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The global partnership for sustainable development

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Abstract

This paper examines whether foreign aid, together with other economic, social and environmental factors, contributes to sustainable development. It starts with a theoretical model where sustainable development is modelled as a different kind of growth that protects the environment. Using factor analysis and newly developed estimation methods for a dynamic panel data model with endogenous regressors, the empirical section finds evidence that foreign aid has been a significantly positive influence on sustainable development in aid recipient countries. This effect is very likely to go through channels related to growth and resources as well as a technology channel with respect to energy intensity. This research has important implications for a post-2015 development framework on international collective action with regard to a sustainable future.

Keywords: sustainable development, aid effectiveness, post-2015 development agenda, economic growth, natural resource exploitations, energy intensity, factor-IV, factor-GMM
JEL classification: O10, O44, I00, F35, F60

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Acronyms

EKC	environmental Kuznets curve
factor-GMM	factor-based generalized method of moments estimator
GNI	gross national income
HDI	human development index
ODA	official development assistance
SHDI	sustainability-adjusted human development index
WDI	world development indicators (of the World Bank)

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1 Introduction

Expanding populations and economies in the current world are adding considerable pressure on the environment while the widespread aging of the populace and rapid technological change are placing great stress on social equity and cohesion. Environmental sustainability and social inclusion have become major political priorities, especially for developing countries. This research focuses on the global partnership in areas such as foreign aid for sustainable development, which is one important vision articulated in the Millennium Declaration.[1]

Since high growth performance does not necessarily bring about high levels of development, sustainable development has been increasingly regarded as the primary objective in many countries. As an alternative approach to the traditional growth path that concentrates only on economic advancement, sustainable development pursues a balance between economic development, social equity and environmental protection, not as conflicting goals but as pillars which complement each other.[2]

At a time when the world is faced with environmental degradation and rising inequity and poverty, developing countries are much more vulnerable to adverse situations than the developed nations. This is due to various reasons such as low adaptation capacity, weak regulatory systems and disproportionate dependency on natural resources. They need financial assistance from the developed countries to support their efforts towards a sustainable future. In this respect, foreign aid has played an important role in the global arena in the attempt by developed countries to boost prosperity in the developing countries.

The history of foreign aid dates back to the days immediately after the Second World War when aid was used to address the impacts of war in Europe as well as other reconstruction efforts. Since the 1950s, the objective of foreign aid has been to promote economic growth and combat poverty and inequality in developing countries. In recent decades, as environmental degradation and inequality have reached alarming proportions, the purpose of aid have expanded to multiple goals such as the United Nations' Millennium Development Goals (MDGs) that focus on poverty, environment, literacy, health, woman's right, etc. A number of foreign aid projects and programmes have been designed and established to integrate environmental sustainability and social inclusion into all aspects of development cooperation.[3]

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[1] The Millennium Declaration calls for global policies and measures to ensure that 'globalization becomes a positive force for all the world's people'. It focuses on development, poverty eradication, environmental protection, peace, security, disarmament, human right, good governance and protecting the vulnerable, etc. Its broad vision is encapsulated as inclusive and sustainable development.

[2] Formally introduced by the WCED (1987) or Brundtland Report, the most widely accepted definition of sustainable development is 'development which meets the needs of the present without compromising the ability of future generations to meet their own needs'.

[3] For example, in 1992, the World Conference on Development and Environment initiated the Global Environment Facility (GEF), a mechanism to facilitate aid for environment. OECD's Green Growth Strategy, announced in 2009 is aimed at helping developing countries achieve economic growth, job creation, environmental protection and the development of more equitable societies.

The total volume of official development assistance (ODA) in the recent post-economic crisis period reached a peak in 2010, but declined in 2011 for the first time since 1997. This widened the gap between actual disbursements and the amounts committed in accordance with the United Nations' target of 0.7 per cent of donor country gross national income (GNI). The recent fiscal austerity and economic challenges have increased pressure on the traditional donors to produce tangible results to their governments and taxpayers, e.g., the sceptics of aid effectiveness, of ODA's contribution to development outcomes.

The literature on aid effectiveness is voluminous and it focusses primarily on the impact of foreign aid in advancing economic growth. Foreign aid has always had its proponents and opponents.[4] Proponents argue that aid is the driver of continued economic growth in developing countries, and that it generally leads to technological advances, for instance, and the accumulation of human capital that can sustain economic growth (Hansen and Tarp 2001; Stiglitz 2003; Sachs, 2006). The opponents, however, disparage most aid as unproductive and even counter-productive, and a waste of money. For example, aid has been criticized as undermining democracy and freedom, retarding economic development and contributing to larger bureaucracies and less efficient governments (Friedman 1995; Rajan and Subramanian 2008; Easterly 2009). However, systematic research on aid effectiveness for sustainable development is hugely lacking.

This paper aims to explore the role of a renewed global partnership in promoting sustainable development, with a specific focus on foreign aid, which is highly significant and policy relevant for the developing countries.[5] The underlying argument is that with foreign aid, these countries are in a better financial situation to take care of their natural resources, protect the environment and develop more equitable societies. To achieve sustainable development, the Millennium Declaration calls for international cooperation to go beyond aid to encompass trade, investment, governance, etc. This implies that fundamental changes in the global partnership are required to address current and emerging challenges in such areas as climate change mitigation and adaptation, employment and migration.

This research, based on the traditional Solow growth model, starts with a theoretical model where sustainable development is modelled as a different kind of growth that protects the environment and promotes social development. It then moves on to an empirical analysis based on annual data for 70 aid recipient countries covering the period of 1985-2010. Factor-based instrumental variable estimator (factor-IV) and factor-based generalized method of moments estimator (factor-GMM) according to Bai and Ng (2010) and Kapetanios and Marcellino (2010) are used to estimate a dynamic panel data model with endogenous regressors. Three potential channels through which foreign aid could stimulate sustainable development are investigated: economic growth, natural resource exploitation and energy intensity.

Our research provides evidence that foreign aid has boosted sustainable development of aid recipient countries. This is measured with three different indicators: 'genuine savings', the 'ecological footprint/bio-capacity ratio' and 'sustainability-adjusted HDI'. It further suggests that foreign aid has a significant effect on sustainable development through such channels as

[4] See Temple (2010) for a review.

[5] See UN System Task Team on the Post-2015 UN Development Agenda, UN/DESA, UNDP and others, 'A renewed global partnership for development', March 2013.

growth, natural resources and technology in connection with energy intensity. Although other innovative sources of international financing for development such as non-DAC aid and private philanthropy continue to grow, foreign aid remains the main source of funding for development cooperation. We believe this research has important implications for an enhanced global partnership in areas such as foreign aid in a post-2015 development agenda for achieving a sustainable future.

The structure of the paper is as follows. The theoretical model is given in Section 2. Section 3 outlines the empirical framework, followed by the data and stylized facts in Section 4. The evidence is discussed in Section 5 and Section 6 concludes the paper.

2 A theoretical model

This section models 'sustainable development' basically as environmental sustainability. Taken together with 'inclusive growth' modelled in Huang and Quibria (2013), these elements refer to a different kind of growth.

In the following, we develop a simple Solow model, according to Brock and Taylor (2010), to explore the simple analytics of the environmental Kuznets curve (EKC). However, we believe that our formulation, which deviates from Brock and Taylor in the specification of the emission function, is analytically somewhat simpler and intuitively more straight-forward.

The production function is assumed to be Cobb-Douglas and is given by:

$$X = AK^{a}L^{(1-a)} \tag{1}$$

where X, K, L, A represent output, capital, labour and total factor productivity, respectively. Eq. (1) can be expressed in intensive form:

$$x = Ak^{a} \tag{2}$$

where $x = X / L,$ is gross output per worker; and $k = K / L,$ capital per worker. Finally, as is well-known, $0 \prec a \prec 1,$ which implies that there are diminishing returns to output per worker.

The (net) output is defined by:

$$y = x(1-\lambda) \tag{3}$$

where $Y =$ net output and $y = Y / L,$ net output per worker; and $\lambda =$ a fixed proportion of the domestic (gross) output devoted to emission control.

The capital accumulation equation is given by:

$$dk / dt = sAk^{a}(1-\lambda) - (\delta + n) \tag{4}$$

where dk / dt = change in capital per worker. It is assumed that a proportion of net output is saved and invested. The first term on the right-hand side, $sAk^{a}(1-\lambda),$ represents gross investment; the second term, $\delta + n$, is the sum of the depreciation rate and the labour force growth rate. In other words, we have assumed that:

$$\hat{L} \equiv (1/L)(dL/dt) = n .$$

Eq. (4) can be rewritten as follows:

$$dk/dt = sAk^{a}(1-\lambda) - (\delta + n)k \tag{5}$$

With respect to pollution, we have assumed the following emission function:

$$e = \phi x / Az , \qquad \text{with } 0 \prec \phi \prec 1. \tag{6}$$

where, as in the rest of the paper, we have expressed emission, e, in per worker units.

A number of observations are in order with respect to the emission eq. (6):

- First, it is assumed that emission varies proportionately with gross output x, the scale of activity. The proportion is given by ϕ. This is a standard assumption in the literature, used among others by Brock and Taylor (2010).

- Second, we assume that abatement of emissions varies inversely with technology. As Reis (2001) suggests, the higher value of A indicates cleaner technology. We have further assumed that technological progress takes place exogenously at a rate π. In other words, $\hat{A} = \pi$.

- Finally, it is assumed that emissions decrease with resources targeted to abatement. We have assumed that a fixed proportion of gross output, λx, is devoted to abatement. The abatement function is given by:

$$z = (\lambda x)^{\mu} \qquad \text{with } 0 \prec \mu \prec 1 \tag{7}$$

Eq. (7) states that resource expenditures for pollution control have a positive but diminishing impact on abatement. This assumption, which is plausible, is consistent with the existing literature.

