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Abstract

In this paper we investigate the relationship between per capita income and foreign aid for a panel of 131 (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 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).

JEL-Classification: F35; O11; C23; C51

Keywords: Foreign aid; real per capita income; panel time series techniques; dynamic feasible generalized linear least squares (DFGLS)

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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 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. (2008a) look at sectoral aid rather than looking at aggregates and investigate how aid given for education affects educational outcomes. It has also been argued that some 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. (2006) find no indication that donor countries were able to push through their individual trade and political interests 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, 2010; Dreher and Jensen 2007).

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

Rajan and Subramanian (2008) investigate all those suggestions in one common framework revisiting the cross-section and the panel evidence. According to their results, it is 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 to and how long it takes to have a potential 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 has some limitations 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 economic growth, which is generally stationary, and population growth, technology growth, savings, investment and aid, which are generally non-stationary, must be ruled out from a statistical and econometric point of view.

A second drawback, 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. A third 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 and Chang, 2002) to obtain consistent estimators. Amazingly, both problems have not adequately been treated in the existing 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).

A fourth and major flaw of the existing empirical literature is the way 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.

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

However, utilization of lagged variables as instruments (as it is standard in the Generalized Method of Moments (GMM) procedure) 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 four methodological issues that our paper contributes. While arguably being less fancy than other models (we employ a parsimonious growth model without the invention of a new interaction term or a new category of aid on which to focus), we will concentrate on some of the neglected issues, such as existence of a long-run relationship between aid and income, control for autocorrelation and omitted variables, elimination of endogeneity and the estimation of a short-to-medium run model. With panel time series data at hand that stretch over a long period of time, dynamic ordinary least squares (DOLS) or dynamic feasible generalized least squares (DFGLS) could be the methods of choice for treating endogeneity (Stock and Watson, 1993). The application of the GMM procedure could be another option to “exogenize” variables but this technique requires averaging the data over time (utilizing 5-year averages) to avoid an explosion of instruments in our case. Surprisingly, these techniques have only been applied to the problem at hand without due control of autocorrelation. Moreover, if a long-run aid-income relationship cannot be established with some certainty, we will then estimate the indirect effects of aid in a long-run model and set-up a short-to-medium term autoregressive (ARMAX-model) to quantify the short- and medium term impact of aid. In all applications, 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).

As to the results regarding the long-run relationship between aid and per capita income, we find that aid has mostly *an insignificant impact on the level of real GDP per capita* in our long-run Solow-type growth model. However, the search for a long-run relationship in the aid-income context has not been easy and the results have not been clear-cut. We have obtained mixed and contradicting signals applying various cointegration tests. These inconclusive results seem to be perfectly in line with the insignificant long-run aid coefficient that we obtained by applying DFGLS. In addition, it has to be pointed out that the other explanatory variables of the Solow-type model (internal and external savings, population growth and technological change) have all passed the cointegration tests with clear, unanimous results implying a long-run equilibrium with real per capita income. We therefore conclude that aid has not been part of the cointegrating (long-run) relationship.

Investigating possible long-run transmission channels (indirect links) between aid and per capita income, 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. 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 impact on the level of real per capita GDP in the long run. As to reverse causality between aid and per capita income, we find that on the one hand aid Granger causes the level of real per capita GDP in the short run (the impact is positive but very small!) together with population growth, internal and external saving, which have a long-run impact on aid. On the other hand, per capita income does not Granger cause aid at conventional error levels in the short term and the relationship is therefore uni-directional going from aid to income. This finding leads us to look for a short-to-medium run relationship between aid and real per capita income. 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 been rejected.

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. 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 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 or in the model specification.

Other empirical studies have even pointed to a questionable or 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), whether it crowds out domestic investment or whether it is primarily consumed.

An intermediate perspective is taken in the so-called “medicine” model (Jensen and Paldam 2006) that 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 donors to refuse 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; Kuziemko and Werker, 2006; Bourguignon and Sundberg, 2007).

It is often argued that the motivation with which aid is given (Dreher, 2006; Dreher et al., 2008b, 2009, 2010) and the type of aid given (Clemens et al., 2004; Reddy and Minoiu, 2006) have an impact on the effectiveness of aid.

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). 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 or its macroeconomic side effects (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 (1960-2006). In our 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, and 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 an "omitted variables" problem.

We will address the problem of "omitted variables,"[5] 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. 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 moderate the 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).

[4] Michaelowa and Weber (2006) and Dreher et al. (2008a) look at whether aid for education raises primary enrollment rates. Mishra and Newhouse (2007) study the relationship between health aid and infant mortality.

[5] The omitted variable problem is more pressing in our type of approach as it will be very difficult to get coherent series on institutional quality, rent-seeking, corruption or organizational aspect of aid over the period 1960-2006.

