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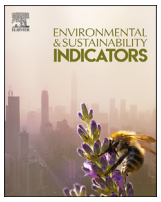

The impact of foreign direct investment on the ecological footprints of nations

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ABSTRACT

We study the effects of foreign direct investment (FDI) on the rate of exhaustion of bioproductive physical land. We test for differential ecological performance of FDI in developed vs. developing countries, as well as in "clean" vs. "dirty" sectors. We examine the impact of six sector-level FDI flows on four ecological footprints (*EF*): *Consumption EF, Production EF, Imports EF,* and *Exports EF*, compiled by the Global Footprint Network. We estimate a dynamic panel model incorporating an Environmental Kuznets Curve (EKC) and differentiating across country development levels. The findings are intriguing. *First*, High Income countries tend to experience a consumption-related ecological impact of FDI, whereas Low- and Middle-Income countries tend to experience a production-related ecological impact of FDI. *Second*, the burden of FDI-generated *Exports EF* is born disproportionately by Middle Income countries; High Income countries bear none (evidence of *FDI ecological haven*). *Third*, in High Income countries, financial services FDI reduces the *Production EF* (evidence of *FDI ecological halo*). *Finally*, non-financial services FDI is more ecologically damaging than manufacturing FDI.

Introduction

Increasing human demand for biologically productive land and ocean areas has started to have a significant impact on nature's ability to recover its ecosystems (Winzettel et al., 2013; Butchart et al., 2010; DeFries et al., 2010; Foley et al., 2005, 2011; Godfray et al., 2010a,b; Lambin and Meyfroidt, 2011; Pauly et al., 2002; Tilman et al., 2009; Wirsenius et al., 2010; Borghesi and Vercelli, 2003). The Global Footprint Network estimates that currently more than 80 percent of the world's population lives in countries that are running ecological deficits, using more resources than what their ecosystems can renew.[1] We set out to examine the effects of foreign direct investment (FDI) on the rate of exhaustion of bioproductive physical land through testing for the differential ecological performance of FDI in developed vs. developing countries, as well as in "clean" vs. "dirty" sectors. We use the *Ecological Footprint (EF),* compiled by the *Global Footprint Network* as the measure of biologically productive land.

EF is a physical, rather than an economic indicator.[2] It measures the amount of ecologically productive land area that is needed to support the resource demands and absorb the wastes from a given economic activity (Wackernagel and Rees, 1998). Since it captures the biophysical burden imposed by populations and industrial processes on the supportive ecosystems, it could be viewed as human demand for consuming nature (Rees, 2001; Kissinger and Rees, 2010a,b).[3] *EF* is measured in global hectares area (gha); that is, in units of biologically productive space based on world average productivity. The *Global Footprint Network* defines four different kinds of ecological footprints: *Consumption EF, Production EF, Imports EF,* and *Exports EF*, computed based on the National Footprint Accounts of Global Footprint Network. The *Consumption EF* indicates the consumption of biocapacity embedded directly in human consumption of goods and services; the *Production EF* indicates the consumption of biocapacity resulting from production processes, and the

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[1] http://www.footprintnetwork.org/our-work/ecological-footprint/.

[2] A critical overview of the EF methodology, limitations, and related issues is available in Giampietro, M., & Saltelli, A. (2014). A response to the critical overview is available in Goldfinger et al. (2014).

[3] This biophysical burden is quantified by adding the energy, the material consumption, the waste generation, and the ecosystem productivity to estimate a total ecosystem area required to support economic activities (Rees, 1992; Rees and Wackernagel, 1996; Wackernagel and Rees, 1997; Kissinger and Rees, 2010a,b).

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Imports EF and *Exports EF* indicate consumption of biocapacity, associated with international trade activities. The four ecological footprints are related to each other according to equation (1):

$$\text{Consumption EF} = \text{Production EF} + (\text{Imports EF} - \text{Exports EF}) \quad (1)$$

Foreign Direct Investment (FDI) is a financial flow traditionally associated with the transfer of knowledge, technology, and management practices from home to host countries. In the past two decades, FDI has become a very significant part of planetary-scale globalization activities. On the production side of the economy, FDI is known to have a *scale effect*, a *composition effect*, and a *technological effect* on the receiving economies. The *scale effect* is an effect on the level of economic activity, induced by the influx of additional investment in the economy. The scale effect is expected to contribute to pollution, waste, and ecological degradation. The *composition effect* of FDI is reflected in a structural shift that changes the industry mix of the receiving economies. Depending on what kinds of industries are expanding or shrinking, the composition effect can translate into different environmental and ecological outcomes. The *technological effect* refers to a transfer of new knowledge and techniques, including superior technologies that have the potential to improve productivity and state of ecosystems. On the consumption side of the economy, FDI has an impact on income and income inequality. We can argue that the more uniformly (equally) income is distributed among populations, the greater the number of consumers with average income, and the greater the ecological impact of consumption. Asteriou et al. (2014) find in favor of the opposite in a study of OECD countries. In their evidence, FDI increases and does not decrease income inequality. Such results would imply a mitigating role of FDI on *EF*.

The existing environmental economics literature links FDI to pollution, primary to air pollution, but not to overall ecosystem degradation. There are several hypotheses about the link between FDI and environmental outcomes: "race to the bottom", also known as the "*pollution haven hypothesis*" (Copeland and Taylor, 1994; Gallagher, 2009), "*FDI halo hypothesis*" (Eskeland and Harrison, 2003; Doytch and Uctum, 2016; Ashraf et al., 2020; Jorgenson, 2007),[4] and an "Environmental Kuznets Curve (EKC) hypothesis" (Shafik, 1994; Grossman and Krueger, 1995; Holtz-Eaking and Selden, 1995; Hilton and Levinson, 1998; Dinda, 2004). The "*pollution heaven hypothesis*" states that FDI flows tend to go to countries where the environmental regulations are lax and therefore bring enterprises with environmentally dirty production processes from more developed to less-developed nations.[5] The "*FDI halo*" hypothesis states that multinational firms that originate from more developed countries have the ability and resources to disseminate superior knowledge and environmental practices to local firms in less developed economies. In that way, multinationals become a vehicle for spreading of improved environmental laws and environmental standards. The "Environmental Kuznets curve (EKC)" hypothesis assumes an inverse U-shaped relation between pollution and income. This is a reflection of the fact that countries tend to pollute more in the industrialization phase of their development and less as they develop and decrease the share of their "dirty" economic sectors.[6] The EKC interplays with FDI in impacting the environment.

The impact of FDI on the rate of exhaustion of bioproductive land, and therefore, on the ecological footprint has not been studied.[7] In this study, we set out to investigate whether the three hypotheses, previously tested for the impact of FDI on pollution, apply for FDI impact on the four ecological footprints of host nations. We formulate a hypothesis similar to the *pollution haven*, which tests whether FDI is more ecologically degrading in developing countries than in industrialized nations. We further refer to as an *FDI ecological haven* hypothesis. We also test whether FDI in certain sectors transfers superior technologies helping with ecological preservation. If such effects occur, they could be regarded as *FDI ecological halo* effects.

Both potential effects, the *ecological haven*, and the *FDI ecological halo* depend on the industry mix of the receiving economies. On one hand, the industry ratio of clean to dirty sectors matters for environmental pollution and ecosystems exhaustion; on the other, it matters for the potential transfer of ecology-improving technologies. We argue that FDI flows to different industries are of a different nature. The different technologies they transfer lead to different productivity effects (Vu and Noy, 2009; Doytch and Uctum, 2011; Slimane et al., 2016), to different renewable vs. non-renewable energy mixes of receiving economies (Ting et al., 2011; Doytch and Narayan, 2016)[8] and to different effects on CO2 emissions (Doytch and Uctum, 2016).[9] Therefore, due to the hypothesized technological differences of industry-level FDI, we chose to study separately the effects of mining, manufacturing, aggregate services, and disaggregated services (financial and non-financial) FDI.

As previously stated, to the best of our knowledge, the subject of the ecological effects of FDI is new. In the current paper, we study the effects of sector-level FDI on the four *EF,* while accounting for the country level of development. We contribute to the existing literature in several different ways. *First,* this is the first study to our knowledge to estimate FDI effects across the four different ecological footprints: *Consumption EF, Production EF, Imports EF, and Exports EF. Second,* we study the ecological effects of FDI within and across country groups accounting for country level of development: Low Income, Middle Income, and High Income countries. *Third,* we account for the sectoral distribution of FDI in the ecological analysis. *Forth,* we test for EKC in the model estimating the ecological impact of FDI. *Fifth,* we merge two unique data sets-the *EF* and the proprietary data on sectoral FDI[10]. *Sixth,* we use a dynamic Blundell-Bond system GMM estimator, which allows us to control for endogeneity and explore both the cross-section and the time-series variation in the data.[11]

We find a rich set of results. *First*, High Income countries tend to experience a consumption-related ecological impact of FDI, whereas Low- and Middle-Income countries tend to experience a production-related ecological impact of FDI. *Second*, the burden of FDI-related *Exports EF* is born disproportionately by Middle Income countries; High Income countries carry none (evidence of *ecological haven*). *Third*, in High Income countries, financial services FDI reduces the *Production EF,* which is evidence of *FDI ecological halo. Finally*, although the effects of FDI are fairly well-spread among different sectoral flows, one general finding that emerges is the detrimental role of non-financial services FDI. Surprisingly, and this is different from some pollution studies of FDI,[12] manufacturing FDI is not the most ecologically damaging for biological ecosystems type of foreign investment. Since ecological footprints

[4] Some studies include aggregate FDI as a control variable and also find an emissions-decreasing effect (Tamazian et al., 2009; Tamazian and Rao, 2010).

[5] The original *pollution haven* hypothesis (Copeland and Taylor, 1994) states that as trade is liberalized, industries that pollute shift from rich countries with tight regulation to poor countries with weak regulation and conversely, clean industries migrate towards rich countries. For a survey of the earlier literature see Jaffee et al. (1995) and more recent literature Dong et al. (2012) and Chung (2014).

[6] The original EKC argument can be credited to Shafik (1994), Grossman and Krueger (1995), Holtz-Eakin and Selden (1995) and Hilton and Levinson (1998). More recent research, however casts doubt on the existence of a neat inverse U-shaped relation (Stern, 1998; Harbaugh et al., 2002; Hettige et al., 2000).

[7] Two recent studies, which we review in the next section, include aggregate FDI implicitly as they examine the impacts of the KOF index of globalization and the Maastricht Globalization Index (MGI) and the on *EF* (Rudolph and Figge, 2017; Figge et al., 2017). However, FDI is a small part of these indexes.

[8] The studies find evidence of energy-saving impact of services FDI.

[9] The study finds that services FDI to industrialized countries have "halo effect"; that is, they reduce environmental pollution.

[10] Compiled by UNCTAD.

[11] See Arellano and Bover (1995) and Blundell and Bond (1998).

[12] Doytch and Uctum (2016).

measure not only the pollution generated directly as a result of economic activity but also resource exhaustion needed to support economic activities, the manufacturing sector activities need not be the most ecologically-demanding ones.