Balanced growth path

Eq. (4) would imply:

$$\hat{k} \equiv \dot{k}/k = sAk^{a-1}(1-\lambda) - (\delta + n) = 0 \tag{8}$$

Thus, the steady-state solution $k*$ is given by:

$$k* = \{sA(1-\lambda)/(\delta + n)\}^{1/(1-a)}$$

This expression shows that the higher the proportion of output devoted to abatement, the lower the steady-state $k*$. As $k*$ decreases, $y*$, the steady-state per capita income decreases. This, however, does not affect the steady-state growth rate.

Next, we seek to relate the Solow steady-state with the ECK. However, to do so, let us consider eq. (6). Substituting $z = (\lambda x)^{\mu}$ from eq. (7) into eq. (6) and simplifying, we can derive:

$$e = \theta k^{(1-\mu)a} / A^{\mu} \lambda^{\mu} \tag{9}$$

The equation can be rewritten in the proportionate rate of change form:

$$\hat{e} = \hat{\theta} + (1-\mu)a\hat{k} + \mu\hat{A} - \mu\hat{\lambda} \tag{10}$$

This can be rewritten by:

$$\hat{e} = \hat{\theta} + (1-\mu)a\hat{k} - \mu\pi - \mu\hat{\lambda} \tag{11}$$

As is evident from eq. (11):

- Growth in emissions is negatively related to technological progress as well as increases in the rate of expenditures in abatement.
- Other things remaining the same, the emission curve mirrors the Solow fundamental equation of growth exactly and produces the environmental Kuznets curve (EKC).
- When $\hat{k} = \hat{\theta} = \hat{\lambda} = 0$, $\hat{e} = -\mu\pi \prec 0$. This implies that the ECK reaches its downward slope before the model reaches the Solow steady-state solution if there is technological progress, assuming other parameters remain the same. However, the maximum point of the ECK will approach faster if expenditures for abatement increase or if there is an improvement in technology that reduces the emission parameter related to output, θ.
- When $\hat{e} = (1-\mu)a\hat{k} - \mu\pi = 0$, that is, when growth in emissions stops, it can be seen: $\hat{k} = \mu\pi / (1-\mu)a \succ 0$. In other words, the emissions growth rate reaches zero at a capital per worker or income level that lies below the corresponding Solow steady-state levels.

The above relationship between the Solow steady-state solution and the ECK can be seen from the following geometric exposition. From eq. (8), we can define the steady solution as follows:

$$k^* \equiv \{k : sAk^{a-1}(1-\lambda) - (\delta + n) = 0\} \tag{12}$$

Assuming $\hat{\theta} = \hat{\lambda} = 0$ and substituting $\hat{k}$ from eq. (8) into eq. (11), we can define k^{**}, the capital per worker where the ECK reaches its maximum, as follows:

$$k^{**} = \{k : sAk^{(1-a)}(1-\lambda) - (\delta + n) - (\pi\mu) / a(1-\mu) = 0\} \tag{13}$$

It can be easily seen that $k^{**} \prec k^*$.

The above exposition shows that a natural outcome of the Solow model is the EKC. It also shows that appropriate domestic policies, such as higher expenditures on pollution abatement or technological innovations in green technology, can help usher in a greener phase of the ECK faster than a stance of benign neglect.

3 An empirical framework

This section formulates the empirical model and outlines estimation methods developed by Bai and Ng (2010) and Kapetanios and Marcellino (2010) for the linear dynamic panel data model with fixed effects and endogenous regressors when the cross-sectional dimension (*N)* and time series dimension (*T)* are large.

The sustainable development process, denoted by SD_{it}, can be modelled as a function of its lag ($SD_{i,t-1}$), foreign aid indicator (AID_{it}), a number of control variables of 'beyond aid' ($BEYONDAID_{it}$) and transmission channels ($CHANNEL_{it}$), for country *i* (*i*=1,2,…70) at time period *t* (*t*=1,2,…26), as follows:

$$SD_{it} = \gamma_i + \alpha_1 SD_{i,t-1} + \alpha_2 AID_{it} + \alpha_8 CHANNEL_{it} + \alpha_4 AID \times CHANNEL_{it} + \alpha_5 BEYONDAID_{it} + \varepsilon_{it} \quad (14)$$
$$i = 1,2,...70; t = 1,2,...26$$

γ_i is fixed effects and ε_{it} is the error term. Independent variables (AID_{it}, $CHANNEL_{it}$, $AID_{it} \times CHANNEL_{it}$, $BEYONDAID_{it}$) are assumed to be endogenous with respect to the error ε_{it}, due to possible measurement error and/or simultaneity. Data and measures for the dependent variable and independent variables are discussed in the next section.

To estimate the above dynamic panel data model with fixed effects, we demean the data for each country to control for fixed effects at the first place. The above model can be simplified as follows:

$$y_{it} = \alpha y_{i,t-1} + x_{it}^{'} \beta + \theta_{it}$$
$$i = 1,2,..70; t = 1,2,..,26 \quad (15)$$

where y_{it} is the demeaned SD_{it}, x_{it} is a vector of demeaned endogenous regressors (AID_{it}, $CHANNEL_{it}$, $AID_{it} \times CHANNEL_{it}$, $BEYONDAID_{it}$), and θ_{it} is the demeaned error ε_{it}. More specifically, $y_{it} = SD_{it} - T^{-1} \sum_{t=1}^{T} SD_{it}$. $y_{i,t-1}$, x_{it} and θ_{it} are defined in the same manner. We assume that $E(x_{it}\theta_{it}) \neq 0$ for all *i* and *t*.

For a dynamic panel data model with endogenous regressors, it is common practice to use the past values of observed variables as instruments to estimate the parameters of the model following, for example, the well-known GMM approaches by Arellano and Bond (1991) and Blundell and Bond (1998). However, these approaches are typically effective for the case of fixed *T* panel data setting.

To estimate a dynamic panel data model with endogenous regressors when *N* and *T* are both large, Bai and Ng (2010) and Kapetanios and Marcellino (2010) propose using estimated factors as instruments for endogenous regressors. Using a standard instrument and strong factor asymptotics in a data-rich environment where many instruments are weakly exogenous for endogenous regressors, Bai and Ng (2010) propose the factor-based instrumental variable estimator, denoted by factor-IV. Bai and Ng (2010) note that 'if the variables in the system are driven by common sources of variations, then the ideal instruments for endogenous variables in the system are their common components'. They suggest using the estimated common factors as instrumental variables for endogenous regressors. More specifically, they assume that regressors are driven by a small number of unobservable common factors as follows:

$$x_{it} = \Lambda_i^{'} F_t + u_{it} \tag{16}$$

where Λ_i is a $r \times K$ matrix of factor loadings with fixed and bounded components (*r* is the number of common factors and *K* is the number of regressors). F_t is a $r \times 1$ matrix of common factors, which are assumed to be uncorrelated with θ_{it}. u_{it} is the error term, which is assumed to be correlated with θ_{it}.

These researchers (2010) show that the common component, $\Lambda_i^{'} F_t$, is the ideal instrument for x_{it}, and is more effective than F_t in terms of convergence rate and the mean squared errors of the estimator. However, $\Lambda_i^{'} F_t$ is not observable, and needs to be estimated.

Bai and Ng (2004, 2010) suggest using a principal component analysis on the observed data on endogenous regressors to estimate Λ_i and F_t by solving the following minimization problem:[6]

$$\begin{aligned} &V(k) = (NT)^{-1} \sum_{i=1}^{N} \sum_{j=1}^{T} (x_{it} - \Lambda_i^{'} F_t)^2 \\ &s.t. \frac{\Lambda_i^{'} \Lambda_i}{N} = I_r ; \frac{F_t^{'} F_t}{T} = I_r \end{aligned} \tag{17}$$

Let $X_i = (x_{i1}, x_{i2}, ..., x_{iT})^{'}$ be the $T \times K$ matrix of endogenous regressors for the *i*th cross-sectional unit, so we have the following $T \times (NK)$ matrix for all cross-sectional units:

$$X = (X_1, X_2, ..., X_N)$$

The principal component estimate of factor matrix, denoted by $\tilde{F}_t$, can be expressed as $\sqrt{T}$ times the eigenvectors corresponding to the *r* largest eigenvalues of the $T \times T$ matrix XX'. Given $\tilde{F}_t$, the estimated factor loading matrix, denoted by $\tilde{\Lambda}_i$, can be computed by $\frac{X^{'} \tilde{F}_t}{T}$.

[6] Typically, when $T<N$, the normalization of $\frac{F_t^{'} F_t}{T} = I_r$ is used. In case of $T>N$, the normalization that $\frac{\Lambda_i^{'} \Lambda_i}{N} = I_r$ is used.

The estimated common factors, $\tilde{\Lambda}_i' \tilde{F}_t$, are the ideal instruments for x_{it}. A remaining issue now is how to determine the number of common factors, *r*.

For the approximate factor model such as $x_{it} = \Lambda_i' F_t + u_{it}$, Bai and Ng (2002) develop a method to estimate the number of factors using information criteria, which could be the only rigorous method available so far.[7] They suggest (ibid.) using a principal component analysis on the observed data to calculate the number of factors by minimizing:[8]

$$IC(r) = \ln\left[(NT)^{-1}\sum_{i=1}^{N}\sum_{j=1}^{T}(x_{it} - \Lambda_i^{r'} F_t^{r})^2\right] + rg(N,T) \tag{18}$$

with respect to $r \in \{0,1,\ldots,r_{\max}\}$ for some fixed $r_{\max}$. The above criterion function captures a trade-off between a measure of fit captured by the first term and a penalty function, $g(N,T)$, that depends on the size of panel. When the number of factors increases, the fit must improve, but the penalty goes up. Among the many criterion functions proposed by Bai and Ng (2002), $IC_{p2}(r)$ is used since it has the largest penalty on the fitted factor number where $g(N,T) = \left(\frac{N+T}{NT}\right)\ln(\frac{NT}{N+T})$. The estimation of $\tilde{F}_t^r$ and $\tilde{\Lambda}_i^r$ are the same as above. The integer that minimizes a criterion function is the estimated number of factors.

