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# The effects of globalization on Ecological Footprints: an empirical analysis

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**Abstract** Whether globalization is sustainable is a contested issue. The quantitative literature on the Maastricht Globalization Index (MGI) and the KOF index of globalization shows that globalization contributes positively to economic and human development, environmental performance, mortality, gender equality and physical integrity rights. However, globalization also drives within-country income inequality, especially in developing countries. Evidence on the effects of globalization on the ecological environment does not provide clear patterns; various dimensions of globalization have different effects on various pollutants. This article analyzes the statistical relationship between the most recent MGI (2012 edition) and the ecological dimension of sustainable development. The latter will be operationalized by considering four variants of the Ecological Footprint. The relation between globalization and sustainable development will be controlled for GDP per capita as a proxy for affluence and report the results for Pearson's correlations and multivariate regressions for up to 171 countries. We conclude that the overall index of globalization significantly increases the Ecological Footprint of consumption, exports and imports. The decomposition of globalization into different domains reveals that apart from the political dimension, all dimensions drive human pressures and demands on the environment. Globalization needs to go into new directions if it is to make a contribution toward all aspects of sustainable development.

**Keywords** Globalization · MGI · Sustainable development · Environmental footprints · Ecological Footprint

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## 1 Introduction

Globalization and its causes and consequences are defined and analyzed in different ways by different scholars depending on their discipline and worldview (Dreher et al. 2008; Jones 2010). Notwithstanding the vast amount of literature on the topic of globalization, it remains hard to get the drift of this phenomenon. This partially results from the ways in which globalization is defined. A commonly accepted definition of globalization is *the intensification of cross-national interactions that promote the establishment of trans-national structures and the global integration of cultural, economic, ecological, political, technological and social processes on global, supra-national, national, regional and local levels* (Rennen and Martens 2003). This definition's focus on multiple scales and domains imposes methodological challenges to measure the phenomenon of globalization. From a global systems perspective, globalization can be approached as the growing interconnectedness of subsystems resulting in increasing system complexity at various scales (Jessop 2000; Urry 2005), further exacerbating the methodological challenges of assessment.

Measurement and quantitative assessment of globalization and its consequences is important to provide sound empirical facts for a debate that is ridden by conceptual ambiguity, ambivalent causal claims and conflicting worldviews. One powerful tool to measure, illustrate, monitor and communicate the complexity and multidimensionality inherent to globalization is globalization indices (GI). GIs allow for a relative ranking or comparison of country performance (OECD 2008) with respect to globalization, on the basis of indicators. Two scientifically validated indices are the Maastricht Globalization Index (MGI) (Figge and Martens 2014; Martens and Raza 2009) and the KOF index of globalization (the latter index was developed at the KOF Swiss Economic Institute, and KOF is the acronym for the German word "Konjunkturforschungsstelle" which means business cycle research institute; Dreher 2006; Dreher et al. 2008). Previous indices usually praised those countries which have been most globalized, implying that being more globalized is a desirable outcome (Dreher et al. 2008). However, being more globalized does not necessarily imply positive outcomes as illustrated by the MGI which, for example, includes the Ecological Footprint of trade as a percentage of domestic biocapacity as a measure of ecological globalization (Figge and Martens 2014). This means that a more globalized country puts larger pressures on ecosystems, either at home or elsewhere, which can be considered negative from a sustainability perspective. Therefore, the most globalized countries are not necessarily the most sustainable countries. GIs by themselves do not say anything about the effects or consequences of globalization and are unable to conclude whether globalization is "good or bad." There is an increasing need for assessing the consequences or effects of globalization, for instance through researching the (statistical) effects of GIs on sustainability indicators in the ecological, economic and social domain.

A positive effect between GIs and sustainability indicators would generally be considered sustainable. However, the sustainability of globalization (e.g., the relation between GIs and sustainability indicators) may not be in the same direction for all nations and an evaluation of trade-offs may be necessary. Besides, sustainable development in one domain may not necessarily coincide with sustainable development in another domain. In the best-case scenario globalization simultaneously contributes to sustainable development in the economy, society and ecology in all countries. Literature however already indicates that globalization is unlikely to achieve these objectives simultaneously (Martens and Rotmans

2002). One of the most pressing sustainability issues of our times is the increasing human demands on ecosystems which have been quantified as environmental footprints. The evidence shows that humanity's environmental footprint is highly un-sustainable and that radical changes in the global human organization are warranted (Hoekstra and Wiedmann 2014).

Section two of this paper reviews the quantitative globalization literature and reveals that very little is known about the effects of globalization on ecological aspects related to human consumption and production. This represents a crucial gap in the academic literature that is addressed in this article. From a global perspective, it is relevant to know whether externalized pressures are intensified by the process of globalization, irrespective of the geography of their impact. Our research question is: To what extent does globalization and its different domains intensify environmental footprints and/or contribute to ecologically sustainable development?