The rest of the paper is organized as follows: Part 1 reviews the existing literature; Part 2 reveals some statistical facts about the ecological footprints; Part 3 discussed the methodology; Part 4- the data; Part 5 overviews the empirical results; Part 6- discusses further the empirical results and the last part concludes.

1. Literature review

The key question of our paper is how the globalization of production activities changes ecosystems sharing for economic development. Through FDI, firms can use ecosystems located abroad to cover for home consumption of food, minerals, and energy, as well as to absorb home-country generated waste. Scientists are yet to understand how much ecological inequality is caused by the fact that production activities can be moved to foreign countries. The question of the international transfers of biocapacity burden recently gave rise to the topic of ecological inequality between countries (Moran et al., 2013). Classical trade theory posits that countries, which are rich in certain resources tend to specialize in production that uses intensively these same resources. According to this view, ecologically unequal exchanges are a "natural" outcome. In that respect, proponents of the classical view state that globalization tends to increase factor productivity and wealth (Das, 2004; Bhagwati, 2004; Stiglitz, 2006). As per this view, in the long run, international trade leads to increased standards of living, which includes environmental standards as well (Easterbrook et al, 1995; Simon, 1996; Das, 2004; Bhagwati, 2004). Thus, globalization and trade generate the necessary income to lead to environmental improvement (Beckerman, 1995; Bhagwati, 2004).

Newer studies, however, criticize the classical view raising the issues of externalities and market failure (Daly and Townsend, 1993; Norgaard, 1990; Rees and Wackernagel, 1999). According to this view, the inadequate valuation of ecosystem services turns certain ecosystems into pollution sinks and leads to overexploitation of natural resources. However, the driving factors of the current patterns of international biomass use are still not well understood (Moran et al., 2013). Some of the unresolved questions include the issue of decoupling: does the process of economic growth decouple from the process of biomass consumption (Myers and Kent, 2003; Tilman et al., 2011, Krausmann et al., 2009). Another question is whether the EKC holds in the context of ecological degradation (Steinberger and Krausmann, 2011; Al-Mulali et al., 2015). Finally, what role globalization plays in the process of coupling/decoupling of ecological change and economic development? For example, what role do import factors of production (food, energy, fiber, etc.) and exporting production waste play for the ecological footprints (Erb et al., 2009; Lambin and Meyfroidt, 2011; Mayer et al., 2005; Rudel et al., 2009a,b; Jorgenson and Clark, 2011). Although there are studies that focus on the impact of international trade on the ecological burden sharing our goal is to provide a different angle at the role of internationalization of ecological biomass consumption: looking at the direct effects of FDI on the ecological footprints.

Although the pollution effects of FDI have been studied to some extent, the ecological effects of FDI in terms of loss of biomass, have not been examined. In the pollution literature, FDI is usually examined at the firm-level and the analysis is confined to the manufacturing sector. The firm-level studies on FDI effects on pollution give mixed evidence Pargal and Wheeler (1996); Hartman et al. (1997); Dasgupta et al. (2000). More recently, a few studies found stronger support for the *FDI halo* hypothesis. For example, Eskeland and Harrison (2003), who analyze outbound US FDI, find that foreign plants are significantly more energy-efficient and cleaner in energy use than their domestic partners. Cole et al. (2008) find that foreign training of firm managers does reduce fuel use, especially in foreign-owned firms. Some of the strongest support for the *FDI halo* hypothesis is found in Albornoz et al. (2009), who study Argentinian firms. They find that foreign-owned firms are more likely to implement environmental management systems compared to domestic firms; that firms that supply to sectors with high presence of multinationals are more likely adopt environmental management systems; and that firms' absorptive capacity, ownership, and export status also influence the extent to which they benefit from environmental spillovers. The goal of our study is to cast light over the ecological effects of FDI and test for the presence of *FDI ecological halo* at the macro level.

There are a few recent studies on the impact of globalization indexes on *EF*. Rudolph and Figge (2017) and Figge et al. (2017) study, respectively, the impact of the KOF index of globalization and the Maastricht Globalization Index (MGI) on the ecological footprints. These indexes are broader than just FDI and contain social and political aspects of globalization next to the economic aspect. FDI is a relatively small part of them. Like us, the authors analyze the impact of the globalization indexes on the four footprints individually. Their analysis is carried out including 170 countries without differentiating across levels of development. Figge et al. (2017) find support that the MGI index of globalization contributes significantly to the *Consumption EF*, *Exports EF*, and *Imports EF*. Rudolph and Figge (2017) find evidence that while the economic aspects of globalization drive all four ecological footprints, the social aspects of globalization decrease the footprints of the domestic sector- *Consumption EF* and *Production EF* and increase the footprints of the external sector- *Exports EF* and *Imports EF*. They also find that political globalization does not impact significantly the footprints.

Finally, in a recent study, Zafar et al. (2019) examine the impact of natural resources, human capital, and FDI on the *Consumption EF*. The authors find that all three curtail the footprints in a unidirectional relation flowing from these three factors to the footprints. Their study, however, is limited to the US and uses an ARDL methodology, which is different from us. It also does not consider disaggregated sector-level FDI and does not consider four different footprints, but only the *Consumption EF*.

The above-described quest-seeking *FDI ecological halo* vs. FDI *ecological haven* effects could be also viewed as part of the theory of ecologically unequal exchange.[13] Ecologically unequal exchange theory posits that trade flows are a mechanism through which high-income countries externalize the negative environmental impacts arising from their consumption to the low- and medium-income countries of the world (Jorgenson et al., 2009). This leads to overconsumption, driven by demand in high-income countries. The ecologically unequal trade exchanges have been proven to increase *EF*s through deforestation (Jorgenson et al., 2009), greenhouse emissions (Jorgenson, 2012), and through biodiversity loss, water pollution and related human well-being outcomes Givens et al. (2019) [14] Similar to trade flows, FDI flows can also be viewed as means for externalizing negative environmental effects to less-developed countries. Should evidence of this be found, it would be a confirmation of the *FDI ecological haven* hypothesis. If the opposite effects are detected, they would be evidence of *FDI ecological halo*. The defined below are testing for presence of ecologically inequal exchange in the context of different *EFs*.

H1. For High Income countries the effect of FDI is on their *Consumption EF;* for Low- and Middle-Income countries, the effect is on their *Production EF*;

H2. For High Income countries, FDI does not generate impact on *Exports EF;* Middle Income countries bear the effect of FDI on *Exports EF*;

H3. In High Income countries, some sectoral FDI flows reduce the

[13] We thank an anonymous referee for this perspective.

[14] A limitation of the above-listed studies is that they are not correct for endogeneity the key variables of interest. The current study takes care of this problem.

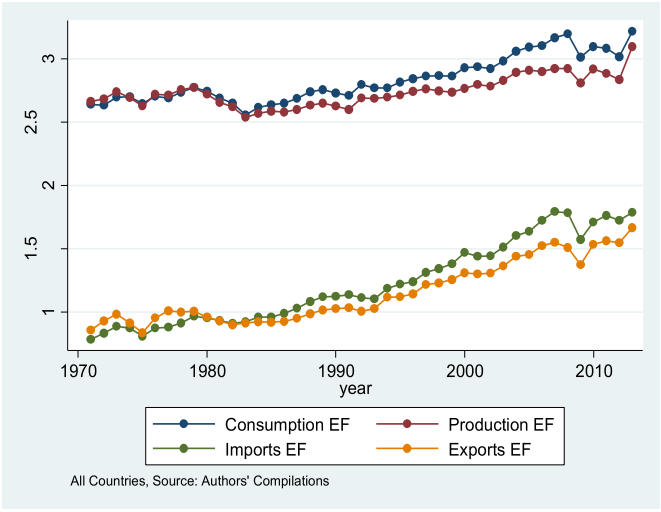

Fig. 1. Per-capita Ecological Footprints, All countries.

Production EF due to transfer of "clean" superior technology; in Low- and Middle Income countries are no positive effects of any sectoral FDI on the *Production EF*.

H4. Ecological Kuznets curve exists for this sample of countries in the context of the four different *EF*.

2. Stylized facts about ecological footprints

All four ecological footprints have been increasing over time (Fig. 1). The rates of increase are more significant for the *Imports EF* and the *Exports EF*. However, if we look within countries groups, we see that *EF* increases have been most significant in High Income countries (Fig. 2), less so in Middle Income countries (Fig. 3), and virtually non-existent in Low Income countries (Fig. 4).[15]

When the mean values of the four ecological footprints are examined by country group, we notice significant differences (Table 1). For example, the mean *Consumption EF* and *Production EF* for Low Income countries approximate 1.5 gha/capita (Table 1). These values double to 3 gha/capita for Middle Income countries and double from this level, to approximately 6 gha/capita in High Income economies. The mean *Import EF* and *Export EF* more than triple, from 0.3 gha/capita to 1 gha/capita, between the samples of Low Income and Middle Income economies and more than triple, from 1 gha/capita to 3.4 gha/capita, between Middle Income and High Income countries (Table 1).

3. Methodology

Following the literature on pollution effects of FDI, we use a dynamic empirical model that controls for EKC and incorporates as a control institutional quality, country-fixed effects, and time-fixed effects[16]:

$$\ln\left(EF_{it}^{k}\right) = \beta_0 + \beta_1 \ln\left(EF_{it-1}^{k}\right) + \beta_2 \log(y_{it}) + \beta_3 [\log(y_{it})]^2 + \beta_4 f_{it}^{j} + \beta_5 anticor_{it} + \beta_6 D_t + \mu_i + \varepsilon_{it} \quad (2)$$

with $\mu_i \sim$ i.i.d$(0, \sigma_{\mu_i})$, $\varepsilon_{it} \sim$ i.i.d$(0, \sigma_{\varepsilon})$, $E[\mu_i \varepsilon_{it}] = 0$ and where i is the country

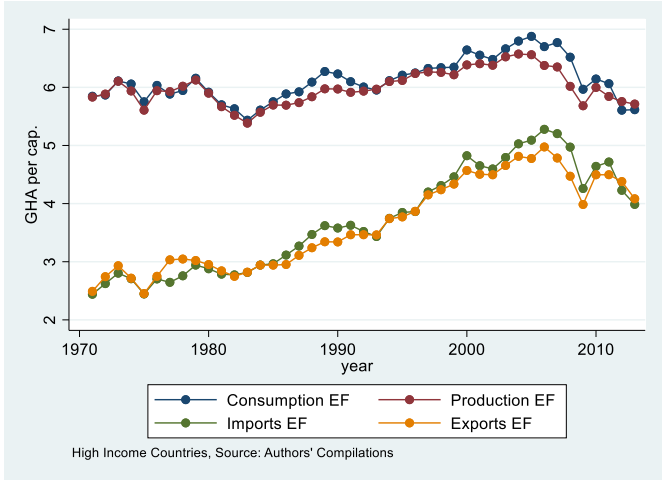

Fig. 2. Per-capita ecological footprints, high income countries.