With $\tilde{\Lambda}_i' \tilde{F}_t$ as instruments, the following pooled two-step least squares estimator has been proposed:

$$\hat{\beta}_{PFIV} = (\sum_{i=1}^{N}\sum_{t=1}^{T}\tilde{\Lambda}_i' \tilde{F}_t x_{it}')^{-1}\sum_{i=1}^{N}\sum_{t=1}^{T}\tilde{\Lambda}_i' \tilde{F}_t y_{it} \tag{19}$$

Bai and Ng (2010) show that when *T* and *N* are of comparable magnitudes, $\hat{\beta}_{PFIV}$ is $\sqrt{T}$ consistent and asymptotically normal. They suggest that the factors contracted from the endogenous regressors are not only valid but also more strongly correlated with endogenous regressors than each individually observed instrument. Accordingly, factor-IV estimation is more efficient than standard IV or GMM estimation that uses a large number of observed variables as instruments. The factor-IV estimator is consistent when the number of instruments exceeds the sample size. It is also consistent even when the instruments themselves are invalid, as long as the unobserved factors driving the economy are valid instruments.

Based on the assumption that there are many or weak instruments having a weak factor structure, Kapetanios and Marcellino (2010) propose the factor-based GMM approach,

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[7] Recent research estimates the number of factors for static factor models. For example, Kapetanios (2010) develops a method for this purpose based on the behaviour of eigenvalues of a large sample covariance matrix. Onatski (2010) proposes the edge distribution estimator using differenced eigenvalues while Ahn and Horenstein (2012) propose a new approach by maximizing the ratio of two adjacent eigenvalues.

[8] Bai and Ng (2002) provide six criterion functions, $IC_{p1}(r)$, $IC_{p2}(r)$, $IC_{p3}(r)$, $PC_{p1}(r)$, $PC_{p2}(r)$ and $PC_{p3}(r)$. In general, *IC*(*r*) are easier to use since they do not involve the estimation of a penalty function.

denoted by factor-GMM, to estimate this type of model. They argue that the new penalty function, $g(N,T)=\ln[\min(N,T)]^{-1}$, ensures consistency of the estimated number of factors even in the case of weak-factor structure, while the criteria by Bai and Ng (2002) tend to underestimate the number of factors. They also argue that variable pre-selection based on their correlations with endogenous variables, in comparison to using a large number of variables from a large dataset such as in Stock and Watson (2005), can effectively alleviate the problems of weak instrument and weak-factor structure when constructing instruments. However, Bai and Ng (2010) find that valid instruments can be constructed from endogenous regressors, which are a small number of variables selected from a large dataset. Kapetanios and Marcellino (2010) also show that factor-GMM estimation is more efficient than the standard GMM estimation that applies the observed variables as instruments.

4 Data and stylized facts

4.1 Measures and data on sustainable development

A number of indicators have been proposed in the literature for measuring sustainable development, such as the sustainability-adjusted human development index (SHDI), adjusted net savings, total wealth, and ecological footprint. The following summarizes the sustainability indicators used in this study: [9]

Sustainability-adjusted human development index (SHDI)

The human development index (HDI) is the most widely used overall measure for human progress covering four aspects: life expectancy, literacy, education and standard of living (UNDP 2011). However, 'the HDI does not take into account sustainability variables in a broader sense', as Pineda (2012) notes. He subsequently suggests imposing a loss function to a country's human development achievements, given its unfair use of the environment, according to planetary boundaries. The following representations have been proposed:

$$SHDI^i=(1-G^i)*HDI^i$$

$$G^i=\frac{1}{p}\sum_{j=1}^{p}G_j^i$$

$$G_j^i=\min\{1,\frac{POP_i}{POP-POP_i}\frac{[S_j^i-\overline{S_j}]_+}{\overline{S_j}}\}$$

where G_j^i and S_j^i are the loss function and the level of environmental use for environmental indicator j ($j=1,2,..p$) and country i, respectively. POP_i is the population of country i and POP is the population in the world. $\overline{S_j}$ is the global planetary boundary for environmental indicator j. The operator $[\ ]_+$ is defined as $[x]_+=\max[x,0]$. $\frac{POP_i}{POP-POP_i}$ is the global responsibility term which implies that the larger a country's population, the greater its

[9] Data on sustainable development used in this paper are downloadable from www.yongfu-huang.net/research.html.

responsibility for the use of the environment. $\frac{[S_j^i - \overline{S_j}]_+}{\overline{S_j}}$ is the fair share of the environment term, which captures the situation when a country's environmental utilization exceeds its fair share.

Following Pineda (2012), this analysis considers three environmental indicators to compute SHDI: CO_2 emissions per capita, natural resource depletion and the share of permanent cropland.[10] For the lower threshold of the planetary boundary for these environmental indicators, this research uses one standard deviation above the mean. Data on population, total CO_2 emissions per capita, forest depletion (per cent of GNI), mineral depletion (per cent of GNI), energy depletion (per cent of GNI) and permanent cropland (per cent of land area) are from the World Development Indicators (WDI) Database (World Bank 2012). Annual data on HDI for the period of 1980-2010 are taken from UNDP (2011).[11]

Genuine savings or adjusted net saving (*GSAV*)

This sustainability indicator, developed by the World Bank under its work programme on the wealth of nations, is based on stock accounting (total wealth) and flow accounting (genuine or adjusted new savings). Genuine or adjusted new savings measures changes in total wealth over time, taking into account natural resources depletion, pollution damage and investment in human capital. More specifically, the series of adjusted net savings provided by the WDI Database (World Bank 2012) are equal to net national savings (gross savings less the value of depreciation of produced assets) plus the value of investment in human capital (education expenditure) and minus the value of resource depletion (energy depletion, mineral depletion, net forest depletion) and environmental degradation (carbon dioxide). It measures the extent to which countries use the income generated from produced and nature capital to invest in education to increase their total wealth over time. It is the true savings rate of an economy in terms of generating and maintaining total wealth, including produced capital, human capital and natural capital.[12] Data on adjusted net savings, excluding particulate emission damage (per cent of GNI) are taken from the WDI Database (World Bank 2012).

Ratio of ecological footprint to bio capacity (*EFBIO*)

This indicator, proposed by Moran et al. (2008), measures environmental sustainability: the higher the indicator, the lower the level of sustainable development. Labelling it the 'earth-equivalent ratio', Moran et al. (2008) calculate the ratio of ecological footprint per capita to globally available bio-capacity per capita. They argue that this ratio measures 'the minimum number of earth-equivalent planets that would be required to support the current human population if a given country's level of consumption were universal'. An increasing earth-

[10] One of the three indicators used by Pineda (2012) is fresh water withdrawals. However, data on this indicator are largely missing in the WDI; therefore this analysis uses instead natural resource depletion, the sum of forest depletion (per cent of GNI), mineral depletion (per cent of GNI), and energy depletion.

[11] A multiplication factor of 100 is applied on the calculated SHDI.

[12] Although this indicator has advantages over GDP as a measure of economic progress, it has been criticized (Stiglitz, Sen and Fitoussi 2009). For example, it has been said to have narrow economic view of human capital and wealth and to ignore social capital such as trust, respect, altruism, culture and institutions. It focuses on producers that produce and export using their natural resources, rather than consumers that consume natural resources. As such, most developing countries that depend on natural resources exploitation are unsustainable whereas developed nations are fairly sustainable. Moreover, its assumptions on consumption growth, discount rates asset lifetimes are viewed as unrealistic. Nevertheless, it has been widely used in the literature.

equivalent ratio would imply that man is consuming more of the earth's natural resources and adding to the acceleration of environmental degradation while a decreasing ratio would indicate that we are approaching sustainability. Since a ratio above 1 indicates that ecological goods and services are consumed faster than the rate of biosphere regeneration, Moran et al. (2008) argue that if sustainability is to be achieved, the minimum requirement is an earth-equivalent ratio no greater than 1. In other words, development and resource use can be sustainable only if the demand on the biosphere stays within the regenerative capacity of the planet over time.

The framework of ecological footprint and bio-capacity, first proposed by Rees (1992), remains a leading biological accounting tool in comparing man's demands on the present-day ecosystems with the planet's gross ecological capacity to sustain human life.[13] More specifically, ecological footprint addresses the aggregate demand of an economy on ecosystems by measuring how much land and water areas are needed to support the consumption of a given population and to assimilate the corresponding wastes. It is a consumption-based indicator, equal to the sum of the ecological footprint of production and imports of ecologically embedded goods minus the exports of ecologically embedded goods. Bio-capacity describes the supply side of an economy in providing a flux of biological resources and services useful to humanity by calculating the total area of ecologically productive land. The unit of the two measurements is the global hectare per capita.

The Global Footprint Network has gathered facts annually since 2007 from FAO and UNDP to develop a database of ecological footprint and bio-capacity data for 241 countries for the period 1961 to 2008. Our analysis utilizes the data from the Global Footprint Network (2012).[14]

4.2 Measures and data on independent variables

The key independent variable is foreign aid, denoted by *AID*. Foreign aid is the international transfers of capital, goods, or services from a country or international organization for the benefit of a recipient country or its population. It can be humanitarian or development aid, official or private or non-governmental aid, and bilateral or multilateral. Development aid was defined by OECD's Development Assistance Committee (DAC) in 1969 as the 'flows of official financing administered with the promotion of the economic development and welfare of developing countries as the main objective and which are concessional in character with a grant element of at least 25 per cent'.[15] Development aid usually consists of official development assistance (ODA), official assistance and private voluntary assistance. ODA, accounting for the bulk of total development aid, refers to grants or loans to countries and territories on the DAC list of recipients (developing countries) and to multilateral agencies that meet certain conditions.

