The Search for a Long-run Aid and Growth Relationship: Pitfalls and Findings

Felicitas Nowak-Lehmann D.*, Inmaculada Martínez-Zarzoso**, Dierk Herzer[i],

Stephan Klasen*** and Axel Dreher****

Abstract

In this paper we investigate the relationship between per capita income and foreign aid for a panel of131 (alternatively 52) recipient countries over the period 1960 to 2006 by employing annual data and 5-year averages. Reliance on standard panel estimation techniques (such as 2-ways FE estimation, panel GMM and SUR estimation) points to some pitfalls (impossibility of possible cointegration between aid and growth, autocorrelation of the error terms, endogeneity of the variables) that must be dealt with panel time series techniques (such as panel unit root test, panel cointegration tests, a panel Granger causality test and panel dynamic feasible generalized least squares estimation (DFGLS). Estimations with DFGLS show that aid has an insignificant or a minute negative significant impact on per capita income. This result holds for countries with above- and below-average aid-to-GDP ratios, for countries with different levels of human development, with different income levels and from different regions of the world. It can be shown that by not controlling for autocorrelation, one erroneously attributes to aid a larger, significant negative impact on per capita income. We also find that aid has a significant positive (even though) small impact on investment, but a negative and significant impact on domestic savings (crowding out) and the real exchange rate (appreciation).

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For addresses please see next page!

For *, **, ***, ****

address:

University of Göttingen; Department of Economics; Platz der Göttinger Sieben 3, 37073 Göttingen, Germany

e-mail addresses, phone and fax numbers.

* fnowak@uni-goettingen.de; Ph.: +49 551 397487; Fax: +49 551 398173;

** martinei@eco.uji.es; Ph.: +49 551 399770; Fax: +49 551 398173

*** sklasen@uni-goettingen.de; Ph.: +49 551 397303; Fax: +49 551 398173

**** axel.dreher@uni-goettingen.de; Ph.: +49 551 39 10614; Fax: +49 551 398173

For [i] : address, e-mail address, phone and fax numbers:

DierkHerzer@wiwi.uni-frankfurt.de; Ph.: +49 69 79834783; Fax: +49 69 79835051;

Goethe-Universität; Postfach 11 1932 (Haus-PF 47); 60629 Frankfurt am Main, Germany

1. Introduction

For a new paper investigating the impact of aid on economic growth, it may be good practice to begin with an apology for adding to such an immense literature. However, there is still heated debate on whether or not foreign aid is effective in promoting economic development in aid-recipient countries. According to Sen (2006) and Tarp (2006), Easterly's (2006) claim that aid has done "so much ill and so little good" obscures that aid can work if done right. Even recent surveys of the literature on the aid-growth nexus come to sharply opposing conclusions. While Doucouliagos and Paldam (2008a and 2008b) conclude that the aid effectiveness literature has failed to establish that aid works, McGillivray et al. (2005) stress that practically all research published since the late 1990s finds exactly that.

Rather than looking at the unconditional average effect of aid, the recent literature has tried to establish that aid works under certain conditions only. Starting with Burnside and Dollar (2000), various scholars have argued that aid is indeed effective in "good" policy environments. Daalgard et al. (2004) focus on the recipient country's geography, rather than its policies. Hansen, Finn and Tarp (2004) argue that aid is effective up to a certain amount of aid, after which the marginal effect becomes negative. Still others claim that aid has to be decomposed rather then investigated in total. Dreher et al. (2008) look at sectoral aid and investigate how aid given for education affects educational outcomes rather than looking at aggregates. According to Clemens et al. (2004), only "short-impact aid" can reasonably be expected to make a difference in the short-run. It has also been argued that various donors might be more effective in promoting growth than others, e.g., because their aid is not given for strategic or commercial reasons.[1] Results might even depend on the specifics of how aid flows are measured.[2]

[1] For the United States and Japan, geopolitical and commercial interests seem to be the most important determinants of aid, respectively (Alesina and Dollar 2000). Berthélemy (2006) finds that "all donors are not the same" with respect to various indicators of recipient need as well as donor interests. Multilateral institutions seem to generally pay greater attention to recipient needs than bilateral donors do (Burnside and Dollar 2000; Alesina and Dollar 2000). Canavire et al. (2005) find no indication that donor countries were able to push through their individual trade and political interests

Rajan and Subramanian (2008) investigate all those suggestions in one common framework revisiting the cross-section and the panel evidence. According to their results, they find it difficult to discern any systematic effect of aid on growth. This finding holds across time horizons, time periods, cross-section and panel contexts, types of aid distinguished by what it is used for, who gives it, who it is given and how long it takes to have effect (contemporaneous versus lagged aid).

While these studies are clearly important and innovative, they all rely on a similar econometric framework. As we will argue below, this framework is not suitable to analyze the question at hand. As one major drawback, the existing empirical literature keeps on looking at growth relationships that cannot be cointegrated (cannot reflect a long-run equilibrium) by any means. The existence of a long-run relation between growth, which is generally stationary, and population growth, technology growth, savings and investment and aid, which are generally non-stationary, must be ruled out for statistical, econometric and intuitive reasons. Clearly, the long-run development of a stationary series (e.g., real per capita income growth as dependent variable) can never be explained by the development of one or more non-stationary series (like population growth, savings-GDP ratio, investment-GDP ratio). variables). If the results show a positive or negative relationship between aid and output in the long-run one could safely conclude that there was positive growth (if the coefficient is positive) or a shrinkage in real terms (if the coefficient is negative) in the long run. Rajan and Subramanian (2008), to the contrary, focus on growth rates rather than levels.

Linked to the problem of non-stationarity is the problem of autocorrelation of the disturbances that can be dealt with by some type of feasible Generalized Least Squares (FGLS) estimation. Another problem inter-linked with autocorrelation is the problem of omitted-variable bias that can be tackled in various ways, e.g., by auxiliary variables or so-called concomitants (Swamy, 2003) to obtain consistent estimators. Amazingly, both problems have not adequately been treated in the existing

at the multilateral level. However, various other studies suggest that multilateral institutions are also not invulnerable to donor pressure (Weck-Hannemann and Schneider 1981; Frey and Schneider 1986; Fleck and Kilby 2006; Kilby 2006; Dreher, Sturm and Vreeland, 2009; Dreher and Jensen 2007).

