 2020). (a) land, (b) biomass, (c) minerals, (d) metals, (e) fossil fuels, and (f) labour.

million kt of materials, and 16 trillion hours of labour drained from the South. Latin America experienced higher appropriation per capita of land, biomass, and metals compared to other Southern regions, and the slowest decline in labour appropriation. Labour drain from Latin America spans across all skill levels and sectors, reaching the equivalent of €816 billion in 2020 when valued in Northern wages, with a cumulative total of €13 trillion between 1995 and 2020. These findings confirm the argument that Northern countries sustain high levels of consumption and capital accumulation by extracting from poorer regions the productive capacities crucial for their development (Amin, 1976; Marini, 2022).

Sectoral disaggregation confirms that primary resources from Latin America are used to sustain final consumption in manufacturing and services in the North (Fig. 2). According to Furtado (2021), the external market structurally dictates the internal economies of dependent countries, where the focus on primary exports for the core determines the organisation of internal production and labour supply (Furtado, 2021, p. 2). Our results show these sectors to be more subjected to unequal exchange. The persistent reliance on low-priced exports, particularly from agriculture and mining, makes it harder for peripheral countries to obtain enough foreign exchange to finance the import of capital goods needed for development (Bambirra, 2023, p. 28; Marini, 2022, p. 147; Prebisch, 1950, p. 7). This reinforces the extractive-export orientation as a core feature of dependent capitalism (dos Santos, 1970), and places unequal exchange as a central mechanism in reproducing dependency.

Further disaggregation by production sector reveals that 52% of appropriated land from Latin America in 2020 was embodied in cattle exports, followed by forest and mining products. This indicates a productive structure that remains anchored in primary sectors, despite nominal industrialisation. Strong reliance on primary sectors might be

explained by how capitalist relations of production in Latin America developed first in the export sector, which meant that industrial evolution continuously relied on it (Bambirra, 2023, p. 41). The reliance on sectors geared toward external demand for raw materials structurally limits the expansion of a domestic, diversified industrial base.

Appropriation, in this sense, extends beyond material flows to encompass the structural mechanisms that allow the North to absorb surplus. Unequal exchange operates not merely through unequal trade balances but through the imperialist organisation of production and exchange (Ajl, 2023, p. 27). The global economic system is shaped by colonial histories and reinforced by institutions such as financial markets, trade agreements, and transnational corporate power (Ghosh, 2025; Yeros and Jha, 2020). The North's dependency on net appropriation from Latin America and the rest of the periphery to sustain its final consumption (Table 1) illustrates how its prosperity relies materially on the continuous transfer of surplus from the South (Amin, 1976; Marini, 2022).

This system is enabled by geopolitical and financial asymmetries that cheapen Southern resources and labour. Structural adjustment programs, debt dependency, and transnational corporate power lower environmental protections and suppress wages (Hickel, 2017). This results in lower environmental and operational costs in the South, allowing multinational corporations to profit by selling at global market prices while capturing the surplus. Underpaid labour and underpriced nature allow the North to benefit from resources without bearing the full social, ecological, or economic cost (Muradian and Martinez-Alier, 2001). Via EUE, global South economies lose the potential value of their natural resources, which could otherwise meet internal needs or provide inherent use value, meaning the qualitative aspect of nature that makes it essential for maintaining particular social relations, including the reproduction of labour power through non-market production



Fig. 7. Exchange ratios (exports/imports) of global South regions with the global North, 1995–2020. (a) land, (b) biomass, (c) minerals, (d) metals, (e) fossil fuels, and (f) labour.

(Prasad, 2019; Ricci, 2023). Other forms of value appropriation through EUE include the unpaid costs of maintaining renewable resources, such as soil nutrients lost in agricultural exports; the future costs of depleted or destroyed non-renewable resources; uncompensated local environmental damage; and the unpaid commercial use of genetic resources and traditional knowledge (Martinez-Alier, 2003).

The problem lies not only in the intensity of exports and the social-environmental damage associated to extraction, but also in the drain and appropriation of economic value (Ricci, 2023, p. 31). In international trade at the initial stages of the global value chain, developing countries export natural resources as primary products. Unequal exchange theory argues that, because these prices are artificially suppressed, much of the economic value is lost, or in fact, appropriated. As a result, these countries must export even greater volumes of resources, further exacerbating the drain. This dynamic is driven by the need to balance trade deficits, afford imports—and specifically the imports of capital goods (Prebisch, 1950, p. 2; Vernengo, 2006, p. 559)—and repay external debts (Tavares, 1985). The cycle of export, unequal exchange, increasing export dependency, and debt perpetuates underdevelopment, keeping these economies locked into low-value-added, extractive economic activities while wealth is systematically drained toward developed economies (Infante-Amate et al., 2022).