This research considers two indicators: the ratio of net aid transfers to GDP, denoted by *NAT*, and the ratio of ODA received to GDP, denoted by *ODA*. Data on net aid transfers and net

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[13] Although the indicators of ecological footprint and bio-capacity are appealing, they are not exempt from reproach. The conversion methods that transform energy, food, timber consumption per capita into land units have been heavily criticized as having limited scope with some important consumption and emission aspects not included. They are also assessed to have limited relevance to policy- and decision-makers.

[14] A multiplication factor of 100 is applied on the ratio of ecological footprint of consumption per capita to bio-capacity per capita.

[15] OECD (n.d.) 'Glossy of Statistical Terms'. Available at: //stats.oecd.org/glossary/detail.asp?ID=6043

ODA received are taken from Roodman (2006).[16] Data for total GDP by PPP (constant 2005 international dollars) are from the WDI Database (World Bank 2012).
The following control variables for the 'beyond aid' scenario are used in this analysis:

- gross domestic savings (*GDS*);
- gross national income per capita (*GNIPC*);
- trade openness (*TRADE*);
- financial depth measured by the ratio of M2 to GDP (*M2*)
- institutional quality measured by polity indicator (*POLITY*);
- urbanization (*URBAN*); and
- population growth rate (*POPGR*).

Data for gross domestic savings (per cent of GDP), GNI per capita (constant 2000 US$), trade (per cent of GDP), M2 (money and quasi money, per cent of GDP), urban population (per cent of total population), and population growth rate (annual per cent) are from the WDI Database (World Bank 2012). Data for the polity indicator, polity2, are taken from the PolityIV Database (Marshall and Jaggers 2012). The polity indicator is used often to measure institutional quality based on freedom of suffrage, operational constraints, balance of executives, and respect for other basic political rights and civil liberties.

Three potential channels are investigated, namely 'economic growth', and 'nature resource exploitation' and 'energy intensity'. Economic growth, denoted by *GR*, is the GDP per capita growth (annual per cent); nature resource exploitations, denoted by *NRENT*, is measured by total natural resources rents (per cent of GDP), which is the sum of rents from oil, natural gas, coal (hard and soft), minerals, and forests that are generated from the exploitations of those natural resources. Data for annual GDP per capita growth rate and total natural resources rents (per cent of GDP) are taken from the WDI Database (World Bank 2012). Energy intensity, denoted by *EINTEN*, is measured by the final energy intensity of GDP at purchasing power parities. Data for energy intensity are from the Enerdata's Global Energy Market Data (2012).

The sample includes 70 aid recipient countries over 1985-2010, as listed in the Appendix Table A2. We exclude the countries that have less than 15 annual observations for the dependent variables, ODA-to-GDP ratio, GNI per capita, polity indicator, or natural resource rents.[17]

4.3 Stylized facts

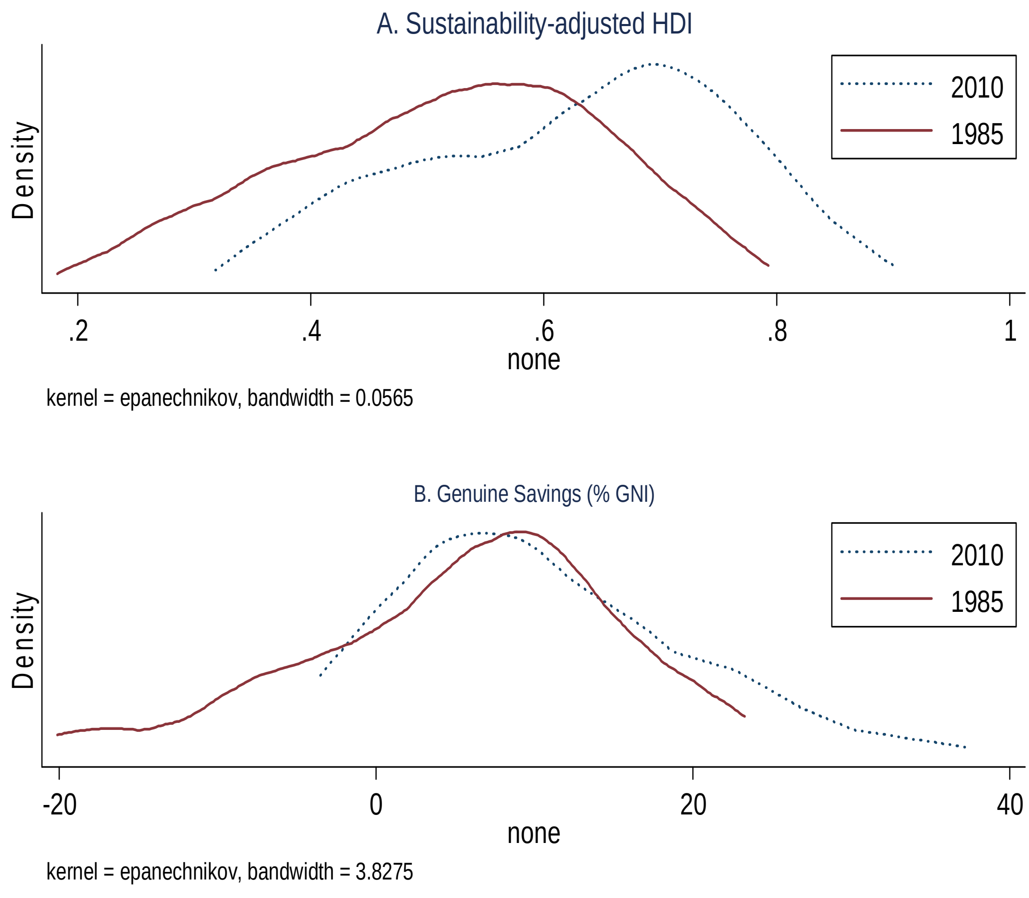
Before presenting the panel data evidence, we review a few stylized facts on the sustainable development process of the past decades. Figure 1, which plots the kernel density evolution

[16] Net ODA is a capital flow concept while NAT is a net transfer concept. Net ODA data are from DAC-OECD. *NAT* is the net ODA minus old non-aid loan cancellations and interest payments received from developing countries on outstanding concessional loans. A multiplication factor of 1,000,000 is applied on data for net ODA and NAT.

[17] Missing data are predicted by using linear approximations based on real GDP per capita (constant prices: chain series) from Heston, Summers and Aten (2012).

path of sustainability-adjusted HDI and genuine savings,[18] shows that in 1985 the sustainability-adjusted HDI ranged between 0.2 to 0.8 with the most concentrated value less than 0.6. Since then, this sustainability indicator has been increasing, reaching its most concentrated value at about 0.7 in 2010. Although the most concentrated value of genuine savings was almost the same in 1985 and 2010, its distribution in 1985 was dispersed mainly between –20 to 20 per cent while in 2010 it was about –5 to about 40 per cent. This figure shows in general a trend towards increased sustainability over the past decades. Here we attempt to investigate whether foreign aid has played any significant role in this process.

Figure 1: Kernel density evolution of sustainable indicators



Note: This figure shows the kernel density plots of the distribution of two sustainability indicators in 1985 and 2010. Variables and data are described in the text.

Source: Authors' own calculation.

5 Evidence

This section presents econometric evidence on the sustainability effects of foreign aid for 70 aid recipient countries over the period from 1985 to 2010. It then examines the potential channels through which foreign aid can stimulate sustainable development. Both the factor-

[18] Since the Global Footprint Network (2012) has annual data on the ecological footprint of consumption per capita and bio-capacity per capita only until 2008, we are unable to report the kernel density distribution in 2010 for *EFBIO*.

IV and factor-GMM estimates are based on Bai and Ng (2010) and Kapetanios and Marcellino (2010). The number of common factors is determined as one, using the new penalty function, $g(N,T) = \ln[\min(N,T)]^{-1}$, from Kapetanios and Marcellino (2010). For the factor-GMM estimates, the lagged values of estimated factors from *t*-1 to *t*-10 are used as instruments. The panel-robust standard errors based on Arellano (1987) are reported in brackets to adjust for serial correlation.

