Can aid stimulate productivity in Sub-Saharan Africa? A dynamic panel approach

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Abstract: The aim of the study was to examine the impact of the official development aid (ODA) on productivity in Sub-Saharan Africa. As development policies embrace different types of aid interventions, we decomposed aid by type of flows and analysed their relations with 24 African states’ productivity (measured by total factor productivity) over the period 1995-2014. Results of the dynamic panel model estimation reveal important implications for the development cooperation policy agenda. It appears that although total value of ODA does not support productivity, technical aid disbursements are associated with higher total factor productivity. This implies that the implementation of technical cooperation enables absorption of technology and contributes to the increase of technology development in recipient Sub-Saharan African countries. The results are fairly robust. Moreover, in this study we confirm that low infrastructure development and shortages in primary education are associated with lower productivity, while trade openness, development of financial market, and political stability - with higher productivity values.

JEL Classifications: O55

Keywords: Official development assistance, technical cooperation, Sub-Saharan Africa, technology absorption, total factor productivity

http://dx.doi.org/10.15208/beh.2019.10

1. Introduction

The debate on the effectiveness of development cooperation remains an important issue in the development economics literature. For a number of countries, particularly in Sub-Saharan Africa and South Asia, aid is an important source of capital and foreign currency. Some studies suggest that aid contribute to economic growth (Irandoust & Ericsson, 2005; Banerjee, 2007; Ssozi & Asongu, 2016). However, other researchers argue that development assistance is ineffective in economic growth stimulation, mainly due to its inherent nature and mismanagements (e.g. Papanek, 1972; Boone, 1996; Radelet et al., 2004; Easterly, 2009; Loxley & Sackey, 2008; Rodrik, 2009; Rajan & Subramanian, 2011). Undoubtedly, aid transfers are susceptible to the rent seeking problem in both donor and recipient countries. They serve a plethora of goals in domestic and foreign policy (Easterly, 2009). At the same time, the development cooperation system has undergone major policy changes since the 2000, thanks to the establishment of Millennium Development Goals and subsequent agreements.

Due to the dichotomy of the attitudes to development aid, in the article we reconsider the impact of aid and investigate whether the declarations to increase aid effectiveness were
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fulfilled. The goal of the study is to assess recent (1995-2014) impact of aid on fundamental economic indicators in Sub-Saharan Africa. Particularly, we look for the answers to the following research questions:

(a) Does technical ODA flow contribute to the increase of the productivity?

(b) What is the impact of total ODA on productivity growth (previous studies show that the flows are ineffective - see e.g. Alvi & Senbeta 2012)?

(c) Is the impact of selected forms of ODA on productivity more important than the impact of total ODA (which forms of ODA are most effective)?

Our results suggest that some aid flows, particularly technical cooperation, have a significant and positive effect on the productivity in the region. This implies that this form of international cooperation is indeed conducive for technology development. Technology development, often approximated with productivity, is expected to enable structural change by moving labour force from low- to high-productivity sectors (McMillan et al., 2014; Solow, 2016). Because of that, increasing productivity in Sub-Saharan Africa is of paramount importance for its economic development.

This paper adds to the literature in two major ways. First, we decompose aid and verify the impact of different aid instruments on productivity in Sub-Saharan African states. Quite a lot of papers have addressed the issue of country characteristics that are crucial to increase the level of productivity and FDI impact on TFP (Chengchun & Sailesh, 2018). Less attention has been put on the choice of channels of aid flows (Kumar & Pacheco, 2012; Ssozi & Asongu, 2016). Hence, in this study we examined which types of aid are more likely to raise TFP in Sub-Saharan Africa.

Secondly, based on our results, we formulate policy implications for the development cooperation strategy and technology development in the analysed region.

As suggested by Solow (2001), in order to explore the determinants of TFP, we concentrate on a group of fairly similar countries*. We estimate a panel model for 24 countries for the region, check different specifications and include a set of control variables, what makes our results fairly robust.

The reminder of the paper is as follows. In the following section (2), we review development aid literature and explain why productivity was selected as the dependent variable in the research. Next, we present the data (section 3), and the empirical model

* In sub-Saharan Africa, the level and the pace of economic growth differ from other continents, but also inside the region (Fosu, 2013; Anyanwu, 2014). Heterogeneity of the region is reflected in a number of socioeconomic features, including human resources, physical infrastructure, private sector development, quality of governance, and institutional capacity (Acemoglu, Johnson, & Robinson, 2001; Birdsal & Rodrik, 2005; Fosu, 2013; Anyanwu, 2014; Rodrik, 2014; Świerczyńska, 2019). Despite these differences, if compared to other groups of countries and world regions, Sub-Saharan Africa reserves some shared characteristics, especially in the context of the level of industrialization and technological advancement (Easterly, 2009). Economies in the region are generally commodity exporters with domination of traditional sector and relatively low rates of high technology exports (Lipton, 2012). Their industry is dominated by the extractive sector, particularly in energy and minerals, with limited role of manufacturing. Despite the fact that industrial upgrading based on technological changes is deemed crucial for economic development in the region (Lin & Monga, 2010), the pace of structural change is far too moderate. In terms of institutional development, Fosu (2013) presented evidence of “policy-syndromes” which hinder expected growth rates. Hence, the countries from the region still find themselves in the OECD “developing countries” list, largely in the low and lower middle-income groups; their societies face deep inequality issues and exclusion of vulnerable groups.
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(Section 4) applied in the study. In section 5 we discuss the results of our research and provide some policy implications. We include our main research conclusions in the last section (6).

2. Literature review

Development literature devoted a lot of attention to the aid and growth nexus, as aid was supposed to solve saving gap and poverty issues in low-income countries. However, currently the development economics concentrates not only on direct sources of growth (and development), but also on its indirect causes such as a productivity (Klenow & Rodríguez, 1997; Hausman, 2009). This is especially useful when a limited time series data is available. In this research we approximate economic progress with technology development, which can be expressed by the productivity concept, rooted in the Solow-Swan exogenous growth model.