## 2 Literature review

### 2.1 On MGI

Analyzing the relation between globalization and sustainable development is not entirely new. Martens and Raza (2010) already analyzed whether globalization is sustainable by regressing the 2008 edition of the MGI for 117 countries against a broad selection of sustainability indices: the Human Development Index (HDI), the Environmental Performance Index (EPI), the Global Environment Facility Benefits Index (GBI), the Responsible Competitiveness Index (RCI) and the Sustainable Society Index (SSI). The results of their analysis do not provide clear patterns as the MGI correlates positively with the HDI, EPI and RCI, negatively with the GBI and has no significant correlation with the SSI. However, when controlling for the potential effects of GDP per capita, the results change: The coefficient of the MGI (and therewith the relation between globalization and sustainability) turns negative for the HDI, remains negative for the GBI and positive for the RCI and has no significant correlation with the EPI and SSI. Furthermore, the authors showed that the means of high and low globalized countries significantly differ for the HDI, EPI and RCI, but not for the GBI and the SSI. Martens and Raza (2010) conclude that the relationship between sustainability and globalization is a complex one since it may be positive in one domain (e.g., economic or human development) and negative in another one (e.g., environmental). This however may also be due to conceptual and empirical ambiguity of sustainability. In their review of sustainability indices, Pillarisetti and van den Bergh (2010) show that the different indices produce contradicting results that vary greatly—countries deemed sustainable according to one index, are un-sustainable according to another. Accordingly, the usefulness and particularly the accurateness of linking GIs to a multitude of diverging sustainability indices can be questioned. We argue that part of the ambiguity can be explained by the use and inclusion of (too) many indices that are too broad. For instance, the study of Martens and Raza (2010) looks at a wide ranging diversity of topics, and as a consequence, no clear conclusions and recommendations can be reached for any of the issues. It may therefore be better to focus the analysis of individual studies on single issues and more specific indicators.

Another study with the MGI that does so examined the question whether globalization is healthy (Martens et al. 2010) by looking at mortality rates of infants, under 5-year olds and

adults. The study gives an overview of potential positive and negative impacts of globalization on health outcomes. Overall, the MGI and its five subdomains (political, economic, social, technological and ecological) are all significantly and negatively correlated with the mortality indicators. The more globalized countries can thus be considered to have lower mortality rates. Martens et al. (2010) included control variables and tested their relevance in multiple regression models. In this procedure, the coefficient of the MGI remains negative and significant in multiple regression models for all three health indicators. The authors conclude that countries which are more globalized achieve better health results.

## 2.2 On KOF

The KOF index of globalization has been used in more than 100 studies which reveal diverging results in terms of the effects of globalization on several indicators. None of those framed the study of globalization in terms of ecological sustainability and/or sustainable development. A review study by Potrafke (2014) has shown that globalization has positive effects on economic growth, human development, gender equality, women's rights and physical integrity rights. However, also negative effects were revealed as globalization has been shown to increase within-country income inequality, especially in developing countries (Potrafke 2014). The review study does not discuss the ecological consequences or effects of globalization which is due to the absence of articles on those issues.

The only exemption is the book by Dreher et al. (2008). They use the KOF index to analyze the effects of globalization on various ecological pressures: carbon dioxide, sulfur dioxide, biochemical oxygen demand (a proxy for water pollution) and round wood production. The authors estimated a panel (1970–2000) and a 30-year cross-sectional average. The panel regressions show that overall globalization reduces sulfur dioxide emissions and water pollution, and find no effect on carbon dioxide and round wood production. When splitting up the globalization index in three subcomponents (economic, political and social), the study finds that economic globalization has a small positive (increasing) effect on round wood production; social globalization has a small and positive effect on the emission of carbon dioxide and political globalization decreases water pollution. The 30-year cross-sectional approach yields that overall globalization increases water pollution and round wood production, economic globalization increases sulfur dioxide emissions, social globalization increases water pollution and round wood production, while the political dimension has no effect at all. These results can be considered ambiguous and even contradictory, which comes from the fact that the study looks at a diverse set of ecological pressures, instead of focusing on one specific issue. This further justifies more research to conceptualize, operationalize and analyze the effects of globalization on the ecological dimension of sustainable development.

Although the current literature covers the effects of globalization on various (sustainability) indicators, there is not a lot of attention to the effects on globalization on environmental footprints. This represents a crucial gap that is addressed in this article. The next section presents a method to analyze the relation between the multiple dimensions of globalization and the ecological aspects of sustainable development. Innovative in our approach is the inclusion of environmental footprints to expand the focus of the current literature in two ways: First we go beyond social, health and economic factors and explicitly add the ecological sustainability domain in the analysis. We do so by focusing on a single issue (human demands on ecosystems) rather than employing a collection of broad indices and/or indicators.

## 3 Method and data

In order to address our research question, we use the MGI to measure globalization and include Ecological Footprints to operationalize the ecological dimension of sustainable development.