5.1 Baseline models

Using the three different sustainability indicators, we examine here whether foreign aid has increased sustainability in recipient countries. Table 1 gives the results when *NAT* (net aid transfers, per cent of GDP), is used to measure foreign aid. In this table, factor-GMM estimates are preferable for genuine savings and the footprint/bio-capacity ratio, as endogeneity tests clearly reject the null and Hansen J tests cannot reject the null for factor-GMM estimates. This suggests that regressors in this context are endogenous and instruments constructed from these regressors are valid. For the sustainability-adjusted HDI indicator, factor-IV estimates are preferable, as indicated by the p-value of endogeneity test. *NAT* is

Table 1: The effects of foreign aid (measured by NAT) on various sustainability indicators, 1985-2010

Dependent variable	Sustainability-HDI		Genuine savings		Footprint/bio-capacity ratio	
Method	Factor-IV	Factor-GMM	Factor-IV	Factor-GMM	Factor-IV	Factor-GMM
Lag dependent var.	0.966 ***	0.984 ***	-0.576	0.004 ***	0.758 ***	0.493 ***
	[0.010]	[0.007]	[0.738]	[0.001]	[0.140]	[0.041]
Net aid transfers (% GDP)	0.020 *	0.017 ***	13.870 *	7.472 ***	-0.006	-0.112 ***
	[0.012]	[0.003]	[7.781]	[0.247]	[0.038]	[0.017]
'Beyond aid'						
Domestic gross savings	0.000 ***	0.000 ***	-0.008	0.001	0.000	0.000 ***
	[0.000]	[0.000]	[0.007]	[0.000]	[0.000]	[0.000]
GNI per capita	0.000	0.000	-0.011	-0.007 ***	0.000	0.000 ***
	[0.000]	[0.000]	[0.009]	[0.002]	[0.000]	[0.000]
Trade openness	0.007 ***	0.001	1.425	0.576 ***	-0.003 ***	-0.000
	[0.001]	[0.001]	[1.018]	[0.073]	[0.001]	[0.001]
Financial depth	-0.005	-0.005 ***	0.477	0.360 ***	0.006 *	0.009 ***
	[0.004]	[0.001]	[0.419]	[0.087]	[0.003]	[0.001]
Governance	0.015	0.039 ***	-2.117	0.475	0.005	-0.019
	[0.011]	[0.006]	[2.487]	[0.446]	[0.007]	[0.012]
Urbanization	0.043 **	0.031 ***	2.363	0.915 ***	-0.004	-0.017 ***
	[0.021]	[0.010]	[2.059]	[0.329]	[0.009]	[0.006]
Population growth	0.088	-0.086 *	27.016	13.780 ***	-0.011	0.097 ***
	[0.106]	[0.051]	[21.717]	[1.443]	[0.046]	[0.030]
Constant	0.439 ***	0.422 ***	3.966 **	0.542 *	0.040 *	0.020 ***
	[0.029]	[0.017]	[1.940]	[0.288]	[0.022]	[0.006]
R-squared	0.969	0.967	0.941	0.982	0.779	0.612
Hansen J (P-value)	0.00	23.16	0.00	20.12	0.00	16.53
Endogeneity (P-value)	0.01	0.12	0.55	0.00	0.20	0.07
Number of countries	70	70	70	70	70	70
Observations	1,750	1,610	1,750	1,610	1,725	1,587

Note: This table reports factor IV/GMM estimates based on Bai and Ng (2010) and Kapetanios and Marcellino (2010). See text for definitions of variables and data sources. Hansen J test examines the null that the instruments are valid. Endogeneity test examines the null that the specified endogenous regressors can actually be treated as exogenous. Panel-robust standard errors based on Arellano (1987) are reported in brackets.
* significant at 10%; ** significant at 5%; *** significant at 1%.
Source: Authors' own calculations.

found to exert a positive impact on sustainable development, as measured by both sustainability-adjusted HDI and genuine savings. As we noted earlier, ‘the higher this indicator, the lower the level of sustainable development’ if sustainable development is measured by the footprint/bio-capacity ratio, and we expect therefore that *NAT* has a negative impact. Factor-GMM estimates clearly support this assumption for *EFBIO*.

Appendix Table A3 presents evidence for the robustness of the results, when ODA (per cent of GDP) is used to measure foreign aid. The pattern in Appendix Table A3 is fairly similar to that of Table 1.

5.2 Full models

Whereas the previous section reported the results for the baseline models, here we examine the full models (with interaction terms). Tables 2 to 4 present our investigation OF the existence of three potential channels through which foreign aid may stimulate sustainable development: economic growth, natural resource exploitations and energy efficiency; these and their interaction terms with *NAT* have been added to the baseline models in which the three different sustainability indicators are still used.

Table 2: Transmission channel: economic growth

Dependent variable	Sustainability-HDI		Genuine savings		Footprint/bio-capacity ratio	
Method	Factor-IV	Factor-GMM	Factor-IV	Factor-GMM	Factor-IV	Factor-GMM
Lag dependent var.	0.974 ***	0.974 ***	1.001 ***	0.960 ***	0.527 **	0.677 ***
	[0.011]	[0.012]	[0.016]	[0.018]	[0.225]	[0.080]
Net aid transfers (NAT)	0.016	0.011	-0.007	0.362 **	-0.121	-0.049 **
	[0.012]	[0.007]	[0.124]	[0.146]	[0.116]	[0.025]
Economic growth (GR)	0.073 ***	0.076 ***	0.069	0.168* *	-0.000	0.006
	[0.011]	[0.010]	[0.047]	[0.088]	[0.012]	[0.010]
NAT × GR	-0.001	-0.001 **	0.008	-0.035 *	0.012	-0.002
	[0.001]	[0.001]	[0.005]	[0.018]	[0.024]	[0.002]
'Beyond aid'						
Domestic gross savings	-0.000	0.000	-0.000	0.001	0.000	0.000
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
GNI per capita	0.000	0.000	-0.000	0.000 **	0.000 *	0.000 ***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Trade openness	0.002	0.001	0.019 ***	0.012	0.002	-0.002
	[0.002]	[0.002]	[0.006]	[0.010]	[0.005]	[0.002]
Financial depth	-0.003	-0.002	-0.010	0.025 **	0.008	0.007
	[0.003]	[0.003]	[0.006]	[0.011]	[0.006]	[0.004]
Governance	0.012	0.019	0.019	0.041	-0.019	-0.007
	[0.010]	[0.012]	[0.033]	[0.062]	[0.021]	[0.009]
Urbanization	0.030 *	0.035 **	-0.020	0.082 *	-0.025	-0.010
	[0.015]	[0.016]	[0.031]	[0.043]	[0.026]	[0.007]
Population growth	0.131 *	0.128	0.595 **	1.505 ***	0.021	0.035
	[0.073]	[0.096]	[0.248]	[0.366]	[0.115]	[0.067]
Constant	0.456 ***	0.443 ***	0.077	0.055	0.024	0.028 ***
	[0.025]	[0.027]	[0.053]	[0.074]	[0.017]	[0.008]
R-squared	0.982	0.981	0.993	0.990	-0.062	0.709
Hansen J (P-value)	0.00	31.61	0.00	38.78	0.00	26.55
Endogeneity (P-value)	0.16	0.64	0.36	0.97	0.31	0.73
Number of countries	70	70	70	70	70	70
Observations	1,718	1,578	1,718	1,578	1,713	1,575

Note: This table reports the evidence for the channel of economic growth, GDP per capita growth (annual %), using NAT (% GDP) to measure foreign aid. See Table 1 for more notes.
Source: Authors' own calculations.

Divergent patterns emerge for the sustainability indicators when economic growth and its interaction term with *NAT* are included (Table 2). The factor-GMM estimates suggest that for sustainability-adjusted HDI, *NAT* is no longer significant; however, both economic growth and its interaction term with *NAT* were significant in entering the model. This implies that the level of economic growth is a crucial factor in achieving sustainable development. It also implies that the effect of foreign aid on sustainable development is likely to be transmitted through economic growth as spurred growth; however, once the growth rate reaches a certain level, foreign aid could be detrimental to sustainable development process in aid recipient countries.

As suggested by factor-GMM estimates, both *NAT* and economic growth are significant in the model for genuine savings, as is their interaction term. This indicates that *NAT* could have both direct and indirect effects on genuine savings, and the indirect effect of *NAT* is likely to be transmitted through economic growth. The indirect effect is likely to be positive when growth rates are low; however, as growth rates rise, the indirect effect of foreign aid on sustainable development fades and finally becomes negative. This is suggested by the signs of the three coefficients.

With respect to the footprint/bio-capacity ratio, the factor-GMM estimates show no evidence for either economic growth or its *NAT* interaction term, although *NAT* remains significant in the model. Foreign aid could be conducive to a reduction of the ecological footprint; but economic growth seems to have no direct or indirect role in preventing it.

Table 3:Transmission channel: natural resource exploitations

Dependent variable	Sustainability-HDI		Genuine savings		Footprint/bio-capacity ratio	
Method	Factor-IV	Factor-GMM	Factor-IV	Factor-GMM	Factor-IV	Factor-GMM
Lag dependent var.	0.938 ***	0.981 ***	0.884 ***	0.888 ***	0.760 ***	0.405 **
	[0.025]	[0.011]	[0.027]	[0.032]	[0.147]	[0.169]
Net aid transfers (NAT)	0.040	0.019 *	0.828 ***	0.512 ***	-0.004	-0.146 ***
	[0.071]	[0.010]	[0.201]	[0.130]	[0.040]	[0.053]
Natural resources rents (NRENT)	0.011	0.014	0.080	-0.155	0.004	0.003
	[0.010]	[0.009]	[0.049]	[0.101]	[0.006]	[0.006]
NAT × NRENT	-0.034 **	-0.001	-0.056	-0.303 *	0.001	0.022 **
	[0.016]	[0.009]	[0.064]	[0.159]	[0.002]	[0.010]
'Beyond aid'						
Domestic gross savings	0.000 ***	0.000 **	-0.000	-0.001 **	0.000	0.000
	[0.000]	[0.000]	[0.001]	[0.001]	[0.000]	[0.000]
GNI per capita	0.000	0.000	-0.000	0.000 *	0.000	0.000 ***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Trade openness	0.009 *	-0.001	-0.015	0.067 *	-0.003 ***	-0.001
	[0.005]	[0.002]	[0.023]	[0.036]	[0.001]	[0.003]
Financial depth	-0.005	-0.007 *	0.005	0.004	0.006	0.012 *
	[0.005]	[0.004]	[0.013]	[0.012]	[0.004]	[0.006]
Governance	0.016	0.048 **	0.171 **	-0.148	0.006	-0.028
	[0.014]	[0.019]	[0.083]	[0.191]	[0.008]	[0.020]
Urbanization	0.059 *	0.031	0.087	0.103	-0.004	-0.021
	[0.035]	[0.019]	[0.056]	[0.068]	[0.008]	[0.013]
Population growth	0.056	-0.111	0.274	1.463	-0.012	0.103
	[0.154]	[0.114]	[0.676]	[1.071]	[0.048]	[0.138]
Constant	0.448 ***	0.430 ***	0.350	0.209	0.041 *	0.035 ***
	[0.033]	[0.030]	[0.291]	[0.191]	[0.023]	[0.012]
R-squared	0.948	0.967	0.991	0.987	0.779	0.584
Hansen J (P-value)	0.00	25.68	0.00	27.82	0.00	20.56
Endogeneity (P-value)	0.17	0.34	0.04	0.37	0.65	0.94
Number of countries	70	70	70	70	70	70
Observations	1,731	1,590	1,731	1,590	1,725	1,586

Note: This table reports the evidence for the channel of natural resources rents (% GDP) using NAT (% GDP) to measure foreign aid. See Table 1 for more notes.
Source: Authors' own calculations

In addition, GNI per capita is noted to be negatively associated with sustainable development while trade openness, financial depth, urbanization and population growth are found to be significantly positively linked to sustainable development.