There are two major groups of factors which foster productivity: technological and non-technological factors. The first group encompasses technology embodied in new production processes, new tools, new and higher quality goods and services, new methods and solutions (Klenow & Rodríguez 1997; Comin, Hobijn, & Rovito, 2006; Comin, 2008; Comin & Mestieri, 2014). The non-technological factors include i.a. the structure of the economy, human capital and institutions (Chanda & Dalgaard, 2008; Ascari & Di Cosmo, 2004; Byrne et al., 2005; Comin, 2008; Jajri, 2007; Frija et al., 2015). In this research, productivity is represented by TFP - the residuals from growth regression equation. It measures the growth of income per worker, which is not due to factor accumulation (physical capital, labour) (Lipsey & Carlaw, 2004). TFP allows to follow the change in efficiency of the usage of factor inputs and change in technology mix (Byrne, 2005; Comin, 2008; Jajri, 2007). As such, it has the potential to contribute to economic development in laggard economies. Consequently, there arises a question, whether development cooperation can stimulate the efficiency of the utilization of existing resources.

In theory, aid combines measures of capital injection and capacity building, which makes it an instrument suitable to address both groups of productivity factors. It is committed to sectors of social infrastructure, economic infrastructure and production in forms of grants and loans. Moreover, technical cooperation, includes free-standing technical cooperation (FTC, the provision of resources aimed at the transfer of technical and managerial skills or of technology for the purpose of building up general national capacity without reference to the implementation of any specific investment projects) and investment-related technical cooperation (IRTC, the provision of technical services required for the implementation of specific investment projects). Generally, it is dedicated to improve technology use in a recipient country (IMF, 2003).

Dual nature of aid (capital and non-capital instruments) is rooted in the main concepts of development economics, and as a policy instrument it was designed to fit into various kinds of development thinking. In the context of exogenous theories of growth, aid was supposed to compensate the shortage of capital in order to stimulate growth. It was supposed to contribute to input driven growth based on capital accumulation. As the practical realisation of the Rosenstien Roden “big push” idea, aid was meant to help low income countries escape a low-income equilibrium state in which they were stuck (the poverty trap) (Sachs et al., 2004; Graham et al., 2006). According to the second influential
theory, aid could fill in the financing gap based on the two gap model delivered by Chenery & Strout in 1966 (Chenery, 1969). Aid was supposed to eliminate the distance between low domestic saving rate and the investment required to keep up with population growth and the depreciation of capital.

Justification of donating aid is also found in the endogenous growth models. Namely, it involves investments in human capital and the overall recipient capacity building, indispensable to launch economic growth (Romer, 1990; Grossman & Helpman, 1991; Aghion, 1992). Increase of technical capacity in the recipient countries was supposed to stimulate productivity and growth by increasing endogenous capacity to adopt and develop technology. While grants and program aid engage distribution of financial flows, project aid and technical cooperation involves direct actions in recipient countries.

According to Nachega & Fontaine (2006), aid can contribute to TFP growth especially if it involves investments in infrastructure (roads, power points, irrigation). In such cases aid may limit the strains on the domestic tax base, and thus prevent costly distortions. Therefore, aid has the potential to addresses the technology and non-technology aspects of TFP. However, Byrne et al. (2005) warn that aid in forms of projects and financial investments is not effective in achieving long-term convergence, when it is not successfully targeting the structural differences. Notably, it is the lack of compliance of aid flows with recipient’s development strategies, which may constitute a major potential limitation for aid impact on productivity in Sub-Saharan Africa.

The functioning of aid received some heavy criticism (e.g. Bonne, 1996; Easterly, 2009; Cohen & Easterly, 2009) based on both theoretical and practical arguments. While some researchers consider aid ineffective in growth stimulation due to its primordial inadequacy for the purpose, including fungibility (Bonne, 1996; Rodrik, 2008; Easterly, 2009; Rajan & Subramanian, 2011), others associate it with the donors’ approach (e.g. Easterly, 2009; Andrzejczak & Kliber, 2015). Alvi & Senbeta (2012) claim that aid negatively affects TFP; it reduces the efficacy of financial institutions and causes efficiency losses which undermine its overall effect on growth. Durlauf et al. (2005) did not include aid in their list of 145 separate variables which they found to be significant in growth regressions (with a typical sample of around 100 observations). The instrumentalization of aid and lack of consistency in terms of what it should be doing and how, seem to explain much of its indolence in solving poverty issues. Aid projects were criticized for not integrating with the recipient’s infrastructures, or the societies (“white elephants” projects, e.g. Brunel, 1993), or simply not working at all (Banjerlee, 2007; Cohen & Easterly, 2009). Aid failures were often caused by the lack of funds for long-term sustainability. There is evidence of the aid initiatives which provided fleeting improvements, which eroded after the project finished (Ovadia, 2015). The aid’s image crisis reached its peak in the context of the “lost decade” of the 90s, when especially African countries faced rising problems of poverty, debt, and conflicts.

It is worth noting, that not only aid itself, but also aid research receives a lot of criticism. Easterly (2009) divides approaches in aid literature to transformational and marginal, while Rodrik (2009) distinguishes between micro-evaluation enthusiasts and growth-diagnosticians. Transformational approach is criticized because it is based on low quality data and provides little guidance about how to adjust any intervention to work better. According to Easterly: “there are too many things changing at once to know what caused the failure” (2009, p. 377). As opposed to the large sample cross-country studies, development economics turned towards randomized evaluation (RE) of particular
interventions in the academic literature (which lies in the scope of Easterly’s marginal approach) (Duflo, Kremer, & Robinson, 2008; 2009). The RE research is based on micro data (as opposed to aggregate econometrics), brings the risk of bias in “random” project selection (Ravaillon 2009) and the possibility of groundless extrapolation of its conclusions to general aid policies. Ravaillon (2009) claims that the “randomistas” methodology may help solving some issues in development economics, but the random field experiment method may not be sufficient to determine that a given development intervention is or is not working in general.

Finally, there is the science and policy nexus, which impacts the issue of development aid. Donors, particularly from DAC, follow the pendulum of views on desirable development paths presented in economic literature. The lines of Berg report, Washington consensus, Burnside & Dollar “sound policies paper” (2000), or lately Lin’s New Structural Economics, were setting the standards for development policies (not necessarily thinking). As noticed by Easterly (2009), aid ideas have often been cyclical, with the same ideas going out of fashion only to come back again many years later. Volatility of ideology/paradigm behind the aid system (e.g. market paradigm vs. state paradigm) indicates lack of long-term strategies which would allow any development reforms to be actually implemented, ameliorated and tested. Aid and development recipes try to keep up with the state and market failure debate, unfortunately without serious reflection. This was exemplified by the structural adjustment episode in Africa (Devarajan & Kanbur 2013).