3. Empirical growth model: Linking aid and per capita income, but not aid and growth

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)

$$K = K_1 + K_2 + K_3 \qquad (1)$$

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

$$Y_{i,t} = K_{1i,t}^{\alpha_1} \cdot K_{2i,t}^{\alpha_2} \cdot K_{3i,t}^{\alpha_3} \cdot (A_{i,t} \cdot L_{i,t})^{1-\alpha_1-\alpha_2-\alpha_3} \cdot e^{u_{i,t}} \qquad (2)$$

where $\alpha_{1,}$ $\alpha_{2,}$ α_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

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

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

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

Where $sdomsy$ is the domestic savings-to-GDP ratio, $sextny$ is equal to $= sexty - snaty$, which is the external savings-to-GDP ratio minus external savings in the form of aid (NAT $(snaty)$; 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:

$$A_{i,t} = A_{i,0} e^{gt} \qquad (6)$$

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

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

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

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

$$(Y / AL)^* = y* = \begin{pmatrix} sdomy^{\alpha_1 \;/1-\alpha_1-\alpha_2-\alpha_3} sextny^{\alpha_2 /1-\alpha_1-\alpha_2-\alpha_3} snaty^{\alpha_3 /1-\alpha_1-\alpha_2-\alpha_3} / \\ (n+g+\delta)^{\alpha_1+\alpha_2+\alpha_3/1-\alpha_1-\alpha_2-\alpha_3} \end{pmatrix}$$

(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 stochastic equation:

$$\ln y_{i,t}^{*} = (\ln A_0 + gt) + \frac{\alpha_1}{1-\alpha_1-\alpha_2-\alpha_3}\ln sdomy_{i,t} + \frac{\alpha_2}{1-\alpha_1-\alpha_2-\alpha_3}\ln sextny_{i,t} + \frac{\alpha_3}{1-\alpha_1-\alpha_2-\alpha_3}\ln snaty_{i,t} - \frac{\alpha_1+\alpha_2+\alpha_3}{1-\alpha_1-\alpha_2-\alpha_3}\ln(n_{i,t}+g+\delta) + u_{i,t}$$

(12)

In the neighborhood of the steady state path, per capita income growth evolves according to the following equation

$$\ln y_{i,t+1} - \ln y_{i,t} = g + (1-e^{-\lambda_{i,t}}).((\ln A_0 + gt) + \frac{\alpha_1}{1-\alpha_1-\alpha_2-\alpha_3}\ln sdomy_{i,t} + \frac{\alpha_2}{1-\alpha_1-\alpha_2-\alpha_3}\ln sextny_{i,t} + \frac{\alpha_3}{1-\alpha_1-\alpha_2-\alpha_3}\ln snaty_{i,t} - \frac{\alpha_1+\alpha_2+\alpha_3}{1-\alpha_1-\alpha_2-\alpha_3}\ln(n_{i,t}+g+\delta) - \ln y_{i,t} + u_{i,t}$$

……………………………………………………………………………… (13)

where $\lambda_{i,t} = (n_{i,t} + g + \delta)\cdot(1- \alpha_1 - \alpha_2 - \alpha_3)$, 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.

Note that Eq. (12) explains the *level* of real per capita income in the long-run, whereas Eq. (13) describes the determinants of per capita income *growth*. A long-run equilibrium or a long-run relationship between growth and the level of real per capita income and its determinants requires all variables to be non-stationary (e.g. I(1)). Looking at Appendix A1 it becomes clear that in eq. (13) growth is I(0) and can therefore not be determined by variables that are I(1), which are characterized by larger upward and downward movements. In visualized form the relationship between growth and aid does not show a clear upward or downward-sloping regression line for the period 1960-2006 in our sample of recipient countries (see Appendix A2). The correlation coefficient between aid and growth is about -7.8 % and the correlation coefficient between aid and growth controlling for domestic savings and other factors is around +0.6%, pointing to insufficient correlation which would express itself by a very low R^2 (around 13%) when estimating a regression. Therefore we must conclude that eq. (13), i.e. *the aid –growth relationship*, is not amenable to econometric treatment.

For statistical reasons, only eq. (12), the *aid-per capita income relationship*, can be estimated with econometric techniques, all regression variables being I(1)). Non-stationarity of the series implies that real per capita income could *potentially* be in a long-run relationship with domestic and external savings and aid. This, however, will be more closely investigated by panel cointegration tests in section 4.3.

Eq. (12) is estimated 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 all variables are in natural logs;

subscripts i and t indicate country and time, respectively

$LRYPOP_{i,t}$ = real per capita income

$LSDOMY_{i,t}$ = domestic savings-to-GDP ratio

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

$LPOPGPLUS_{i,t}$ = population growth + 5% (includes technological progress and capital depreciation[6])

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

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 transfers-to-GDP ratio (in

[6] 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).

logs). NAT is available from the Center for Global Development.[7] It has been computed by Roodman (2008) and embodies two modifications of Net ODA (from the DAC committee of the OECD). First, it substracts interest payments received from developing countries on outstanding aid loans, which are now treated as 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. [8]