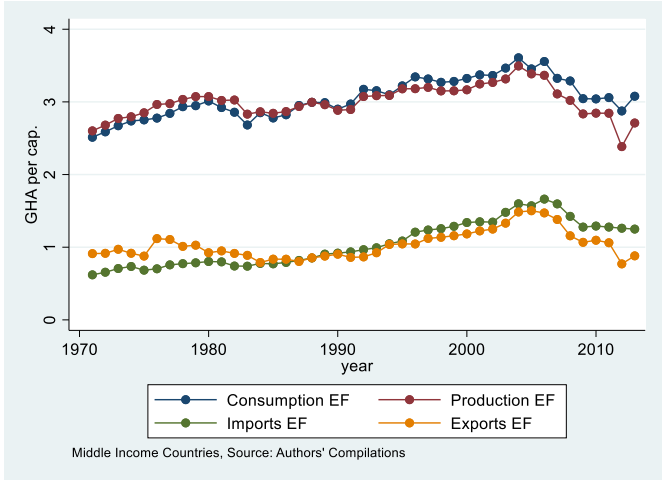

Fig. 3. Per-capita ecological footprints, middle income countries.

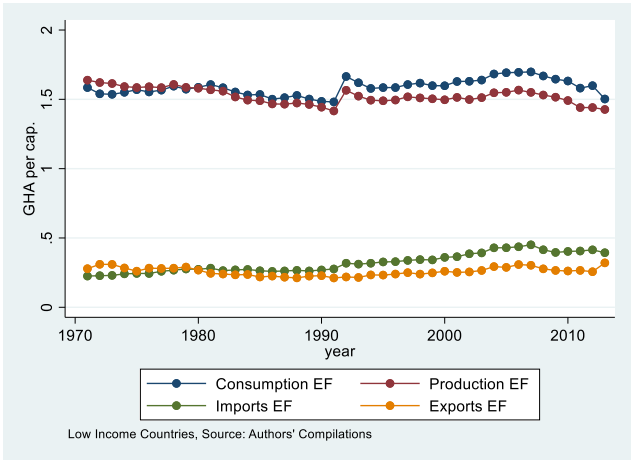

Fig. 4. Per-capita ecological footprints, low income countries.

sub-subscript and the subscript j stands for an index of: total; mining; manufacturing; total services; financial services; non-financial services FDI. The variable EF_{it}^{k} is the index of the ecological footprint with the super-script k denoting respectively *Consumption EF*; *Production EF*; *Imports EF*; and *Exports EF*; y_{it} is measure of per-capita GDP in const. 2005

[15] The three categories of country income levels follow the World Bank classification with two modifications. First, we combine the two lowest categories into one called "Low Income" and use a total of three, rather than four categories. Second, we made the income level a dynamic concept, allowing countries to transition between categories. More details are presented in the data section.

[16] A similar model is used by Doytch and Uctum (2016).

Table 1
Descriptive statistics.

	All Countries			Low Income Countries			Middle Income Countries			High Income Countries		
Variable	Obs	Mean	Std. Dev.	Obs	Mean	Std. Dev.	Obs	Mean	Std. Dev.	Obs	Mean	Std. Dev.
Consumption EF per capita	7914	2.763	2.265	4696	1.578	0.973	1384	2.940	1.177	1672	5.914	2.460
Production EF per capita	7914	2.697	2.693	4696	1.537	1.130	1384	2.897	1.688	1672	5.845	3.789
Imports EF per capita	7914	1.141	1.953	4696	0.298	0.305	1384	0.999	0.672	1672	3.440	2.909
Exports EF per capita	7914	1.094	2.050	4696	0.258	0.344	1384	1.001	0.968	1672	3.422	3.215
Per-capita GDP in cons. 2005 USD	7931	8999.056	15092.06	4123	1099.83	929.7793	1533	4750.05	2417.819	2275	26178.06	19189.41
Anticorruption index	3903	3.012	1.347	1957	2.418	1.008	763	2.790	1.006	1183	4.139	1.331
Total FDI %GDP	6348	0.039	0.194	3379	0.030	0.123	1152	0.039	0.062	1817	0.055	0.318
Mining FDI %GDP	1552	0.009	0.032	543	0.015	0.044	377	0.008	0.017	632	0.006	0.024
Manufacturing FDI %GDP	1909	0.008	0.027	566	0.007	0.009	467	0.010	0.010	876	0.007	0.038
Total Services FDI %GDP	1711	0.037	0.271	575	0.013	0.015	445	0.023	0.031	691	0.067	0.423
Financial Services % GDP	1553	0.025	0.272	443	0.003	0.005	414	0.008	0.012	696	0.048	0.406
Non-financial Services % GDP	1307	0.017	0.037	390	0.010	0.014	370	0.017	0.025	547	0.023	0.051

Source: Author's compilations

USD, and f_{it}^{j} is the respective net FDI inflow share of GDP. The superscript of *j* is an index that stands for: total FDI; mining FDI; manufacturing FDI; services FDI; financial services FDI; and non-financial services FDI.

The EKC effect is captured by the terms $\beta_2 \log(y_{it}) + \beta_3[\log(y_{i,t})]^2$. If $\beta_2 > 0$ *and* $\beta_3 < 0$, then there is an inverse U-shaped relation between EF_{it}^{k} and y_{it}. The $anticor_{it}$ is an index of control of corruption, which is used as a proxy for institutional quality. It ranges [0 to 6], 6 being the highest degree of control of corruption. D_t is a vector of time dummies and μ_i is an idiosyncratic country-specific effect.

If $\beta_2 > 0$ *and* $\beta_3 < 0$, then there is an inverse U-shaped relation between EF_{it}^{k} and y_{it}. If $\beta_4 < 0$, then the impact of FDI on *EF* is one of reduction, whereas $\beta_4 > 0$ indicates a contribution of FDI to the accumulation of *EF*. Although we expect that $\beta_5 < 0$, meaning that control of corruption reduces *EF*, this effect can also go in reverse-stronger control of corruption may induce more ecological degradation, because of a positive effect on production capacity and income.

We choose a dynamic-effects methodology to capture the long memory in the process of accumulation of the ecological footprints. The system GMM method allows us to capture both, the cross-sectional, and the time-series characteristics of the data (Alonso-Borrego and Arellano, 1996; Blundell and Bond, 1998). At the same time, it allows us to control for the endogeneity and possible reverse causality between FDI and the four ecological footprints. We also control for the correlation between the lagged dependent variable, which is part of the process by design, and the unobserved residual. This method is an improvement upon the static method of fixed effects, which suffers a bias, caused by the correlation between $EF_{i,t-1}^{k}$ and μ_i - a bias that does not disappear with time--averaging.[17] [18] We instrument FDI with 2-lag GMM-style instruments, which account for reverse causality between FDI and the *EF* indexes.[19] We perform robustness checks with the method of fixed effects[20].

4. Data

We use annual data for 117 countries, spanning 1984 to 2011, which represents an unbalanced panel. As previously mentioned, we disaggregate the sample of countries based on their income distribution: 1-Low Income Countries; 2- Middle Income; and 3-High Income.[21]

In addition, we treat country income levels as dynamic, allowing for countries to transition from one income group to another as they develop. Following "World Bank Atlas" method that defines the cut-off levels of per-capita gross national product (GNI) for each group, we form the three groups as follows: "Low Income", if GNI<= $4125; "Middle Income", if $4125 < GNI<= $12,736; and "High Income" if GNI >$12,736. The country group assignments are listed in Table 2.

The dependent variables, the four Ecological Footprint indicators, *Consumption EF, Production EF, Imports EF,* and *Exports EF*, are computed based on the National Footprint Accounts of Global Footprint Network.[22]

The Ecological Footprint is derived by tracing how much biologically productive area is lost in the process of absorbing populations' waste and providing the resources that populations consume via four economic activities: direct consumption, production, importing and exporting (Global Footprint Network, 2016). In other words, all commodities carry embedded in them the amount of bioproductive land and sea area necessary to produce them and absorb the waste associated with them. The *Consumption EF* indicates the consumption of biocapacity by the inhabitants of a country. The *Consumption EF* accounts for both, the export of natural resources and ecological services for use in other countries, and the import of resources and ecological services for domestic consumption according to equation (1) (Global Footprint Network). The *Production EF* indicates the consumption of biocapacity resulting from production processes with a given geographical area, such as a country. It represents the sum of all bioproductive areas within a country, necessary for supporting the actual harvest of primary products (cropland, grazing land, forestland, and fisheries), the country's built-up area (rods, factories, cities), and the area needed to absorb all fossil fuel carbon emissions generated within the country.[23] The *Imports EF* and *Exports EF* indicate the use of biocapacity in international trade activities. If *Exports EF* > *Imports EF,* the country is a net exporter of natural resources and ecological services. If *Imports EF* > *Exports EF,* then the country is a net importer of natural resources and ecological services (Global Footprint Network).[24]

[17] The conditions for GMM are: (i) No second order autocorrelation in the error term: $E[EF_{i,t-s}^{k}(\varepsilon_{it} - \varepsilon_{i,t-1})] = 0$ for $s \geq 2$ and $t = 3, \ldots T$; $E[y_{i,t-s}(\varepsilon_{it} - \varepsilon_{i,t-1})] = 0$ for $s \geq 2$ and $t = 3, \ldots T$; $E[f_{i,t-s}^{j}(\varepsilon_{it} - \varepsilon_{i,t-1})] = 0$ for $s \geq 2$ and $t = 3, \ldots T$, where y_{it} , f_{it}^{j} are the level of income and FDI, respectively, and where we instrument differences with past levels and levels-with past differences. (ii) No correlation of the unobserved country-specific effect with their difference requires: $E[(EF_{i,t-1}^{k} - EF_{i,t-2}^{k})(\mu_i + \varepsilon_{it})] = 0$; $E[(y_{i,t-1} - y_{i,t-2})(\mu_i + \varepsilon_{it})] = 0$; $E[(f_{i,t-1}^{j} - f_{i,t-2}^{j})(\mu_i + \varepsilon_{it})] = 0$. This condition allows using lagged first differences as instruments for levels.

[18] If such a correlation exists, the true underlying structure of the data is dynamic, and time-averaging introduces a bias that cannot be removed by applying the method of fixed effects (See Doytch and Uctum, 2011).

[19] We present here a set of results based on the minimum optimum lags, an approach that we selected to preserve the degrees of freedom (Roodman, 2009).

[20] We also explored the use of income-level dummies instead of splitting the sample by country groups. The outcome was less clear-cut and often insignificant. This result suggests that dummies are not able to account for income-level heterogeneity within subgroups as explicitly as the sub-samples, possibly because group-specific variables reflect the effect of several unknown factors besides the regional idiosyncrasies.

[21] The groups are based on the World Bank country classification, combining the categories "Low Income" and "Lower Middle Income" into our "Low Income" category, renaming the "Upper Middle Income" category as "Middle Income", and using the "High Income" category as is.

[22] We treat the ecosystem productivity, which is based on nature's biocapacity as exogenous and therefore, estimate the effects of FDI directly on the footprints, not the ecological deficits or surpluses.

[23] For more on the physical components of *EF,* please see Jorgenson et al. (2005).

[24] More details of the *EF* index could be found in Jorgenson and Clark (2013).

Table 2
Country income group classification. "1" low income countries; "2" middle income countries; "3" high income countries.

