Aid and Foreign Direct Investment: substitutes, complements or neither?

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Abstract: This paper examines whether official aid (Aid) and Foreign Direct Investment (FDI), defined here as shares of recipients' gross domestic product, are substitutes, complements or neither. We hypothesise that there is no direct relationship between the two flows. We explain how we address endogeneity and heterogeneity issues through a number of econometric methods. Applying standard panel estimators on data for around 180 countries from 1971 to 2007, Aid and FDI seem to be substitutes even after controlling for Gross Domestic Product per Capita (GDPc). However, this correlation is not significant once we allow for parameter heterogeneity and common correlated effects. When we allow for endogeneity we find that there is no causal relationship between Aid and FDI, and that GDPc does impact on Aid, but not on FDI. We conclude that there is no evidence of causal relationship between Aid and FDI.

Keywords: aid; FDI; foreign direct investment; global market; development; substitutes; complements; endogeneity.

Reference to this paper should be made as follows: Janský, P. (2012) 'Aid and Foreign Direct Investment: substitutes, complements or neither?', *Int. J. Trade and Global Markets*, Vol. 5, No. 2, pp.119–132.

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1 Introduction

Two decades after Lucas (1990) famously asked "Why does not capital flow from rich to poor countries?" we ask a somewhat related question on the kind of capital that does flow between rich and poor countries. Are official aid (Aid) and FDI inflows, defined here as shares of total gross domestic product, substitutes, complements, or neither? Better understanding of this question enhances our knowledge related to the ultimate Lucas question and therefore to economic development.

We aim to answer a range of questions as to how Aid and FDI might be linked and consider a negative and positive relationship as analogous to substitutes and complements. Do countries really receive more or less Aid in years when FDI is relatively low and vice versa? Do we observe that donors supply Aid so that it substitutes for insufficient amounts of FDI and therefore possibly corrects a potential capital market failure? Is FDI crowded in or out by Aid? Is there a direct relationship between Aid and FDI or is it only indirect through GDPc?.

We hypothesise that there is no direct relationship between the two flows. Although these two flows are of similar nature, no rule binds them together and they are determined by different factors that seem to be independent of each other. We hypothesise that donors have different objectives other than substituting Aid for insufficient FDI and thus correcting a potential capital market failure. We also hypothesise that FDI contracting parties act independent of Aid.

We test this hypothesis and explain how we address endogeneity and heterogeneity problems through a number of econometric methods. Some of these econometric methods are standard ones, especially those focussed on endogeneity, such as generalised method of moments. Other methods, especially those concentrating on heterogeneity are more novel ones, such as parameter heterogeneity and common correlated effects, which have not been applied in this context before.

2 Literature review

The economics literature on the relationship between Aid and FDI, or foreign assistance and public capital and private capital in general, is quite voluminous. In contrast to most of this paper where Aid and FDI refer to the shares of these flows in income, in this section, Aid and FDI are always defined in accordance with the discussed piece of literature. The following section overviews an extensive discussion in the literature as to the relationship between Aid and FDI.

We discuss in turn groups of papers according to their predominant answers to the question in the title of the current paper. First, Cogneau and Lambert (2006) argue that they are substitutes, although their compensatory role decreased over time. Chauvet and Mesplé-Somps (2006) show that Aid compensates for a lack of external private capital, but also promotes the attraction of FDI in Africa.

Second, at least two recent papers consider Aid and FDI to be complements. OECD (2007) argues that aid alone cannot finance development and that private sources of finance are essential complements to it. Kimura and Todo (2007) find no general effect of Aid as a facilitator of FDI into less developed countries.

Finally, there are contributions to the literature suggesting that there is no direct relationship between the public and private capital flows. Frot and Santiso (2008) find that Aid and FDI are substitutes between countries, but find no relationship within countries for flows over time. We refer to this paper quite intensively throughout this paper, as it is relatively similar to our analysis. Also, we have successfully replicated their results, which we do not reproduce here in detail because of space constraints. However, we do find neither their specification (regressing Aid on FDI while controlling for population and year effects) nor methods (FE and between estimator without any dynamics) very robust. Furthermore, the choices they made are not properly explained

and discussed. This paper tries to improve on both of these points by applying a number of specifications and methods and justifying the inclusion of GDPc as a control variable.