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 frequently 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 http://www.cgdev.org/content/publications/detail/5492 (February 20, 2009).
[8] 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 (5-year averages)	GMM (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)	0.17 (1.28)	0.37 (1.33)	0.28 (1.57)	0.30 (0.36)
LSDOMY	0.09*** (12.99)	0.10*** (5.17)	0.02* (1.56)	0.04* (1.92)	0.01* (1.99)	-0.18 (-1.11)
LSEXTNY	0.01 (1.32)	0.01 (0.70)	0.01** (2.07)	0.01 (0.53)	0.01 (1.61)	0.12 (1.10)
LSNATY	-0.06*** (-13.05)	-0.05*** (-4.03)	-0.02** (-2.01)	-0.02* (-1.69)	-0.02 (-1.37)	-0.13 (-1.40)
Fixed effects	yes	yes	yes	yes	yes	yes
Time effects	yes	yes	no	yes	yes	no
Instruments (IV)	no	no	no	yes	yes	no
Auto-correlation control	no	no	yes	no	yes	yes via SUR
AR-term			0.94*** (7.52)			
R^2 adj.	0.99	0.99	0.86	___	___	___
DW-stat.	**0.21**	**0.77**	**2.48**	___	___	___

Note: t-values in parentheses. 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[9] 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.[10] The results are presented in column 5. We control for autocorrelation in a first step and then apply GMM (results are presented in column 6). Running this 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.[11] Therefore, we follow Alesina et al. (2003) and 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. 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. Following this estimation procedure, we basically estimate nine cross-section equations (with 131 countries in each equation) in the 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.

[9] Working with 5-year averages we have already created 144 moment conditions.
[10] Due to lack of control for autocorrelation in the xtabond2 procedure in STATA, we do not use this procedure.
[11] 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.

4.2 Dealing with possible endogeneity of the explanatory variables

So far we have dealt with endogeneity only in the GMM procedure. However, GMM can only be utilized if the number of observations over time is small or kept small by averaging data over time.[12] In the GMM procedure all explanatory variables of the model are replaced by instruments (either the lagged values of the variables in levels or the lagged values of the variables in differences); autocorrelation of the error terms must be ruled out in the xtabond2 procedure of STATA which led us to run an autocorrelation-corrected version of it. Another option is the instrumental variable technique utilizing Two Stage Least Squares (TSLS) to get rid of endogeneity; either lagged values of the endogenous variables in question (not applicable in the presence of autocorrelation) or external instruments can be utilized (this is extremely difficult and not always advisable; see Rajan and Subramanian, 2005a, 2008). A third option are the dynamic ordinary least squares (DOLS) and the dynamic feasible generalized least squares technique (DFGLS if autocorrelation must be taken care of) which can be utilized if the time series are long enough; endogeneity is controlled for by using numerous leads and lags of the variables in differences that absorb the effect of the correlation with the error term (Stock and Watson, 1993). However, when utilizing DOLS and DFGLS the variables must be linked to each other in the long run (they must be cointegrated, i.e. in a long-run equilibrium).[13] DFGLS has an advantage over DOLS since it controls for spuriousness in the regression due to autocorrelation. We therefore have

[12] In our case this requires averaging the data over time.

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

to test for these properties before we can estimate the aid-per capita income relationship via DOLS/DFGLS. Note that unit-root and cointegration tests require long coherent time spans so that the sample size must be reduced to 52 countries.

4.3. Existence of a long-run equilibrium between aid and per capita income (52 country sample): mixed evidence

In Appendix Table A1 we find that per capita income growth is stationary *(I(0))* and that real per capita income, population growth + technological progress + capital depreciation (*LPOPGPLUS*), the domestic savings-to-GDP ratio *(LSDOMY),* the net external savings-to-GDP ratio *(LSEXTNY)* and the net aid transfer-to-GDP measure *(LSNATY)* (all in logs) are *(I(1)*. In visual terms we observe that *growth rates of real per capita income* show, in general, very little persistence over time *(they are stationary series, I(0)))*, whereas *the aid-to-GDP ratio and the level of real per capita income and the other covariates* exhibit large and persistent movements with strong positive trends for most developing countries since 1960 *(they are non-stationary series, I(1))*. 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 (Herzer, 2008). Cointegration between a dependent *I(0)*-variable and independent *(I(1))*-variables must be ruled out for statistical reasons since a long-run statistical correlation between *I(0)* and *I(1)*-variables is impossible. 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).

We investigate the long-run relationship between aid and per capita income by first testing for cointegration between aid, its covariates and per capita income, which are all *I(1)*-variables. Various cointegration tests are applied (Johansen, 1988; Kao, 1999; Pedroni, 1999, 2004). However, cointegrations tests can be problematic themselves. Gregory et al. (2004) emphasize the instability of cointegration tests, i.e. a relatively high test statistic for one test and a relatively low test statistic for another, for time series cointegration tests. This effect is particularly strong when comparing residual and system-based tests. This finding is confirmed by Hanck (2006) who compares cointegration test results by means of p-values in panel data settings. In panel data cointegration tests this problem is exacerbated by cross-sections which might cover different spans of time. In our case Pedroni's, Kao's and Johansen's cointegration tests deliver contradicting results. Kao's and Johansen's cointegration test signal the existence of cointegration (even though Johansen signals several cointegrating vectors) whereas Pedroni's cointegration test rejects the existence of a long-run relationship between *LYRPOP* and *LPOPGPLUS, LSDOMY, LSEXTNY* and *LSNATY*.[14]

To recall, cointegration would imply 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. However, the finding of 'no cointegration' does neither preclude the existence of a long-run relationship in which aid does not play a role nor the existence of a short-to-medium run relationship between the level of per capita income and the explanatory variables (including aid).