Country	Data Coverage	Income Group	Country	Data Coverage	Income Group	Country	Data Coverage	Income Group
Albania	1971–2007	1	Greece	1971–2011	3	Pakistan	1971–2008	1
Albania	2008–2011	2	Guatemala	1971–2001	1	Pakistan	2009–2011	1
Argentina	1971–2012	2	Honduras	1971–2001	1	Panama	1971–2011	2
Armenia	1991–2011	1	Honduras	2002–2011	1	Paraguay	1971–2011	1
Austria	1971–2012	3	Hong Kong	1971–2011	3	Peru	1971–2009	1
Australia	1971–2012	3	Hungary	1971–2007	2	Peru	2010–2011	2
Azerbaijan	1991–2008	1	Hungary	2008–2011	3	Philippines	1971–2011	1
Azerbaijan	2009–2011	2	Iceland	1971–2011	3	Poland	1971–2011	2
Cambodia	1995–2011	1	India	1971–2008	1	Portugal	1971–2011	3
Bangladesh	1971–2011	1	India	2009–2011	1	Romania	1971–2011	2
Belgium	1971–2011	3	Indonesia	1971–2011	1	Russian Fed.	1991–2011	2
Bolivia	1971–2011	1	Ireland	1971–2011	3	Saudi Arabia	1971–2011	3
Bosnia & Herzegovina	1991–2007	1	Israel	1971–2011	3	Serbia	1991–2011	2
Bosnia & Herzegovina	2008–2011	2	Italy	1971–2011	3	Singapore	1971–2011	3
Brazil	1971–2011	2	Jamaica	1971–2004	1	Slovak Rep	1971–2005	2
Brunei	1971–2011	3	Jamaica	2005–2011	2	Slovak Rep	2006–2011	3
Bulgaria	1971–2012	2	Japan	1971–2011	3	Slovenia	1991–2011	3
Canada	1971–2011	3	Kazakhstan	1991–2011	2	Sri Lanka	1971–2011	1
Chile	1971–2011	2	Korea, Rep.	1971–2011	3	Spain	1971–2011	3
China	1971–2009	1	Kyrgyz Rep	1991–2011	1	Sweden	1971–2011	3
China	2010–2011	2	Latvia	1991–2011	2	Switzerland	1993–2012	3
Colombia	1971–2006	1	Lithuania	1991–2007	2	Syrian Arab Rep.	1971–2011	1
Colombia	2007–2011	2	Lithuania	2008–2011	3	Tanzania	1971–2011	1
Costa Rica	1971–2011	2	Luxembourg	1971–2011	3	Thailand	1971–2009	1
Croatia	1991–2007	2	Macedonia, FYR	1991–2007	1	Thailand	2010–2011	2
Croatia	2008–2011	3	Macedonia, FYR	2008–2011	2	Tunisia	1971–2008	1
Cyprus	1971–2011	3	Malaysia	1971–2011	2	Tunisia	2009–2011	2
Czech Rep.	1971–2011	3	Mexico	1971–2011	2	Turkey	1971–2011	2
Denmark	1971–2011	3	Moldova	1971–2008	1	UA Emirates	1971–2011	3
Dominican Rep.	1971–2007	1	Morocco	1971–2011	1	United Kingdom	1971–2011	3
Dominican Rep.	2008–2011	2	Mozambique	1971–2011	1	United States	1971–2011	3
Ecuador	1971–2009	1	Myanmar	1971–2011	1	Uruguay	1971–2011	2
Ecuador	2010–2011	2	Netherlands	1971–2011	3	Venezuela	1971–2011	2
El Salvador	1971–2011	1	New Zealand	1971–2011	3	Vietnam	1971–2008	1
Estonia	1991–2011	3	Nicaragua	1971–2011	1	Vietnam	2009–2011	2
Finland	1971–2011	3	Norway	1971–2011	3			
France	1971–2011	3	Oman	1971–2006	2			
Germany	1971–2011	3	Oman	2007–2011	3			

Source: Author's calculations based on the income level methodology of the World Bank

The key independent variables are disaggregated FDI flows share of GDP denominated in current USD. All *FDI* series are *net flows*, accounting for the purchases and sales of domestic assets by foreigners in the corresponding year. FDI is defined as an investment that "reflects the objective of obtaining a lasting interest by a resident entity in one economy ("direct investor") in an entity resident in an economy other than that of the investor ("direct investment enterprise") (OECD, *International direct investment database,* Metadata). This lasting interest implies a long-term relationship between the direct investor and the enterprise and a significant influence on the management of the enterprise. The data on sectoral FDI inflows to mining, manufacturing, financial services, and non-financial services FDI are compiled from a proprietary data set of *United Nations Conference on Trade and Development* (UNCTAD).

The institutional variable "anticorruption" (or control of corruption) is from the *International Country Risk Group* (ICRG, 2012). We use it as a proxy for the overall quality of institutions.[25] It is measured in the range [0 to 6], with 0 representing the countries with worst corruption and 6 representing countries with the best practices. The index refers to the actual or potential corruption in the form of excessive patronage, nepotism, job reservations, 'favor-for-favors', secret party funding, and suspiciously close ties between politics and business. These sorts of corruption are potentially corrosive to growth performance and of great risk to foreign business in that they can lead to popular discontent, unrealistic and inefficient controls on the state economy, and encourage the development of the black market (*International Country Risk Guide)*.

5. Empirical results

The empirical results are summarized in Tables 3 and 4, where we list respectively extracted coefficients of FDI effects on *EF* (β4) and the estimates related to EKC (β2 and β3). We run models with four different *EF* indexes, four country-groups, and six different sectoral FDI. The full regression results of the sample of "All countries" are presented in Tables A1-A4 in the Appendix. Both, Tables 3 and 4, consist of four panels: upper left- "Panel 1- Impact of FDI on *Consumption EF*"; lower left- "Panel 2- Impact of FDI on *Production EF*"; upper right- "Panel 3- Impact of FDI on *Imports EF*"; and lower right- "Panel 4- Impact of FDI on *Exports EF*". Table 4 has the same structure, however, the panels present estimates of coefficients β2 and β3, which indicate the presence or absence of an EKC.

If we view the panels of Tables 3 and 4 as vertical blocks, the *Left Block*, consisting of Panels 1 & 2 represents coefficients related to the domestic economy EF- *Consumption EF* and *Production EF*. At the same time, the *Right Block*, consisting of Panels 3 & 4, represents coefficients related to the economy's trade sector- *Imports EF* and *Exports EF*. Similarly, if we view Tables 3 and 4 as horizontal blocks, the *Top Block*, consisting of Panels 1 & 3, represents impact from activities related to consumption - *Consumption EF* and *Imports EF* and the *Bottom Block,* consisting of Panels 2 & 4 - activities related to production, *Production EF,* and *Exports EF*.

The role of the different idiosyncratic shocks to different sectors is

[25] We have performed robustness checks including the World Bank *Environmental Protection Index*, which is a comprehensive cross-country environmental policy measure. The results were robust. Unfortunately, including the index would have led to reducing our sample size by about one third.

Table 3
Effect of FDI on the four ecological footprints*.

		(1) Total FDI/ GDP	(2) Mining FDI/GDP	(3) Manufact. FDI/GDP	(4) Services FDI/GDP	(5) Finance FDI/GDP	(6) Nonfinanc FDI/GDP
	PANEL 1; CONSUMPTION EF						
(1)	**All countries**	−0.000362	0.0944	0.110	0.00317	0.00292	**0.168****
		(0.00356)	(0.0720)	(0.0853)	(0.00281)	(0.00516)	**(0.0685)**
	Observations	3007	1285	1488	1294	1224	1032
	Countries	117	83	87	86	76	76
(2)	**Low Income Countries**	0.0433	0.0934	−1.097	0.880	2.932	**1.176***
		(0.0376)	(0.0594)	(1.317)	(0.558)	(1.931)	**(0.661)**
	Observations	1610	441	462	465	336	311
	Countries	63	34	36	36	29	29
(3)	**Middle Income Countries**	0.151	0.333	0.0175	0.146	−0.291	0.353
		(0.306)	(0.646)	(0.603)	(0.189)	(0.423)	(0.369)
	Observations	587	305	348	314	308	272
	Countries	41	28	29	29	27	26
(4)	**High Income Countries**	0.00600	0.428	0.0967	**0.00849***	0.00275	**0.184****
		(0.00723)	(0.343)	(0.0765)	**(0.00439)**	(0.00692)	**(0.0820)**
	Observations	810	539	678	515	580	449
	Countries	39	38	39	38	35	35
	PANEL 2; PRODUCTION EF						
		Total FDI/ GDP	**Mining FDI/GDP**	**Manufact. FDI/GDP**	**Services FDI/GDP**	**Finance FDI/GDP**	**Nonfinanc FDI/GDP**
(1)	**All countries**	−0.000340#	0.0290	0.0361	**−0.00544*****	**−0.00575****	0.00902
		(0.00314)	(0.0672)	(0.0311)	**(0.00186)**	**(0.00280)**	(0.0579)
	Observations	3007	1285	1488	1294	1224	1032
	Countries	117	83	87	86	76	76
						0.536	0.310
(2)	**Low Income Countries**	**0.0411***#	−0.00864	−2.140	**1.497*****	2.419	**1.666*****
		(0.0139)	(0.0311)	(1.418)	**(0.530)**	(1.961)	**(0.622)**
	Observations	1610	441	462	465	336	311
	Countries	63	34	36	36	29	29
(3)	**Middle Income Countries**	0.119	**1.128*****	0.403	0.238	0.188	0.164
		(0.211)	**(0.333)**	(0.426)	(0.146)	(0.385)	(0.309)
	Observations	587	305	348	314	308	272
	Countries	41	28	29	29	27	26
(4)	**High Income Countries**	0.000386	**0.369****	0.0490	**−0.00527****	**−0.00744***	−0.0672
		(0.00338)	**(0.167)**	(0.0446)	**(0.00267)**	**(0.00446)**	(0.0466)
	Observations	810	539	678	515	580	449
	Countries	39	38	39	38	35	35