Kosack and Tobin (2006) argue both theoretically and empirically in a not very robust way that Aid and FDI are neither substitutes nor complements in accelerating the development of poor countries. Kosack and Tobin (2006) employ system GMM with economic growth and rate of human development as dependent variables and a number of independent variables. We have a number of objections to their analysis, but for reasons of brevity, we restrict ourselves to one point. We think that their empirical analysis is not very robust at least in the sense that for all their specifications Hansen test at 0.05 significance level rejects the null of valid instruments. This observation invalidates their results, as they seem to be based on invalid instruments. We attempt to improve our empirical analysis by, among other things, paying attention what the Hansen test has to say and employing also other methods than GMM.

Clemens (2002) argues that the World Bank's (WB) lending neither substituted for, nor catalysed private finance. Clemens (2002) employs VAR method to discuss the relationship, which we do not employ here for a lack of time and space; we prefer to use panel data econometrics. We now describe the data and outline a simple theoretical framework and explain how we address endogeneity and heterogeneity issues, some of which most of the existing literature did not take into account when examining the relationship.

3 Data and endogeneity

We employ data from the World Development Indicators (WDI) by the WB. The database provides us with annual panel data from 1971 to 2007 for a maximum of around 180 countries. This panel is therefore quite long and, with a minimum of 75 countries for 1971, relatively balanced as well. We use WDI's data series on official development assistance and official aid, net FDI and gross domestic product, all in current US dollars, and on total population. We provide their detailed descriptions in the Appendix. We employ the first three series to create Aid and FDI variables. We use the last two series to construct our GDPc variable. We take natural logarithms of GDPc as it is a common practice and to control for outliers, since this series cannot by definition be zero or negative in contrast to Aid and FDI series.

$$\text{Aid}_{it} = \frac{\text{Official development assistance and offical aid}_{it}}{\text{Total Gross domestic product}_{it}}$$

$$\text{FDI}_{it} = \frac{\text{Foreign direct investment in flow}_{it}}{\text{Total Gross domestic product}_{it}}$$

$$\text{GDP}_{it} = \text{In}\left(\frac{\text{Total Gross domestic product}_{it}}{\text{Total population}_{it}}\right).$$

In fact, we create these variables twice for data of different frequency. First, we use standard one-year values, and second, we use five-year averaged data for seven periods between 1973 and 2007, reasons for which we explain when we discuss the GMM method. For the second set of variables, we exclude the first two years to enable analysis

with five-year averaged data, and we check that the exclusions do not bias our results. The fact that both Aid and FDI series are net suits our analysis since we are interested in changes of foreign capital stock rather than gross flows. We use shares of income for Aid and FDI because it is in line with our theoretical model, we are interested in relative rather than absolute values, and it allows us to keep the negative values and zeros undistorted in contrast to taking logarithms, as done by, for example, Frot and Santiso (2008). We keep all available data in our sample. By that we aim to avoid selection bias from which some other studies suffer, for example, due to the inclusion of only countries at some level of income at one point in time. Some of these studies, such as Frot and Santiso (2008), therefore fail to include countries such as South Korea or Japan that over the last decades became aid donors from aid recipients and therefore represent interesting cases that are arguably worth including in the analysis. We discuss some of these issues in a results section, but now turn to what the data has to say.

In an answer to the Lucas question, we observe that foreign capital seems to flow to poor countries when we define it as a sum of Aid and FDI. One preliminary piece of possible evidence is as follows. Regressing foreign capital on income per capita using fixed effect estimator with year dummies yields strongly significant negative estimates of the coefficient of income per capita. This result is mostly driven by Aid and is very robust across different specifications as well as methods. This question is not the focus of this current paper and should be further explored in a future research.

To reveal the true relationship between Aid and FDI we have to try to deal with endogeneity and heterogeneity problems as best as we can. We do so mainly by applying various econometric methods that allow for different kinds of endogeneity and heterogeneity: Pooled OLS (POLS), Fixed Effects (FE), Random Effects (RE), First Differences (FD), difference and system Generalised Method of Moments (dGMM and sGMM), Mean Group (MG), Common Correlated Effects: Pooled (CCEP), and Common Correlated Effects Mean Group (CCEMG).