In case of a long-run relationship we can formulate a long-run model. If the estimates show an insignificant impact of aid on per capita income in the long run, this can be taken as evidence of no cointegration between aid and per capita income. Therefore, we consider the estimation of the long-run relationship as a further test of cointegration.

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

According to Stock and Watson (1993), both the DOLS and the DFGLS procedure generate unbiased estimates for variables that cointegrate, even with endogenous regressors. 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.

[14] 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.

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

(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 outlined in the Technical Appendix below.

Table 2: The impact of aid on per capita income: DFGLS versus DOLS estimation

(1) Independent variables	**The aid-per capita income relationship (DOLS estimation)** **(2)** Dependent variable: Real per capita income (in logs) *LRYPOP*	**The aid-per capita income relationship (DFGLS estimation)** **(3)** 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**

t-values in parentheses.

As can be seen from column (2), the regression results of the DOLS estimation are subject to autocorrelation. They will not be discussed. The DFGLS results show an insignificant impact of the aid-to-GDP ratio on real per capita income. This result seems to be in line with the "mixed" results of the cointegration tests which pointed to cointegration (twice) and no cointegration (once) depending on the cointegration test applied. 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%). In column 3 autocorrelation is controlled for, the DW-statistic being 2.02.

4.5 The impact of aid on income in different sub-samples

Considering countries with different aid-to-GDP ratios (Table 3) and only interpreting the DFGLS results which have validity, 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. Again, correction for autocorrelation strongly reduces aid's negative impact on per capita income.

Table 3: Different impact depending on the aid-to-GDP ratio? DOLS versus DFGLS estimation

	Above-average aid-to-GDP ratio countries		**Below-average aid-to-GDP ratio countries**	
	DOLS	**DFGLS**	**DOLS**	**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**

t-values in parentheses.

To see whether the aid-per capita income link depends on other influencing factors that are linked to a country's human development, economic development or regional affiliation, we estimated the long-run relationship for different sub-categories of the above-mentioned characteristics.

Again when controlling for autocorrelation, the impact of aid on per capita income becomes insignificant (see Tables 4, 5 and 6; DOLS-results are available upon request). These findings support the result of no cointegration (no long-run link between aid and per capita income).

The aid and per capita income relationship in different subsamples of developing countries

Table 4: Different impact depending on the level of human development? DFGLS estimation

	Dependent variable: *LRYPOP* (log of real per capita income); estimation via DFGLS for different levels of human development		
Independent variables↓	Low human development countries (HDI below 0.500)	Medium human development countries (HDI 0.500-0.799)	High human development countries (HDI 0.800 and above)
LPOPGPLUS	-0.53 (-1.47)	0.43* (1.69)	0.68 (0.06)
LSDOMY	0.06*** (3.53)	0.09*** (3.46)	1.91 (0.43)
LSEXTNY	0.02 (0.69)	0.05*** (4.08)	-1.01 (-0.30)
LSNATY	-0.03 (-1.11)	-0.01 (-0.45)	-0.17 (-0.21)
Fixed effects	yes	yes	yes
2 leads and 2 lags	yes	yes	yes
Cross-sections included	20	25	4
R-squared adj.	0.99	0.99	0.99
Durbin-Watson stat.	**1.89**	**2.14**	**1.55**

Note: t-values in parentheses.

Table 5: Different impact depending on the level of income? DFGLS estimation

	Dependent variable: *LRYPOP* (log of real per capita income); estimation via DFGLS for different levels of income		
Independent variables↓	Least developed countries (LLDC)	Low income countries (GNI per capita of $735 or less in 2002)	Middle income countries (GNI per capita of $736-9,075 in 2002)
LPOPGPLUS	-0.23 (-0.71)	-0.30 (-1.09)	0.23 (0.70)
LSDOMY	0.05*** (3.37)	0.06*** (4.08)	0.18*** (4.62)
LSEXTNY	0.08*** (3.25)	0.05*** (3.37)	0.06*** (3.99)
LSNATY	-0.01 (-0.53)	-0.02 (-1.12)	-0.01 (-0.93)
Fixed effects	yes	yes	yes
2 leads and 2 lags	yes	yes	yes
Cross-sections included	18	24	24
R-squared adj.	0.99	0.99	0.99
Durbin-Watson stat.	**2.14**	**1.73**	**2.41**

Note: t-values in parentheses.
High income countries (GNI per capita of $9,076 or more in 2002) were not among our 58 developing countries.
LLDC are defined by the United Nations. It is a socioeconomic classification considering per capita income, economic vulnerability and human development.