### 3.1 The Ecological Footprint

Environmental footprints quantify the human demand on the natural environment and have the advantage that they can be linked to the (theoretical) carrying capacity of our earth's ecosystems (Borucke et al. 2013; Global Footprint Network 2012; Hoekstra and Wiedmann 2014). This is crucial as development can only be deemed sustainable if it stays within the (global) boundary conditions of the ecological environment and/or the world budget constraint (Lianos 2013). Recent research makes clear that humanity's pressures on the environment are currently unsustainable (Hoekstra and Wiedmann 2014; Steffen et al. 2015a, b). One of the most advanced concepts and measures available that quantifies human demands on the ecological environment is the Ecological Footprint (Borucke et al. 2013; Global Footprint Network 2012; Hoekstra and Wiedmann 2014).

The Ecological Footprint (EF) was developed in a response to the incapacity of monetary analyses to capture the consequences of the accelerating depletion of natural capital stocks. The EF has been designed as direct biophysical measurement of relevant stocks and flows to comprehend human demands on natural capital (Wackernagel and Rees 1996). It captures the productive capacity of nature to provide resources for consumption (provisioning services) and its capacity as a sink to take up waste (regulating services; Ewing et al. 2010). More specifically, biocapacity represents *a measure of the amount of biologically productive land and sea area available to provide the ecosystem services that humanity consumes—our ecological budget or nature's regenerative capacity* (Borucke et al. 2013). The EF is quantified by multiplying the productive area (standardized to global hectares) with the specific domestic yield factor of a country (Global Footprint Network 2012). The EF accounts for six different land use types in terms of bioproductive area: cropland, forest, grazing land, marine and inland water, built-up land and carbon uptake land. The built-up land represents constructed areas like cities. Uptake land is an expression for the demand on waste disposal in equivalent $CO_2$ emissions to be taken up by vegetation and also referred to as the energy footprint (Borucke et al. 2013).

To increase the relevance of the concept of EFs in the discussion on globalization, we need to realize that in a world with increasingly globalized trade flows many products are not consumed at their place of production. To analyze the effect of globalization on human pressures, it would therefore not be enough to only analyze a (country-specific) footprint of production; what we need is a consumption-based quantification of the EF. Therefore, the EF of consumption is calculated as the sum of the EF of production and imports minus the EF of exports (see Borucke et al. 2013). As such, it considers the EF necessary to fulfill the (present) consumption demands of countries while considering the externalities that the production of these consumption goods exerts on the countries of production. We employ the 2011 edition of the National Footprint Accounts (Global Footprint Network 2012) and look at the per capita EF of consumption, production, exports and imports, at the national level, to make it comparable across countries. It is important to make this distinction, as according to Chen and Han (2015) one-third of global arable land use is embodied in trade flows.

### 3.2 The Maastricht Globalization Index

In this study, we employ the extended 2012 edition of the Maastricht Globalization Index (Figge and Martens 2014). The MGI was first developed by Martens and Zywietz (2006) and later on improved by Martens and Raza (2009) and Figge and Martens (2014). The MGI covers five domains: the political, economic, social–cultural, technological and ecological. Except for the latter, these domains are further operationalized by different variables (see Table 1). The choice of variables and their data sources have been documented and elaborated before and are therefore not addressed in more detail here. For a recent critical perspective and overview on the measurement of globalization, we refer to Martens et al. (2015).

To calculate the globalization indices, each variable is transformed on a zero to hundred scale using the formula $((V_i - V_{min})/(V_{max} - V_{min}) \times 100)$ with V meaning value. Indicator values are aggregated by simple addition, using equal weighting on the domain and index level. Values closer to hundred denote more globalization. To be able to draw a more nuanced picture and to disentangle the effects of the different domains, we use the overall index and the subindices although previous studies with the MGI only employed the overall index in multivariate regressions.

The single indicator for the ecological dimension refers to the earlier-discussed EF of imports and exports as a share of biocapacity. In order to not include the same measurement (EF of imports and exports) in the dependent and independent variable at the same time, we adjust the overall MGI by omitting the ecological dimension in the final index calculation. This is a necessary adjustment of the MGI which is in line with an argument put forward by Rennen and Martens (2003) that the environmental factors of globalization