[2] See, e.g., the discussion in Clemens et al. (2004) concerning effective development assistance vs. official development assistance.

aid-growth literature so far (Rajan and Subramanian, 2008).[3] Averaging data over time and the application of time dummies are often thought to be suitable to eradicate the autocorrelation of the error terms and cross-section dummies are utilized to capture time-invariant cross-section characteristics (sample heterogeneity). Relative to the literature that is aware of the importance of the time series properties of the series under analysis and that therefore applies time-series techniques, there are severe shortcomings in the aid effectiveness literature.

A major flaw of the existing empirical literature is the way how it treats the likely endogeneity of the explanatory variables. At times all right hand side variables are treated as exogenous, at other times endogeneity is taken care of by (internal or external) instruments. However, utilization of lagged variables as instruments becomes doubtful if series and error terms show signs of persistence (autocorrelation) as endogeneity will not disappear by mere replacement of the endogenous variable by its lagged value. At other instances the instruments are very weak, e.g., if they are insufficiently correlated with the endogenous variables or still strongly correlated with the error term (Roodman, 2007a).

It is to these methodological issues that our paper contributes. While arguably being less fancy than the invention of a new interaction term, or a new category of aid on which to focus, such methodological details are part and parcel to successfully identifying a potential link from aid to growth. Below, we will apply a parsimonious growth model, enabling us to control for other factors that are crucial for generating income and growth, but also allows focusing on sufficiently long horizons of time. With panel time series data at hand that stretch over a long period of time, treating endogeneity by means of dynamic ordinary least squares (DOLS) or dynamic feasible generalized least squares (DFGLS) are the methods of choice (Stock and Watson, 1993). Surprisingly, they have only been applied to the problem at hand in a bivariate context (Herzer, 2008).

Specifically this paper tries to fill gaps and make contributions to the following issues: First, the time series properties of the series will be studied beforehand and the period analyzed will be long

[3] Rajan and Subramanian (2005b) raise the issue of autocorrelation and Roodman (2007a) points to autocorrelation in several studies.

(40 years or more). Second, to make statements on the development of the aid-per capita income nexus over time, an analysis of the long-run relationship (equilibrium) between aid and other variables and real per capita income will follow the introductory analysis. Dynamic Ordinary Least Squares (DOLS) and or Dynamic Feasible Generalized Least Squares (DFGLS) will be the preferred estimation techniques. These techniques allow controlling for endogeneity by insertion of leads and lags of the variables in differences. DFGLS furthermore allows controlling for autocorrelation. While DOLS and to a smaller extent DFGLS have been extensively applied in the time series literature, it has never been used to study the impact of aid on per capita income. Third, a study of reverse causality between aid and growth or real output will round up this analysis to see whether aid is given to low income/low growth countries or rather to the better off countries. Fourth, we will utilize an improved measure of Net ODA, which is called Net Aid Transfers (NAT) and which has been computed by David Roodman (Roodman, 2008).

In our long-run Solow-type growth model we find that aid has *an insignificant impact or an extremely small negative impact on the level of real GDP per capita.* Searching for possible transmission channels we can observe that the impact of aid on investment is positive, but very small. Its impact on the domestic savings-GDP ratio is quite small but negative, which indicates some crowding out of domestic savings. This finding equally applies to different regions of the world, to recipient countries with different income levels (high, middle, low income countries) and to recipient countries with different levels of human development (high, medium and low human development) as well as to developing countries that have above- or below-average aid-to-GDP ratios. Furthermore, we find that capital inflows (aid being one component of it) lead to a slight appreciation of the real exchange rate in the long run.

This finding together with the very small positive impact on investment and a small crowding out effect with respect to domestic savings might result in an insignificant or minor negative impact on the level of real per capita GDP in the long run.

Contrary to what is argued in much of the recent literature, we also find that the impact of aid on real per capita income is linear. The non-linear model has to be rejected. With respect to the debate on reverse causality in the aid-income relationship, we find that aid Granger causes the level of real per capita GDP in the long run together with population growth, internal and external saving and that per capita income causing aid. Therefore, we can safely assume a bi-directional relationship.

The outline of the study is as follows. After reporting the related literature in Section 2 the empirical growth model will be motivated and derived in Section 3. Section 4 presents the empirical findings. The study uses data for the period 1960-2006 and basically starts with regular panel techniques to make the pitfalls of the analysis evident. The following sub-sections of section 4 will then use annual data and panel time series techniques based on the existence of a long-run relationship. Endogeneity will be controlled for by means of DOLS or DGLS and the direction of causality will be checked. In section 5 the results will be evaluated from an economic policy and an econometric point of view.

2. Review of related literature and points of concern

In recent decades a multitude of studies has evolved that examine the effectiveness of aid in terms of increases in real per capita GDP or growth and studies that analyze the effectiveness of aid in terms of reaching the Millennium Development goals (MDGs). While we think that reducing poverty and hunger, child mortality, overcoming HIV and malaria, improving gender equality, literacy and so forth are extremely important objectives of giving aid, the “older” question of whether we can increase per capita income and enable a self-sustaining growth process in recipient countries is equally important from a development economics point of view. Morrissey (2001), Hansen and Tarp (2001), Easterly (2003), Easterly, Levine and Roodman (2004), and Pattillo et al. (2007) concentrate on studying the effectiveness of aid in terms of promoting real GDP growth in recipient countries and get mixed results. Morrissey (2001), Reddy and Minoiu (2006) and Minoiu and Reddy (2007) point to a positive growth effect of developmental aid even independent of the quality of economic policies in recipient countries. The famous results by Burnside and Dollar (2000) suggested that aid promoted growth only in an environment of ‘good policies’. Following Burnside and Dollar, most of the research has focused on the importance (or lack of) of certain conditions in the recipient country. The “good policy” model, in which aid is effective only when the recipient country government already pursues growth-promoting policies, has been very influential in shaping aid allocation procedures of major multilateral development agencies and bilateral donors. Related research considers the effectiveness of aid to be dependent on certain features of recipient countries such as the share of a country’s area that lies in the tropics (Daalgard et al., 2004), the level of democratization (Svensson, 1999), institutional quality (Burnside and Dollar, 2004), political stability (Chauvet and Guillaumont, 2004), vulnerability to external shocks (Guillaumont and Chauvet, 2001) and absorptive capacity (Chauvet and Guillaumont, 2004). However, Easterly et al. (2004) and Rajan and Subramanian (2008) showed that the results were very fragile, being sensitive to small changes in the data set.