Table 6: Different impact when countries are sorted by region? DFGLS estimation

	Dependent variable: *LRYPOP* (log of real per capita income); estimation via DFGLS for different regions				
Independent variables↓	Caribbean countries	Latin American countries	Latin American and Caribbean countries	African countries	Asian countries
LPOPG-PLUS	2.87*** (2.84)	0.58 (1.17)	1.22*** (3.07)	-0.10 (-0.41)	-0.51 (-1.18)
LSDOMY	0.17*** (2.89)	0.12** (2.44)	0.12*** (3.67)	0.06*** (4.00)	0.02 (0.61)
LSEXTNY	0.06 (0.94)	0.06*** (2.78)	0.07*** (3.32)	0.04+** (2.45)	0.02 (1.12)
LSNATY	-0.04 (-1.17)	-0.03 (-0.67)	-0.05** (-2.30)	-0.01 (-0.44)	-0.03 (-1.30)
Fixed effects	yes	yes	yes	yes	yes
2 leads and 2 lags	yes	yes	yes	yes	yes
Cross-sections included	5	11	16	25	6
R-squared adj.	0.99	0.99	0.99	0.99	0.99
Durbin-Watson stat.	**2.18**	**2.16**	**1.92**	**1.93**	**2.16**

Note: t-values in parentheses.

In general we observe that aid has an insignificant impact on per capita income irrespective of the level of human development, irrespective of the level of income and irrespective of the region.

The mixed results with respect to cointegration (together with the finding of an insignificant impact of aid on real per capita income in the DFGLS estimations) lead us to conclude that there is no long-run relationship between aid and income.[15]

4.6 Transmission channels from aid to per capita income (the long-run view)

[15] This conclusion is further reinforced by a long-run Granger causality test that points to a bi-directional link between aid and per capita income which makes the quantification of the aid impact on income impossible (results are available from the authors upon request).

Even though we found a statistically insignificant impact of aid on per capita income in the overall and sub-samples in the long run, aid could still affect per capita income in an indirect way. In the literature on the transmission channels of aid to per capita income, one is exactly concerned about aid's impact on investment, on domestic savings (public and private) and on the real exchange rate in the long run (Rajan and Subramanian, 2005a, 2005b).

As to the transmission channels of aid to per capita income, we clearly find cointegration (all cointegration tests find a long-run equilibrium between aid and investment, aid and domestic savings and aid and the real exchange rate). Table 7 presents the strength of the above-mentioned transmission channels. The relationships are estimated by applying DFGLS and thus controlling for autocorrelation and endogeneity.

Table 7. 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**

Note: t-values in parentheses.

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 declines with the aid-to-GDP ratio so that there is some crowding out and the real effective exchange rate appreciates with an increase in the aid-to GDP ratio.

To sum up the results, we find that aid does not directly affect per capita income in the long run, while we do observe that aid has a long-run impact on per capita income via investment, domestic savings and the real exchange rate. Thus, aid is not directly, but indirectly linked to per capita income in the long-run.

4.7 In search of a short- to medium-term relationship between aid and per capita income

However, per capita income could still be determined by aid in the short-to-medium run. The short-run Granger causality test (results are available upon request) shows that aid determines per capita income in the short run but not the other way around. Therefore, aid can be considered a weakly exogenous variable and instrumentation for aid is not necessary. Instrumentation for the other variables in the model might be a good idea. Concentrating on the short-to-medium run relationship between aid and its covariates and per capita income, we estimate an ARMAX-model (Autoregressive-moving average model) that explains variations in the dependent variable not only by its lagged values but also by additional variables, (X). Given that our observations over time are large (T=47) we cannot utilize GMM[16] to instrument for potentially endogenous variables.

Searching for the specific form of the ARMAX (p,q)-model we find that the error term is a first order moving average process (MA1 with q=1), i.e. we observe first order autocorrelation and start by estimating the autoregressive process by p lags. As lags higher than p=1 are not significant at conventional levels, we end up estimating an ARMAX (p=1, q=1) model[17] of the following form

[16] GMM was developed for panel data that consist of many cross-sections (large N) and few observations over time (small T).

[17] The lags of the ARMAX (p,1) models turned out to be not significant at conventional levels.

$$LRYPOP_{i,t} = \mu_i + \eta_t + \chi LRYPOP_{i,t-1} + \sum_{p=0}^{1} \alpha_p LPOPGPLUS_{i,t-p} + \sum_{p=0}^{1} \beta_p LSDOMY_{i,t-p} + \sum_{p=0}^{1} \gamma_p LSEXTNY_{i,t-p} + \sum_{p=0}^{1} \delta_p LSNATY_{i,t-p} + \varepsilon_{i,t} - \rho\varepsilon_{i,t-1} \quad (16)$$

In estimating the ARMAX-model we have three options: The first option is to estimate the model by two ways- fixed effects (cross-section fixed effects and time year dummies) instrumenting for the lagged dependent variable. Since the other explanatory variables (including aid)[18] turned out to be weakly exogenous, we don't have to instrument for them. The second option is to estimate the model in a stepwise regression (suggesting appropriate instruments that are added at a later step) via FGLS, removing the moving average process of the disturbances.[19] The third option is to take 5-year averages and to estimate the model by means of an autocorrelation-corrected GMM.

[18] See also the Granger causality test.

[19] This is accomplished by transforming the error term and all the variables; time year dummies cannot be utilized then. $TLRYPOP_{i,t-2}$ and $TLRYPOP_{i,t-3}$ are utilized as search regressors of which $TLRYPOP_{i,t-3}$ is added to the regression.