**Table 1** Domains and indicators of the Maastricht Globalization Index (MGI), adjusted from Figge and Martens (2014)

| Category | Variable name | Variable definition |
|---|---|---|
| Political domain (1/4) | Embassies (1/3) | Absolute number of in-country embassies and high commissions |
| | Organizations (1/3) | Absolute number of memberships in international organizations |
| | Military (1/3) | Trade in conventional arms as a share of military spending |
| Economic domain (1/4) | Trade (1/3) | Imports + exports of goods and services as a share of GDP |
| | Foreign direct investment (FDI) (1/3) | Gross foreign direct investment, stocks (% of GDP) |
| | Capital (1/3) | Absolute value of net private capital flows (% of GDP) |
| Social and cultural domain (1/4) | Migrants (1/2) | International migrant stock as a share of population |
| | Tourism (1/2) | International arrivals + departures per 100 inhabitants |
| Technological domain (1/4) | Phone (1/2) | Mobile cellular subscriptions per 100 inhabitants |
| | Internet (1/2) | Internet users as a share of population |
| Ecological domain (omitted) | Eco footprint | Ecological Footprint of imports and exports as a share of biocapacity |

differ from the others in so far that those are rather the consequence of globalization than a driving force. This adjustment has to be taken into consideration when analyzing and interpreting the results. For the sake of completeness, we report the results for the ecological dimension in the calculations when splitting up the index.

While the 2012 MGI edition (Figge and Martens 2014) covered 117 countries, we extended the coverage to 183 countries for this study which is close to global coverage. The addition of further countries is restricted due to the absence of available data. Also for the countries that are currently included in the MGI, we sometimes face missing data, an often occurring problem when calculating composite indices (OECD 2008). Two different methods are being used here: cold check imputations and unconditional mean imputations [see OECD (2008) for more information] while using mean values for 19 different geographical regions intended to serve the accuracy of the results. The imputation of data is restricted to maximal four missing values in variables, and the methods have been checked against their impact on the normal distribution of the indicators for every domain.

### 3.3 Estimation strategy to relate globalization to Ecological Footprints

In order to assess to what extent globalization contributes to ecologically sustainable development, we conduct a regression analysis with the footprints as the dependent and the globalization indices as the independent variables. First, we estimate Spearman's correlations to assess the bivariate statistical relationship between the globalization indices and the EFs irrespective of other factors. This provides a first crude overview of the (potential) effects of globalization. The disadvantage is, however, that it only allows looking at the relationship between globalization and one footprint (production, consumption, export or import) at a time. Following Dreher et al. (2008), Martens et al. (2010) and Martens and Raza (2010), we subsequently estimate multivariate equations of the following type, using ordinary least squares (OLS):

$$Y_i = \alpha_i + \beta_1 \mathrm{Glob}_i + \beta_2 A_i + \beta_3 A_i^2 + \varepsilon_i$$

where $Y$ is the natural log of the EF per capita measure. Glob is overall globalization index or the respective subindices. A is the level of affluence, measured as the natural log of GDP per capita (World Bank 2014). Affluence is considered to be the key determinant of human demands on the environment and is consistently shown to have significant and sizable effects (Jorgenson and Clark 2011; Rosa et al. 2004; York et al. 2003). We include the squared term to test for nonlinear relationships. $\alpha$ is the intercept, and $\varepsilon$ is the standard error term. In order to disentangle the effects of the domains of globalization, we conduct stepwise inclusion based on the individual results of the Spearman correlations. In the final models, we only include or report those variables (dependent and independent) for which have found significant effects. If the ecological globalization index is found to be significant, we also report the respective models. This will show which aspects of globalization (if any) have significant effects on the environmental footprints and therefore provide more nuanced insights. Coefficients that are significant and negative would provide evidence that globalization contributes so sustainable development as it contributes to decreasing environmental footprints. Insignificant coefficients mean that there is no relationship and coefficients that are positive and significant mean that globalization increases ecological demands and thereby contributes to ecologically un-sustainable development.

## 4 Results and discussion

Table 2 and Fig. 1 indicate that overall globalization and the subindices positively and significantly correlate with all variants of the EF. This leads us to a first unambiguous conclusion that more globalized countries have higher EFs and therefore put higher pressures on ecosystems. This is in stark contrast with the finding of Martens and Raza (2010) who found that globalization and all its dimensions correlate positively with the Environmental Performance Index (EPI). The EPI looks at two issues, protection of human health and ecosystems, and however is quite different from the EF in two respects: First, it contains aspects of human health, which correlate strongly with development indicators (and thereby globalization). Second, the ecosystem vitality aspects, which are more comparable to the EF, look at efficiency and trend indicators issues, rather than actual impacts or levels. From an environmental perspective, trends are of course important, but what matters more are the actual levels, which are better captured by the EFs.

We now turn to the results for the multivariate regressions while controlling for GDP and its squared term. For the EF of consumption, we find that the overall MGI is positive and significant at the 10 % level (note that we do not indicate the 10 % significance level in the results tables, see Table 3). Further we see that this effect is not only significant, but also sizeable as a one-point increase in globalization corresponds with a 1 % increase of the EF of consumption. To put this into context, the standard deviation of the MGI is 12 points with a mean score of 44.88. The results from Figge and Martens (2014) found that on average countries globalized by about 11 points between 2000 and 2012, thereby increasing EFs by 11 percent. This corresponds to a difference in globalization, for example, between the Netherlands (64) and Poland (53). Globally the EF is approximately 50 % beyond biocapacity. Accordingly, a reduction of the EF by approximately 30 % would reconcile human demands with biophysical limits, a condition for sustainable development. In terms of globalization, this is the difference between the Netherlands (64) and Indonesia (34). A deglobalization of this magnitude on a global scale is probably not desirable and certainly not put forward here. Much more, given the global development agenda and discourse, including the new set of sustainable development goals, this is obviously also not a policy consideration or option that would be taken seriously. A remaining policy question would rather be how globalization could be used to steer and support development into more sustainable directions.