Clearer evidence on the effectiveness of aid in certain policy environments and under certain conditions may however be impeded by adequate and long enough time series on democratization, corruption, institutional quality, indicators of economic policy (trade openness, macroeconomic stability, structural adjustment and so forth).

Other empirical studies have even pointed to a questionable or even negative growth effect of aid in the long run (Svensson, 1999; Ovaska, 2003). Doucouliagos and Paldam (2008a and 2008b) conclude that the aid effectiveness literature has failed to establish that aid works. The insignificant long-run effect is said to be due to weak institutions, increased corruption and a dwindling willingness to raise taxes (Knack, 2004; Rajan and Subramanian, 2007) and/or to real exchange-rate appreciation (Rajan and Subramanian, 2005b) in the recipient economies. It is argued that real exchange rate overvaluation, which eventually harms exports and the import-substitution sectors, is brought about by the aid inflow which affects the capital account under both flexible and fixed exchange rate systems. Next to the effect on the exchange rate the impact of aid on investment has to be clarified. It is relatively unclear whether aid increases investment (overall investment; i.e., public and private investment) or whether it crowds out domestic investment or whether it is primarily consumed.

In contrast, another perspective, sometimes called the “medicine” model (Jensen and Paldam 2006), sees some levels of aid as growth-promoting regardless of recipient government policies. However, at higher levels of aid, the marginal effect on growth becomes negative so that aid is less effective, or even harmful.

Even though donors surely would want aid to be effective in furthering exports, growth and human development in recipient countries, ineffectiveness of aid is apparently not a sufficient condition for refusing aid. Studies on aid allocation have shown that historical ties, political and strategic interests of donor countries, as well as incentive structures within the donor community and its agencies are also very important factors in determining aid flows and can easily ensure aid flows even in the absence of effectiveness (Alesina and Dollar, 2000; Mosley, Harrington, and Toye, 1990; Bourguignon and Sundberg, 2007).

It is often argued that the motivation with which aid is given (Dreher et al., 2008, 2009) and the type of aid given (Clemens et al., 2004; Reddy and Minoiu, 2006) have an impact on the effectiveness of aid. This argument makes a lot of sense, but it is difficult to be tested empirically both in cross-section type studies and in long-run panel studies. As to the cross-section type studies, what is true at a certain point in time must not hold over an extended period of time. Likewise aid given with a “bad” intention might have the same impact as aid given with a “good” intention. On top of that, if such an approach were rigorously followed, one would also have to take into account that the effectiveness of aid hinges on other factors as well, such as the way how the allocation of aid has been organized and implemented in the recipient country and on the discipline and honesty of the people handling foreign aid (Doucouliagos and Paldam, 2008a and 2008b). Given so many imponderabilities (some of which are quantifiable, while others are not), how can we safely conclude that the impact of aid observed at a certain point in time can also be observed at later points in time (see also Roodman, 2007a and 2007b)? E.g., Chile has prospered under a dictatorship (1973-1989) and a democracy (1990 until now), corruption under Pinochet was lower than it is now, infrastructure has improved under both regimes and economic policies have not changed too much in the last two decades compared to the Pinochet era. Some donors gave development aid to Pinochet to help the Chilean population, other donors gave less aid to punish the regime or again others gave more aid to support the regime.

Besides, while it is plausible that country-characteristics in terms of political regime, socio-economic conditions, institutions, infrastructure endowment, economic policies and so forth *and* donors' motivations can have an impact on aid effectiveness, we would then prefer to follow their impact over time in long-run analyses and not erratically. As to long-run panel studies, this would require collecting those data (data on donors' motivation as well as and corruption data, institutional quality data, and doing business data for recipient countries) over the long run.

Likewise, it has been argued that aid given for different sectors of an economy[4] might have a different impact on per capita income (Clemens et al., 2004). The argument that the sectoral allocation of aid matters, depending on the rate of return of investment projects, is very plausible but again it might be extremely hard or even impossible to find sectoral aid data for the entire period of 1960-2006 which is our sample period. On top of that, there might exist a "macro-micro paradox" of aid. Many aid-funded projects report positive micro-level returns that are undetectable at the macro-level (Boone, 1994).

Also while it is clear that the short-run impact of aid on growth may differ from its long-run impact (Clemens et al., 2004), that aid may impact positively or negatively in the short run depending on the project (Roodman, 2007a), from an economic policy point of view the analysis of the long-term aid-growth relationship should be given priority. This involves observation of the aid-growth nexus over a long time horizon (more than 40 years) and the organization of the data in groups of countries to control for heterogeneity or the application of estimation techniques that allow for an

[4] Michaelowa and Weber (2006) and Dreher et al. (2009) look at whether aid for education raises primary enrollment rates. Mishra and Newhouse (2007) study the relationship between health aid and infant mortality.

estimation of cross-section (country-specific) coefficients. In our type of analysis we will work with aggregate data as we are interested in studying the aid-per capita income relationship *over the long-run* in a complex environment of institutions, motivations, organizational abilities. Given that data on the latter will not be available for the whole sample period and all the recipient countries under study, we are confronted with the "omitted variables" problem.

We will address the problem of "omitted variables", which is more pressing in our type of approach than in a cross-section analysis, in two ways: first, we will insert country fixed effects and second, we will correct for autocorrelation with due caution (Mizon, 1995). Under the condition that omitted variables cannot be quantified and must therefore be relegated to the error term (!), the correction of autocorrelation via Feasible Generalized Least Squares (FGLS) or a similar method also helps to correct for omitted variable problem. Whereas the country fixed effects capture omitted country characteristics that are time-invariant, taking out the "swings of the error terms" will also absorb unobservable or unquantifiable country characteristics that might vary over time (changing attitudes towards corruption, rent-seeking, inequality, poverty, and law enforcement; improvement of administrative efficiency; progress in efficiency in handling projects, changing organizational and managerial capabilities).