This paper investigates the relationship between Aid and FDI within the cross country framework, and focuses on the differences over time rather than across countries. By that we particularly mean that we do not analyse this phenomenon through case studies or other methods. Here we briefly investigate our hypothesis using across and between country framework as done by Frot and Santiso (2008). In contrast to Frot and Santiso (2008), who control for population and find negative relationship using between countries differences, we find no significant correlation, regardless whether we control for GDPc or not. However, when we do control for population, we confirm the results of Frot and Santiso (2008). However, in our opinion, it does not make much economic sense to control for population and the authors also do not make an argument for it.

Below we discuss how we apply these methods to address endogeneity problems within a simple theoretical framework, in which Aid and FDI are assumed to be determined by functions *f* and *g*, respectively.

$$\mathrm{Aid}_{it} = f(\mathrm{FDI}_{it}, \mathrm{GDPc}_{it}, \mathrm{Aid}_{it-1}, \mathrm{FDI}_{it-1}, \mathrm{GDPc}_{it-1}, y_t, a_i, k_{it})$$

$$\mathrm{FDI}_{it} = g(\mathrm{Aid}_{it}, \mathrm{GDPc}_{it}, \mathrm{FDI}_{it-1}, \mathrm{Aid}_{it-1}, \mathrm{GDPc}_{it-1}, y_t, a_i, k_{it})$$

where Aid_{it} is official aid inflow as a share of recipients' gross domestic product, FDI_{it} is FDI inflow as a share of recipients' gross domestic product, GDPc_{it} is gross domestic product per capita, all three for country *i* in year *t*, y_t is a year-specific unobserved effect

common to all countries for year *t*, a_i is a country-specific time-invariant unobserved effect for country *i*, k_{it} is a year-specific unobserved effect that is to some extent allowed to differ across countries for year *t*.

It solely serves the purposes of this paper's discussion of their relationship and does not aim to cover all potential determining relationships, from which we abstract, for the purposes of simplicity. Among other things, we assume linear relationships and quite simple dynamics. In addition to GDPc, we do not take into account other possible omitted variables such as common history as outlined in studies such as Adekola and Sergi (2007) and Sergi (2004). Also, there are a few alternative models that could be used to frame the discussion. One alternative would be inspired by Clemens (2002), who developed an inter-temporal framework to empirically test what is the function of WB lending.

The hypothesis we test is whether there is no direct relationship between Aid and FDI, and, if we observe an indirect negative relationship, whether it is driven by GDPc. First, the major problem in estimating the above relationships is that the model is under identified. In other words, there are many combinations of the variables that are consistent with the specific values of Aid or FDI. Feedbacks from dependent variables to independent variables naturally arise because of the interdependence of the variables, as shown by the two equations above.

We can employ instruments to solve this problem, and to properly identify the system. One of the potentially more robust ways to model the relationship would be to use simultaneous equations models, which we do not carry out in this present paper because of space and time constraints. We apply the lagged values of variables as instruments, since they are arguably the only suitable instruments available. We do so through the application of dGMM and sGMM. Also, we further partially and insufficiently address this issue by using a number of specifications, incorporating dynamics, and investigating separately two scenarios with Aid and FDI as dependent variables.

Second, the link between Aid and FDI might be driven by omitted variables. However, we do not control for other variables than GDPc, mainly because of space and time constraints and we therefore leave this area for future research, but also partly because this paper focuses on the role played by GDPc, and hypothesises that it is a major omitted variable driving the relationship between Aid and FDI.

Third, panel data enables us to address all three types of unobserved heterogeneity that are deemed to be present as we indicated in the above functions. We take two standard and three recently developed approaches. We control for country specific time invariant FE, a_i , through applying FE, RE, or FD, and we include year dummies in all methods to control for year specific effects, y_t. We include year dummies for all methods applied in this paper, even if we do not mention them explicitly. We prefer this approach because it allows for more general effects of time than including a trend variable, which imposes linearity on the way time affects the dependent variable. Furthermore we address the third type of unobserved heterogeneity, k_{it}, by employing MG to allow parameters to differ across countries, CEEP to control for unobserved common correlated effects, and CEEPMG to combine the two. Common correlated effects might be thought of as interaction terms between country and year dummies.