Table 3 attempts to determine whether foreign aid has worked through the natural resource exploitation channel, which is measured by natural resource rents (per cent of GDP). For the marker sustainability-adjusted HDI, the factor-IV estimates show evidence of a significantly negative effect for the interaction term between *NAT* but no evidence is found for *NAT* and natural resource rents. Based on a comparison of column 1 in Table 1, we expect that foreign aid could exert an indirect effect on sustainable development via natural resource exploitations.

For the indicators genuine savings and footprint/bio capacity ratio, the factor-GMM estimates suggest both *NAT* and its interaction term with natural resource rents enter the models

Table 4: Transmission channel: energy intensity

Dependent variable	Sustainability-HDI		Genuine savings		Footprint/bio-capacity ratio	
Method	Factor-IV	Factor-GMM	Factor-IV	Factor-GMM	Factor-IV	Factor-GMM
Lag dependent var.	0.960 ***	0.939 ***	0.996 ***	0.597 ***	0.659 ***	0.640 ***
	[0.015]	[0.026]	[0.034]	[0.049]	[0.091]	[0.084]
Net aid transfers (NAT)	-0.002	-0.079	0.051	-0.054	-0.039 **	-0.042 **
	[0.017]	[0.048]	[0.155]	[0.160]	[0.019]	[0.020]
Energy intensity (EINTEN)	-0.027 ***	-0.042 ***	-0.015	-0.207 ***	0.004	0.004
	[0.006]	[0.009]	[0.023]	[0.055]	[0.003]	[0.003]
NAT × EINTEN	0.000	0.006	0.004	-0.06 ***	0.001	-0.002
	[0.002]	[0.006]	[0.015]	[0.019]	[0.001]	[0.002]
'Beyond aid'						
Domestic gross savings	-0.000	0.000	-0.001 **	0.001	-0.000	-0.000
	[0.000]	[0.000]	[0.000]	[0.001]	[0.000]	[0.000]
GNI per capita	0.000	0.000	-0.000	-0.000	0.000 ***	0.000 ***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Trade openness	0.003	0.005 *	0.017 ***	0.033 *	-0.003	-0.003 *
	[0.002]	[0.003]	[0.006]	[0.017]	[0.002]	[0.002]
Financial depth	-0.006	-0.006 **	-0.013 **	-0.016	0.007 *	0.007 *
	[0.004]	[0.003]	[0.005]	[0.013]	[0.004]	[0.004]
Governance	0.016	0.013	0.025	-0.054	0.003	0.002
	[0.010]	[0.012]	[0.032]	[0.074]	[0.006]	[0.008]
Urbanization	0.038 *	0.047 **	-0.012	-0.036	-0.007	-0.007
	[0.019]	[0.021]	[0.032]	[0.058]	[0.007]	[0.007]
Population growth	0.045	0.084	0.435	0.312	0.020	0.036
	[0.101]	[0.094]	[0.288]	[0.556]	[0.057]	[0.062]
Constant	0.449 ***	0.409 ***	0.083	0.075	0.023 ***	0.028 ***
	[0.026]	[0.033]	[0.057]	[0.086]	[0.006]	[0.009]
R-squared	0.975	0.975	0.984	0.419	0.735	0.695
Hansen J (P-value)	0.00	24.12	0.00	20.97	0.00	32.80
Endogeneity (P-value)	0.23	0.42	0.02	0.04	0.18	0.98
Number of countries	70	70	70	70	70	70
Observations	1,694	1,552	1,694	1,552	1,692	1,552

Note: This table reports the evidence for the channel of energy intensity (measured by final energy intensity of GDP at purchasing power parities). See Table 1 for more notes.
Source: Authors' own calculations.

as significant. Natural resource rents are insignificant in four models. This implies that foreign aid could have a significant direct impact on sustainable development; moreover, it stimulates the process of sustainable development via discouraging the exploitation of natural resources. Furthermore, we observe that domestic gross savings has a negative impact on sustainable development while governance plays a positive role in this process.

In Table 4 we investigate whether energy intensity also constitutes a transmission channel through which foreign aid promotes sustainable development. For the sustainability-adjusted HDI and genuine savings, energy intensity enters the models as significant while the significance of *NAT* fades. The effects of foreign aid on sustainable development are likely to be picked up by energy intensity. When the indicator genuine savings is utilized, the factor-GMM estimates further reveal that energy intensity is indeed a transmission path through which the effect of foreign aid is channelled. More specifically, foreign aid could be used to incentivize technological development that could lead to reduced energy intensity and increased sustainable development. The higher the level of energy intensity is, the slower the sustainable development process will be. As energy efficiency improves because of aid-financed technological developments, the effect of foreign aid on sustainable development diminishes.

Both factor-IV and factor-GMM estimates show no evidence on the part of the footprint/bio-capacity ratio for either energy intensity or its *NAT* interaction term, while *NAT* remains negative in the model. Energy efficiency seems to have no role in limiting our ecological footprint.

Columns 3 and 4 further confirm the significantly negative effects of domestic gross savings and financial depth, and a positive impact of trade openness for sustainability. In sum, this analysis shows that the effect of foreign aid on sustainable development has materialized in 70 aid recipient countries over the past two-three decades. It also finds evidence of an effect for GNI per capita, governance, trade openness, financial depth, urbanization, and population growth, which are all closely linked to sustainable development. Three transmission paths were identified through which the effect of foreign aid is channelled to sustainable development—economic growth, natural resource exploitations and/or energy intensity.

5.3 Policy discussion

There have been considerable doubts about the effectiveness of foreign aid for sustainable development. For example, UNEP (2007) and Purvis (2003) argue that some foreign aid programmes in the developing countries can give rise to unsustainable development at an excessive pace in terms of worsening pollution and accelerated exploitation of the aid recipient's natural resources.[19] Over the past decades, and especially after adoption of the MDGs in 2000, the international community has taken serious steps to improve aid effectiveness. Major efforts include the 2005 Paris Declaration, 2008 Accra Agenda for Action and 2011 Busan Partnership for Effective Development Cooperation, all of which are important platforms for discussions on mutual cooperation for meeting the development goals

[19] The UNEP (2007) evaluation of the environmental impacts of 661 humanitarian, recovery and development aid programmes in Sudan in 2006 reports that the vast majority of foreign aid programmes had no positive impact on the environment while three projects actually had adverse environmental effects.

and increasing aid effectiveness.[20] However, progress for compliance with the Paris Declaration principles and targets has been disappointing.[21]

The results produced here support the existing research that international assistance programmes generate benefits not only as economic growth but also as sustainable development in the developing countries that lack sufficient financial resources to embark on a sustainable development path on their own (e.g., Arvin, Kayani and Scigliano 2009).[22] The emergence of some developing countries as growth poles and important sources of non-aid development finance has in recent years eroded the relative importance of foreign aid as a financing instrument for development. Nevertheless, foreign aid, in the era of global sustainability, will continue to play an important role in assisting developing countries implement policies and programmes that facilitate the attainment of sustainable development goals. But more efforts are still warranted in this regard.[23]

Although foreign aid remains important for development finance, achieving positive sustainable development outcomes needs more than just financial resources. Policies are also essential in such areas as trade openness, financial depth, urbanization and governance to create an environment that is conducive to sustainable development. In the post-2015 development agenda 'beyond aid', the renewed global partnership should identify effective mechanisms for mobilizing ODA and other development assistance, look to build more equitable multilateral trading and financial systems, maximize the potential benefits of greater labour mobility, and work towards an inclusive and equitable system of global governance with increasing voice for and representation by the developing countries, etc.

Our findings on the growth channel contribute to the existing aid-growth literature, where fierce debates of whether foreign aid fosters economic development in aid recipient countries have been common. Although positive results are broadly generated by aid, a particular pessimism on its effectiveness has been recently expressed by Rajan and Subramanian (2008) and Doucouliagos and Paldam (2008). Based on a detailed analysis of Rajan and Subramanian's cross-country dataset, together with a better instrumentation strategy, improved specification and a preferred estimator, Arndt, Jones and Tarp (2010) demonstrate

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[20] The 2005 Paris Declaration on Aid Effectiveness adopted five principles to strengthen aid effectiveness and 13 targets to measure their implementation which were to be achieved by 2010. The principles and targets set out in Paris were reinforced in Accra in 2008. The Fourth High-level Forum on Aid Effectiveness in Busan in 2011 shifted from focusing purely on aid effectiveness to a more holistic approach that looks at the contribution that cooperation can make to overall development effectiveness, marking a turning point in the international consideration of development cooperation.

[21] OECD's final report (2012) on the implementation of the Paris principles shows that only Target 4 in terms of coordinated technical cooperation was met at the global level.