**Table 2** Spearman's correlations for MGI, its domains, the Ecological Footprint of consumption, exports, imports and production

| $n = 181$ | ln $EF_{Consumption}$ | ln $EF_{Exports}$ | ln $EF_{Imports}$ | ln $EF_{Production}$ |
|---|---|---|---|---|
| MGI | 0.7505** | 0.7187** | 0.8891** | 0.5420** |
| *MGI domains* | | | | |
| Political | 0.3218** | 0.4135** | 0.2357** | 0.4035** |
| Economic | 0.3420** | 0.1954** | 0.3935** | 0.1711* |
| Social and cultural | 0.6207** | 0.5933** | 0.7710** | 0.4181** |
| Technological | 0.7373** | 0.7200** | 0.8386** | 0.5725** |
| Ecological | 0.5659** | 0.5294** | 0.8190** | 0.2848** |

* $p \leq 0.05$; ** $p \leq 0.01$; all dependent variables are in per capita terms

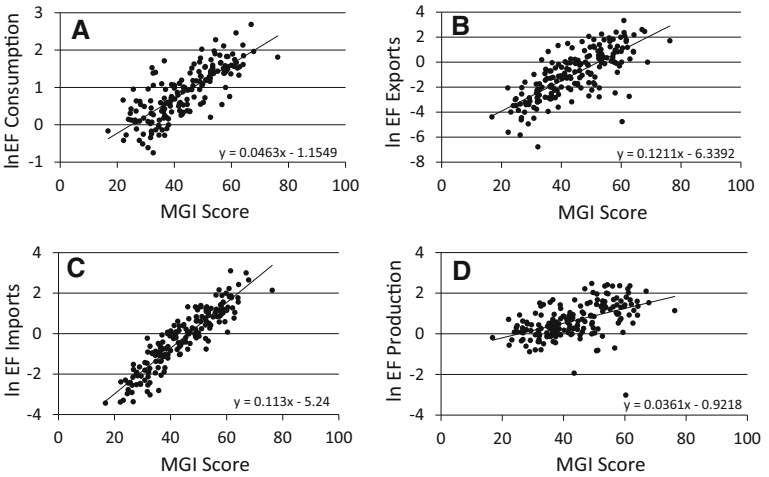


**Fig. 1** Scatterplots and linear regressions of the MGI and the logarithm of **a** the Ecological Footprint of consumption, **b** the EF of exports, **c** of imports, **d** of production ($n = 181$)

**Table 3** Multivariate regression models of the MGI, the Ecological Footprint of consumption, exports, imports and production, controlling for GDP per capita and its squared expression

| Model | ln $EF_{Consumption}$ | ln $EF_{Exports}$ | ln $EF_{Imports}$ | ln $EF_{Production}$ |
|---|---|---|---|---|
| MGI | 0.0098 (1.92) | 0.0366* (2.39) | 0.0725** (9.39) | −0.0124 (−1.70) |
| ln GDPpc | −0.0468 (−0.23) | 1.6744** (2.78) | 0.8930** (3.12) | −0.0140 (−0.05) |
| ln $(GDPpc)^2$ | 0.0223 (1.88) | −0.0521 (−1.46) | −0.0319 (−1.90) | 0.0282 (1.71) |
| Constant | −0.7938 (−0.97) | −12.8458** (−5.19) | −8.6368** (−7.36) | −0.6888 (−0.60) |
| Adj. $r^2$ | 0.7391 | 0.6871 | 0.8718 | 0.5691 |
| $F$ value | 159.67** | 125.45** | 384.20 | 74.53** |
| $n$ | 169 | 171 | 170 | 168 |

* $p \leq 0.05$; ** $p \leq 0.01$; $t$ values in parentheses; all dependent variables are in per capita (pc) terms

While the explained variance is high ($r^2 = 0.74$) and the $F$ value is highly significant, we do not find GDP per capita to be significant in explaining differences in the EF of consumption. This is in stark contrast with previous research that looked at the determinants of the EF. GDP had consistently been shown to be a significant and sizable determinant of EFs (Dietz et al. 2007; Jorgenson and Clark 2009, 2011; Rosa et al. 2004; York et al. 2003) and other pollutants (Dreher et al. 2008; Gassebner et al. 2011; Lamla 2009). This raises some questions about the relation between affluence and globalization. One interpretation could be that in those other studies GDP captures effects that should be attributed to the process of globalization. The discussion around the Environmental Kuznets Curve switches the argument around and argues that globalization processes operate through GDP [see for instance (Dinda 2004; Stern 2004)], which makes controlling for globalization theoretically redundant. The globalization literature has consistently shown that globalization drives GDP and its growth rates (Dreher 2006; Dreher et al. 2008;

Potrafke 2014). So there is no definite answer to this issue, as those processes are very likely to influence each other which creates a complexity that cannot be addressed with the methods employed here. It seems, nevertheless, that taken together affluence and globalization rather increase EFs.