Table 8: Impact of aid on per capita income in the short and medium term (ARMAX-model)

Estimation methods →	**The aid-per capita income relationship (2 ways-fixed effects estimation)**	**The aid-per capita income relationship (Stepwise FGLS estimation)**	**The aid-per capita income relationship (5-year averages; auto-correlation corrected GMM)**
Independent variables ↓	Dependent variable: Real per capita income (in logs) *LRYPOP*	Dependent variable: Real per capita income (in logs and transformed)	Dependent variable: Real per capita income (in logs and transformed)
$LRYPOP_{i,t-1}$	0.97*** (146.15)	0.99*** (50.07)	0.87***(11.23)
$LPOPGPLUS_{i,t}$	-0.02 (-0.52)	-0.01 (-0.08)	-0.01 (-0.14)
$LPOPGPLUS_{i,t-1}$	-0.02 (-0.77)	-0.00 (-0.04)	-0.15 (-1.10)
$LSDOMY_{i,t}$	0.01*** (4.05)	0.01*** (4.53)	0.03** (2.38)
$LSDOMY_{i,t-1}$	0.00 (-0.19)	0.00 (-0.09)	0.02 (1.25)
$LSEXTNY_{i,t}$	0.01*** (2.15)	0.01*** (2.37)	---
$LSEXTNY_{i,t-1}$	0.00 (-0.16)	0.00 (-1.23)	---
$LSNATY_{i,t}$	-0.01*** (-2.74)	-0.01*** (-2.77)	-0.03* (-1.87)
$LSNATY_{i,t-1}$	0.01*** (3.51)	0.01*** (2.86)	0.06*** (4.40)
Added regressors	no	$TLRYPOP_{i,t-3}$	no
Fixed effects	yes	no	yes
Time year dummies	yes	no	yes
Number of observations	1366	1182	461
R-squared adj.	0.97	0.99	___
Durbin-Watson statistic		1.98	___

Note: t-values in parentheses

We observe very similar results across the different techniques of estimation chosen. As expected, today's per capita income depends on lagged per capita income and domestic and external savings (net of aid) increase per capita income. This year's aid decreases per capita income and we consider real exchange rate appreciation responsible for this empirical finding as capital flows react faster than the real economy. Furthermore, last year's aid impacts positively on per capita income as it has been either used for investment or consumption, both adding to GDP.

5. Conclusions

In this paper, we have shown that the direct impact of aid impact on per capita income is statistically 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. In the short and medium run the impact of current aid (slightly negative) and of lagged aid (slightly positive) cancel themselves out. From an economic policy view the negative short run impact through (presumably) real exchange rate appreciation could be ameliorated by building up foreign exchange reserves or other types of macroeconomic management.

Furthermore, we find for the long run that aid increases 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 increase 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 the impact of aid on per capita income gets smaller when we control for autocorrelation by means of FGLS. 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 at the same time. 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.

However, to see our main finding (no statistically significant long-run relationship between aid and real per capita income) in perspective, It has to be kept in mind that per capita income is influenced by a multitude of factors[20] (unfortunately they cannot be all possibly captured), aid playing only one part in it. In addition, given that the average amount of aid provided is quite small (on average 5% of recipient countries' GDP), it is reasonable to assume that at best aid will only marginally contribute to per capita income. This is not to say that aid cannot have important indirect effects (e.g. on investment). Development projects should therefore concentrate on delivering those effects and emphasize on infrastructure projects with many backward and forward linkages. Crowding out of domestic saving (the dwindling willingness of recipient countries' governments to tax) should be hampered by helping developing countries set up a functioning tax system and an efficient administration. Some donor countries have started to send experts and provide training in exactly that area.The real appreciation effect linked to the inflow of aid is probably something recipient countries have to live with to a certain extent, but there are promising country experiences in which real exchange rate appreciation could be attenuated by a successful macroeconomic management of aid flows.[21] In addition, a positive aspect of a real exchange rate appreciation can be found in a strengthening of the service sectors (resources are allocated away from tradables to non-tradables), such as the provision of water, electricity, oil and gas, health services, education and public transport.

[20] 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) exist when performing panel analyses which stretch over long time periods.

[21] See Aiyar et al. (2008).

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Appendix

Table A1. Results of the ADF-Fisher panel unit root test

Variable tested	*Fisher statistic*	*Probability*	**Variable is integrated**
Δ*LRYPOP* (growth of per capita income)	226.91	0.00	*I(0)*
LRYPOP (per capita income (in levels))	82.73	0.99	$I(1)$
LPOPGPLUS (population growth, technological change and capital depreciation rate)	104.20	0.78	$I(1)$
LSDOMY (domestic savings)	89.35	0.94	$I(1)$
LSEXTNY (external savings \ aid)	100.84	0.20	$I(1)$
LSNATY (aid)	95.64	0.89	$I(1)$
LINVY (investment)	110.70	0.62	$I(1)$
LRER (real exchange rate)	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.