[22] Arvin, Dabir-Alai and Lew (2006) observe that for the full sample, aid overall had a positive impact on environmental protection. More specifically, they note that in the full sample and in the subsample of upper income nations, a bidirectional causality link existed between foreign aid and pollution. In the lower-income country subsample, only one directional causal relationship existed; environmental pollution decreased with the increase of foreign assistance.

[23] For example, environmental aid still attracts only a small percentage of the total international assistance funding. According to a report by UK's National Audit Office (2011), the majority of the overseas aid provided by the UK in 2009-10 was earmarked to such traditional causes as economic development and humanitarian aid. Only very limited funding was given primarily for environmental conservation and climate change mitigation.

that in the long term foreign aid has a positive and statistically significant impact on growth.[24] Mekasha and Tarp (2013) apply different meta-analysis techniques on a database of 68 studies on the aid-growth link employed by Doucouliagos and Paldam (2008). They find evidence of the positive and significant weighted average effect of aid on growth and no evidence for the existence of publication bias.[25] As pointed out by Temple (2010), the lack of evidence does not necessarily imply the absence of evidence. With this in mind, empirical results should be interpreted with caution, and the recent pessimism should not be considered particularly daunting. The finding of this analysis with respect to the growth channel complements the current debate on the growth-enhancing impact of aid.

The finding with respect to the natural resource channel for aid effectiveness points to the central issue of sustainable development. Natural resources, land and ecological systems provide the goods and services vital for the economy, society and all living creatures. Sustainable development is a pattern of resource use that aims to meet human needs while preserving the environment so that these needs can be met not only by the present generation, but also by future generations. More specifically, it means that human activity must be limited to the carrying (finite) capacity of ecosystems. Man must not exploit nature beyond the point or rate of natural replenishment of resources. If nature's resources (natural capital) are used up faster than they can be replenished, the result is 'unsustainability' of the environment. It is important to take measures to conserve natural resources and prevent their overexploitation. These measures need to include finance and investment, and in this regard, foreign aid can play a crucial role. In 2010 the IMF launched the Topical Trust Fund on Managing Natural Resource Wealth, a multi-donor trust fund, for 15-20 low-income and lower middle-income countries endowed with oil, gas, and minerals to finance technical assistance on effectively managing their natural resource wealth.

Our findings with regard to the energy intensity channel are consistent with Kretschmer, Hübler and Nunnenkamp (2010) who report that aid has been effective in reducing the energy intensity of GDP in 80 recipient countries over 1973-2005. Thus substantial ODA, other forms of development assistance and domestic investment should be earmarked for renewable energy and efficiency projects in developing countries; this could help avoid the otherwise resultant higher greenhouse gas emissions.

6 Conclusion

This analysis, which was rooted in careful theoretical and econometric work, finds that an enhanced global partnership with deeper international collective action could effectively contribute to a sustainable development process. It further suggests that foreign aid has significant effects on sustainable development through channels relating to growth, natural resources and a technology with respect to energy intensity. Following a theoretical framework that modelled sustainable development as a growth process that promotes

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[24] Juselius, Møller, and Tarp (2013) further provide evidence on the long-run impact of foreign aid on some key macroeconomic variables in 36 African countries.

[25] Mekasha and Tarp (2013) argue further that the homogeneity assumption of fixed effect model is unrealistic in the aid-growth literature; accordingly random effects model is to be preferred. They find that, with and without non-linear term, the weighted average effect of aid is positive and significant in the random effects model. Also publication bias is not a problem once heterogeneity is controlled for.

environmental sustainability and social development, a dynamic panel data study based on annual data for 70 countries over 1985-2010 was conducted with three indicators to measure sustainable development. Special attention was given to possible channels through which this effect could be transmitted. To address the issue of endogeneity in a large *T* dynamic panel data model, this research applied factor-IV and factor-GMM methods according to Bai and Ng (2010) and Kapetanios and Marcellino (2010).

This research has shed some light on the interaction between finance, economic growth, natural resource conservation and energy technological progress in the process of global sustainability. The significant, observed effect of foreign aid on growth is also likely to be channelled through to sustainable development. The positive effect of aid on sustainability is also likely to work through natural resource conservation and/or energy intensity where foreign aid is used to encourage natural resource conservation and technological innovation of energy systems. Growth provides a concrete foundation for environmental protection and social development, and equips governments financially and technologically to fight climate change and stimulate social inclusiveness and development. This research has significant implications for both research and practice.

The finding has significant implications in the sense that an enhanced global partnership in areas such as foreign aid, trade, investment, migration (from rural to urban areas) and governance could play a crucial role in the process of global sustainability. Although efforts at the national level are crucial for sustainable development, action at the global level is also needed to provide support for diverging national needs and circumstances. The global partnership for sustainable development should be strengthened to encompass explicit commitments by all countries to the various goals and internationally coordinated measures that strive to create an enabling environment for development, to address the causes of climate change and income inequality, to facilitate sustainable management of the global commons and to achieve economic and financial stability.

Appendix

Appendix Table A1: Variables

Variable	Description	Source
SHDI	Sustainability-adjusted human development indicator, based on Pineda (2012).	Own calculations based on annual data on HDI from UNDP.
GSAV	The adjusted net savings excludes particulate emission damage (% of GNI).	Calculated on the basis of WDI (World Bank 2012, December edition)
EFBIO	The ratio of ecological footprint per capita to globally available bio-capacity per capita (also known as earth-equivalents ratio).	Annual data from Global Footprint Network (2012)
NAT	Net aid transfer (NAT) (% of GDP)	Calculated based on aid data from Roodman (2013) and GDP data from the WDI (2012)
ODA	Net official development assistance (ODA) received (% of GDP)	Calculated based on aid data from Roodman (2013) and GDP data from the WDI (2012)
GR	GDP per capita growth (annual %)	WDI (2012)
NRENT	Total natural resources rents (% of GDP), the sum of rents from oils , natural gas, coal (hard and soft), minerals and forests.	WDI (2012)
EINTEN	Final energy intensity of GDP at purchasing power parities	Enerdata(2012)
GDS	Gross domestic savings (% of GDP)	WDI (2012)
GNIPC	Gross national income per capita	WDI (2012)
TRADE	Trade openness (% GDP)	WDI (2012)
M2	Money and quasi money (M2) (% of GDP)	WDI (2012)
POLITY	Polity indicator “polity2”	Marshall and Jaggers (2012)
URBAN	Urban population (% of total)	WDI (2012)
POPGR	Population growth (annual %)	WDI (2012)

Source: Compiled by authors.

Appendix Table A2: Names and country codes for the 70 aid recipient countries considered in this study

Country name	Country code	Country name	Country code
Albania	ALB	Mexico	MEX
Argentina	ARG	Mali	MLI
Armenia	ARM	Mozambique	MOZ
Benin	BEN	Mauritius	MUS
Bangladesh	BGD	Malaysia	MYS
Bulgaria	BGR	Namibia	NAM
Bolivia	BOL	Nicaragua	NIC
Brazil	BRA	Pakistan	PAK
Botswana	BWA	Panama	PAN
Chile	CHL	Peru	PER
China	CHN	Philippines	PHL
Cote d'Ivoire	CIV	Poland	POL
Cameroon	CMR	Paraguay	PRY
Congo, Rep.	COG	Romania	ROU
Colombia	COL	Russian Federation	RUS
Costa Rica	CRI	Rwanda	RWA
Cyprus	CYP	Sudan	SDN
Dominican Republic	DOM	Senegal	SEN
Ecuador	ECU	El Salvador	SLV
Egypt, Arab Rep.	EGY	Slovak Republic	SVK
Gambia, The	GMB	Swaziland	SWZ
Guatemala	GTM	Syrian Arab Republic	SYR
Honduras	HND	Togo	TGO
Hungary	HUN	Thailand	THA
Indonesia	IDN	Trinidad and Tobago	TTO
India	IND	Tunisia	TUN
Israel	ISR	Turkey	TUR
Jordan	JOR	Tanzania	TZA
Kazakhstan	KAZ	Uganda	UGA
Kenya	KEN	Ukraine	UKR
Kyrgyz Republic	KGZ	Uruguay	URY
Korea, Rep.	KOR	Venezuela, RB	VEN
Sri Lanka	LKA	Vietnam	VNM
Morocco	MAR	South Africa	ZAF
Moldova	MDA	Zambia	ZMB

Source: Compiled by authors.

Appendix Table A3: The effects of foreign aid (measured by ODA) on various sustainability indicators, 1985-2010

Dependent variable	Sustainability-HDI		Genuine savings		Footprint/bio-capacity ratio	
Method	Factor-IV	Factor-GMM	Factor-IV	Factor-GMM	Factor-IV	Factor-GMM
Lag dependent var.	0.966 ***	0.984 ***	-0.590	0.006 ***	0.762 ***	0.498 ***
	[0.010]	[0.008]	[0.807]	[0.002]	[0.135]	[0.048]
ODA (% GDP)	0.021 *	0.019 ***	14.331 *	7.633 ***	-0.003	-0.110 ***
	[0.012]	[0.004]	[8.696]	[0.281]	[0.035]	[0.019]
'Beyond aid'						
Domestic gross savings	0.000 ***	0.000 ***	-0.007	0.001 **	0.000	0.000 ***
	[0.000]	[0.000]	[0.007]	[0.000]	[0.000]	[0.000]
GNI per capita	0.000	0.000	-0.011	-0.006 **	0.000	0.000 ***
	[0.000]	[0.000]	[0.009]	[0.002]	[0.000]	[0.000]
Trade openness	0.007 ***	0.001	1.446	0.578 ***	-0.003 ***	-0.000
	[0.001]	[0.001]	[1.099]	[0.083]	[0.001]	[0.001]
Financial depth	-0.005	-0.006 ***	0.588	0.416 ***	0.006 *	0.009 ***
	[0.004]	[0.001]	[0.502]	[0.092]	[0.003]	[0.001]
Governance	0.015	0.035 ***	-2.122	0.606	0.005	-0.021 *
	[0.011]	[0.006]	[2.605]	[0.447]	[0.007]	[0.011]
Urbanization	0.043 **	0.032 ***	2.186	0.672 *	-0.003	-0.016 **
	[0.021]	[0.011]	[2.142]	[0.384]	[0.008]	[0.006]
Population growth	0.089	-0.090 *	27.843	14.601 ***	-0.010	0.109 ***
	[0.107]	[0.051]	[23.730]	[1.647]	[0.046]	[0.033]
Constant	0.439 ***	0.423 ***	3.961 *	0.517 *	0.040 *	0.021 ***
	[0.029]	[0.017]	[2.163]	[0.294]	[0.022]	[0.006]
R-squared	0.969	0.967	0.935	0.979	0.778	0.599
Hansen J (P-value)	0.00	23.51	0.00	20.42	0.00	17.77
Endogeneity (P-value)	0.01	0.21	0.56	0.02	0.18	0.10
Number of countries	70	70	70	70	70	70
Observations	1,750	1,610	1,750	1,610	1,725	1,587

Note: This table makes use of ODA (% of GDP). See Table 1 for more notes.
Source: Authors' own calculations.