This is supported by our further findings. For the EF of exports and imports, the effects are even higher and more significant. A one-point increase in globalization corresponds to an increase of 3.6 % in exports and 7.2 % in imports. This should be of no surprise. Studies with the EF have shown that almost a third of global arable land use is embodied in international trade (Chen and Han 2015), so these effects of globalization need to be taken seriously.

The further elaboration of multivariate models builds on the previous findings; as the results indicate that the EF of production is not significantly influenced by globalization, we omit this variable in the subsequent analysis. Table 4 reports the final multivariate regression models of globalization (the MGI subindices) and the EF of consumption, exports and imports. Table 5 summarizes the main findings. Overall we find that globalization contributes to higher environmental footprints and thereby to ecologically unsustainable development.

We also find that not all dimensions of globalization have significant effects on the different footprints. The results show that it is indeed worthwhile to split up the MGI into its subindices as it draws a more nuanced picture and allowed us to see which aspects of globalization are driving which footprints. While this has been common practice in studies with the KOF, previous studies with the MGI refrained from splitting up the globalization index. Why is this important?

Despite finding significant bivariate effects in the Spearman correlations, some of those cancel each other out in the multivariate regressions models: Different dimensions of globalization have different effects on EFs. Further, as was the case before, some of the effects are canceled out by the inclusion of GDP per capita. As argued before, globalization

**Table 4** Multivariate regression models of MGI dimensions and the Ecological Footprints under the control of GDP per capita and its squared term

| Model | ln $EF_{Consumption}$ | ln $EF_{Exports}$ | ln $EF_{Imports}$ | ln $EF_{Imports}$ |
|---|---|---|---|---|
| Technological | – | – | 0.0106** (3.03) | 0.0143** (3.43) |
| Social and cultural | – | 0.0152* (2.02) | 0.0118** (3.34) | 0.0183** (4.53) |
| Ecological | – | – | 0.0265** (8.08) | – |
| Economic | 0.0107** (3.61) | – | 0.0203** (4.85) | 0.0194** (4.10) |
| Political | – | – | – | – |
| ln GDPpc | −0.0291 (−0.15) | 1.7842** (2.96) | −0.4241 (−1.89) | 0.9526** (3.23) |
| ln $(GDPpc)^2$ | 0.0238* (2.07) | −0.0514 (−1.44) | 0.1893** (4.45) | −0.0288 (−1.68) |
| Constant | −1.0660 (−1.33) | −13.0659** (−5.25) | −4.3302** (−12.06) | −8.5738** (−6.89) |
| Adj. $r^2$ | 0.7528 | 0.6842 | 0.9008 | 0.8664 |
| $F$ value | 171.58** | 123.75** | 253.88** | 220.12** |
| $n$ | 169 | 171 | 170 | 170 |

Only significant variables are mentioned

* $p \leq 0.05$; ** $p \leq 0.01$, $t$ values in parentheses; all dependent variables are in per capita (pc) terms

**Table 5** Summary of % effects of a one-point increase in globalization on the footprints

| | EF cons. (%) | EF prod. | EF imports (%) | EF exports (%) |
|---|---|---|---|---|
| MGI overall | +1 | | +7.2 | +3.6 |
| Economic | +1 | | +2 | |
| Political | | | | |
| Socio-cultural | | | +1.5 | +1.8 |
| Technological | | | +1.4 | |

has been shown to enhance GDP and its growth. So despite some of the direct effects decreasing or disappearing, the overall effects of globalization are not to be neglected as indirect ones are captured by GDP. The same can and should be expected for other indicators and indices, for instance those looked at in the study by Martens and Raza (2010). They find ample significant effects for the subindices of the MGI in the bivariate regressions, but then do not include those separately in the multivariate regressions.

For the ecological dimension, we find significant effects for the EF of imports; however, for the reasons mentioned before those results should not be further taken into consideration. A point to be made, however, is that the omission of the ecological domain leads only to small changes in the size of the effects of the variables. The overall explained variances ($r^2$) do not change dramatically. This shows that the omission of the ecological dimension is unproblematic when assessing the impacts of globalization. For GDP per capita, we find very similar effects as in the previous models when looking at overall globalization.