3. Empirical growth model: Linking aid and per capita income

Following Cellini (1997) we apply a parsimonious Solow-type model based on non-stationary ($I(1)$)-variables with a stochastic steady state. We relegate time-varying unobservable or unquantifiable country characteristics (of the above-mentioned type) into the error term ($e^{u_{i,t}}$). In contrast to Cellini's model, our model reflects an open economy that allows for external financing. It is assumed that external savings are used to finance at least partly domestic investment. The capital stock in the recipient country's economy (the domestic capital stock) can be either domestically financed (by domestic savings (private+public), externally financed (without a grant element; by net external savings=external savings minus foreign aid or externally financed by Net

Official Development Aid (ODA)) or Net Aid Transfers (NAT). NAT is our preferred measure of ODA for the reasons given above. The domestic capital stock then consists of domestically financed physical capital (K_1), externally financed physical capital following market conditions (K_2) and externally financed physical capital involving a grant element (K_3)

$$K = K_1 + K_2 + K_3 \tag{1}$$

The output equation that assumes constant returns to scale then reads as follows

$$Y_{i,t} = K_{1i,t}^{\alpha_1} \cdot K_{2i,t}^{\alpha_2} \cdot K_{3i,t}^{\alpha_3} \cdot (A_t \cdot L_t)^{1-\alpha_1-\alpha_2-\alpha_3} \cdot e^{u_{i,t}} \tag{2}$$

where $\alpha_1, \alpha_2, \alpha_3$ are technology parameters; subscripts i and t indicate country and time, respectively; $e^{u_{i,t}}$ is the error term; L is labor, K_1, K_2 and K_3 are physical capital financed by three different sources, while A indicates the technology level, which is the same across countries at date t.

K_1, K_2 and K_3 grow according to the following equations

$$\frac{dK_{1i,t}}{dt} = sdomy_{i,t}^{K_1} Y_{i,t} - \delta K_1 \tag{3}$$

$$\frac{dK_{2i,t}}{dt} = sextny_{i,t}^{K_2} Y_{i,t} - \delta K_2 \tag{4}$$

$$\frac{dK_{3i,t}}{dt} = snaty_{i,t}^{K_3} Y_{i,t} - \delta K_3 \tag{5}$$

Where $sdomsy$ is the domestic savings-to-GDP ratio, $sextny$ is the external savings-to-GDP ratio $sexty$ substracting external savings in the form of aid (NAT $(snaty)$); $i.e.\cdot$ $sextny = sexty - snaty$. δ is the depreciation rate, which is assumed to be the same for all three types of capital and to be constant across countries and over time. The rate of technological progress g, is also constant and such that:

$$A_{i,t} = A_{i,0} e^{gt} \tag{6}$$

And the growth of labor force is denoted by $n_{i,t}$, so that

$$L_{i,t} = L_{i,0} e^{n_{i,t}} \qquad (7)$$

A constant steady state level can be derived for

$$\left(K_1 / AL\right)^* = k_1^* = \left(sdomy^{1-\alpha_2-\alpha_3} sextny^{\alpha_2} snaty^{\alpha_3} /(n+g+\delta)\right)^{1/(1-\alpha_1-\alpha_2-\alpha_3)} \qquad (8)$$

$$\left(K_2 / AL\right)^* = k_2^* = \left(sdomy^{\alpha_1} sextny^{1-\alpha_1-\alpha_3} snaty^{\alpha_3} /(n+g+\delta)\right)^{1/(1-\alpha_1-\alpha_2-\alpha_3)} \qquad (9)$$

$$\left(K_3 / AL\right)^* = k_3^* = \left(sdomy^{\alpha_1} sextny^{\alpha_2} snaty^{1-\alpha_1-\alpha_2} /(n+g+\delta)\right)^{1/(1-\alpha_1-\alpha_2-\alpha_3)} \qquad (10)$$

$$\left(Y / AL\right)^* = y^* =$$

$$\left(sdomy^{\alpha_1 /1-\alpha_1-\alpha_2-\alpha_3} sextny^{\alpha_2 /1-\alpha_1-\alpha_2-\alpha_3} snaty^{\alpha_3 /1-\alpha_1-\alpha_2-\alpha_3} /(n+g+\delta)^{\alpha_1+\alpha_2+\alpha_3/1-\alpha_1-\alpha_2-\alpha_3} \right)$$

(11)

where the variables *k* and *y* are in efficiency units, and stars indicate steady state variables.

The steady state per capita income y^* varies according to the following equation:

$$\ln y_{i,t}^* = (\ln A_0 + gt) + \frac{\alpha_1}{1-\alpha_1-\alpha_2-\alpha_3} \ln sdomy + \frac{\alpha_2}{1-\alpha_1-\alpha_2-\alpha_3} \ln sextny + \frac{\alpha_3}{1-\alpha_1-\alpha_2-\alpha_3} \ln snaty$$
$$- \frac{\alpha_1+\alpha_2+\alpha_3}{1-\alpha_1-\alpha_2-\alpha_3} \ln(n+g+\delta)$$

(12)

In the neighborhood of the steady state path, per capita income evolves according to the following equation (see Cellini, 1997)

$$\ln y_{i,t+1} - \ln y_{i,t} = g + (1-e^{-\lambda_{i,t}}).((\ln A_0 + gt) + \frac{\alpha_1}{1-\alpha_1-\alpha_2-\alpha_3} \ln sdomy + \frac{\alpha_2}{1-\alpha_1-\alpha_2-\alpha_3} \ln sextny$$
$$+ \frac{\alpha_3}{1-\alpha_1-\alpha_2-\alpha_3} \ln snaty - \frac{\alpha_1+\alpha_2+\alpha_3}{1-\alpha_1-\alpha_2-\alpha_3} \ln(n+g+\delta) - \ln y_{i,t}$$

…………………………………………………………………………… (13)

$\lambda_{i,t} = (n_{i,t} + g + \delta) \cdot (1 - \alpha_1 - \alpha_2 - \alpha_3)$, which is the speed of convergence. It is not constant due to the variability of the employment rate (population growth rate). In theory, g and δ could also vary over time.

