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Analysis

Material use and material efficiency in Latin America and the Caribbean

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ABSTRACT

Different world regions have followed very different trajectories for natural resources use over the recent decades. Latin America has pursued a development path based largely on exports of primary resources. Adopting this path has characteristic environmental and social impacts. In this paper, we provide the first broad based estimate of material use and material efficiency for the region, beginning in 1970 and extending to the onset of the global financial crisis in 2008. The results show a region with rapidly growing primary materials consumption, which is simultaneously becoming less efficient at converting those resources into national income. Using an IPAT framework, we found that population growth and rising per-capita incomes made comparable contributions to growing material use, while technological change as reflected in material intensity, did not moderate consumption. Increasing materials intensity, observed for the region as a whole, is also observed for most individual countries. This contrasts with some other world regions, and implies that many countries in Latin America and the Caribbean will confront higher environmental pressures than expected when expanding their extractive industries to take advantage of new demand from other world regions, while simultaneously supplying the requirements for their own domestic industrial transformations and urbanization.

1. Introduction

The intent of this study is to provide new insights into material use and material efficiency patterns for Latin America and the Caribbean, and the drivers behind the observed patterns. To this end we constructed a new material flows data set which covers 22 countries within the region, for the period 1970 to 2008, using a standardized methodology based on that defined in Eurostat (2011). This considerably extends the number of countries and the length of time series for which such standardized data is now available, and is important in facilitating more direct comparison with other national, regional, and global studies(Gierlinger and Krausmann, 2012; Krausmann et al., 2009, 2011; Schandl and West, 2010). The extended and standardized data coverage has enabled us to provide analysis for the region as a whole, a major point of difference with previous studies which tended to focus on individual countries e.g. Chile (Giljum, 2004), Colombia (Perez Rincon, 2006; Vallejo et al., 2011), Ecuador (Vallejo, 2010), and Mexico (Gonzalez-Martinez and Schandl, 2008), or provide comparative analysis for a small group of countries e.g. 5 countries (Russi et al., 2008).

We also develop an account of the degree to which this world region's socio-metabolic profile is shaped by development abroad, highlighting how much of Latin America's economic development has been oriented towards increasing exports of primary resources. This is significant because previous studies have linked primary export driven patterns of development to economic structures characterized by underdevelopment and inequality (Bunker, 1984a; Giljum and Eisenmenger, 2004).

From the turn of the millennium the global economy entered a period characterized by rising and more volatile prices for natural resources—fossil fuels, metals, and food—(McKinsey Global Institute 2011), driven by the dynamic growth of large developing economies, especially China (UNEP, 2011). In such a rapidly changing context, governments increasingly require information systems that provide insight into the trends of natural resources production and use, to complement the set of economic indicators traditionally used for policy formation and planning. There is a need to broaden the compass employed in decision making (Bartelmus, 2003). Two main systems have been employed to organize such information, the System of Economic and Environmental Accounts (SEEA) of the United Nations (Bartelmus, 2007) and the material flows accounting (MFA) approach promoted by the Organisation for Economic Co-operation and Development (Haberl et al., 2004). The latter approach is relevant to this study. Both frameworks are compatible with the System of National Accounts. The SEEA accounts for changes in natural resource stocks, while the MFA accounts for flows between the economy and the environment. Usually, MFA data is easier to gather than data for a comprehensive SEEA but both frameworks are highly linked which has now been formally acknowledged by the updated version of SEEA (United Nations 2012).

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Material flow accounting has been used to assemble information on the material requirements of national economies since the 1990s, largely implementing a basic program set out in the late 1960s by Robert Ayres and Allen Kneese (Fischer-Kowalski, 1998). This accounting approach provides a knowledge base essential to quantifying the relative resource efficiencies and socio-metabolic performance of different national economies, i.e. the amounts and characteristics of materials used in production and consumption. Such information has increasingly been regarded as policy relevant (NRC 2004, 2008) especially with regard to the supply security of strategic materials such as certain metals.

More recently, the science and policy community has reached broad agreement on the methodologies to be employed in MFA (Fischer-Kowalski et al., 2011), and produced studies on global material use (Behrens et al., 2007; Krausmann et al., 2009; Schandl and Eisenmenger, 2006), and for a number of world regions e.g. Europe (Weisz et al., 2006) and Asia and the Pacific (Schandl and West, 2010).[1] This research adds Latin America and the Caribbean as a third world region for which we now have material flow and resource productivity data, which can now be used to inform an integrated approach to economic and environmental policy making in this region.

2. Methods and Data Sources

The methods used to create the material flow account for Latin America and the Caribbean were largely the same as those used previously to assemble a similar database for the Asia Pacific region, as described in Schandl and West (2010). We provide here a summary and references to base data sources, along with detail on any significant departures from, or refinements of, the earlier methods. An expanded description is available in the technical annex to the online data set, available at www.csiro.au/LatinAmericaCaribbeanResourceFlows.