Appendix Table A4: The transmission channel of economic growth (using ODA)

Dependent variable	Sustainability-HDI		Genuine savings		Footprint/bio-capacity ratio	
Method	Factor-IV	Factor-GMM	Factor-IV	Factor-GMM	Factor-IV	Factor-GMM
Lag dependent var.	0.974***	0.975***	0.995***	0.963***	0.538**	0.680***
	[0.011]	[0.012]	[0.015]	[0.017]	[0.222]	[0.080]
ODA	0.014	0.012*	0.040	0.346**	-0.114	-0.047*
	[0.012]	[0.007]	[0.120]	[0.139]	[0.114]	[0.024]
Economic growth (GR)	0.072***	0.076***	0.076	0.161*	0.002	0.007
	[0.011]	[0.011]	[0.046]	[0.087]	[0.013]	[0.010]
ODA × GR	-0.001	-0.001*	0.009*	-0.034*	0.013	-0.002
	[0.001]	[0.001]	[0.005]	[0.018]	[0.024]	[0.002]
'Beyond aid'						
Domestic gross savings	-0.000	0.000	-0.000	0.001	0.000	0.000
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
GNI per capita	0.000	0.000	-0.000	-0.000**	0.000*	0.000***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Trade openness	0.003	0.001	0.019***	0.013	0.002	-0.002
	[0.002]	[0.002]	[0.006]	[0.010]	[0.005]	[0.002]
Financial depth	-0.003	-0.002	-0.009	0.025**	0.008	0.007
	[0.003]	[0.003]	[0.006]	[0.011]	[0.006]	[0.004]
Governance	0.012	0.018	0.020	0.044	-0.020	-0.008
	[0.010]	[0.013]	[0.031]	[0.064]	[0.022]	[0.009]
Urbanization	0.030*	0.035**	-0.014	0.079*	-0.023	-0.009
	[0.015]	[0.016]	[0.031]	[0.043]	[0.025]	[0.007]
Population growth	0.130*	0.129	0.618**	1.534***	0.023	0.038
	[0.072]	[0.096]	[0.245]	[0.387]	[0.117]	[0.067]
Constant	0.455***	0.443***	0.082	0.048	0.025	0.030***
	[0.025]	[0.027]	[0.051]	[0.075]	[0.017]	[0.008]
R-squared	0.982	0.981	0.993	0.990	-0.105	0.706
Hansen J (P-value)	0.00	31.74	0.00	39.87	0.00	28.96
Endogeneity (P-value)	0.31	0.57	0.41	0.93	0.30	0.59
Number of countries	70	70	70	70	70	70
Observations	1,718	1,578	1,718	1,578	1,713	1,575

Note: This table uses ODA (% of GDP) to measure foreign aid. See Tables 1 and 3 for more notes.
Source: Authors' own calculations.

Appendix Table A5: The transmission channel of natural resources exploitation (using ODA)

Dependent variable	Sustainability-HDI		Genuine savings		Footprint/bio-capacity ratio	
Method	Factor-IV	Factor-GMM	Factor-IV	Factor-GMM	Factor-IV	Factor-GMM
Lag dependent var.	0.907***	0.981***	0.898***	0.896***	0.764***	0.416**
	[0.177]	[0.011]	[0.027]	[0.024]	[0.141]	[0.169]
ODA	0.025	0.020*	0.747***	0.578***	-0.003	-0.139***
	[0.128]	[0.011]	[0.178]	[0.130]	[0.037]	[0.052]
Natural resources rents (NRENT)	0.009	0.013*	0.060	-0.072	0.004	0.002
	[0.017]	[0.007]	[0.048]	[0.064]	[0.005]	[0.006]
ODA × NRENT	-0.099	-0.002	-0.047	-0.222*	0.000	0.017**
	[0.268]	[0.011]	[0.063]	[0.116]	[0.002]	[0.008]
'Beyond aid'						
Domestic gross savings	-0.001	-0.000***	-0.000	-0.001	0.000	0.000
	[0.001]	[0.000]	[0.001]	[0.000]	[0.000]	[0.000]
GNI per capita	0.000	0.000	-0.000	-0.001*	0.000	0.000***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Trade openness	0.010	-0.000	-0.027	0.070*	-0.003***	-0.001
	[0.015]	[0.002]	[0.020]	[0.035]	[0.001]	[0.002]
Financial depth	-0.008	-0.008*	0.003	0.013	0.006*	0.011*
	[0.006]	[0.004]	[0.012]	[0.013]	[0.003]	[0.006]
Governance	0.003	0.043**	0.185**	-0.147	0.006	-0.030
	[0.045]	[0.019]	[0.076]	[0.182]	[0.008]	[0.020]
Urbanization	0.075	0.032*	0.068	0.131*	-0.004	-0.020
	[0.123]	[0.019]	[0.055]	[0.072]	[0.008]	[0.013]
Populationg growth	-0.091	-0.112	0.092	1.896*	-0.013	0.088
	[0.340]	[0.099]	[0.668]	[1.133]	[0.048]	[0.130]
Constant	0.460***	0.430***	0.354	0.265	0.041*	0.035***
	[0.058]	[0.029]	[0.295]	[0.202]	[0.022]	[0.012]
R-squared	0.829	0.967	0.992	0.990	0.778	0.577
Hansen J (P-value)	0.00	23.86	0.00	26.22	0.00	20.24
Endogeneity (P-value)	0.22	0.25	0.05	0.98	0.77	0.74
Number of countries	70	70	70	70	70	70
Observations	1,732	1,591	1,732	1,591	1,725	1,586

Note: This table uses ODA (% of GDP) to measure foreign aid. See Tables 1 and 4 for more notes.
Source: Authors' own calculations.

Appendix Table A6: The transmission channel of energy intensity (using ODA)

Dependent variable	Sustainability-HDI		Genuine savings		Footprint/bio-capacity ratio	
Method	Factor-IV	Factor-GMM	Factor-IV	Factor-GMM	Factor-IV	Factor-GMM
Lag dependent var.	0.960***	0.949***	0.991***	0.599***	0.670***	0.644***
	[0.016]	[0.023]	[0.031]	[0.049]	[0.090]	[0.084]
ODA	-0.008	-0.058	0.124	-0.125	-0.026	-0.035
	[0.022]	[0.041]	[0.150]	[0.197]	[0.017]	[0.021]
Energy intensity (EINTEN)	-0.024***	-0.035***	-0.017	-0.178***	0.003	0.004
	[0.007]	[0.007]	[0.021]	[0.048]	[0.003]	[0.003]
ODA × EINTEN	0.000	0.002	0.008	-0.042***	-0.000	-0.003*
	[0.002]	[0.003]	[0.014]	[0.014]	[0.001]	[0.001]
'Beyond aid'						
Domestic gross savings	-0.000*	0.000	-0.001**	0.001	0.000	-0.000
	[0.000]	[0.000]	[0.000]	[0.001]	[0.000]	[0.000]
GNI per capita	0.000	0.000	-0.000	-0.000	0.000***	0.000***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Trade openness	0.004*	0.004*	0.018**	0.034**	-0.003*	-0.003*
	[0.002]	[0.002]	[0.007]	[0.017]	[0.002]	[0.002]
Financial depth	-0.005	-0.005*	-0.013**	-0.010	0.007*	0.007*
	[0.004]	[0.003]	[0.005]	[0.012]	[0.004]	[0.004]
Governance	0.015	0.018	0.024	-0.046	0.004	0.004
	[0.010]	[0.012]	[0.032]	[0.074]	[0.005]	[0.007]
Urbanization	0.039*	0.045**	-0.005	-0.039	-0.005	-0.006
	[0.020]	[0.020]	[0.030]	[0.060]	[0.007]	[0.007]
Population growth	0.064	0.077	0.425	0.510	0.012	0.034
	[0.106]	[0.079]	[0.283]	[0.530]	[0.056]	[0.058]
Constant	0.447***	0.423***	0.081	0.076	0.025***	0.030***
	[0.027]	[0.030]	[0.059]	[0.080]	[0.007]	[0.009]
R-squared	0.974	0.977	0.984	0.430	0.740	0.701
Hansen J (P-value)	0.00	25.55	0.00	21.24	0.00	34.18
Endogeneity (P-value)	0.12	0.44	0.01	0.04	0.12	0.55
Number of countries	70	70	70	70	70	70
Observations	1,694	1,553	1,694	1,553	1,692	1,553

Note: This table uses ODA (% of GDP) to measure foreign aid. See Tables 1 and 5 for more notes.

Source: Compiled by the authors.

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