As we are interested in the aid-per capita income relationship *in the long run* when all adjustments have come to an end we estimate the model as depicted in Eq. (12) in a simplified form (see Eq. (14)).

$$LRYPOP_{i,t} = b_{0i} + b_1 LSDOMY_{i,t} + b_2 LSEXTNY_{i,t} + b_3 LSNATY_{i,t} + b_4 LPOPGPLUS_{i,t} + u_{i,t} \quad (14)$$

where

subscripts i and t indicate country and time, respectively

$LRYPOP_{i,t}$ = real per capita income (in logs)

$LSDOMY_{i,t}$ = domestic savings-to-GDP ratio (in logs)

$LSEXTNY_{i,t}$ = external savings minus aid-to-GDP ratio (in logs)

$LPOPGPLUS_{i,t}$ = population growth + 5% (includes technological progress and capital depreciation[5]); in logs

The data of *LRYPOP*, *LSDOMY*, *LSEXTNY* and *LPOPGPLUS* are taken and compiled from the World Development Indicators 2008 CD-ROM.

$LSNATY_{i,t}$ = net aid tranfers-to-GDP ratio (in logs). NAT is available from the Center for Global Development. Washington, D.C.[6] It has been computed by Roodman (2008) and embodies two modifications of Net ODA (from the DAC committee of the OECD). First, it substracts out interest payments received from developing countries on outstanding aid loans, which are now treated as

[5] Sum of the growth rate of technology and the rate of capital depreciation are assumed to be equal to 5 percent (following Mankiw, Romer and Weil, 1992, p. 413).
[6] See http://www.cgdev.org/content/publications/detail/5492 (February 20, 2009).

capital outflows just as principal payments. Second, NAT takes out debt relief. The cancellation of old *non-aid* loans (in the form of export credits or loans with too high interest rates) boosted Net ODA and is therefore removed in NAT. [7]

$u_{i,t}$ = all unobservable and unquantifiable variables that impact on per capita income and that vary over cross-sections and over time.

4. The aid-per capita income link: Empirical findings

4.1. Applying regular panel data estimation techniques

This section follows the panel data approach where emphasis is often put on the "within" estimation, i.e. an exploitation of the variation of the variables over time. Studies of this type are usually performed to present an overview of what happened in the 1960-2006 period on average in the developing world when it received aid.

We use a panel of 131 countries, utilize annual and averaged data (5-year averages; to smooth the data over time) and then estimate Eq. (14) in various ways: with fixed effects, time-effects, controlling for autocorrelation, panel Generalized Method of Moments (GMM) and Seemingly Unrelated Regression (SUR). In addition, we will discuss the inclusion of time effects to control for events that vary over time but are the same in all cross-sections, leading to a 2-ways fixed effects estimation and the problem of finding adequate instruments.

[7] See examples given by David Roodman in:
http://blogs.cgdev.org/globaldevelopment/2007/01/new_aid_data_paint_more_realis_1.php

Table 1. The income-aid relationship: Dependent variable: real per capita income *(LRYPOP);* sample size: 131 countries

	2-ways-FE estimation (annual data)	2-ways-FE estimation (5-year averages)	FE+FGLS estimation (annual data)	FE+FGLS estimation (5-year averages)	GMM estimation (5-year averages)	SUR estimation (5-year averages)
Indepen. Vars↓	Dependent variable: Real per capita income *(LRYPOP)*					
LPOPG-PLUS	-0.12** (-2.43)	-0.08 (-0.46)	-0.01 (-1.16)	0.17 (1.28)	-0.04 (-0.20)	0.30 (0.36)
LSDOMY	0.09*** (12.99)	0.10*** (5.17)	0.01*** (3.11)	0.02* (1.56)	0.01*** (4.25)	-0.18 (-1.11)
LSEXTNY	0.01 (1.32)	0.01 (0.70)	0.004*** (3.53)	0.01** (2.07)	-0.00 (-0.25)	0.12 (1.10)
LSNATY	-0.06*** (-13.05)	-0.05*** (-4.03)	-0.004* (-1.72)	-0.02** (-2.01)	0.02 (1.35)	-0.13 (-1.40)
Fixed effects	yes	yes	yes	yes	yes	yes
Time effects	yes	yes	no	no	yes	no
Instruments (IV)	no	no	no	no	yes	no
Auto-correlation control	no	no	yes	yes	no	yes via SUR
AR-term			0.98*** (177.43)	0.94*** (7.52)		
R^2 adj.	0.99	0.99	0.99	0.86	___	___
DW-stat.	**0.21**	**0.77**	**1.64**	**2.48**	___	___

Note: The 2-ways-FE-estimation relies on cross-section fixed effects and time effects. The FE+FGLS estimation utilizes cross-section fixed (country fixed effects) and corrects for autocorrelation of the error terms. Panel GMM (Generalized Method of Moments) is applied to the sample with 5-year averages to limit the number of moment conditions. Due to autocorrelation of the disturbances the instruments (lagged values of the variables) become invalid.

As we can see from Table 1, the two-ways fixed effects estimation (columns 2 and 3) remains subject to autocorrelation, the Durbin-Watson statistic being 0.21 and 0.77. In columns 4 and 5 the equation has been estimated via Feasible Generalized Least Squares (FGLS) to purge the error term from autocorrelation. By doing so, the impact of domestic and external savings and of aid on per capita income has been reduced compared to the 2-ways-FE estimation. The FGLS-results point to a minute negative impact of aid on per capita income. The Durbin-Watson statistic improves and moves closer towards two (the DW-statistic being 1.64 and 2.48). The application of the panel GMM estimation technique (column 6) is only possible when we work with 5-year averages[8] or 10-year averages. If we utilized annual data, we would create 4324 (47*46*4/2) moment conditions. A potential "plus" of GMM is that it works in dynamic models and can handle endogenous variables, if autocorrelation of the error terms is absent.[9] Applying GMM, we obtain an insignificant impact of aid on per capita income. As to the SUR estimation (column 7), this estimation method will not be feasible if we work with yearly data.[10] Therefore, it has been proposed to work with 5-year averages, to set up a system of equations and to switch! cross-section and periods when the number of cross-sections is large and the number of time periods is small (see Alesina et al., 2003). In our case, this implies that separate equations are utilized for the 60-64, 65-69, 70-74, 75-79, 80-84, 85-89, 90-94, 95-99, 00-06 (in case of 5-year averages). Following this estimation procedure, we basically estimate nine (we get nine different time-periods) cross-section equations (with 131 countries in each equation) in a system. By switching cross-sections and time-periods the estimation becomes a "between" estimation and autocorrelation over time is controlled for by the Seemingly Unrelated Regression (SUR)-technique. Also in the SUR estimation the impact of aid on per capita income is insignificant.