We do not find any effects for political globalization. While this is suspicious, Dreher et al. (2008) find the same when looking at the effects of globalization on different pollutants, without discussing it further. Although we did not investigate this empirically, we see three potential reasons and/or complications: First, the level to which a country is politically globalized does indeed not have an effect on ecological pressures. Second, it may be a measurement issue. The indicators used to proxy the political dimension may not capture the phenomenon precisely. Also, and more importantly, the political indicators are measured in different units: absolute number of embassies and organizations, for instance, rather than in per capita terms or as a percentage of the economy, as all of the other indicators (see Table 1). They therefore may not be fit for purpose, and more suitable indicators and data may be necessary. A third possible explanation is that positive and negative effects cancel each other out.

Assuming correct measurement, this means that some aspects of political globalization may have positive effects on EFs, while other ones may have negative effects. This is not an unlikely explanation as integration into international organizations and more diplomatic relations, for example, may result in better policies and actions for the environment, by enhancing knowledge and improving international cooperation on environmental issues. But it may equally also result in policies and actions that rather intensify ecological pressures, by opening up markets and thereby creating new pressures on the environment. Other globalization indicators and domains may of course suffer from the same issues. Globalization and its subdomains describe and capture broad societal processes which may have very ambiguous effects on the environment and are difficult to disentangle with the data and the estimation techniques used in this study.

We want to discuss two limitations and suggestions for further research. First, we recommend employing panel data, which allows studying a longer time period instead of

looking at one point in time only. This would allow filtering out time and country-specific effects. Using the KOF index which is available from 1971 onwards, may be a promising strategy in this respect. Second, the broad variation in results between the different employed methods (simple regression and multivariate regression) reveals the necessity to further investigate confounding factors that potentially effect the relation between globalization and sustainability and that could be taken into consideration. In this study, we control only for GDP per capita, while the literature looking at the determinants of EFs and pollution suggests many more potential variables (e.g., (Dietz et al. 2007; Gassebner et al. 2011; Jorgenson and Clark 2011; Lamla 2009). This means that the results may suffer from an omitted variable bias. It is worthwhile to do more research into this direction.

## 5 Conclusions

The ecological consequences have not been a main concern of the quantitative globalization literature so far. The few studies that do include environmental aspects solely focus on water and air pollutants or look at a too diverse range of sustainability indices and therefore provide ambiguous results. In this study, we put forward and employ the Ecological Footprint as a comprehensive indicator to assess "to what extent does globalization and its different domains intensify environmental footprints and/or contribute to ecologically sustainable development?"

Methodologically, we have shown that it is worthwhile to split up the MGI in multivariate regression models as it draws a more nuanced picture. Further, the omission of the ecological dimension from the index has been necessary for this study but remains unproblematic. Recent evidence on the MGI has shown that globalization continues to increase despite the economic crisis which started unfolding in 2008 (Figge and Martens 2014). However, in its current form it does not simultaneously contribute to sustainable development in the social, economic and ecological domains. Our results show that globalization contributes to increasing pressures on the environment. And the overall effects may be even bigger as some of them operate indirectly through the level of affluence. Further control variables should be included and tested in future research. While previous studies with the MGI and KOF have found ambiguous results on the sustainability of globalization, this study provides unambiguous results. While, yes, for some variants of the EF we do not find effects, it is very clear that globalization does not have decreasing effects on EFs. Reconciling human demands within the Earth's carrying capacity remains one of the greatest challenges, and globalization is not contributing to it.

A key issue or question remains whether humanity will be able to re-direct the globalizing trends in new directions in which we continue to improve human and economic development while maintaining the health of our ecosystems. This calls for new directions and forms of future globalizations if humanity is to develop in a more sustainable way. Deterioration of the ecological environment may also result in un-intended and undesirable effects in the social and economic domain. For the future, it will be crucial to embrace the positive aspects of globalization while mitigating the related risks of an increasingly interconnected world.

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**Compliance with ethical standards**

**Conflict of interest** The authors declare that they have no conflict of interest.



## References

Borucke, M., Moore, D., Cranston, G., Gracey, K., Iha, K., Larson, J., et al. (2013). Accounting for demand and supply of the biosphere's regenerative capacity: The National Footprint Accounts' underlying methodology and framework. *Ecological Indicators, 24*, 518–533.

Chen, G., & Han, M. (2015). Global supply chain of arable land use: Production-based and consumption-based trade imbalance. *Land Use Policy, 49*, 118–130.

Dietz, T., Rosa, E. A., & York, R. (2007). Driving the human ecological footprint. *Frontiers in Ecology and the Environment, 5*(1), 13–18.

Dinda, S. (2004). Environmental Kuznets curve hypothesis: A survey. *Ecological Economics, 49*(4), 431–455. doi:10.1016/j.ecolecon.2004.02.011.

Dreher, A. (2006). Does globalization affect growth? Evidence from a new index of globalization. *Applied Economics, 38*(10), 1091–1110.