It is not only major in the sense that it is of high importance for both Aid and FDI, but also because it is likely to be correlated with at least some of the other candidates for an omitted variable and therefore represents them to some extent. Fourth, we try to minimise

the potential of selection bias by using a relatively large and quite balanced dataset, and by not truncating our sample as long as the dataset and methods allow us to do so. As the dataset is unbalanced with different coverage for different variables, the sample naturally changes as well, for example, according to what variables we need and whether we take lagged values or differences. In the section on robustness checks, we further establish that our results are robust to some of these changes. Fifth, we expect dynamics to play an important role, and therefore employ two different specifications. As outlined for POLS, we use two dynamics specifications. The simple dynamics includes the lagged dependent variable as an independent variable. The general dynamics includes the lagged values of all independent and independent variables. We apply these specifications using POLS, FE, and GMM. Sixth, measurement error might be an issue with the data we have, but we limit our efforts to using methods with different vulnerability to measurement error, such as POLS and FE.

4 Standard regression and GMM methods

We apply four standard methods (POLS, FE, RE, FD) with four specifications that we describe only for Pooled Ordinary Least Squares (POLS), which is a OLS pooled for each country over time.

$$\mathrm{Aid}_{it} = \beta_0 + \beta \mathrm{FDI}_{it} + \gamma \mathrm{GDPc}_{it} + \delta \mathrm{Aid}_{it-1} + \theta \mathrm{FDI}_{it-1} + \mu \mathrm{GDPc}_{it-1} + y_t + (a_i + u_{it})$$

where Aid_{it}, FDI_{it}, and GDP_{it} are the respective values for country i in year t, y_t is a year dummy for year t, a_i is the unobserved effect for country i, u_{it} is a residual, and β_0, β, γ, δ, θ, and μ are parameters. By omitting the lagged values of FDI and GDPc from the above general dynamics specification, we get the simple dynamics one. Exclusion of Aid's lagged value from the simple dynamics specification yields the general one, and further exclusion of GDPc gives us the simple one.

Fixed Effects (FE) removes country–specific FE by demeaning the equation. As with other standard methods except for POLS, we present only the simple specification.

$$\ddot{\mathrm{Aid}}_{it} = \beta_0 + \beta \ddot{\mathrm{FDI}}_{it} + \ddot{y}_t + \ddot{u}_{it}$$

where the dotted variables are time demeaned, $\ddot{\mathrm{Aid}}_{it} = \mathrm{Aid}_{it} - \overline{\mathrm{Aid}}_i$, and where $\overline{\mathrm{Aid}}_i$ are the averages of each individual over time. Assuming the residuals are not correlated with explanatory variables, RE uses the following transformation to remove the FE and obtain efficient estimates in the presence of serial correlation.

$$\mathrm{Aid}_{it} - \lambda \overline{\mathrm{Aid}}_{it} = \beta_0 + \beta(\mathrm{FDI}_{it} - \overline{\mathrm{FDI}}_{it}\lambda) + (y_t - \lambda \bar{y}_t) + (v_{it} - \lambda \bar{v}_{it})$$

where $\lambda = 1 - \left(\dfrac{\sigma_u^2}{T\sigma_\alpha^2 + \sigma_u^2} \right)^{1/2}$, and $v_{it} = a_i + u_{it}$.

First Differences (FD) also removes the FE, by differencing the equation.

$$\Delta \mathrm{Aid}_{it} = \beta_0 + \beta \Delta \mathrm{FDI}_{it} + \Delta u_{it}$$

where the variables with deltas are FD, $\Delta y_{it} = y_{it} - y_{it-1}$.

Table 1 shows the results and FE is our preferred method. Not only are country specific factors important, but the Hausman test also says that FE is preferred to RE. Dynamics seems crucial and is better modelled by FE than by FD; this fact also establishes general specification as the preferred one. We also carry out analysis using five-year averages that confirm our one-year data results: we lose some information but it also reduces business-cycle effects and measurement error. There appears to be a strong negative relationship between Aid and FDI even after accounting for dynamics and the influence of GDPc. However, the validity of all these results depends crucially on a few assumptions such as the handling of lagged variables. The next method, GMM, controls for these.