		(1) Total FDI/ GDP	(2) Mining FDI/GDP	(3) Manufact. FDI/GDP	(4) Services FDI/GDP	(5) Finance FDI/GDP	(6) Nonfinanc FDI/GDP
	PANEL 3; IMPORTS EF						
(1)	**All countries**	−0.00428	**0.405*****	0.0325	0.000511	0.00185	**0.229****
		(0.00445)	**(0.139)**	(0.0761)	(0.00547)	(0.00706)	**(0.113)**
	Observations	3007	1285	1488	1294	1224	1032
	Countries	117	83	87	86	76	76
(2)	**Low Income Countries**	0.0588	**0.398*****	1.998	1.330	0.964	0.300
		(0.0906)	**(0.0823)**	(1.832)	(0.895)	(1.803)	(1.193)
	Observations	1610	441	462	465	336	311
	Countries	63	34	36	36	29	2
(3)	**Middle Income Countries**	0.360	−0.398	−0.568	0.502	1.201	**1.205****
		(0.343)	(1.377)	(1.346)	(0.507)	(0.963)	**(0.550)**
	Observations	587	305	348	314	308	272
	Countries	41	28	29	29	27	26
(4)	**High Income Countries**	0.00596	−0.542	0.0709	0.00949	−0.00835	**0.212****
		(0.00786)	(0.401)	(0.0487)	(0.00765)	(0.0114)	**(0.0893)**
	Observations	810	539	678	515	580	449
	Countries	39	38	39	38	35	35
	PANEL 4; EXPORT EF						
		Total FDI/ GDP	**Mining FDI/GDP**	**Manufact. FDI/GDP**	**Services FDI/GDP**	**Finance FDI/GDP**	**Nonfinanc FDI/GDP**
(1)	**All countries**	0.00298	0.125	−0.0938	0.000497	0.00418	0.219
		(0.00782)	(0.0798)	(0.158)	(0.00460)	(0.00612)	(0.194)
	Observations	3007	1285	1488	1294	1224	1032
	Countries	117	83	87	86	76	76
(2)	**Low Income Countries**	0.0328	**0.171***	0.0456	1.788	0.0988	1.089
		(0.0996)	**(0.0878)**	(1.632)	(1.429)	(2.554)	(1.355)
	Observations	1610	441	462	465	336	311
	Countries	63	34	36	36	29	29
(3)	**Middle Income Countries**	0.969	**1.809****	0.623	**0.648**#	**3.337*****	**0.701***
		(0.773)	**(0.760)**	(0.654)	**(0.325)**	**(0.898)**	**(0.360)**
	Observations	587	305	348	314	308	272
	Countries	41	28	29	29	27	26
(4)	**High Income Countries**	−0.000629	−0.0298	0.0439	−0.00164	−0.00104	−0.0221
		(0.00477)	(0.312)	(0.0622)	(0.00503)	(0.00465)	(0.0730)
	Observations	810	539	678	515	580	449
	Countries	39	38	39	38	35	35

* The first entry in each cell is the estimate of the effect of FDI flows on the respective Ecological Footprint, estimated by the System GMM method. Figures in parentheses are standard errors; * and ** denote significance at the 10% and 5% respectively. Results are robust to heteroscedasticity. # Presence of AR(2).

Table 4
Environmental Kuznets Curve (EKC) with the four ecological footprints*.

		(1) Total FDI/GDP	(2) Mining FDI/GDP	(3) Manufact. FDI/GDP	(4) Services FDI/GDP	(5) Finance FDI/GDP	(6) Non-finan. FDI/GDP
	PANEL 1: CONSUMPTION EF						
(1)	ln(*GDP per cap.*)	**0.0339*****	**0.0382**	**0.0698*****	**0.0542*****	**0.0762****	**0.0733***
		(0.00757)	**(0.0275)**	**(0.0238)**	**(0.0190)**	**(0.0380)**	**(0.0397)**
	$[ln\ (GDP\ per\ cap.)]^2$	**−0.00196***	**−0.00188***	**−0.00344*****	**−0.00248****	**−0.00342****	**−0.00350****
		(0.00115)	**(0.00111)**	**(0.00126)**	**(0.000973)**	**(0.00146)**	**(0.00165)**
(2)	ln(*GDP per cap.*)	0.0213	**0.117***	**0.129*****	**0.119*****	**0.328****	**0.213***
		(0.0213)	**(0.0703)**	**(0.0466)**	**(0.0445)**	**(0.135)**	**(0.127)**
	$[ln(GDP\ per\ cap.)]^2$	−0.00105	**−0.00771***	**−0.00898*****	**−0.00810*****	**−0.0211****	**−0.0142***
		(0.00180)	**(0.00456)**	**(0.00348)**	**(0.00299)**	**(0.00926)**	**(0.00836)**
(3)	ln(*GDP per cap.*)	−0.308	−0.232	−0.188	−0.0633	−0.284	0.107
		(0.419)	(0.480)	(0.409)	(0.367)	(0.505)	(0.473)
	$[ln(GDP\ per\ cap.)]^2$	0.0208	0.0147	0.0118	0.00439	0.0173	−0.00491
		(0.0237)	(0.0280)	(0.0240)	(0.0214)	(0.0295)	(0.0276)
(4)	ln(*GDP per cap.*)	0.0800	0.187	0.0532	0.113	−0.111	−0.123
		(0.172)	(0.228)	(0.129)	(0.197)	(0.288)	(0.167)
	$[ln(GDP\ per\ cap.)]^2$	−0.00379	−0.0108	−0.00348	−0.00548	0.00643	0.00561
		(0.00854)	(0.0117)	(0.00661)	(0.00995)	(0.0141)	(0.00855)
	PANEL 2: PRODUCTION EF	**Total FDI/GDP**	**Mining FDI/GDP**	**Manufact. FDI/GDP**	**Services FDI/GDP**	**Finance FDI/GDP**	**Non-finan. FDI/GDP**
(1)	ln(*GDP per cap.*)	**0.0376*****	**0.0377***	**0.0577*****	**0.0391***	**0.0407***	**0.0914*****
		(0.00703)	**(0.0205)**	**(0.0216)**	**(0.0206)**	**(0.0233)**	**(0.0273)**
	$[ln(GDP\ per\ cap.)]^2$	**−0.00227*****	**−0.00244****	**−0.00306****	**−0.00264****	**−0.00282****	**−0.00506*****
		(0.000679)	**(0.00101)**	**(0.00124)**	**(0.00107)**	**(0.00118)**	**(0.00140)**
(2)	ln(*GDP per capita*)	0.0370	0.127	**0.130*****	**0.123****	**0.270***	**0.308****
		(0.0276)	(0.0777)	**(0.0477)**	**(0.0555)**	**(0.158)**	**(0.132)**
	$[ln(GDP\ per\ cap.)]^2$	−0.00227	**−0.00879***	**−0.00950*****	**−0.00827****	**−0.0180***	**−0.0211****
		(0.00198)	**(0.00527)**	**(0.00350)**	**(0.00390)**	**(0.0107)**	**(0.00891)**
(3)	ln(*GDP per cap.*)	**−0.727***	**−0.779****	−0.562	**−0.585***	−0.542	−0.430
		(0.382)	**(0.308)**	(0.424)	**(0.309)**	(0.406)	(0.338)
	$[ln(GDP\ per\ cap.)]^2$	**0.0434****	**0.0450****	0.0325	**0.0340***	0.0312	0.0252
		(0.0220)	**(0.0178)**	(0.0246)	**(0.0178)**	(0.0234)	(0.0197)
(4)	ln(*GDP per cap.*)	−0.175	−0.0250	−0.123	−0.0925	−0.194	−0.0894
		(0.154)	(0.146)	(0.140)	(0.124)	(0.171)	(0.121)
	$[ln(GDP\ per\ cap.)]^2$	0.00832	−8.42e-05	0.00593	0.00368	0.00905	0.00327
		(0.00786)	(0.00755)	(0.00718)	(0.00638)	(0.00867)	(0.00603)

		(1) Total FDI/GDP	(2) Mining FDI/GDP	(3) Manufact. FDI/GDP	(4) Services FDI/GDP	(5) Finance FDI/GDP	(6) Non-finan. FDI/GDP
	PANEL 3: IMPORTS EF						
	ln(*GDP per cap.*)	0.0330	0.0734	0.0479	0.00724	0.0773	0.00394
		(0.0208)	(0.0571)	(0.0317)	(0.0545)	(0.0530)	(0.0590)
	$[ln\ (GDP\ per\ cap.)]^2$	**−0.00205****	**−0.00400***	**−0.00339****	−0.000792	−0.00359	−0.00108
		(0.00100)	**(0.00241)**	**(0.00160)**	(0.00222)	(0.00236)	(0.00255)
	ln(*GDP per cap.*)	−0.0144	0.185	0.0799	0.0102	0.241	0.00252
		(0.0445)	(0.162)	(0.157)	(0.142)	(0.167)	(0.233)
	$[ln(GDP\ per\ cap.)]^2$	0.00210	−0.0114	−0.00362	0.00117	−0.0154	−0.000738
		(0.00334)	(0.0102)	(0.00908)	(0.00860)	(0.0112)	(0.0154)
	ln(*GDP per cap.*)	−0.427	0.245	0.247	0.503	0.836	1.255
		(0.629)	(1.523)	(1.205)	(0.979)	(1.278)	(1.491)
	$[ln(GDP\ per\ cap.)]^2$	0.0289	−0.0106	−0.0110	−0.0264	−0.0427	−0.0682
		(0.0368)	(0.0897)	(0.0712)	(0.0566)	(0.0738)	(0.0853)
	ln(*GDP per cap.*)	0.276	−0.0522	0.00579	0.354	−0.0614	0.104
		(0.246)	(0.397)	(0.262)	(0.232)	(0.236)	(0.144)
	$[ln(GDP\ per\ cap.)]^2$	−0.0157	0.000315	−0.000893	−0.0186	0.00208	−0.00654
		(0.0126)	(0.0201)	(0.0132)	(0.0117)	(0.0118)	(0.00714)
	PANEL4: EXPORTS EF	**Total FDI/GDP**	**Mining FDI/GDP**	**Manufact. FDI/GDP**	**Services FDI/GDP**	**Finance FDI/GDP**	**Non-finan. FDI/GDP**
	ln(*GDP per cap.*)	**0.0934*****	0.120	0.0364	0.0620	**0.147***	0.0746
		(0.0205)	(0.0862)	(0.0421)	(0.0606)	**(0.0826)**	(0.0697)
	$[ln(GDP\ per\ cap.)]^2$	**−0.0046*****	**−0.00659***	−0.00229	−0.00344	**−0.00775***	−0.00475
		(0.00141)	**(0.00383)**	(0.00241)	(0.00310)	**(0.00415)**	(0.00376)
	ln(*GDP per capita*)	0.0952	0.0212	−0.0310	0.101	0.0535	**0.823*****
		(0.0682)	(0.248)	(0.175)	(0.223)	(0.238)	**(0.253)**
	$[ln(GDP\ per\ cap.)]^2$	−0.00362	0.000908	0.00348	−0.00478	−0.00374	**−0.0547*****
		(0.00538)	(0.0165)	(0.0122)	(0.0148)	(0.0162)	**(0.0176)**
	ln(*GDP per cap.*)	−0.871	**−1.212***	−0.821	−0.467	0.431	−0.661
		(0.598)	**(0.659)**	(0.588)	(0.519)	(0.864)	(0.504)
	$[ln(GDP\ per\ cap.)]^2$	0.0519	**0.0685***	0.0477	0.0263	−0.0254	0.0384
		(0.0355)	**(0.0379)**	(0.0347)	(0.0297)	(0.0494)	(0.0289)
	ln(*GDP per cap.*)	−0.151	0.149	−0.326	0.104	−0.129	−0.0156
		(0.243)	(0.237)	(0.223)	(0.194)	(0.217)	(0.227)
	$[ln(GDP\ per\ cap.)]^2$	0.00555	−0.00931	0.0153	−0.00639	0.00462	−0.000562
		(0.0122)	(0.0120)	(0.0112)	(0.00933)	(0.0107)	(0.0111)

* The first entry in each cell is the reported coefficients a estimates of GDP per capita and the squared term of GDP per capita that capture EKC. Figures in parentheses are standard errors; * and ** denote significance at the 10% and 5% respectively. Results are robust to heteroscedasticity.

reflected in estimates of different sectoral FDI, presented in columns of each of the four panels of Tables 3 and 4 The six columns present respectively estimates of: (1) total (aggregate) FDI; (2) mining (extractive sectors) FDI; (3) manufacturing (secondary sector) FDI; (4) total services (an aggregate of financial and non-financial services) FDI; (5) financial services FDI; and (6) non-financial services FDI. The coefficients for the different sub-groups of countries are displayed in rows of each of the four *EF* panels in the following fashion: row (1)- "All Countries"; row (2)- "Low Income Countries"; row (3) – "Middle Income Countries"; row (4)- "High Income Countries". In Table 3, next to the FDI estimates, we also report the number of observations and countries. The full results of models for rows (1), corresponding to the full country sample-all 117 countries are listed in Tables A1-A4.