To sum up, based on the literature query, we find evidence, that aid flows have the potential to address both factor accumulation and productivity growth (Abegaz, 2005). For the countries with insufficient inflow of FDIs and trade, or limited capacity to absorb technology coming via commercial channels, aid may be an alternative technology source. Aid flows combine the non-profit and semi-profit capacity building instruments of technology promotion in the less economically advanced countries. A range of different aid flows may impact both tangible and intangible assets in recipient countries, with a potential to improve the quality of inputs in production process. Hence, it is plausible that aid may contribute to the overall economic system’ capacity to develop by increasing its productivity. Since the new development economics should be concentrated on seeking “what works for development” (Rodrik, 2009, p. 2), an attempt to evaluate aid flows impact on productivity seems a justifiable task, especially in the context of Sub-Saharan Africa. Based on the TFP literature (e.g. Ascari, 2004; Byrne et al., 2005, Comin, 2008, Ssozi & Assongu, 2016) we intend to apply a cross-country GMM panel model, which seems to better suit the research problem stated in our study and examine the hypothesis that flows of aid are susceptible to impact productivity.

3. Data

In the research, we used data from Penn World Tables (PWT), OECD International Development Statistics, and World Development Indicators (WDI). The measure of TFP was taken from the PWT (see Feenstra et al., 2013 for the details of the measure computation). The data covered 24 countries from Sub-Saharan region over the years 1995-2014. The selection of 24 out of over 40 Sub-Saharan countries was motivated by the availability of TFP data in PWT. The choice of the time frame is dictated by the idea to:
(a) verify the impact of aid on productivity since the general launch of democratic systems in a number of Sub-Saharan states in mid 90s and

(b) test the hypothesis, that aid evaluation programs inspired by severe criticism in the 90s increased its efficiency (Carbone, Memoli, & Quartapelle, 2016).

We expect, that improvements in donor policy and in recipients’ governance could have solved the fungibility problem at least partially (see Easterly, 2009), and hence could have increased aid flows efficiency. With the spread of democracy in Africa the improvements in structure of available resources allocation is more likely (McMillan et al., 2014).

As explanatory variables we used the data on total ODA received by African countries over the period 1995-2014, technical ODA, and loans from DAC countries - according to OECD statistics (see Appendix for detailed data description). The decomposition of ODA was based on OECD methodology in reporting aid flows; such approach was earlier adopted in similar research (e.g. Kang & Won, 2017). All the explanatory variables were expressed in US 2015 dollars. Next, using the PWT data on population we expressed the variables in per-capita values. In Table 1 we present the descriptive statistics of the data. We notice that the most volatile are the inflows of loans (with either positive or negative sign, when the country repaid its debt).

### Table 1. Descriptive Statistics of Total Productivity Factors and Foreign Disbursements

<table>
<thead>
<tr>
<th>VARIABLE</th>
<th>ctfp</th>
<th>techODApc</th>
<th>netODApc</th>
<th>LoansPC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>0.45</td>
<td>9.05</td>
<td>32.57</td>
<td>-1.49</td>
</tr>
<tr>
<td>Median</td>
<td>0.38</td>
<td>6.56</td>
<td>27.55</td>
<td>-0.48</td>
</tr>
<tr>
<td>Minimum</td>
<td>0.11</td>
<td>0.34</td>
<td>0.50</td>
<td>134.84</td>
</tr>
<tr>
<td>Maximum</td>
<td>1.56</td>
<td>52.01</td>
<td>338.08</td>
<td>31.14</td>
</tr>
<tr>
<td>Std. deviation</td>
<td>0.25</td>
<td>8.30</td>
<td>25.12</td>
<td>10.07</td>
</tr>
<tr>
<td>Volatility coefficient</td>
<td>0.55</td>
<td>0.92</td>
<td>0.77</td>
<td>6.75</td>
</tr>
<tr>
<td>skewness</td>
<td>0.98</td>
<td>2.17</td>
<td>4.56</td>
<td>-6.61</td>
</tr>
<tr>
<td>kurtosis</td>
<td>0.89</td>
<td>5.10</td>
<td>45.59</td>
<td>74.32</td>
</tr>
<tr>
<td>5%-percentile</td>
<td>0.14</td>
<td>1.20</td>
<td>6.81</td>
<td>-11.72</td>
</tr>
<tr>
<td>95%-percentile</td>
<td>0.90</td>
<td>30.25</td>
<td>79.13</td>
<td>6.31</td>
</tr>
</tbody>
</table>

Source: Own elaboration based on data from Penn World Tables, 2018 and OECDstat, 2018.
Note: ctfp - total productivity factor, techODApc - technical ODA in 2015 US dollars received per 1 mln citizens, netODApc - net ODA received per 1 mln citizens, LoansPC - value of loans received per 1 mln citizens.

Total productivity factors were expressed in categories of purchasing power parity, where US=1. When we analyse the values in Table 1, the variable does not appear to vary substantially across the sample. However, we may detect the actual variability of the data in Figure 1. The maximum value was obtained in the case of Gabon in 1995, and the country appears to be the productivity leader in the region. Very high values of productivity are noted also in the case of Kenya, Nigeria, Tanzania, Swaziland, while the lowest - in Burundi, Niger and Rwanda.

In Table 2 we present the list of the countries which are covered by the study. We associated a number with the name of each country in the sample. These numbers are
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used in some of the following charts, where the usage of the country’s names would make the figure unclear.

**Figure 1. Total Factor Productivity Over the Period 1995 - 2014 in 24 Sub-Saharan Economies**

![Total Factor Productivity Chart]

Source: Own elaboration on PWT data.