To properly identify the relationship, we use the lagged values as instruments through both difference and system GMM (dGMM, and sGMM) by Arellano and Bond (1991). The panel is too long for GMM and it might also suffer from too many instruments (Roodman, 2006). The Sargent test does reject the null that instruments are valid consistently across different specifications, lags, and both dGMM, and sGMM. To shorten our time panel we use five-year averaged data as is standard in the economics literature. With the averaged data we have seven periods and around 180 countries that loosely correspond to short T and long N. To further increase the trustworthiness of the GMM usage, we present results for both GMM methods, two specifications and different lags, to show whether our results are robust to these changes. Otherwise GMM seems to be a suitable method as it is designed for a dynamic dependent variable, not strictly exogenous independent variables, FE, and is arguably able to identify causality (Bond, 2002; Roodman, 2006).

Table 1 Aid as the dependent variable, one-year data

Simple	*POLS*	*FE*	*RE*	*FD*
FDI	–0.0142*	–0.0667***	–0.0571***	–0.0497***
	(0.00809)	(0.0104)	(0.00952)	(0.00719)
Constant	0.0382***	0.0336***	0.0433***	0.00193
	(0.00607)	(0.00665)	(0.00870)	(0.00510)
Observations	5196	5196	5196	4974
R-squared	0.019	0.052		0.025
Countries	180	180	180	180
General	*POLS*	*FE*	*RE*	*FD*
FDI	0.0143	–0.0654***	–0.0419***	–0.0528***
	(0.0116)	(0.00955)	(0.00861)	(0.00699)
GDPc	–0.0371***	–0.0656***	–0.0564***	–0.0845***
	(0.00344)	(0.00214)	(0.00180)	(0.00454)
Constant	0.249***	0.436***	0.388***	0.00776
	(0.0207)	(0.0145)	(0.0134)	(0.00508)
Observations	5180	5180	5180	4959
R-squared	0.316	0.203		0.090
Countries	178	178	178	178

Table 1 Aid as the dependent variable, one-year data (continued)

Dynamics	*POLS*	*FE*	*RE*	*FD*
FDI	–0.00373	–0.0445***	–0.0481	–0.0588***
	(0.00733)	(0.00754)	(0.0384)	(0.00829)
GDPc	–0.00671***	–0.0314***	–0.0808***	–0.0756***
	(0.00101)	(0.00180)	(0.0148)	(0.00444)
L.Aid	0.849***	0.601***	0.867***	0.652***
	(0.0203)	(0.0110)	(0.0191)	(0.0114)
L.FDI			0.0504	0.0360***
			(0.0398)	(0.00800)
L.GDPc			0.0759***	0.0522***
			(0.0145)	(0.00449)
Constant	0.0439***	0.206***	0.0402***	0.222***
	(0.00664)	(0.0122)	(0.00599)	(0.0158)
Observations	5180	5180	4959	4959
R-squared	0.801	0.504	0.825	0.523
Countries	178	178	178	178

Coefficients on year dummies not included in the tables because of the space.

The significance levels correspond to the following *p*-values: *$p < 0.1$, **$p < 0.05$, ***$p < 0.01$.

Standard errors in round brackets and *t*-statistics in square brackets.

The preference for general dynamics specification is supported by the Hansen test that rejects the validity of instruments at 0.05 significance level for all specifications, except for general dynamics with sGMM. We prefer sGMM to dGMM, because once our instruments are valid, sGMM instruments are deemed to be stronger, in line with Bond (2002). We therefore focus on general dynamics estimated by sGMM. The results for different specifications and sets of lags are in Table 2.

Table 2 Aid as the dependent variable, five-year-averaged data, GMM

Dynamics	*dGMM2*	*dGMM3*	*dGMM4*	*sGMM2*	*sGMM3*	*sGMM4*
FDI	0.0276	–0.00122	–0.044	0.103	0.165	0.197
	–0.107	–0.0979	–0.123	–0.0915	–0.125	–0.207
GDPc	–0.0251	–0.0292	–0.0358	–0.0254***	–0.0213***	–0.0255**
	–0.029	–0.0235	–0.047	–0.00751	–0.00752	–0.0106
L.Aid	0.208	0.0602	–0.187	0.513***	0.522***	0.299
	–0.198	–0.136	–0.212	–0.0934	–0.124	–0.253
Constant				0.219***	0.182***	0.225**
				–0.0636	–0.0635	–0.0904