A brief overview of the results of the impact of sectoral FDI on the *Consumption EF* (Table 3: Panel 1), shows that non-financial services FDI, which comprise of the value-added in wholesale and retail trade (including hotels and restaurants), transport, and government, financial, professional, and personal services such as education, health care, as well as real estate services, plays is a significant role in the accumulation of the *Consumption EF* in both Low and High Income countries (Table 3: Panel 1, rows 1, 2 & 4, column 6) [26] More specifically, a one percentage point increase in non-financial services FDI relative to GDP is associated with a 0.18% increase in *Consumption EF* in High Income and a 1.18% increase in *Consumption EF* in Low Income countries. This has caused the *Consumption EF* to increase by 0.007% and by respectively, over the examined period.

Non-financial services FDI and the mining FDI flows appear to be significant determinants of the *Production EF* (Table 3: Panel 2). We see several pieces of evidence for FDI contributing to ecological degradation: the effects of non-financial services FDI to Low Income countries (Table 3: Panel 2, row 2, columns 4 & 6) and mining FDI to wealthier nations (Table 3: Panel 2, rows 3&4, column 2). A one percentage point increase of the respective FDI flows causes respectively 1.67% and 1.13% increase in the *Production EF* in the two cases. This results in 0.008% and 0.01% respective worsening of the *Production EF* over the studied period. The effects in these sectors are refuting the *FDI ecological halo* hypothesis. There is, however, evidence that financial services FDI in High Income countries are ecologically-sparing. Financial services FDI has a negative significant impact on the *Production EF* (Table 3: Panel 2, rows 4, column 4&5). A negative impact means a reduction of the *EF* due to ecosystem improvement. The magnitude of this effect suggests a 0.007% improvement in the *Production EF* for every 1 percentage point increase in financial services FDI share of GDP. This is equivalent a 0.002% improvement of *Production EF* in High Income countries over the studied period. This is consistent with previous studies that have found a similar effect on CO2 emissions, supporting the *FDI halo* hypothesis (Doytch and Uctum, 2016). The effect reflects a sectoral shift in these economies towards increasing the share of the financial (perceived as "clean") industry. It also reflects that fact financial FDI can have "greening" spillovers to other sectors, i.e. they can act as a financial intermediary to sectors that are in the process of upgrading their technologies to meet higher nature-preservation standards. Thus, the overall effect of financial FDI can become ecosystems-enhancing. This *FDI ecological halo* effect appears to be most pronounced through an impact on *Production EF*. The *Consumption EF* in these countries reflects a consumption-related effect of FDI that adds up to ecological degradation (Table 3: Panel 1, row 4, column 6).

A different kind of consumption-related footprint is the *Imports EF*, which estimates the *EF* embedded in imported goods (Table 3: Panel 3). We hypothesize that FDI flows that have strong consumption effects would have a similar impact on the *Imports EF* as on the *Consumption EF*. In addition, we hypothesize that this effect should be more pronounced for more advanced economies, as they run larger trade deficits. The evidence shows that non-financial services FDI contributes significantly to the accumulation of *Imports EF* in Middle and High Income economies (Table 3: Panel 3, rows 3&4, column 6). The effect that we see in High Income countries is consistent with the one on *Consumption EF;* the effect in Middle Income countries is new. The magnitudes are respectively 0.21% and 1.21%. To put this in perspective, over the examined period, in the case of High Income countries this resulted in 0.008% worsening and for Middle Income countries- 0.013% worsening-of the *Imports EF*. The flow that influences *Imports EF* in Low Income countries is extractive industries FDI (Table 3: Panel 3, row 2, column 2). The magnitude of that effect is 0.4% and over the studied period it caused a 0.0002% worsening of the *Imports EF*.

In contrast to the *Imports EF*, we hypothesize that the FDI impact on *Exports EF* effects should be stronger for poorer countries. This would be consistent with the *FDI ecological haven* hypothesis, which we formulated as inequality in the ecological performance of FDI in poor and rich economies due to the nature-exploitative practices of firms from wealthier nations. The "*haven*" hypothesis could be analyzed by examining the *Imports EF* of rich countries and the *Exports EF* of poorer nations.

The evidence of FDI effects on the *Exports EF* is consistent with the *FDI ecological haven* hypothesis (Table 3: Panel 4). High Income countries do not suffer exports-related ecological degradation from FDI (Table 3: Panel 4, row 4). At the same time, several FDI flows contribute to *Exports EF* in Low Income and Middle Income economies: extractives sector FDI, financial and non-financial services FDI (Table 3: Panel 4, row 3, columns 2, 4, 5&6), 3.34% and 0.7% respectively. This means that financial FDI share of GDP contributed a 0.04% increase in the *Exports EF* over the study period and non-financial FDI contributed 0.006%. One possible explanation of these adverse effects is direct environmental degradation and depletion of natural resources. Another is an indirect effect through spillovers from these FDI flows. For example, the presence of foreign banks can boost up economic activity in other sectors, including exporting sectors, which contribute to ecological degradation when environmental regulation allows so. The fact that we do not see the same effect from manufacturing FDI in Middle Income countries could be because the foreign manufacturing technologies are not more ecologically-intensive than domestic ones. In other words, manufacturing FDI is neither harming nor improving natures' bio-productivity. The above described coefficients are may seem relatively small, but they are not negligible. They are consistent with what our studies find regarding environmental effects of FDI. In addition, they accumulate over time, which in conjunction with other factors' negative environmental effects build up ecological degradation.

Finally, the estimates related to the EKC are presented in Table 4. They uncover that EKC holds-in models of *Consumption EF* and *Production EF* for samples with larger heterogeneity of countries- "All Countries" and "Low Income Countries" (Table 4: Panels 1&2, rows 1&2).[27] This finding proves the hypothesis that ecological degradation worsens during the initial growth process and improves as national income rises.

6. Discussion

The four hypotheses we started with have largely been confirmed. Examining the *Top Block* (*Consumption EF* and *Imports EF*) vs. *Bottom Block* (*Production EF* and *Exports EF*) of Table 3 gives us a perspective regarding consumption-vs. production-related FDI effects, Most of the consumption-related ecologically-exhaustive effects happen in High Income countries, while almost none of the production-related FDI effects happen in High Income countries.[28] In contrast, almost all production-

[26] Services correspond to ISIC rev. 3 divisions 50–99.

[27] The latter group contains up to 63 countries (based on the sectoral FDI regression), as oppose to up to 41 countries for Middle Income countries and up to 39- for High Income countries.

[28] The exception is of mining FDI impact on Production EF in High Income countries (Table 3: Panel 2, row 4, col. 2).

related FDI impacts are carried out in Low and Middle Income economies. The *Exports EF* impact, in particular, is predominantly born by Middle Income countries. This confirms our H1 hypothesis and is related to the results found in Moran et al. (2013), Jorgenson et al. (2009), and Givens et al. (2019).

Comparing the *Left Block* (domestic economic activities *EFs*) and the *Right Block*, (external sector activities *EFs)* of Table 3, we see another confirmation of ecologically unequal exchange: FDI does not have an impact on *Export EF* in High Income countries. The Middle Income countries of the world bear the effect of FDI on *Exports EF*. However, High Income countries enjoy some *FDI ecological halo* effects in their domestic production sector. These are due to financial FDI and occur under specific circumstances: the receiving countries must have strict environmental regulation so that the spillovers from financial FDI to the production side of the economy could generate activities that are biosystems-friendly. Overall, the above evidence proves our hypothesis H2.

Finally, there are differences in the results across individual columns of Table 3. They are due to differences in technology that FDI transfers. The evidence supports *FDI ecological haven* hypothesis that we have proposed. Low and Middle Income countries tend to bear negative effects of FDI, while High Income countries enjoy some ecology-enhancing ("*halo*") spillover. This confirms our hypothesis H3.

Also, looking from the perspective of individual sectoral FDI flows, while services are perceived to be an environmentally clean sector, there are particular non-financial services industries that are among the most ecologically demanding, such as transport, for example. Van Veen-Groot and Nijkamp (1999) discuss at length the scale effect, the structural effect, the technology effect, and the product effect of transportation on environmental degradation. The authors treat "transport and mobility" as the third pillar in environmental change-next to "global trade" and globalization". Transport and mobility, on one hand, enhance the effects of trade and internalization of production on the environment; on the other-have direct effects on the environment. That is why we see a multitude of effects from non-financial FDI.

Our Ecological Kuznets curve hypothesis (H4) holds in the context of the heterogeneous sample of "all countries", but only for the *Consumption EF* and the *Production EF*.

It also outlines a very clear ecological economics policy recommendation for the two country groups: reduce consumption in High Income countries and secure environmentally clean technologies and practices in Low and Middle Income countries. The example of financial FDI impact on the *Production EF* in High Income economies shows that with the right kind of policies, foreign capital investment can even produce an ecology-enhancing ("*halo*") spillover.

7. Conclusion

In this study, we set out to test three different hypotheses related to ecologically unequal exchange occurring between developed and developing countries. More specifically, we test for whether ecologically unequal exchange occurs through FDI. We consider several possible ossible effects of FDI on bioproductive land: an *ecological haven,* an *ecological halo,* and the well-know EKC hypothesis. The "*haven*" hypothesis emerges as part of the discussion about the differential effects of FDI flows into developed and developing economies. In that respect, we find that FDI inflows to developed economies augment consumption-related footprints, whereas FDI inflows to developing countries tend to add up to production-related footprints. This exposes an unequally distributed ecological burden from FDI, which is consistent with the original *pollution haven* hypothesis and reflects ecologically unequal exchange.

The *FDI ecological halo* hypothesis, on the other hand, is reflected in the FDI industry mix. Although most FDI, such as mining and non-financial services, add to *EF*, we find that certain industry flows, in the right conditions, can produce an ecologically beneficial "*halo*" effect through positive spillovers on "green" industries. However, this occurs only in High Income countries-another evidence of ecologically unequal exchange. Meanwhile, the most heavily affected in their *Exports EF*, are the Middle Income countries. This outlines a very clear ecological economics policy recommendation for the two country groups: reduce consumption in High Income countries and secure environmentally clean technologies and practices in Low and Middle Income countries. The example of financial FDI impact on the *Production EF* in High Income economies shows that with the right kind of policies, foreign capital investment can even produce an ecology-enhancing ("*halo*") spillover.