Although China and other global South regions are net-importers of land, biomass, and minerals from Latin America, this must be understood within the broader context of the world-system. China and other semi-peripheral regions occupy an intermediate position in global commodity chains dominated by Northern firms; they obtain net-imports from the rest of the periphery in the process of sending net-exports to the core. This dynamic should be understood as an effect of the imperialist world-system and not necessarily as an expression of imperialism itself. Semi-peripheral regions might benefit from lower

prices in the periphery created by Northern imperialist interventions, but they do not possess the same power to set prices or dictate how value is allocated within commodity chains (Hickel et al., 2022). Furthermore, our findings show that Latin America's net-outflows of some resources to Southern regions tend to be balanced or offset by counter-flows of other resources, while its net outflows to the North span across all categories, showing a persistent pattern of unequal exchange.

Net imports of resources benefit the receiving economies that gain access to resources with minimal financial, environmental, or social costs (Rice, 2007). In contrast, regions experiencing resource drain face significant environmental pressures and social conflicts (Magalhães Teixeira, 2021). Since resources are limited, when they are appropriated elsewhere, they become unavailable for local needs, both now and in the future (Bunker, 1985). For land, this manifests as degradation, while for other materials, it manifests as depletion. Additionally, beyond the availability of the actual resources, the productive capacity—labour and infrastructure—used for extraction is diverted to serve external capital. This dynamic highlights that the ecological side of unequal exchange is not only about resource availability but also about ecological sovereignty (Bringel and Fernandes, 2024). Through the ecological aspect of unequal exchange, people in the global South have unequal access to nature (Ajl, 2023, p. 28). While uneven material flows alone are not inherently a component of uneven development and exploitation (Frank, 1978, p. 103), the critical issue lies in the power dynamics that underpin these flows. Uneven flows happen as a result of power being leveraged to benefit capital accumulation in wealthy economies.

In 2020 alone, Latin American labour worth €816 billion in Northern wages was drained via trade. While this study does not assess value transfers as such, our labour results underscore Emmanuel's and Amin's argument that labour undervaluation lies at the core of unequal exchange (Amin, 1976; Emmanuel, 1972), and illustrates the process of

super-exploitation whereby workers in the periphery are paid below the value of their labour, enabling a structural extraction of surplus (Marini, 2022, p. 130). Our results show that a large portion of the global workforce is composed of workers in the global South receiving a fraction of the wage of workers in the global North for work of equal skill in the same sector, also confirming how, in the global South, precarious employment tends to be more of a problem than scarcity of labour power (Sylla, 2013, 2023). These results likely underestimate the scale of precarious employment due to unaccounted informal labour. Northern economies both benefit from and contribute to these precarious conditions by squeezing Southern wages and profits.

Our results also show how peripheral regions are differently subjected to unequal exchanges with the North. When looking at appropriation in per capita terms (Fig. 5), Latin America suffers higher per capita drains of land, biomass, and metals than the rest of the South. This pattern suggests the endurance of long-standing historical dynamics between Latin America and the core. Galeano described the process of colonial appropriation of these exact resource types in the form of gold and silver, and king sugar and other agricultural monarchs' (Galeano, 1997, p. 11,59); our findings indicate this dynamic persists into the present, whereby Latin America's export-oriented development remains based on the same type of biophysical resources.

Galeano argued that the metals taken from the colonies not only stimulated Europe's economic development, but rather made it possible (Galeano, 1997, p. 23). Resources extracted from Latin America by the Spanish and Portuguese crowns enabled the existence of commodities for production and capital for investment that created the conditions for the production and reproduction of value within the capitalist system (da Silva, 2022). He also argued that the colonial plantation system evolved directly into the present-day latifundio model, both being structured to enable the drain of natural wealth from the continent (Galeano, 1997, p. 60). The global North appropriates value and resources from the region through primary, low value-added goods, which are ultimately realised as manufactured products and services (Fig. 2). Our results show that Latin America remains structurally reliant on exporting land-based goods and metals while importing higher value-added manufactured products and services. This aligns with dependency theorists who argued that the peripheral economies are constrained by global monopoly power into specialising in exports of low value-added primary commodities and activities, limiting their possibilities for sovereign development (Bambirra, 2023; Marini, 2022). This appears to be truer for Latin America than for the other peripheral regions analysed.