[8] Working with 5-year averages we have already created 144 moment conditions.
[9] GMM cannot be seriously applied in our case due to autocorrelation. Besides, it is very likely that the pre-requirements for using GMM will be violated in all studies with macroeconomic data where in general autocorrelation can be found. To our knowledge, GMM has been recommended for panel data with only a few observations over time (Baltagi, 2001).
[10] A system of 48 equations cannot be estimated with the computer programs at hand.

However, a further finding - given our data - is that averaging over time does not (and cannot) eradicate autocorrelation, as it has often been suggested in the literature since autocorrelation between time-intervals persists. On top of that, we give up a lot of information on the behavior of the variables over time by strongly averaging the data over time and/or working with time effects. We would therefore vote against averaging data over time and against employing time fixed effects.

In section 4.4 we will see that endogeneity of the right-hand side variables constitutes a problem. Under these circumstances, neither a two-way fixed effect estimation nor a fixed effect estimation that is combined with FGLS estimation nor panel GMM nor SUR estimation can be considered as promising estimation techniques. In the presence of autocorrelation the instrumental variables have to come from outside the model and utilization of lagged variables becomes a dangerous option (in case of the 2-ways-FE, panel GMM and SUR estimation). In case of a FGLS estimation, lagged instruments of the transformed variables could be utilized. This requires that all the variables in the model would have to be transformed by hand with the FGLS-technique beforehand. But doing so can lead to an increase in autocorrelation in the second stage. Given the pitfalls associated with the instrumentalization of the endogenous variables we do not report the estimation results at this stage.

We will rather concentrate on presenting the results (in section 4.3) obtained by means of the dynamic ordinary least squares and the dynamic feasible generalized least squares technique (DOLS and DFGLS). DOLS and DFGLS are able to control for endogeneity by simultaneously estimating the impact of lead and lag differences of the explanatory variables (Stock and Watson, 1993). However, these techniques require the variables to be linked to each other in the long run (to be cointegrated, to be in a long-run equilibrium).[11] We therefore have to test these properties before we can estimate the aid-per capita income relationship via DOLS/DFGLS. Besides, unit-root and cointegration test require longer coherent time spans so that the sample size is reduced to 52 countries.

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[11] To avoid spurious regression results, we estimated the relationship between aid and real per capita income (and not growth) in the previous section.

4.2. Existence of a long-run equilibrium between aid and per capita income (52 country sample)

A cointegrating relationship can only be found between non-stationary series with the same order of integration. Therefore, one must utilize and rely on non-stationary series that can potentially be inter-linked. In our case, one must study the relationship between the level of real per capita output, which is non-stationary and *I(1)*, and population growth, technology growth, savings and investment and aid, which are all non-stationary (*I(1)*).

As to the time series properties of the variables, we find that growth rates of real per capita income show, in general, very little persistence over time (they are stationary series), whereas the aid-to-GDP ratio and the level of real per capita income exhibit large and persistent movements with strong positive trends for most developing countries since 1960 (they are non-stationary series). The empirical implication of this fact is that there can be a long-run relationship between the level of per capita output and the level of the aid-to-GDP ratio over time, *but there cannot be a long-run relationship between the growth rate of per capita output and the level of the aid-to-GDP ratio over time*. Consequently panels with stationary and non-stationary variables can, even in cross-country growth analyses, lead to misleading results (see, e.g. Ericsson et al., 2001). However, applying panel time series techniques comes at a cost. Since these techniques require a balanced panel with long enough time series, only 52 out of 131 countries qualified for this procedure.

Table 2. Results of the ADF-Fisher panel unit root test

Variable tested	Fisher statistic	Probability	Variable is integrated
LRYPOP	82.73	0.99	$I(1)$
LPOPGPLUS	104.20	0.78	$I(1)$
LSDOMY	89.35	0.94	$I(1)$
LSEXTNY	100.84	0.20	$I(1)$

LSNATY	95.64	0.89	$I(1)$
LINVY	110.70	0.62	$I(1)$
LRER	60.00	0.33	$I(1)$

Note: the first differences of the series are stationary (results not reported). The Fisher statistic is distributed as χ^2 with $2 \times N$ degrees of freedom, where N is the number of countries in the panel.

From the note of Table 2 it becomes obvious that growth is stationary *(I(0))* and that it cannot possibly be related to *I(1)* - variables such as population growth, technological progress and capital depreciation (*LPOPGPLUS*), the domestic savings-to-GDP ratio *(LDOMY),* the net external savings-to-GDP ratio minus the aid-to-GDP ratio *(LEXTNY)* and the net aid transfer-to-GDP measure *(LNATY)*. However, we also observe that *LRYPOP* is an *I(1)*-variable and therefore it could be related to the above-mentioned *I(1)*-variables. Whether such a long-run relationship exists will be tested by means of Kao's co-integration test listed below.

Table 3. Results of the Kao residual cointegration test

	t-statistic	p-value
DF*-statistics	-2.97***	0.00

Note: H_0: The variables of interest are not cointegrated ; H_1: The variables of interest are cointegrated (Kao, 1999). Kao's cointegration test is based on a fixed effects models (our model of choice) which Pedroni does not discuss. *** indicate a rejection of the null of no cointegration at the 1% level. All test statistics are asymptotically normally distributed. The number of lags was automatically determined by the Schwartz criterion.

Table 3 shows that a cointegrating long-run relationship between *LYRPOP* and *LPOPGPLUS, LDOMSY, LEXTNY* and *LNATY* is confirmed by Kao's Residual Cointegration test.[12]

Cointegration of the above form implies that the augmented Solow model (Eq. (14)) holds in the long run and that aid helps to determine real per capita income in the long run.

[12] Hjalmarsson and Österholm (2007) propose a more robust residual-based cointegration test for near unit root variables which are usually detected in macroeconomic data settings. This test possesses very good finite sample properties.

Given that a cointegration relationship exists between aid and per capita income, we can now estimate the coefficients of this relationship by means of Dynamic ordinary and/or feasible generalized least squares technique.