Table A2. Scatterplot of the aid-growth relationship (1960-2006) in a sample of 58 recipient countries

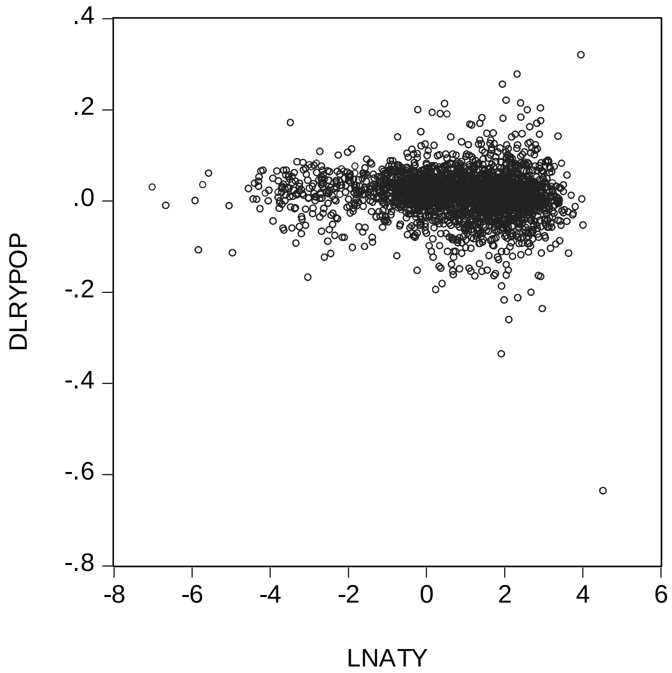

Table A3. The growth rate of real per capita income in a sample of 58 recipient countries (1960-2006)

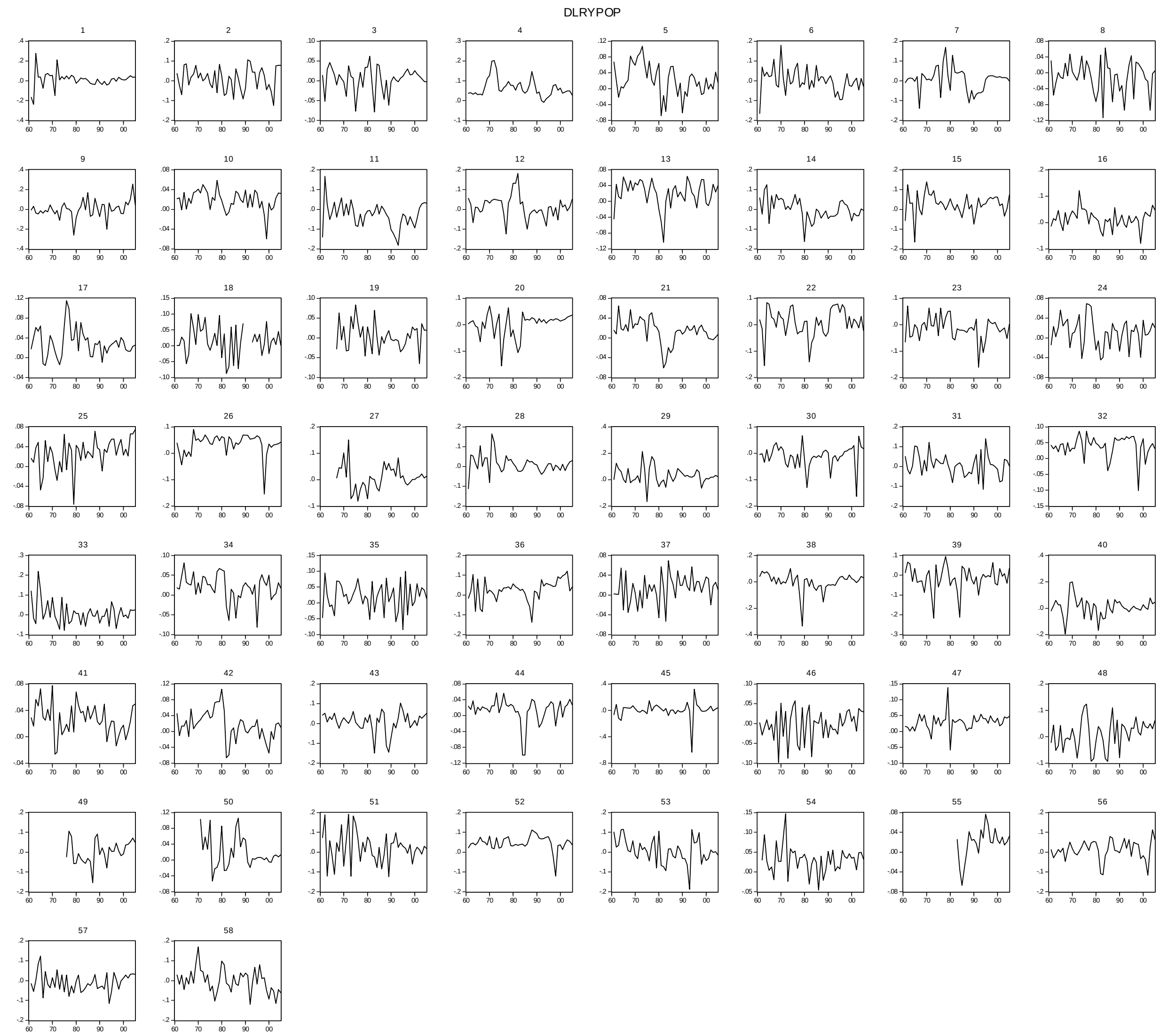

Table A4. The aid-to-GDP ratio in a sample of 58 recipient countries (1960-2006)