Globalisation in the 1980s and 1990s marked the consolidation of new rules governing trade and capital flows in Latin America, requiring its integration into the global economy via structural adjustment programs that imposed austerity, deregulation, and privatisation, and were pushed by international financial institutions such as the World Bank and the International Monetary Fund. This created the conditions for the expansion of extractive projects, with Latin America's nation-states acting as guardians of capital reproduction, contributing to the continent's current subaltern position (Féiz and Elisa Melón, 2023; Hickel et al., 2026). During the same period, China followed a different trajectory. It implemented industrial policies that prioritised the development of capital-intensive industries under strong state guidance. Chinese industrial policy has evolved and developed into the twenty first century, with its most recent five-year plan focusing on sectors such as aerospace, clean energy, and high-end manufacturing (Fu et al., 2026).

Overall, when compared to other peripheral regions, Latin America shows sustained or increasing peripheralisation, with per capita drain either rising or remaining stable over the period analysed. In contrast, China exhibits a decline in per capita drain across all resources except minerals, which may indicate greater demand for manufactured goods (a sectoral disaggregation of China's embodied mineral net outflows would be necessary to confirm this interpretation). The rest of the Global South also shows an overall decrease in per capita drain by the North,

except for minerals. These findings are further confirmed by our analysis of exchange ratios, which shows China as the only region to achieve sustained improvement. Amin (1976) warned of the emergence of differentiated peripheries, where certain regions take on more strategic positions, and Marini (2022) reinforced that Latin America's trajectory must be read relationally within global capital flows. Our results suggest that Latin America is becoming more core-dependent as other regions diversify or ascend global value chains. An effective development strategy for the region must question the role it has been historically assigned, such that Latin American countries can avoid subordinating their production to the interests of global capital (Patterson, 2024, p. 20).

## 6. Conclusions

This article has provided an empirical examination of how unequal exchanges contribute to Latin America remaining structurally embedded in a dependent relationship with the global North. These findings reaffirm major insights of dependency theory: that the development of peripheral countries is constrained by their subordinated roles in the world economy (Amin, 1976; Bambirra, 2023; dos Santos, 1970; Marini, 2022).

Our study offers disaggregated quantification of natural resources and labour flows between Latin America and other global regions, enabling a more detailed account of patterns of unequal exchange than provided by existing literature. By tracing these flows through sectors and particularly showing how Northern consumption of manufactured goods depends on appropriation of Latin America's primary exports, we shed light on how the continent's structures of production are shaped by external demand. The paper also contributes to the discussion on the concepts of unequal and ecologically unequal exchange by arguing that appropriation is characterised by a combination of uneven flows, deeply rooted geopolitical power asymmetries, and labour undervaluation.

Understanding how different sectors experience resource drain can inform industrial policies aimed at ending unequal exchange. Our results show that Latin America remains largely an exporter of raw materials and primary commodities to the global North, but that these commodities are consumed in the form of services and manufactured goods. Further analysis tracing embodied resources throughout various steps of commodity chains can provide insights into where these resources flow to for processing, and where value is added before reaching the final consumer. Our findings support the claims made by the Latin American economists who influenced Galeano, showing that the process of capital accumulation, in this case through international trade, continues to exacerbate the divide between core and periphery (Amin, 1974; Furtado, 2020).

Our results indicate that, without a fundamental restructuring of international trade relations and a rebalancing of power between the global North and South, Latin America's economic dependence and the core-periphery structure of the global economy will likely persist. This restructuring should prioritise coordination rather than competition between Latin American countries, strengthening continental unity in international agreements, and promoting complementary production to increase intra-continental trade. Emphasis should also be placed on expanding domestic value over exports and countering the logic of super-exploitation (Patterson, 2024). Reducing non-essential imports, particularly luxury goods from the North, would alleviate pressure on export volumes. Prioritising South-South trade for necessary imports, including capital goods, would reduce the losses due to unequal exchange. Essential imports should be substituted through domestic production where possible. Latin American populations, like others in the periphery, have endured exploitation, environmental destruction, and precarious living conditions in the name of development. However, peripheral economies will remain underdeveloped as long as the development of the core relies on keeping these regions in a subaltern position in the world-system.

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## CRedit authorship contribution statement

**Morena Hanbury Lemos:** Writing – review & editing, Writing – original draft, Visualization, Software, Methodology, Formal analysis, Data curation, Conceptualization. **Jason Hickel:** Writing – review & editing, Supervision, Conceptualization.

## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

## Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.ecolecon.2026.109055>.

## Data availability

Data will be made available on request.

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