**Table 2. Economies Included in the Study - With Group Numbers**

<table>
<thead>
<tr>
<th>Number</th>
<th>Country</th>
<th>Number</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Benin</td>
<td>13</td>
<td>Namibia</td>
</tr>
<tr>
<td>2</td>
<td>Botswana</td>
<td>14</td>
<td>Niger</td>
</tr>
<tr>
<td>3</td>
<td>Burkina Faso</td>
<td>15</td>
<td>Nigeria</td>
</tr>
<tr>
<td>4</td>
<td>Burundi</td>
<td>16</td>
<td>Rwanda</td>
</tr>
<tr>
<td>5</td>
<td>Cameroon</td>
<td>17</td>
<td>Senegal</td>
</tr>
<tr>
<td>6</td>
<td>Central African Republic</td>
<td>18</td>
<td>Sierra Leone</td>
</tr>
<tr>
<td>7</td>
<td>Côte d'Ivoire</td>
<td>19</td>
<td>South Africa</td>
</tr>
<tr>
<td>8</td>
<td>Gabon</td>
<td>20</td>
<td>Sudan (Former)</td>
</tr>
<tr>
<td>9</td>
<td>Kenya</td>
<td>21</td>
<td>Swaziland</td>
</tr>
<tr>
<td>10</td>
<td>Lesotho</td>
<td>22</td>
<td>Tanzania</td>
</tr>
<tr>
<td>11</td>
<td>Mauritania</td>
<td>23</td>
<td>Togo</td>
</tr>
<tr>
<td>12</td>
<td>Mozambique</td>
<td>24</td>
<td>Zimbabwe</td>
</tr>
</tbody>
</table>

Source: Own elaboration.

In Figure 2 we present the amount of technical aid received by Sub-Saharan African countries over the 1995-2014 period. The highest volume of such help per capita was given to Gabon (number 8), Namibia (number 13), Senegal (number 17) and Botswana (number 2). Nigeria and Sudan were the countries which received the lowest amount of technical aid per capita. We checked, if the per capita amounts of help are simply associated with the population variables in these countries. Indeed, Gabon, Namibia, and
Botswana are relatively low populated, but on the contrary, Senegal has a relatively high population and density of population. Nigeria and Sudan are highly populated economies, which may decrease their per capita values, compared to the sample average. On the other hand, it is noteworthy, that Gabon, Namibia and Botswana are among best performing Sub-Saharan countries in terms of Human Development Index and Global Competitiveness Index (2017). Particularly, Botswana is perceived the “growth miracle” African economy, with well-functioning democracy.

**Figure 2. Technical ODA per 1 million inhabitants received by Sub-Saharan African economies over the period 1995-2014**

![Box plot showing technical ODA per 1 million inhabitants received by Sub-Saharan African economies over the period 1995-2014.](image)

Source: Own elaboration.
Note: Numbers of groups correspond to the list of countries in Table 2.

**Figure 3. Official Development Aid per 1 million inhabitants received by South Africa over the period 1995 - 2014**

![Box plot showing official development aid per 1 million inhabitants received by South Africa over the period 1995-2014.](image)

Source: Own elaboration.
Note: Numbers of groups correspond to the list of countries in Table 2.
In Figure 3 we present the box plot of total net ODA per capita received by each country. We observe that the highest values of the overall foreign help were sent to Gabon (number 8) and Namibia (number 13). Large economies, such as South Africa (regional leader in terms of economic development and industrialization) and Nigeria (largest economy) received much smaller amounts of aid. However, also low income countries like Burkina Faso and Niger were among moderate per capita aid recipients. We may assume that the population density does not seem to constitute a bias. Interestingly, neither does the income of recipients. A closer look at aid data provides more detailed picture. For example, Botswana was generally obtaining comparably moderate foreign aid over the studied period - however the dots in the picture inform us that it received large irregular “injections” of official development aid, such as debt forgiveness in 2008, or infrastructure grant in 2012. Comparing the two plots we can see that for instance Niger received small amount of help in total but compared to other economies - most of the money received was devoted for technological development.

**FIGURE 4. TOTAL NET LOANS RECEIVED BY SUB-SAHARAN ECONOMIES PER 1 MILLION INHABITANTS OVER THE PERIOD 1995-2014**

Eventually in Figure 4 we present the net value of loans received by the economies. Compared to the amount of foreign help the values are not high. Lots of countries had to re-pay its foreign debt in the period over study, such as Gabon, Cameroon, Côte d'Ivoire or Mauritania. We may assume that it will be difficult to interpret the impact of loans net value. When we compare the total productivity factors (Figure 1) and the amount of help devoted to technological development, received by SSA economies, we can notice that the two productivity leaders: Gabon and Botswana are also the receivers of very high amount of technological aid. Thus, the research questions formulated in the introduction of the article seems to be empirically justified.
4. The model

In order to utilize all available information, changes of variables in time and across countries we composed a panel of the data, including \( T = 20 \) time periods (1995-2014) and \( N = 24 \) cross-section units (24 countries listed in Table 2). As the data exhibited strong autocorrelation, we used dynamic panel approach. Thus, the model has the following form:

\[
y_{i,t} = \alpha y_{i,t-1} + \beta X_{i,t} + \eta_i + u_{i,t}
\]  

(1)

Where, \( y_{i,t} \) denotes total factor productivity of the \( i \)-th African country at time \( t \). In our case \( t = 1, ..., 20 \), while \( i = 1, ..., 24 \). \( \beta \) is a \( 1 \times k \) vector of the coefficients, \( \alpha \) is the vector of autoregressive coefficients, \( X_{it} \) is a \( k \times 1 \) vector of explanatory variables observed for country \( i \) at time \( t \), \( \eta_i \) are so called individual effects (time-invariant), while \( u_{i,t} \) - the disturbance specific for country \( i \) at time \( t \). Such models are estimated using either Arellano & Bond (1991) or Blundell & Bond (1998) estimators, especially in the case of macro-panels when \( T \) is much smaller than \( N \).

In our case the difference between \( N \) and \( T \) was not high, therefore we decided to test also other specifications to check robustness of our results. For instance, Judson & Owen (1999) showed that when \( T \) is not very small compared to \( N \), the fixed-effect (FE) estimator is not very biased (see also Nickell, 1981). They performed Monte Carlo experiments and showed that the bias of FE increases with \( \alpha \) and decreases with \( T \) (see also Baltagi & Kao, 2001). Below we describe three estimators used in our study.