This investigation started as a question of how FDI impacts the ecological footprint of nations. The results reveal a multifaceted picture: the effect depends on which FDI, which footprint, what kind of countries. Despite the complexity, we find some evidence that FDI contributes disproportionally to consumption-related *EF* of wealthy nations and production-related footprints of developing economies. This does not mean that countries must disincentivize FDI, but rather it calls for policy changes that influence consumer behavior in wealthier nations, so the extra income generated by FDI is consumed in an ecologically responsible manner. It also calls for policy regulations on production processes in developing countries with special attention paid to extractive industries FDI and non-financial services FDI.

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.

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Appendix

Table A1
FDI Impact on *Consumption EF,* Sample of "All Countries"

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	Total FDI	Mining FDI	Manufacturing FDI	Total Services FDI	Financial FDI	Non-Financial FDI
Lagged Ln (*Consumption EF* per cap.)	0.998***	0.984***	0.958***	0.966***	0.945***	0.957***
	(0.0362)	(0.0347)	(0.0266)	(0.0265)	(0.0406)	(0.0380)
Ln (GDP per cap.)	**0.0339*** **	**0.0382**	**0.0698*** **	**0.0542*** **	**0.0762** **	**0.0733***
	(0.00757)	**(0.0275)**	**(0.0238)**	**(0.0190)**	**(0.0380)**	**(0.0397)**
$[\text{Ln (GDP per cap.)}]^2$	**-0.00196*** **	**-0.00188*** **	**-0.00344*** **	**-0.00248** **	**-0.00342** **	**-0.00350** **
	(0.00115)	**(0.00111)**	**(0.00126)**	**(0.000973)**	**(0.00146)**	**(0.00165)**
Control of Corruption	-0.00150	-0.00103	0.00578	-0.000731	0.000548	0.00110
	(0.00352)	(0.00375)	(0.00513)	(0.00412)	(0.00383)	(0.00346)
FDI	-0.000362	0.0944	0.110	0.00317	0.00292	**0.168** **
	(0.00356)	(0.0720)	(0.0853)	(0.00281)	(0.00516)	**(0.0685)**
Observations	3,007	1,285	1,488	1,294	1,224	1,032
Number of countries	117	83	87	86	76	76
AR(2) pval	0.377	0.470	0.488	0.327	0.0866	0.135
Sargan test chi2	69	66.25	40.72	33.61	37.41	25.80
Sargan test pval	2.57e-05	6.11e-05	0.0570	0.214	0.110	0.584

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table A2
FDI Impact on *Production EF,* Sample of "All Countries"

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	Total FDI	Mining FDI	Manufacturing FDI	Total Services FDI	Financial FDI	Non-Financial FDI
Lagged Ln (*Production EF* per cap.)	1.002***	1.005***	0.981***	1.010***	1.006***	0.974***
	(0.0267)	(0.0155)	(0.0129)	(0.0150)	(0.0143)	(0.0169)
Ln (GDP per cap.)	**0.0376*** **	**0.0377***	**0.0577*** **	**0.0391***	**0.0407***	**0.0914*** **
	(0.00703)	**(0.0205)**	**(0.0216)**	**(0.0206)**	**(0.0233)**	**(0.0273)**
$[\text{Ln (GDP per cap.)}]^2$	**-0.00227*** **	**-0.00244** **	**-0.00306** **	**-0.00264** **	**-0.00282** **	**-0.00506*** **
	(0.000679)	**(0.00101)**	**(0.00124)**	**(0.00107)**	**(0.00118)**	**(0.00140)**
Control of Corruption	-0.00147	-0.00139	-0.000814	-0.00246	0.000373	0.00257
	(0.00233)	(0.00344)	(0.00534)	(0.00366)	(0.00285)	(0.00315)
FDI	-0.000340	0.0290	0.0361	**-0.00544*** **	**-0.00575** **	0.00902
	(0.00314)	(0.0672)	(0.0311)	**(0.00186)**	**(0.00280)**	(0.0579)
Observations	3,007	1,285	1,488	1,294	1,224	1,032
Number of countries	117	83	87	86	76	76
AR(2) pval	0.0318	0.456	0.632	0.361	0.536	0.310
Sargan test chi2	86.61	63.64	40.81	27.25	24.24	27.66
Sargan test pval	6.66e-08	0.000137	0.0559	0.505	0.669	0.483

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table A3
FDI Impact on *Imports EF,* Sample of "All Countries"

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	Total FDI	Mining FDI	Manufacturing FDI	Total Services FDI	Financial FDI	Non-Financial FDI
Lagged Ln (*Imports EF* per cap.)	1.003***	0.991***	1.000***	1.000***	0.968***	1.007***
	(0.0189)	(0.0352)	(0.0145)	(0.0269)	(0.0277)	(0.0317)
Ln (GDP per cap.)	0.0330	0.0734	0.0479	0.00724	0.0773	0.00394
	(0.0208)	(0.0571)	(0.0317)	(0.0545)	(0.0530)	(0.0590)
$[\text{Ln (GDP per cap.)}]^2$	**-0.00205** **	**-0.00400***	**-0.00339** **	-0.000792	-0.00359	-0.00108
	(0.00100)	**(0.00241)**	**(0.00160)**	(0.00222)	(0.00236)	(0.00255)
Control of Corruption	-0.00441	-0.00496	0.00404	-0.00488	-0.00119	-0.00624
	(0.00375)	(0.00848)	(0.00592)	(0.00561)	(0.00596)	(0.00648)
FDI	-0.00428	**0.405*** **	0.0325	0.000511	0.00185	**0.229** **
	(0.00445)	**(0.139)**	(0.0761)	(0.00547)	(0.00706)	**(0.113)**
Observations	3,007	1,285	1,488	1,294	1,224	1,032
Number of countries	117	83	87	86	76	76
AR(2) pval	0.351	0.483	0.704	0.735	0.288	0.439
Sargan test chi2	30.51	49.48	36.08	27.22	27.91	17.51
Sargan test pval	0.339	0.00739	0.141	0.506	0.469	0.938

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table A4
FDI Impact on *Exports EF,* Sample of "All Countries"

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	Total FDI	Mining FDI	Manufacturing FDI	Total Services FDI	Financial FDI	Non-Financial FDI
Lagged Ln (*Exports EF* per cap.)	0.985***	0.984***	1.001***	0.992***	0.977***	1.005***
	(0.0105)	(0.0278)	(0.00773)	(0.0156)	(0.0220)	(0.0144)
Ln (GDP per cap.)	**0.0934****	0.120	0.0364	0.0620	**0.147***	0.0746
	(0.0205)	(0.0862)	(0.0421)	(0.0606)	**(0.0826)**	(0.0697)
$[\text{Ln (GDP per cap.)}]^2$	**-0.00466*****	**-0.00659***	-0.00229	-0.00344	**-0.00775***	-0.00475
	(0.00141)	**(0.00383)**	(0.00241)	(0.00310)	**(0.00415)**	(0.00376)
Control of Corruption	-0.00357	-0.000389	-0.00865	-0.00724	-9.98e-05	-0.00760
	(0.00824)	(0.00878)	(0.00756)	(0.00793)	(0.00957)	(0.00892)
FDI	0.00298	0.125	-0.0938	0.000497	0.00418	0.219
	(0.00782)	(0.0798)	(0.158)	(0.00460)	(0.00612)	(0.194)
Observations	3,007	1,285	1,488	1,294	1,224	1,032
Number of countries	117	83	87	86	76	76
AR(2) pval	0.743	0.311	0.648	0.842	0.323	0.305
Sargan test chi2	72.52	104.3	26.23	23.82	29.09	33.63
Sargan test pval	8.21e-06	1.03e-10	0.561	0.691	0.408	0.213

Robust standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

References

Al-Mulali, U., Weng-Wai, C., Sheau-Ting, L., Mohammed, A.H., 2015. Investigating the environmental Kuznets curve (EKC) hypothesis by utilizing the ecological footprint as an indicator of environmental degradation. Ecol. Indicat. 48, 315–323.

Albornoz, F., Cole, M., Elliott, R.J.R., Ercolani, M., 2009. In search of environmental spillovers. World Econ. 32 (1), 136–163.

Alonso-Borrego, C., Arellano, M., 1999. Symmetrically normalized instrumental-variable estimation using panel data. J. Bus. Econ. Stat. 17 (1), 36–49.

Arellano, M., Bover, O., 1995. Another look at the instrumental variable estimation of error-components models. J. Econom. 68 (1), 29–51.

Ashraf, A., Doytch, N., Uctum, M., 2020. Foreign direct investment and the environment: disentangling the impact of greenfield investment and merger and acquisition sales. Sustain. Account. Manage. Pol. J. Forthcom.

Asteriou, D., Dimelis, S., Moudatsou, A., 2014. Globalization and income inequality: a panel data econometric approach for the EU27 countries. Econ. Modell. 36, 592–599.

Beckerman, W., 1995. How would you like your 'sustainability', sir? Weak or strong? A reply to my critics. Environ. Val. 4 (2), 167–179.

Bhagwati, J., 2004. In Defense of Globalization: with a New Afterword. Oxford University Press.

Blundell, R., Bond, S., 1998. Initial conditions and moment restrictions in dynamic panel data models. J. Econom. 87 (1), 115–143.

Borghesi, S., Vercelli, A., 2003. Sustainable globalization. Ecol. Econ. 44, 77–89.

Butchart, S.H., Walpole, M., Collen, B., Van Strien, A., Scharlemann, J.P., Almond, R.E., et al., 2010. Global biodiversity: indicators of recent declines. Science 328 (5982), 1164–1168.

Chung, S., 2014. Environmental regulation and foreign direct investment: evidence from South Korea. J. Dev. Econ. 108, 222–236.

Cole, M.A., Elliot, R., Strobl, E., 2008. The environmental performance of firms: the role of foreign ownership, training and experience. Ecol. Econ. 65, 538–546.

Copeland, B.R., Taylor, M.S., 1994. North-South trade and the environment. Q. J. Econ. 109 (3), 755–787.

Daly, Herman, Townsend, Kenneth, 1993. Valuing the Earth: Economics. *Ecology, Ethics*, 3. MIT Press.

Das, D.K., 2004. The Economic Dimensions of Globalization. Palgrave MacMillan, New York.

Dasgupta, S., Hettige, H., Wheeler, D., 2000. What improves environmental compliance? Evidence from Mexican industry. J. Environ. Econ. Manag. 39. RC– 66.

DeFries, R.S., Rudel, T., Uriarte, M., Hansen, M., 2010. Deforestation driven by urban population growth and agricultural trade in the twenty-first century. Nat. Geosci. 3 (3), 178.

Dinda, S., 2004. Environmental Kuznets curve hypothesis: a survey. Ecol. Econ. 49, 431–455.

Dong, B., Gong, J., Zhao, X., 2012. FDI and environmental regulation: pollution haven or a race to the top? J. Regul. Econ. 41 (2), 216–237.

Doytch, N., Narayan, S., 2016. Does FDI influence renewable energy consumption? An analysis of sectoral FDI impact on renewable and non-renewable industrial energy consumption. Energy Econ. 54, 291–301.

Doytch, N., Uctum, M., 2011. Does the worldwide shift of FDI from manufacturing to services accelerate economic growth? A GMM estimation study. J. Int. Money Finance 30 (3), 410–427.