4.3. Estimation of the long-run aid-per capita income relationship via DOLS/DFGLS

Both the DOLS and the DFGLS procedure generate unbiased estimates for variables that cointegrate, even with endogenous regressors (Stock and Watson, 1993). They do so by employing leads and lags of the variables in differences that absorb changes in the variables caused by changes in the disturbances if both are correlated.

Eq. (15)

$$\begin{aligned} LRYPOPX_{it} &= \alpha_i + \chi_1 LPOPGPLUS_{it} + \chi_2 LSDOMY_{it} + \chi_3 LSEXTNY_{it} + \chi_4 LSNATY_{it} \\ &+ \sum_{m=-p}^{p} \delta_{im} \Delta LPOPGPLUS_{it-m} + \sum_{m=-p}^{p} \varepsilon_{im} \Delta LSDOMY_{it-m} \\ &+ \sum_{m=-p}^{p} \phi_{im} \Delta LSEXTNY_{it-m} + \sum_{m=-p}^{p} \varepsilon_{im} \Delta LSNATY_{it-m} + u_{it} \end{aligned} \tag{15}$$

can be estimated by a dynamic ordinary least squares technique (DOLS) if autocorrelation of the disturbances is absent (which is not the case in our study). To correct for autocorrelation of the disturbances we utilize Dynamic Feasible Generalized Least Squares (DFGLS). The same way as one would apply FGLS when OLS is inefficient due to autocorrelation by pre-estimating the extent of autocorrelation of the residuals $\hat{\rho}$, one can apply DFGLS when DOLS is inefficient due to autocorrelation (see Stock and Watson, 1993).

DFGLS requires a transformation of the original variables as will be outlined below.

Estimated error terms are obtained by estimating Eq. (14) via DOLS in a first step. The extent of autocorrelation of the disturbances ρ is then estimated via DOLS in a second step: $u_{it} = \rho \cdot u_{it-1} + \varepsilon_{it}$ leading to $\hat{\rho}$. The third step involves the transformation of the variables (see below). Note, that the transformation of the variables is driven by $\hat{\rho}$, the estimated coefficient of autocorrelation of the disturbances. This transformation leads to new variables in soft first differences (characterized by *) and a new error term u^* that is uncorrelated to the error term of the previous period.[13]

$$u^*_{it} = u_{it} - \hat{\rho} \cdot u_{it-1}$$

$$LRYPOP^*_{it} = LRYPOP_{it} - \hat{\rho} \cdot LRYPOP_{it-1};$$

$$LPOPGPLUS^*_{it} = LPOPGPLUS_{it} - \hat{\rho} \cdot LPOPGPLUS_{it-1};$$

$$LSDOMY^*_{it} = LSDOMY_{it} - \hat{\rho} \cdot LSDOMY_{it-1};$$

$$LSEXTNY^*_{it} = LSEXTNY_{it} - \hat{\rho} \cdot LSEXTNY_{it-1};$$

$$LSNATY^*_{it} = LSNATY_{it} - \hat{\rho} \cdot LSNATY_{it-1};$$

and then in a fourth step Equation (16) is estimated by DOLS

$$\begin{aligned} LRYPOPX^*_{it} &= \alpha_j + \chi_1 LPOPGPLUS^*_{it} + \chi_2 LSDOMY^*_{it} + \chi_3 LSEXTNY^*_{it} + \chi_4 LSNATY^*_{it} \\ &+ \sum_{m=-p}^{p} \delta_i \Delta LPOPGPLUS^*_{i-m} + \sum_{m=-p}^{p} \varepsilon_{im} \Delta LSDOMY^*_{it-m} \\ &+ \sum_{m=-p}^{p} \phi_{im} \Delta LSEXTNY^*_{it-m} + \sum_{m=-p}^{p} \varepsilon_{im} \Delta LSNATY^*_{it-m} + u^*_{it} \end{aligned} \quad (16)$$

[13] In our case only first order autocorrelation was detected. However, also higher orders of autocorrelation reaching back two or more periods could be modeled.

Table 4: The impact of aid on per capita income: DFGLS versus DOLS estimation

Independent variables	**The aid-per capita income relationship (DOLS estimation)** Dependent variable: Real per capita income (in logs) *LRYPOP*	**The aid-per capita income relationship (DFGLS estimation)** Dependent variable: Real per capita income (in logs) *LRYPOP*
LPOPGPLUS	-1.20*** (-9.23)	-0.003 (-0.02)
LSDOMY	0.21*** (13.13)	0.07***(5.56)
LSEXTNY	0.11*** (7.29)	0.05***(4.79)
LSNATY	-0.13*** (-10.25)	-0.02 (-1.47)
Fixed effects	yes	yes
2 leads and 2 lags	yes	yes
Cross-sections included	52	50
R-squared adj.	0.99	0.99
Durbin-Watson stat.	**0.15**	**2.02**

The regression results of the DOLS estimation (column 2) are subject to autocorrelation and will not be discussed. Interpreting the significant coefficients of the DFGLS estimation (column 3), we can conclude that a doubling of the domestic savings-to-GDP ratio would increase per capita income by 7% and a doubling of the net capital inflows (minus aid)-to-GDP ratio would increase per capita income by 5% (α being 1%). A doubling of the aid-to-GDP ratio, in contrast, would reduce per capita income by 2% (α being 14%). In column 3 autocorrelation is controlled for, the DW-statistic being 2.02. Interestingly, correction for autocorrelation strongly reduces aid's negative impact on per capita income. This holds even if countries are classified according to the level of human development, according to income levels or according to regions in the world (see Tables A1a, A1b, A2a, A2b, A3a and A3b in the appendix or available from the authors upon request) and if we differentiate between countries (see Table 5) that have an above-average aid-to-GDP ratio (mostly African countries) and a below-average aid-to-GDP ratio (the average being 5.54%). This differentiation serves to check whether more aid helps more or whether more help stands for extremely poor conditions in recipient countries.

Only interpreting the DFGLS results which have validity (given that pure autocorrelation or omitted variables such as poor economic conditions are controlled for), we observe that a higher aid-to-GDP ratio has a slightly negative impact (-0.03) in the recipient countries with a high aid-to-GDP ratio and an insignificant impact in those developing countries that have a low aid-to-GDP ratio. Of course, one could argue that aid-to-GDP ratios in the countries with above-average aid-to-GDP ratios might not yet have been sufficient to generate positive income effects. This, however, is beyond the conclusions one can draw with the data at hand.