4.1. Arellano and Bond (1991) difference estimator

The model can be estimated using the so called “difference estimator”. The main idea of the approach is to first difference the data. Then, one obtains:

\[
\Delta y_{i,t} = \alpha \Delta y_{i,t-1} + \beta \Delta X_{i,t} + \Delta u_{i,t} = \gamma W_{i,t} + \Delta u_{i,t}
\]  

(2)

The error term of the equation (2) is by definition autocorrelated and also correlated with the lagged dependent variable. All values of \( y_{i,t-k} \) with \( k > 1 \) can be used as instruments for \( \Delta y_{i,t-1} \). One-step estimator of equation (2) amounts to computing (Cottrel & Lucchetti, 2014):

\[
\hat{\gamma} = \left[ \left( \sum_{i=1}^{N} W_i' Z_i \right) A_N \left( \sum_{i=1}^{N} Z_i' W_i \right)^{-1} \right]^{-1} \left[ \left( \sum_{i=1}^{N} W_i' Z_i \right) A_N \left( \sum_{i=1}^{N} Z_i' \Delta y_i \right) \right]
\]  

(3)
where:

\[\Delta y_i = [\Delta y_{i,3}, \ldots, \Delta y_{i,T}],\]

\[W_i = \begin{bmatrix} \Delta y_{i,2} & \ldots & \Delta y_{i,T-1} \\ \Delta x_{i,3} & \ldots & \Delta x_{i,t} \end{bmatrix},\]

\[Z_i = \begin{bmatrix} y_{i,1} & 0 & 0 & \ldots & 0 & \Delta x_{i,3} \\ 0 & y_{i,1} & y_{i,2} & \ldots & 0 & \Delta x_{i,4} \\ \ldots & \ldots & \ldots & \ldots & \ldots & \ldots \\ 0 & 0 & 0 & \ldots & 0 & \Delta x_{i,T} \end{bmatrix},\]

\[A_N = \left( \sum_{i=1}^{N} Z_i^t H Z_i \right)^{-1}.\]

Once the 1-step estimator is computed, the 2-step estimated are obtained through replacing the matrix \(H\) with the sample covariance matrix of the estimated residuals. The 2-step estimator is consistent and asymptotically efficient.

### 4.2. GMM-system estimator of Blundell and Bond (1998)

Blundell & Bond (1998) proposed so-called “system” estimator that complements the differenced data with data in levels, so the lagged differences are used as instruments. The system GMM estimator shows dramatic efficiency gain over the “difference”-one, especially when \(\alpha \to 1\) (Baltagi & Kao, 2001). The key equation of the system estimator is as follows (Cottrel and Lucchetti, 2014):

\[\tilde{\gamma} = \left[ (\sum_{i=1}^{N} \tilde{W}_i^t \tilde{Z}_i ) A_N (\sum_{i=1}^{N} \tilde{Z}_i^t \tilde{W}_i ) \right]^{-1} \left[ (\sum_{i=1}^{N} \tilde{W}_i^t \tilde{Z}_i ) A_N (\sum_{i=1}^{N} \tilde{Z}_i^t \Delta \tilde{y}_i ) \right] \]

\[\Delta \tilde{y}_i = [\Delta y_{i,3}, \ldots, \Delta y_{i,T} \ y_{i,3} \ldots y_{i,T}],\]

\[\tilde{W}_i = \begin{bmatrix} \Delta y_{i,2} & \ldots & \Delta y_{i,T-1} & y_{i,2} & \ldots & y_{i,T-1} \\ \Delta x_{i,3} & \ldots & \Delta x_{i,t} & x_{i,3} & \ldots & x_{i,T} \end{bmatrix},\]

\[Z_i = \begin{bmatrix} y_{i,1} & 0 & 0 & \ldots & 0 & \Delta x_{i,3} \\ 0 & y_{i,1} & y_{i,2} & \ldots & 0 & \Delta x_{i,4} \\ \ldots & \ldots & \ldots & \ldots & \ldots & \ldots \\ 0 & 0 & 0 & \ldots & 0 & \Delta x_{i,T} \\ 0 & 0 & 0 & \ldots & 0 & \Delta y_{i,2} \\ 0 & 0 & 0 & \ldots & 0 & \Delta y_{i,T-1} \end{bmatrix},\]

\[A_N = \left( \sum_{i=1}^{N} Z_i^t H Z_i \right)^{-1} .\]

The choice of matrix \(H^*\) is not trivial. The details are presented for instance in Roodman (2009) or Hsiao (2014).
4.3. Fixed-effect estimator

Let us return to the specification (1). The model can be estimated in two ways. In the first method, $\eta_i$s are treated as fixed parameters and a dummy variable is introduced into the model for each group $i$. This is called Least Squares Dummy Variables (LSDV) method. In the second approach the data are de-meaned and a model without constant $\eta_i$ is estimated. The dependent variable is defined as:

$$\tilde{y}_{it} = y_{it} - \bar{y}_i,$$

(7)

and the group-mean:

$$\bar{y}_i = \frac{1}{T_i} \sum_{t=1}^{T_i} y_{it}. $$

(8)

Where, $T_i$ is the number of observations for unit $i$. The two approaches are numerically equivalent (see: Hsiao, 2013). However, we can compute two kinds of $R^2$. LSDV $R^2$ is the measure of fit of the model with binary variable, while “within” $R^2$ - the measure of goodness of fit of the model for $\tilde{y}_{it}$, i.e. assuming that we are interested in the influence of other factors apart from individual effects (Cottrel & Lucchetti, 2014, see also: Greene, 2011).

5. Results

As an opening step the data was tested for non-stationarity through Levin-Lin-Chu (1992) test, and the null hypothesis of unit root was rejected in the case of the test without intercept, with intercept, as well as with intercept and linear trend (and lag=1). Due to data autocorrelation, we estimated the dynamic panel model. This method has also empirical explanation - we expect that the today’s total factor productivity will depend on its value from previous year. Such model is also commonly applied in the case of macro-data (Anoruo & Elike, 2015; Foster-McGregor et al., 2016). A dynamic panel model was estimated of the following form:

$$CTFP_{i,t} = \eta_{i,t} + \beta_1CTFP_{i,t-1} + \beta_2LOANsPC_{i,t} + \beta_3techODAp_{i,t} + \beta_4netODAp_{i,t} + u_{i,t},$$

(9)

here $CTFP_{(i,t)}$ $CTFP_{i,t}$ - denotes the value of total productivity factor in county $i$ at time $t$, $techODAp_{i,t}$ is the amount of technical ODA in 2015 US dollars received per 1
mln citizens, \( netODApc_{it} \) - net ODA received per 1 mln citizens and \( LOANsPC_{it} \) - value of loans received per 1 mln citizens.

In the first approach, two-step system-GMM approach with asymptotic errors was applied. To check the robustness of the results, also the following specifications were tested:

a. Two-step approach with asymptotic errors,

b. Two-step approach with normal errors,

c. Two-step GMM-system approach with normal errors,

d. One-step estimation - which did not pass the Sargan overidentification test and is not reported here,

e. Fixed-effect approach with lagged dependent variable.