Dreher, A., Gaston, N., & Martens, P. (2008). *Measuring globalisation: Gauging its consequences*. New York: Springer.

Ewing, B., Moore, D., Goldfinger, S., Oursler, A., Reed, A., & Wackernagel, M. (2010). *Ecological footprint atlas 2010*. Oakland: Global Footprint Network.

Figge, L., & Martens, P. (2014). Globalisation continues: The Maastricht globalisation index revisited and updated. *Globalizations, 11*(6), 875–893. doi:10.1080/14747731.2014.887389.

Gassebner, M., Lamla, M. J., & Sturm, J.-E. (2011). Determinants of pollution: what do we really know? *Oxford Economic Papers, 63*(3), 568–595. doi:10.1093/oep/gpq029.

Global Footprint Network. (2012). National Footprint Accounts, 2011 edition. http://www.footprintnetwork.org.

Hoekstra, A. Y., & Wiedmann, T. O. (2014). Humanity's unsustainable environmental footprint. *Science, 344*(6188), 1114–1117.

Jessop, B. (2000). The crisis of the national spatio-temporal fix and the tendential ecological dominance of globalizing capitalism. *International Journal of Urban and Regional Research, 24*(2), 323–360. doi:10.1111/1468-2427.00251.

Jones, A. (2010). *Globalization: Key thinkers*. Hoboken: Wiley.

Jorgenson, A. K., & Clark, B. (2009). The economy, military, and ecologically unequal exchange relationships in comparative perspective: A panel study of the ecological footprints of nations, 1975–2000. *Social Problems, 56*(4), 621–646.

Jorgenson, A. K., & Clark, B. (2011). Societies consuming nature: A panel study of the ecological footprints of nations, 1960–2003. *Social Science Research, 40*(1), 226–244.

Lamla, M. J. (2009). Long-run determinants of pollution: A robustness analysis. *Ecological Economics, 69*(1), 135–144.

Lianos, T. P. (2013). The world budget constraint. *Environment, Development and Sustainability, 15*(6), 1543–1553.

Martens, P., Akin, S. M., Huynen, M., & Raza, M. (2010). Is globalization healthy: A statistical indicator analysis of the impacts of globalization on health. *Globalization and Health, 6*(1), 16.

Martens, P., Caselli, M., De Lombaerde, P., Figge, L., & Scholte, J. A. (2015). New directions in globalization indices. *Globalizations, 12*(2), 217–228. doi:10.1080/14747731.2014.944336.

Martens, P., & Raza, M. (2009). Globalisation in the 21st century: Measuring regional changes in multiple domains. *Integrated Assessment, 9*(1), 1–19.

Martens, P., & Raza, M. (2010). Is globalisation sustainable? *Sustainability, 2*(1), 280–293.

Martens, P., & Rotmans, J. (Eds.). (2002). *Transitions in a globalising world*. Lisse: Swets & Zeitlinger.

Martens, P., & Zywietz, D. (2006). Rethinking globalisation: A modified globalisation index. *Journal of International Development, 18*, 331–350.

OECD. (2008). *Handbook on constructing composite indicators: Methodology and user guide*. Paris: OECD Publishing.

Pillarisetti, J. R., & van den Bergh, J. C. (2010). Sustainable nations: What do aggregate indexes tell us? *Environment, Development and Sustainability, 12*(1), 49–62.

Potrafke, N. (2014). The evidence on globalisation. *The World Economy,*. doi:10.1111/twec.12174.

Rennen, W., & Martens, P. (2003). The globalisation timeline. *Integrated Assessment, 4*(3), 137–144.

Rosa, E. A., York, R., & Dietz, T. (2004). Tracking the anthropogenic drivers of ecological impacts. *AMBIO: A Journal of the Human Environment, 33*(8), 509–512.

Steffen, W., Broadgate, W., Deutsch, L., Gaffney, O., & Ludwig, C. (2015a). The trajectory of the Anthropocene: The great acceleration. *The Anthropocene Review,*. doi:10.1177/2053019614564785.

Steffen, W., Richardson, K., Rockström, J., Cornell, S. E., Fetzer, I., Bennett, E. M., et al. (2015b). Planetary boundaries: Guiding human development on a changing planet. *Science*. doi:10.1126/science.1259855.

Stern, D. I. (2004). The rise and fall of the environmental Kuznets curve. *World Development, 32*(8), 1419–1439.

Urry, J. (2005). The complexities of the global. *Theory, Culture and Society, 22*(5), 235–254.

Wackernagel, M., & Rees, W. (1996). *Our ecological footprint: Reducing human impact on the earth* (Vol. 9). Gabriola Island: New Society Publishers.

World Bank. (2014). *World development indicators 2014*. Washington, DC: The World Bank.

York, R., Rosa, E. A., & Dietz, T. (2003). Footprints on the earth: The environmental consequences of modernity. *American Sociological Review, 68*(2), 279–300.