Doytch, N., Uctum, M., 2016. Globalization and the environmental impact of sectoral FDI. Econ. Syst. 40 (4), 582–594.

Easterbrook, G., 1995. A Moment on the Earth: the Coming of Age of Environmental Optimism. Penguin Books USA Inc.

Erb, K.H., Krausmann, F., Lucht, W., Haberl, H., 2009. Embodied HANPP: mapping the spatial disconnect between global biomass production and consumption. Ecol. Econ. 69 (2), 328–334.

Eskeland, G.S., Harrison, A.E., 2003. Moving to greener pastures? Multinationals and the pollution haven hypothesis. J. Dev. Econ. 70 (1), 1–23.

Figge, L., Oebels, K., Offermans, A., 2017. The effects of globalization on Ecological Footprints: an empirical analysis. Environ. Dev. Sustain. 19 (3), 863–876.

Foley, J.A., DeFries, R., Asner, G.P., Barford, C., Bonan, G., Carpenter, S.R., et al., 2005. Global consequences of land use. Science 309 (5734), 570–574.

Gallagher, K.P., 2009. Economic globalization and the environment. Annu. Rev. Environ. Resour. 34, 279–304.

Giampietro, M., Saltelli, A., 2014. Footprints to nowhere. Ecol. Indicat. 46, 610–621.

Givens, J.E., Huang, X., Jorgenson, A.K., 2019. Ecologically unequal exchange: a theory of global environmental injustice. Sociology Compass 13 (5), e12693.

Global Footprint Network, 2016. The national footprint accounts. In: GFN (Ed.), 2016 Edition. Global Footprint Network, Oakland, CA, USA.

Godfray, H.C.J., Beddington, J.R., Crute, I.R., Haddad, L., Lawrence, D., Muir, J.F., et al., 2010a. Food security: the challenge of feeding 9 billion people. Science 327 (5967), 812–818.

Godfray, H.C.J., Crute, I.R., Haddad, L., Lawrence, D., Muir, J.F., Nisbett, N., et al., 2010b. The Future of the Global Food System.

Goldfinger, S., Wackernagel, M., Galli, A., Lazarus, E., Lin, D., 2014. Footprint facts and fallacies: a response to Giampietro and Saltelli (2014) "footprints to nowhere". Ecol. Indicat. 46, 622–632.

Grossman, G.M., Krueger, A.B., 1995. Economic growth and the environment. Q. J. Econ. 110 (2), 353–377.

Harbaugh, W., Levinson, A., Wilson, D., 2002. Reexamining the empirical evidence for an environmental Kuznets curve. Rev. Econ. Stat. 84 (3), 541–551.

Hartman, R.S., Huq, M., Wheeler, D., 1997. Why Paper Mills Clean up Determinants of Pollution Abatement in Four Asian Countries. World Bank Policy Research Working Paper # 1710.

Hettige, H., Mani, M., Wheeler, D., 2000. Industrial pollution in economic development: the environmental Kuznets curve revisited. J. Dev. Econ. 62, 445–476.

Hilton, F.H., Levinson, A., 1998. Factoring the environmental Kuznets curve: evidence from automotive lead emissions. J. Environ. Econ. Manag. 35 (2), 126–141.

Holtz-Eakin, D., Selden, T.M., 1995. Stoking the fires? CO2 emissions and economic growth. J. Publ. Econ. 57, 85–101.

International Country Risk Guide (ICRG), 2012. PRS Group. http://www.prsgroup.com/.

Jaffe, A., Peterson, S., Portney, P., Stavins, R., 1995. Environmental regulation and the competitiveness of U.S. manufacturing: what does the evidence tell us. J. Econ. Lit. 33 (1), 132–163.

Jorgenson, A.K., 2007. Does foreign investment harm the air we breathe and the water we drink? A cross-national study of carbon dioxide emissions and organic water pollution in less-developed countries, 1975 to 2000. Organ. Environ. 20 (2), 137–156.

Jorgenson, A.K., 2012. The sociology of ecologically unequal exchange and carbon dioxide emissions, 1960–2005. Soc. Sci. Res. 41 (2), 242–252.

Jorgenson, A.K., Clark, B., 2011. Societies consuming nature: a panel study of the ecological footprints of nations, 1960–2003. Soc. Sci. Res. 40 (1), 226–244.

Jorgenson, A.K., Clark, B., 2013. Footprints: the division of nations and nature. In: Ecology and Power. Routledge, pp. 171–183.

Jorgenson, A.K., Rice, J., Crowe, J., 2005. Unpacking the ecological footprint of nations. Int. J. Comp. Sociol. 46 (3), 241–260.

Jorgenson, A.K., Austin, K., Dick, C., 2009. Ecologically unequal exchange and the resource consumption/environmental degradation paradox: a panel study of less-developed countries, 1970—2000. Int. J. Comp. Sociol. 50 (3–4), 263–284.

Kissinger, M., Rees, W.E., 2010a. An interregional ecological approach for modelling sustainability in a globalizing world—reviewing existing approaches and emerging directions. Ecol. Model. 221 (21), 2615–2623.
Kissinger, M., Rees, W.E., 2010b. Importing terrestrial biocapacity: the US case and global implications. Land Use Pol. 27 (2), 589–599.
Krausmann, F., Gingrich, S., Eisenmenger, N., Erb, K.H., Haberl, H., Fischer-Kowalski, M., 2009. Growth in global materials use, GDP and population during the 20th century. Ecol. Econ. 68 (10), 2696–2705.
Lambin, E.F., Meyfroidt, P., 2011. Global land use change, economic globalization, and the looming land scarcity. Proc. Natl. Acad. Sci. Unit. States Am. 108 (9), 3465–3472.
Moran, D.D., Lenzen, M., Kanemoto, K., Geschke, A., 2013. Does ecologically unequal exchange occur? Ecol. Econ. 89, 177–186.
Myers, N., Kent, J., 2003. New consumers: the influence of affluence on the environment. Proc. Natl. Acad. Sci. Unit. States Am. 100 (8), 4963–4968.
Mayer, A.L., Kauppi, P.E., Angelstam, P.K., Zhang, Y., Tikka, P., 2003. Importing timber,. exporting ecological impact. Science 308 (8), 359–360.
Norgaard, R.B., 1990. Economic indicators of resource scarcity: a critical essay. J. Environ. Econ. Manag. 19 (1), 19–25.
Pargal, S., Wheeler, D., 1996. Informal regulation of industrial pollution in developing countries: evidence from Indonesia. J. Polit. Econ. 104 (6), 1314–1327.
Pauly, D., Christensen, V., Guénette, S., Pitcher, T.J., 2002. Towards sustainability in world fisheries. Nature 418 (6898), 689.
Rees, W.E., 1992. Ecological footprints and appropriated carrying capacity: what urban economics leaves out. Environ. Urbanization 4 (2), 121–130.
Rees, W.E., 2001. Ecological Footprint, Concept of.
Rees, W., Wackernagel, M., 1996. Urban ecological footprints: why cities cannot be sustainable—and why they are a key to sustainability. Environ. Impact Assess. Rev. 16 (4–6), 223–248.
Rees, W.E., Wackernagel, M., 1999. Monetary analysis: turning a blind eye on sustainability. Ecol. Econ. 29 (1), 47–52.
Roodman, David, 2009. How to do xtabond2: An introduction to difference and system GMM in Stata. The stata journal 9 (1), 86–136.
Rudel, T.K., Defries, R., Asner, G.P., Laurance, W.F., 2009a. Changing drivers of deforestation and new opportunities for conservation. Conserv. Biol. 23 (6), 1396–1405.
Rudel, T.K., Schneider, L., Uriarte, M., Turner, B.L., DeFries, R., Lawrence, D., et al., 2009b. Agricultural intensification and changes in cultivated areas, 1970–2005. Proc. Natl. Acad. Sci. Unit. States Am. 106 (49), 20675–20680.
Rudolph, A., Figge, L., 2017. Determinants of Ecological Footprints: what is the role of globalization? Ecol. Indicat. 81, 348–361.
Shafik, N., 1994. Economic Development and Environmental Quality: an Econometric Analysis. Oxford economic papers, pp. 757–773.
Simon, J., 1996. The Ultimate Resource 2. Princeton University Press, NJ.
Slimane, M.B., Huchet-Bourdon, M., Zitouna, H., 2016. The role of sectoral FDI in promoting agricultural production and improving food security. The ultimate resource 2. Princeton University Press, NJ. 145, 50–65.
Steinberger, J.K., Krausmann, F., 2011. Material and Energy Productivity.
Stern, D., 1998. Progress on the environmental Kuznets curve? Environ. Dev. Econ. 3, 175–198.
Stiglitz, J.E., 2006. Stability with Growth: Macroeconomics, Liberalization and Development. Oxford University Press on Demand.
Tamazian, A., Rao, B.B., 2010. Do economic, financial and institutional developments matter for environmental degradation? Evidence from transitional economies. Energy Econ. 32 (1), 137–145.
Tamazian, A., Chousa, J.P., Vadlamannati, K.C., 2009. Does higher economic and financial development lead to environmental degradation: evidence from BRIC countries. Energy Pol. 37 (1), 246–253.
Tilman, D., Socolow, R., Foley, J.A., Hill, J., Larson, E., Lynd, L., et al., 2009. Beneficial biofuels—the food, energy, and environment trilemma. Science 325 (5938), 270–271.
Tilman, D., Balzer, C., Hill, J., Befort, B.L., 2011. Global food demand and the sustainable intensification of agriculture. Proc. Natl. Acad. Sci. Unit. States Am. 108 (50), 20260–20264.
Ting, Y., Yin, L.R., Ying, Z.Y., 2011. Analysis of the FDI effect on energy consumption intensity in Jiangsu Province. Energy Procedia 5, 100–104.
Van Veen-Groot, D.B., Nijkamp, P., 1999. Globalization, transport and the environment: new perspectives for ecological economics. Ecol. Econ. 31 (3), 331–346.
Vu, T.B., Noy, I., 2009. Sectoral analysis of foreign direct investment and growth in the developed countries. J. Int. Financ. Mark. Inst. Money 19 (2), 402–413.
Wackernagel, M., Rees, W.E., 1997. Perceptual and structural barriers to investing in natural capital: economics from an ecological footprint perspective. Ecol. Econ. 20 (1), 3–24.
Wackernagel, M., Rees, W., 1998. Our Ecological Footprint: Reducing Human Impact on the Earth, vol. 9. New Society Publishers.
Weinzettel, J., Hertwich, E.G., Peters, G.P., Steen-Olsen, K., Galli, A., 2013. Affluence drives the global displacement of land use. Global Environ. Change 23 (2), 433–438.
Wirsenius, S., Azar, C., Berndes, G., 2010. How much land is needed for global food production under scenarios of dietary changes and livestock productivity increases in 2030? Agric. Syst. 103 (9), 621–638.
Zafar, M.W., Zaidi, S.A.H., Khan, N.R., Mirza, F.M., Hou, F., Kirmani, S.A.A., 2019. The impact of natural resources, human capital, and foreign direct investment on the ecological footprint: the case of the United States. Resour. Pol. 63, 101428.