The results of the performed estimations are presented in Table 3. Depending on the specification different sets of significant explanatory variables were obtained. However - regardless of the specification technical ODA per capita appeared to be a significant explanatory variable (in the case of Specification 4, when the model was estimated using GMM-system approach and asymptotic errors are not assumed - with \( p \)-value of 0.062 and in the case of fixed-effect specification - of 0.056). ODA loans received by the beneficiary country proved to be significant variable only in the case of the first specification and based upon the sign of the coefficient we could say that they contributed to the increase of productivity. Eventually, total ODA received was a significant variable only in the Specification 2, and the negative coefficient could suggest that their usage is not effective when increase of productivity is considered.

To summarize - although the total net ODA received and net loans received do not seem to significantly contribute to the productivity growth (which corroborates the results obtained by other researchers i.a. Byrne et al., 2005; Alvi & Senbeta, 2012), technical ODA received by African economies proved to stimulate productivity growth, which extends the results of Ssozi & Asongu (2016). As these flows are devoted to technical development, we can suppose that technical cooperation contributes to productivity growth through technology absorption and development including increasing skills and capacity.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Estimate</th>
<th>Std.error</th>
<th>Student t</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specification 1: 2-step GMM-system, asymptotic errors</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ctfp(-1)</td>
<td>0.5893</td>
<td>0.0114</td>
<td>51.5600</td>
<td>0.0000</td>
</tr>
<tr>
<td>const</td>
<td>0.0002</td>
<td>0.0003</td>
<td>0.6449</td>
<td>0.5190</td>
</tr>
<tr>
<td>LOANspc</td>
<td>0.0002</td>
<td>0.0000</td>
<td>11.0400</td>
<td>0.0000</td>
</tr>
<tr>
<td>techODApc</td>
<td>0.0030</td>
<td>0.0004</td>
<td>7.7460</td>
<td>0.0000</td>
</tr>
<tr>
<td>netODApc</td>
<td>0.0000</td>
<td>0.0000</td>
<td>1.2590</td>
<td>0.2079</td>
</tr>
</tbody>
</table>

| Specification 2: 2-step, asymptotic errors |
| ctfp(-1)     | 0.7247   | 0.0120    | 60.2300   | 0.0000  |
| const        | 0.0802   | 0.0064    | 12.5700   | 0.0000  |

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TABLE 3. RESULTS OF THE ESTIMATION OF PANEL MODELS INVESTIGATING INFLUENCE OF TECHNOLOGICAL ODA ON TOTAL FACTOR PRODUCTIVITY

<table>
<thead>
<tr>
<th>Variable</th>
<th>Estimate</th>
<th>Std.error</th>
<th>Student t</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOANSpC</td>
<td>-3.35·10^{-6}</td>
<td>0.0000</td>
<td>-0.1410</td>
<td>0.8878</td>
</tr>
<tr>
<td>techODApc</td>
<td>0.0034</td>
<td>0.0003</td>
<td>13.5600</td>
<td>0.0000</td>
</tr>
<tr>
<td>netODApc</td>
<td>-9.49·10^{-5}</td>
<td>0.0000</td>
<td>-4.382</td>
<td>0.0000</td>
</tr>
</tbody>
</table>

SPECIFICATION 3: 2-STEP

<table>
<thead>
<tr>
<th>Variable</th>
<th>Estimate</th>
<th>Std.error</th>
<th>Student t</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>ctpf(-1)</td>
<td>0.5893</td>
<td>0.0816</td>
<td>7.2230</td>
<td>0.0000</td>
</tr>
<tr>
<td>const</td>
<td>0.0002</td>
<td>0.0007</td>
<td>0.2713</td>
<td>0.7861</td>
</tr>
<tr>
<td>LOANSpC</td>
<td>0.0002</td>
<td>0.0004</td>
<td>0.4062</td>
<td>0.6846</td>
</tr>
<tr>
<td>techODApc</td>
<td>0.0030</td>
<td>0.0013</td>
<td>2.3630</td>
<td>0.0181</td>
</tr>
<tr>
<td>netODApc</td>
<td>0.0000</td>
<td>0.0001</td>
<td>0.1490</td>
<td>0.8815</td>
</tr>
</tbody>
</table>

SPECIFICATION 4: 2-STEP GMM-SYSTEM

<table>
<thead>
<tr>
<th>Variable</th>
<th>Estimate</th>
<th>Std.error</th>
<th>Student t</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>ctpf(-1)</td>
<td>0.7247</td>
<td>0.0828</td>
<td>8.7490</td>
<td>0.0000</td>
</tr>
<tr>
<td>const</td>
<td>0.0802</td>
<td>0.0245</td>
<td>3.2730</td>
<td>0.0011</td>
</tr>
<tr>
<td>LOANSpC</td>
<td>-3.35·10^{-6}</td>
<td>0.0003</td>
<td>-0.01243</td>
<td>0.9901</td>
</tr>
<tr>
<td>techODApc</td>
<td>0.0034</td>
<td>0.0018</td>
<td>1.8670</td>
<td>0.0620</td>
</tr>
<tr>
<td>netODApc</td>
<td>-9.49·10^{-5}</td>
<td>0.0001</td>
<td>-0.6678</td>
<td>0.5043</td>
</tr>
</tbody>
</table>

SPECIFICATION 5: FIXED-EFFECT MODEL

<table>
<thead>
<tr>
<th>Variable</th>
<th>Estimate</th>
<th>Std.error</th>
<th>Student t</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>const</td>
<td>0.0094</td>
<td>0.0311</td>
<td>3.1950</td>
<td>0.0015</td>
</tr>
<tr>
<td>ctpf(-1)</td>
<td>0.7296</td>
<td>0.0736</td>
<td>9.9190</td>
<td>0.0000</td>
</tr>
<tr>
<td>LOANSpC</td>
<td>-3.35·10^{-6}</td>
<td>0.0003</td>
<td>-0.0124</td>
<td>0.9901</td>
</tr>
<tr>
<td>techODApc</td>
<td>0.0024</td>
<td>0.0012</td>
<td>1.9200</td>
<td>0.0556</td>
</tr>
<tr>
<td>netODApc</td>
<td>-7.29·10^{-5}</td>
<td>0.0001</td>
<td>-1.163</td>
<td>0.2454</td>
</tr>
</tbody>
</table>

SPECIFICATION 6: FIXED-EFFECT MODEL - FGLS ESTIMATOR

<table>
<thead>
<tr>
<th>Variable</th>
<th>Estimate</th>
<th>Std.error</th>
<th>Student t</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>const</td>
<td>0.7220</td>
<td>0.0079</td>
<td>91.7551</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>ctpf(-1)</td>
<td>0.0002</td>
<td>2·10^{-5}</td>
<td>9.0399</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>LOANSpC</td>
<td>0.0029</td>
<td>0.0001</td>
<td>18.7503</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>techODApc</td>
<td>-4·10^{-5}</td>
<td>2·10^{-5}</td>
<td>-1.5644</td>
<td>0.1177</td>
</tr>
</tbody>
</table>

Source: Own calculations.