Virtually all processing and transformation of data from the initial base data sets was carried out using the open source R language platform, which is freely available at http://cran.r-project.org.[2] Well accepted and publically accessible international data sources were used for base data, to the extent possible, however it was not feasible to avoid using some data sets which require subscription fees.

In compiling the data we adhered to the methodological guidelines set out in Eurostat (2011) as closely as practicable. One significant variation is that the highest level four category breakdown of material flows used here is into biomass, fossil energy carriers, metal ores and industrial minerals, and construction minerals, whereas in Eurostat (2011) the industrial minerals and construction minerals are combined under non-metallic minerals, and remain somewhat entangled even at the next level of disaggregation.

2.1. Biomass

Biomass flows were calculated independently for four sub-categories: primary crops, crop residues, grazed biomass, and wood.[3] Base data for the domestic extraction (DE) of primary crops is from (FAO, 2011c), while data on exports and imports used to calculated domestic material consumption (DMC) was sourced from (FAO, 2011d).To calculate crop residues, harvest factors and recovery rates for specific crops and sub-regions of Latin America and the Caribbean were sourced from (Haberl et al., 2007) and applied to the FAO crop production figures for each country.

To calculate grazed biomass, any energy "feed gap" between the energy embodied in animal products produced, and the animal specific energy available from feeds recorded in (FAO, 2011a), was assumed to be made up, for ruminants, by intake of grazed biomass. The animal product, animal specific feed energies, and pasture energy factors were all sourced from (Wirsenius, 2000). In addition to updated data sources, improvements over procedure used in (Schandl and West, 2010) included adjusting animal products production to account for the trade in live animals recorded in (FAO, 2011d), and inclusion of fish in feed inputs.

For wood, DE tonnages were calculated by applying factors supplied in (Eurostat, 2011), to the appropriate volumes of all round woods extracted and reported in (FAO, 2011b). There is an intentional mismatch between the scope of products included in calculating DE tonnages, and that used for traded tonnages. This is to better capture some major flows of near primary materials in trade, while avoiding multiple counting of the same mass in accounting for domestic production. All wood trade data was sourced from (FAO, 2011b).

2.2. Metal Ores and Industrial Minerals

The key base data sources used for DE for both sub-categories (metal ores, industrial minerals) were the same, and used in the same order of preference. Data from (Matos, 2009) was used where available, and where not available (UN Statistics Division, 2011b) used. Data for latter years not covered by (Matos, 2009), for some of the most volumetrically important minerals, was sourced from individual commodity spreadsheets at (USGS, 2011), in preference to using (UN Statistics Division, 2011b) data. These sources typically stated production in terms of contained metals or compounds, so to convert this to tonnages of ore, grade factors have been applied. These grade factors used were largely derived from published and unpublished work by Gavin Mudd, notably (Mudd, 2007a, b), and as such reflect Australian averages. There will clearly be error involved in applying an individual country's grades to other countries, however the large size and market driven nature of the Australian mining sector should mitigate this risk for the major bulk commodities categories, driving average Austalian grades towards a convergence with grades at which such commodities can profitably be mined. One important exception to the use of Australian grades was the grade applied to copper, which had an estimate of world average grades over time available from (Gerst, 2008). Detail on how the disparate reporting bases used in the base data were treated, and on how co-production and by-production were dealt with, are contained in the technical annex at www.csiro.au/LatinAmericaCaribbeanResourceFlows.

The base trade data required to calculate DMC from DE was sourced from (UN Statistics Division, 2011a).

2.3. Construction Minerals

DE of construction minerals has been calculated by applying a time varying factor to DMC of cement. This approach is used in preference to compiling totals from the production statistics on individual construction minerals, due to the generally poor state of such statistics, and the relative reliability of statistics on cement. Statistics on cement production were sourced from (Matos, 2009; USGS, 2011), and cement trade from (UN Statistics Division, 2011a). The time varying factors applied to calculate DE were the same as used in (Schandl and West, 2010), and were originally derived from (Krausmann et al., 2009).[4]

[1] There is a rich literature on material flow accounting at the national level mostly accessible in the 'Journal of Industrial Ecology' and the journal 'Ecological Economics'.

[2] Open source software was chosen to ensure that software cost barriers would not be an issue for anyone choosing to reproduce the set of manipulations on primary data sets outlined in the technical annex at www.csiro.au/LatinAmericaCaribbeanResourceFlows. R was selected due to its widespread use in statistical applications and large existing user base and support network.

[3] Fish catch was ignored in this analysis. Wild fish catch is very small in raw mass terms when compared to other biomass flows. Their contribution to livestock feed energy, however, is proportionally much more significant and had to be included in feed gap modelling for animals.

[4] A detailed description of the methodology and its advantages is given in the technical annex to the online database at www.csiro.au/LatinAmericaCaribbeanResourceFlows.