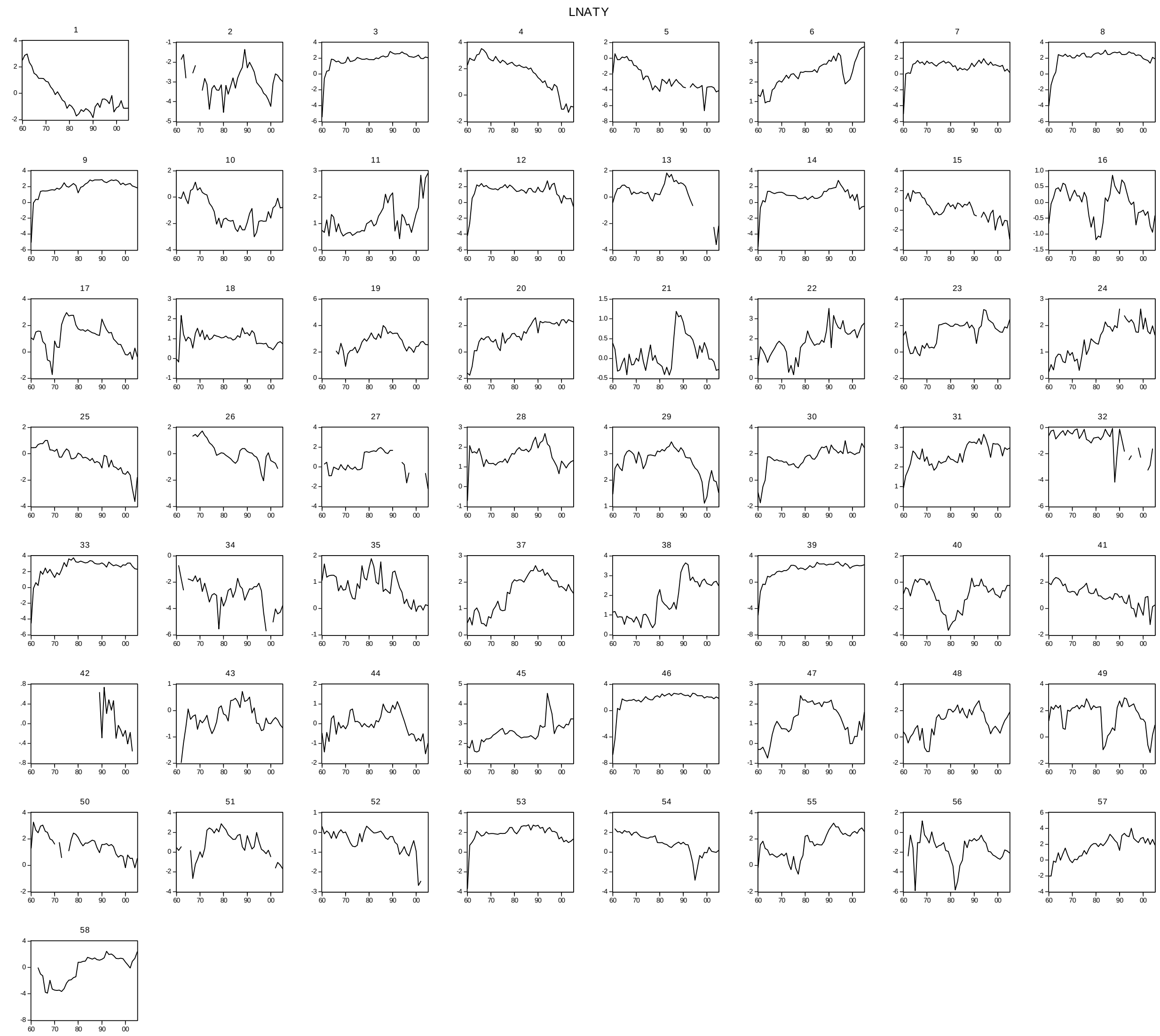

Table A5. Results of Kao's panel cointegration test

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 A6. Results of Pedroni's panel cointegration test

Pedroni's residual cointegration test	statistic	p-value
Common AR-coefficients		
Panel PP-statistic	1.61	0.95
Panel ADF-statistic	6.38	1.00
Individual AR -coefficients		
Group PP-statistic	3.10	1.00
Group ADF-statistic	-0.23	0.41

Note: H_0: The variables of interest are not cointegrated ; $H_{1:}$ The variables of interest are cointegrated . *Lag length selection was automatic based on SIC with lags from 0 to 9* (Pedroni, 1999, 2004).

Table A7. Results of Johansen's panel cointegration test

Johansen's cointegrating test	Trace test statistic	p-value
	106.18	0.02***

Note: H_0: The variables of interest are not cointegrated (no cointegration); H_1 : One cointegrating vector can be identified (Johansen, 1988). .

Technical Appendix

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.[22]

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

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

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

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

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

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

and then in a fourth step Equation (15*) is estimated by DOLS

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

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