An important conclusion at this point is that the correction for autocorrelation reduces the size and the significance of the estimated coefficients (see Table 4 and 5). Given our data, correcting for autocorrelation we achieve two things: First, we can control for pure autocorrelation of the time series. Pure autocorrelation certainly is an issue in our data-set as we already have found that our variables have a memory of the past and were therefore tested non-stationary (see Table 2). Second, the FGLS procedure also responds to omitted variables (such as poor economic conditions, poor management of aid, poor institutions) and can neutralize their influence. We seem to capture this effect by correcting for autocorrelation as the coefficient of aid gets less negative controlling for autocorrelation.

Table 5: Different impact depending on the aid-to-GDP ratio? DOLS versus DFGLS estimation

	Above-average aid-to-GDP ratio countries DOLS	**Above-average aid-to-GDP ratio countries DFGLS**	**Below-average aid-to-GDP ratio countries DOLS**	**Below-average aid-to-GDP ratio countries DFGLS**
Independent variables↓	Dependent variable: *LRYPOP*	Dependent variable: *LRYPOP*	Dependent variable: *LRYPOP*	Dependent variable: *LRYPOP*
LPOPGPLUS	0.98***(5.02)	0.04 (0.23)	-2.06***(-12.49)	0.37 (1.31)

LSDOMY	0.12***(8.67)	0.05***(3.87)	0.39***(11.77)	0.16***(5.37)
LSEXTNY	0.08***(4.28)	0.04**(2.29)	0.16*** (8.26)	0.06***(4.32)
LSNATY	-0.16***(-8.95)	-0.03* (-1.70)	-0.10*** (-5.63)	-0.01 (-0.78)
Fixed effects	yes	yes	yes	yes
2 leads and 2 lags	yes	yes	yes	yes
Cross-sections included	23	23	29	29
R-squared adj.	0.99	0.99	0.99	0.99
Durbin-Watson stat.	**0.19**	**2.27**	**0.20**	**1.99**

In the related literature on the transmission channels of aid to per capita income, one is concerned about aid's impact on investment, on domestic savings (public and private) and on the real exchange rate. As to the transmission channels of aid to per capita income we find the following relationships by applying DFGLS and thus controlling for autocorrelation and endogeneity.

Table 6. Possible transmission channels that link aid and per capita income

	Possible transmission channels (DFGLS estimation)		
Independent variables↓	Dependent variable: Investment-to-GDP ratio (in logs) *LINVY*	Dependent variable: Domestic Savings-to-GDP ratio (in logs) *LDOMSY*	Dependent variable: Real exchange rate (in logs) *LRER*
LPOPGPLUS	---	---	---
LSDOMY	0.42***(19.76)	---	---
LSEXTNY	0.29***(15.30)	---	-0.14 (-0.66)
LSNATY	0.04**(2.17)	-0.12***(-3.45)	-0.51**(-2.27)
Fixed effects	yes	yes	Yes
2 leads and 2 lags	yes	yes	Yes
Cross-sections included	50	56	20
R-squared adj.	0.91	0.66	0.66
Durbin-Watson stat.	**1.92**	**1.83**	**2.13**

The domestic savings-to-GDP ratio, the net external savings-to-GDP and the net aid transfers-to-GDP ratio all have a positive and significant impact on recipient country's investment.

The domestic savings-to-GDP ratio is negatively affected by an increase in the aid-to-GDP ratio so that there is some crowding out and also the real effective exchange rate is negatively affected (appreciation) of an increase in the aid-to GDP ratio.

According to the Granger causality test (results are available from the authors upon request) aid and per capita income Granger-cause each other and are therefore endogenous. Long-run causality is bi-directional from aid to per capita income and the other way around. Estimation of the per capita income-aid relationship via DOLS/DFGLS is therefore called for to control for endogeneity.

5. Conclusions

In this paper, we have shown that aid's impact on per capita income is insignificant or negative, but very small. This finding holds for the long-run and for the recipient countries in general, but also for sub-groups of recipient countries which have been formed according to an above-average/below-average aid-to-GDP ratio, the level of human development, the level of income and the region of the world. Furthermore, we find that aid positively impacts on investment, whereas it causes a small crowding out of domestic savings and leads to some appreciation of the real exchange rate. In contrast to external savings (net capital inflows minus aid), which obey to market conditions (interest rate differentials and exchange rate expectations), net aid transfers (which are grants or loans with a grant element) do not have a positive impact on real per capita income. The rate of return of aid-financed projects seems to be below the interest to be paid on those loans, whereas the rate of return of externally-financed investment projects seems to be higher than the interest to be paid on those loans.

Interestingly, we also observe that aid's impact on per capita income gets smaller when we control for autocorrelation by means of some type of FGLS procedure. As swings of error terms around the regression line can be due to both pure autocorrelation (this is very likely if time series are non-stationary) and omitted variables (this is equally very likely if we have unobservable or unquantifiable country characteristics that vary over time) we eliminate both problems in one go. Intuitively, by controlling for unobservable or unquantifiable country characteristics, which very likely are related to the reasons why aid has been granted in the first place (donors motivations and donors perceptions) or how aid transfers have been managed and spent in the second place (efficiency of bureaucracy, absence of corruption and rent-seeking, organizational, managerial and workers' capabilities) the negative impact of aid on per capita income gets noticeably reduced.

As aid and per capita income are inter-linked (the relationship is bi-directional) it becomes important from an econometric point of view to control for endogeneity to avoid inconsistent parameter estimates.

From an economic policy point of view, it is both counter-intuitive and naïve to expect the "big" effects from aid on per capita income or on the fulfillment of the Millennium Development Goals. Per capita income is influenced by a multitude of factors that unfortunately cannot be all possibly captured. Not controlling for these factors leads to inconsistent parameter estimates (over- or under-estimation of parameter values). Even though cross-section analyses suffer less from finding a certain piece of information on a certain country characteristic for a certain period of time, they are unable to solve the problem of unobserved heterogeneity in general. Much better mechanisms of intervention (tackling the omitted variables problem, dealing with endogeneity) are existent when performing panel analyses which stretch over long time periods even though it is harder in this type of analysis to gather adequate information over long time spans.

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