Note: Insignificant variables are put in italics. Models 1-5 were estimated using GRETL, while model 6 - using package plm in RCRan. Small values of the coefficients are the results of the differences in magnitude.

All the specifications passed the panel diagnostic tests. The tests for Specifications 1-4 are presented in Table 4. In each case order 2 autocorrelation was not present in the errors; all models passed Sargan overidentification test, as well as Wald test. In the case of the Specification 5 the LSDV R² amounted to 0.96, while the within-one to 0.63. The null hypothesis of Hausman (1978) test (that the groups have a common intercept) was rejected with p-value lower than 0.001. Eventually, the specification 6 was estimated using general FGLS estimator of Wooldridge (2002). This estimator is robust against any type of intragroup heteroscedasticity and serial correlation (Croissant & Millo, 2008). Additionally, to account for cross-sectional dependence, we computed robust errors (using Arellano estimator) in the case of specification 5. The test confirmed significance of ctpf(-1) with p-value <0.0001 and techODApc with p-value of 0.002.

Further robustness check in this research was done in two steps. First, we controlled for the business cycle, next we included several control variables into estimated equations.
In order to take into account possible influence of the business cycle on the results we re-estimated the model for averages of variables over 5-years periods (see e.g. Islam, 1995). According to the results of Hausman (2009) and Breusch-Pagan (1980) tests, we estimated the random-effect model. The results are presented in Table 5.

**Table 4. Panel diagnostic tests - specifications 1-4.**

<table>
<thead>
<tr>
<th>Specification</th>
<th>Instruments no</th>
<th>AR(1) test</th>
<th>AR(2) test</th>
<th>Sargan test</th>
<th>Wald test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specification 1</td>
<td>175</td>
<td>-1.97 (0.049)</td>
<td>-1.22 (0.22)</td>
<td>17.23 (&gt;0.99)</td>
<td>3837.72 (&lt;0.01)</td>
</tr>
<tr>
<td>Specification 2</td>
<td>193</td>
<td>-1.87 (0.06)</td>
<td>-1.21 (0.22)</td>
<td>18.04 (&gt;0.99)</td>
<td>10175.6 (&lt;0.01)</td>
</tr>
<tr>
<td>Specification 3</td>
<td>175</td>
<td>-1.86 (0.06)</td>
<td>-1.21 (0.23)</td>
<td>17.23 (&gt;0.99)</td>
<td>111.067 (&lt;0.01)</td>
</tr>
<tr>
<td>Specification 4</td>
<td>193</td>
<td>-1.80 (0.07)</td>
<td>-1.21 (0.23)</td>
<td>18.03 (&gt;0.99)</td>
<td>754.193 (0.01)</td>
</tr>
</tbody>
</table>

Source: Own calculations.

**Table 5. Results of the estimation of the model for data averaged over 5-years intervals**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Estimate</th>
<th>Std error</th>
<th>Stat. t</th>
<th>p-value</th>
<th>Robust errors</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>0.3626</td>
<td>0.0499</td>
<td>7.2616</td>
<td>&lt;0.0001</td>
<td>0.0501</td>
<td>0.0000</td>
</tr>
<tr>
<td>TechODApc</td>
<td>0.0095</td>
<td>0.0021</td>
<td>4.4446</td>
<td>&lt;0.0001</td>
<td>0.0030</td>
<td>0.0019</td>
</tr>
<tr>
<td>LoansPC</td>
<td>-0.0006</td>
<td>0.0015</td>
<td>-0.3906</td>
<td>0.6970</td>
<td>0.0013</td>
<td>0.6412</td>
</tr>
<tr>
<td>netODApc</td>
<td>-0.0001</td>
<td>0.0007</td>
<td>-0.1199</td>
<td>0.9048</td>
<td>0.0007</td>
<td>0.9014</td>
</tr>
</tbody>
</table>

Source: Own calculations.

Note: Model was estimated in R using package plm. Robust errors computed using robust covariance matrix of parameters for a panel model according to the Beck and Katz (1995).

The Pesaran (2015) test for cross-sectional dependence returned p-value of 0.1 (we do not reject the null hypothesis of no cross-sectional dependence), while the Breusch-Godfrey (Breusch, 1978; Godfrey, 1987) test for serial correlation: p-value <0.001 (we reject the null hypothesis of no serial correlation). Thus, we re-estimated the model using robust covariance matrix of parameters for a panel model according to the Beck & Katz (1995). The resulting errors and p-values are presented in two last columns of Table 7.

In order to extend the robustness check of our results, we tested yet another specification of the model, including a list of control variables associated with technological change and growth. List of such variables used in empirical studies is very long. For instance, Durlauf, Johnson, & Temple (2006) present a number of variables used in growth equations in Solow and not-Solow models. The variables are usually associated with such categories, as institutional quality, political stability, human capital, financial development, initial level of technological development, trade openness, etc. To check the robustness of our results we included control variables from the categories presented in Table 6 in the model.

We assumed that high values of indices of political stability, as well as corruption control, should be associated with high values of total factor productivity. The good political climate supports entrepreneurship and foreign investment, lowering the so called “political
risk”. The impact of institutions on the expected levels of productivity is confirmed in the literature (i.a. Chanda & Dalgaard, 2008).