Table 2 Aid as the dependent variable, five-year-averaged data, GMM (continued)

Dynamics	*dGMM2*	*dGMM3*	*dGMM4*	*sGMM2*	*sGMM3*	*sGMM4*
Observations	763	763	763	941	941	941
Countries	177	177	177	178	178	178
No. of IVs	45	31	20	68	49	33
AR(1) test	0.226	0.273	0.600	0.101	0.104	0.173
AR(2) test	0.475	0.230	0.030	0.989	0.936	0.987
Hansen test	0.014	0.008	0.003	0.000	0.004	0.055
FDI	0.128	0.0529	–0.143	0.00688	0.0475	–0.121
	–0.201	–0.231	–0.397	–0.0857	–0.127	–0.188
GDPc	–0.0380*	–0.0448	–0.0278	–0.0793***	–0.0961***	–0.0847
	–0.0229	–0.0312	–0.0423	–0.0223	0.0345	–0.0517
L.Aid	0.297*	0.134	–0.27	0.620***	0.570***	0.3
	–0.151	–0.171	–0.308	–0.0648	–0.131	–0.242
L.FDI	0.0806	0.345	0.295	0.0638**	0.0882	0.185
	–0.0716	–0.343	–0.566	–0.0313	–0.167	–0.235
L.GDPc	0.0403**	0.0339	0.0279	0.0655***	0.0806***	0.0606
	–0.0171	–0.0335	–0.0646	–0.0208	–0.0297	–0.0431
Constant				0.146***	0.166**	0.243**
				–0.0362	–0.0699	–0.118
Observations	697	697	697	874	874	874
Countries	171	171	171	177	177	177
No. of IVs	45	31	20	68	49	33
AR(1) test	0.169	0.221	0.989	0.083	0.091	0.137
AR(2) test	0.890	0.301	0.075	0.865	0.831	0.153
Hansen test	0.035	0.139	0.002	0.124	0.248	0.716

sGMM indicates system GMM. Whereas dGMM difference GMM.

We applied three different sets of lags. Two lags and higher. Three lags and higher. Four lags and higher. As indicated by the shortcuts.

No. of IVs says how many instruments were used in construction of the estimator.

Hansen test tests the validity of instruments. The null is that the instruments are valid.

AR(1) and AR(2) are Arellano-Bond tests for AR(1) and AR(2) in FD, respectively. The null is the AR process.

The significance levels correspond to the following p-values: *$p < 0.1$, **$p < 0.05$, ***$p < 0.01$.

The coefficient on FDI is mostly insignificant at 0.05 significance level, whereas the coefficient on GDPc is largely significant. So conditioned on the validity of instruments, Aid seems to be caused by GDPc and not by FDI. Interestingly, significance of GDPc contrasts with Burnside and Dollar (2000) assuming that Aid is exogenous to GDPc.

These results are robust to changes in a number of lags. Also, AR(1) Arellano-Bond tests indicate borderline results and some of them reject the null of AR(1), which is supportive of our results and indicates that the underlying processes should not be unit root. Moreover, AR(2) fails to reject the null of AR(2), which is what we need for our instruments with three lags and higher to be valid. Overall, GMM results suggest that there is no causal relationship between Aid and FDI. Furthermore, these results suggest that the results of the standard methods indicating negative correlation between Aid and FDI might be spurious.

5 Common factor models

In addition to country- and year-specific unobserved heterogeneity, we now also allow for other types of unobserved heterogeneity. Namely we allow for heterogeneous parameters (MG), developed by stems from Pesaran and Smith (1995), common correlated factors (CCEP), and for the two together (CEEMG), the two estimators developed by Pesaran (2006). MG estimator for parameter heterogeneity, which might be an issue, since the interaction of Aid, FDI, and GDPc differ across countries. MG recognises this fact and allows, for example, GDPc to have different effects on Aid, as far as both the direction and magnitude of the effect are concerned. MG allows parameters to differ, but at the same time delivers one estimator for the whole group.

$$\mathrm{Aid}_{it} = \beta_{0i} + \beta_i \mathrm{FDI}_{it} + \gamma_i \mathrm{GDPc}_{it} + y_{ti} + u_i$$

is an OLS regression for country i across years t, estimated for all countries separately. MG estimator is an average of the individual countries' parameters from these regressions.

$$\beta_{\mathrm{MG}} = n^{-1} \sum_{i=1}^{n} \widehat{\beta}_i$$

where n is the number of countries for which the above equation was estimated.

The next two estimators address cross-section dependence, which arises when we have unobserved common correlated effects, i.e., common year-specific factors that affect individual countries to different extents. In our case these effects might be, for example, global shocks that affect each country in a different way, such as a sharp decrease in disbursements of official aid of a major donor, which affects its biggest recipients most. The test results below suggest the cross-section dependence is indeed important. Table 3 shows that both the average of correlation coefficients and its absolute counterpart suggest strong and positive cross-section dependence. Furthermore, Pesaran's CD test rejects the null of cross-section independence at 0.01 significance level.

Table 3 The results of cross-section dependence tests

Average of correlation coefficients	0.1042
Average of absolute correlation coefficients	0.4003
Pesaran's CD test (*t*-statistic)	57.564

We first consider CCEP estimator, where the FE equation is augmented by including cross-section averages of the variables at time *t*, to allow for unobserved common correlated factors.

$$\ddot{\text{Aid}}_{it} = \beta_0 + \sum_{i=1}^{n} \beta_{0i} \times c_i + \beta \ddot{\text{FDI}}_{it} + \gamma_i \ddot{\text{GDPc}}_{it} + \sum_{i=1}^{n} \delta_i \overline{\text{Aid}} \times c_i + \sum_{i=1}^{n} \theta_i \overline{\text{FDI}} \times c_i + \sum_{i=1}^{n} \mu_i \overline{\text{GDPc}} \times c_i + \ddot{y}_{it} + \ddot{u}_{it}$$

where β_{0i} is an intercept of country *i*, c_i is a dummy for country *i*.

For the CCEMG estimator, the cross-section averages are added to each country's OLS regression across time, and we average the parameters across countries to get the CCEMG estimator. CCEMG therefore allows for common correlated effects by including cross-country averages and for heterogeneity by applying separate parameter sets for each country.

$$\text{Aid}_{it} = \beta_{0i} + \beta_i \text{FDI}_{it} + \gamma_i \text{GDPc}_{it} + \delta \overline{\text{Aid}}_{it} + \theta \overline{\text{FDI}}_{it} + \mu \overline{\text{GDPc}}_{it} + y_{ti} + u_i$$

$$\beta_{\text{CCEMG}} = n^{-1} \sum_{i=1}^{n} \hat{\beta}_i$$

The results in Table 4 show that only GDPc stays significant and negative, whereas FDI is insignificant. This suggests that both cross-section dependence and parameter heterogeneity do play an important role and we should allow for them. To sum up, we find no correlation between Aid and FDI. We also suggest that the negative correlation observed by the FE estimator might be spurious.

Table 4 Aid as the dependent variable, one-year data, common factor models

General	*CCEP*	*GM*	*CCEPGM*
FDI	–0.08518	–0.00315	–0.00331
	[1.23]	[1.39]	[1.37]
GDPc	–0.0584	–0.02098	–0.038
	[5.18]*	[4.55]*	[4.97]*
Constant	0.45792	0.20089	0.16797
	[5.47]*	[6.22]*	[4.65]*
Observations	5180	5180	5180
R-squared	0.51		
Countries	178	178	178

The significance levels correspond to the following p-values: *$p < 0.1$, **$p < 0.05$, ***$p < 0.01$.

We believe it is desirable to check for robustness and therefore three robustness checks follow. First, including only countries with non-zero Aid in a given year, i.e., mostly countries defined by WB as developing countries, yields us about the same results. This is an important result as it says that our results are not driven by a group of 10–40 developed countries that have zero Aid at some point in time. Second, we control for FDI

outliers by excluding the top and bottom 1% from the sample. The results again seem to be very robust for both Aid and FDI equations using one-year data. However, we get different results using five-year averaged data, which might signal different long-run relationships captured by five-year averages. The coefficient on FDI is mostly no longer significant, and positive when it is, and the coefficient on GDPc is consistently significant and negative in Aid equations using standard methods. Third, combining these two changes yields us similar results to the second one.

6 Conclusion

This paper investigated whether official aid, Aid, and foreign direct investment, FDI, defined here as shares of recipients' gross domestic product, are substitutes, complements or neither. We hypothesised that there is no direct relationship between the two flows, and explained how we address endogeneity problems through a number of econometric methods.

Applying standard panel estimators on data for around 180 countries from 1971 to 2007, Aid and FDI seem to be substitutes even after controlling for gross domestic product per capita, GDPc. However, this correlation is not significant once we allow for parameter heterogeneity and common correlated effects. Therefore we conclude that the nature of the Aid and FDI relationship is more complicated than suggested by some earlier studies. We reach a conclusion similar to the one reached by Frot and Santiso (2008), that there is no direct relationship, but through a robust analysis.

Our results cannot reject the hypothesis that there is no direct relationship between Aid and FDI, and we therefore argue that they are neither direct substitutes nor complements. Furthermore our findings suggest that donors do not substitute Aid for insufficient FDI and therefore do not correct a potential capital market failure. Neither crowding-in nor crowding-out processes seem to take place between Aid and FDI.

In this present paper we do not address a few issues that deserve further attention, such as allowing for non-linearities. Also, we have not dealt with the fact that Aid could be allocated following forward-looking principles to compensate for insufficient capital or low GDPc in the future. Our quite long time panel data allows us to carry out a quite robust analysis, but it might also create problems such as the unit root problem that we have not fully accounted for in this paper.

To draw policy conclusions on the basis of any results that cannot reject a hypothesis is a challenging task. One of our main policy-relevant implications seems to be that it does not make sense to direct development assistance according to the allocation of FDI, at least not without a more detailed inspection. Another policy-relevant observation is that the relationships between Aid and FDI do not follow simple rules. More detailed evidence is required and we encourage efforts to get it.

Acknowledgements

The author is grateful for comments on an earlier draft of this paper by Markus Eberhardt, Valpy FitzGerald and Francis Teal of Oxford University and Michal Bauer of Charles University. The author acknowledges the support from the Czech Science

Foundation under grant (GACR 403/10/1235), the Charles University (GAUK 1610 and SVV 261 501) and the Technology Agency of the Czech Republic (TACR TD010137).

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Appendix

WB WDI Data Description

This Appendix describes the data employed by this paper from the World Bank's World Development Indicators.

Official Development Assistance and Official aid (current US$). Code: dt.oda.alld.cd

Net official development assistance consists of disbursements of loans made on concessional terms (net of repayments of principal) and grants by official agencies of the members of the Development Assistance Committee (DAC), by multilateral institutions, and by non-DAC countries to promote economic development and welfare in countries and territories in part I of the DAC list of recipients. It includes loans with a grant element of at least 25% (calculated at a rate of discount of 10%). Net official aid refers to aid flows (net of repayments) from official donors to countries and territories in part II of the DAC list of recipients: more advanced countries of Central and Eastern Europe, the countries of the former Soviet Union, and certain advanced developing countries and territories. Official aid is provided under terms and conditions similar to those for ODA. Data are in current US dollars.

Foreign Direct Investment, net inflows (BoP, current US$). Code: BX.KLT.DINV.CD.WD

Foreign Direct Investment is net inflows of investment to acquire a lasting management interest (10% or more of voting stock) in an enterprise operating in an economy other than that of the investor. It is the sum of equity capital, reinvestment of earnings, other long-term capital, and short-term capital as shown in the balance of payments. This series shows net inflows in the reporting economy. Data are in current US dollars.

Gross Domestic Product (current US$). Code: NY.GDPc.MKTP.CD

Gross Domestic Product at purchaser's prices is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. Data are in current US dollars. Dollar figures for gross domestic product are converted from domestic currencies using single year official exchange rates. For a few countries where the official exchange rate does not reflect the rate effectively applied to actual foreign exchange transactions, an alternative conversion factor is used.

Population, total. Code: SP.POP.TOTL

World Bank staff estimates from various sources including census reports, the United Nations Statistics Division's Population and Vital Statistics Report, country statistical offices, and demographic and health surveys from national sources and Macro International.