### TABLE 6. CONTROL VARIABLES - WITH LITERATURE REFERENCES

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>CONTROL VARIABLE</th>
<th>LITERATURE REFERENCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Political stability</td>
<td>Index of corruption control; Index of political stability;</td>
<td>Chanda and Dalgaard, 2008;</td>
</tr>
<tr>
<td>Level of infrastructure development</td>
<td>Access to electricity;</td>
<td>Frija et al. 2015;</td>
</tr>
<tr>
<td>Human capital</td>
<td>Primary school enrollment - gross;</td>
<td>Mankiw, Romer and Weil, 1992; Easterly and Levine, 1997; Barro and Sala-i-Martin, 2004; Klenow and Rodriguez (1997) and Krueger and Lindahl (2001);</td>
</tr>
<tr>
<td>Financial development</td>
<td>Domestic credit to private sector (% of GDP);</td>
<td>Comin, 2006; Delechat et al., 2010</td>
</tr>
<tr>
<td>Trade openness</td>
<td>Trade to GDP ratio;</td>
<td>Chanda and Dalgaard, 2008; Erken et al. (2016); Edwards (1998);</td>
</tr>
</tbody>
</table>

Source: Own elaboration.

Initial level of infrastructure development and technology readiness is approximated by the variable “access to electricity” (percentage of population with access to electricity). The variable is much diversified across the group - see Figure 5. For instance, in the case of Burundi it takes value lower than 10% (number 4), while in the case of Gabon and South Africa - over 80%. We are aware of the fact that the variable does not encompass the technological level development - therefore we define the variable “lack of electricity access”. At the same time we assume that it may approximate limited access to basic infrastructure for business. We assume that high values of this variable will be associated with low values of total factor productivity (Frija et al., 2015).

### FIGURE 5. ACCESS TO ELECTRICITY - BOX PLOT

![Box plot of access to electricity](image)

Source: Own elaboration

Note: Numbers of groups correspond to the list of countries in Table 2.
Next, we wanted to include human capital as a control variable. Usually secondary or even tertiary school enrolment is taken into account (Mankiw, Romer, & Weil, 1992; Easterly & Levine, 1997; Barro & Sala-i-Martin, 2004), but for Sub-Saharan countries relatively good quality data was available only for primary education. We consulted the literature and based on the evidence presented by Klenow & Rodriguez (1997) and Krueger & Lindahl (2001) decided to accept primary enrolment as a human capital variable. This was also justified by the fact that the study covers a region where primary enrolment ratio is very diversified across countries, which increases its discrimination value (see Figure 6). It takes the lowest values in the case of Niger (where also the literacy rate is one of the lowest in the Sub-Saharan Africa), while the highest - in the case of Gabon. Again, as we are aware of the fact that the variable does not fully encompass the level of human capital, we define the opposite variable - no enrolment to primary school \( \text{lackOfPrimaryEdu} = (100 - \text{PrimarySchoolEnrollment}) \). The variable catches the underdevelopment of human capital, and we assume that it will be associated with low values of total factor productivity (see: de la Fuente & Donénech, 2006).

**Figure 6. Gross Enrolment to Primary School – Box Plot**

![Box Plot](source)

*Source: Own elaboration*

*Note: Numbers of groups correspond to the list of countries in Table 2.*

When it comes to financial market development, we took the variable of access of private enterprises to credit. It measures the ability of financial sector to provide financial services and the density of such operations in the market perspective (to GDP ratio). Such quantification of the extent of financial market development is acceptable from the point of view of the study. The financial development and productivity correlation are presented in Figure 7.

We observe that the most financially developed economy is South Africa. Banking systems and the use of credit in all other economies in the region is lesser - even in the case of Gabon that was the leader in the previous categories. Apart from the South Africa, the highest value of the variable is observed in the case of Namibia and Zimbabwe. We assumed that high value of financial development should be associated with higher value of total factor productivity, as the access to credit stimulates individual entrepreneurship.
FIGURE 7. DOMESTIC CREDIT TO PRIVATE SECTOR – BOX PLOT

Source: Own elaboration
Note: Numbers of groups correspond to the list of countries in Table 2.

FIGURE 8. TRADE OPENNESS – THE CASE OF SSA

Source: Own elaboration.
Eventually, we take into account trade openness (Chanda & Dalgaard, 2008), measured through the ratio of trade to GDP (Figure 8). The highest values of the variable were observed for Swaziland, while the lowest for Burundi, Niger and Rwanda. No data were available for Lesotho. We assume that the higher value of trade openness should be
associated with higher value of total factor productivity. Following Chanda & Dalgaard (2008) and Erken, Donselaar, & Thurik (2018) we assume that the openness of an economy implies a higher level of competition from abroad. This functions as an incentive for firms to innovate, given they dispose of a certain amount of R&D capital (see also Edwards, 1998). Furthermore, more competition stimulates firms to reduce their X-inefficiencies (Leibenstein, 1966).

Results of the estimation for each specification are presented in Table 7. In the case of each specification technical aid per capita appeared to be significant (in the case of models where asymptotic errors were not assumed - at least at 10% significance level). In each specification, the signs of parameters were economically significant, i.e. lack of electricity and lack of primary education were associated with lower productivity, while trade openness, development of financial market, political stability - with higher productivity values. This suggests that in a state where government increases access to education and infrastructure and fosters the development of market institutions, technical aid may be absorbed and contribute to total factor productivity. In the case of each specification high values of technological aid received were associated with higher productivity.

Eventually, to check the validity of the estimates, we re-estimated the model, taking into account 5-year averages of the TFP and the control variables and using the robust covariance matrix. The results are presented in Table 8. We observe that technical aid still remains the significant explanatory variable.

**Table 8. Estimates of the Model with Control Variables and Using Robust Covariance Matrix**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Estimate</th>
<th>Std error</th>
<th>Stat. t</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Intercept)</td>
<td>0.3465</td>
<td>0.1417</td>
<td>2.4449</td>
<td>0.0169</td>
</tr>
<tr>
<td>TradeToGDP</td>
<td>0.0019</td>
<td>0.0008</td>
<td>2.3944</td>
<td>0.0193</td>
</tr>
<tr>
<td>TechODApc</td>
<td>0.0093</td>
<td>0.0025</td>
<td>3.7356</td>
<td>0.0004</td>
</tr>
<tr>
<td>ElectricityLack</td>
<td>-0.0017</td>
<td>0.0015</td>
<td>-1.1211</td>
<td>0.2660</td>
</tr>
<tr>
<td>CorruptionControl</td>
<td>0.0028</td>
<td>0.0405</td>
<td>0.0687</td>
<td>0.9454</td>
</tr>
<tr>
<td>CreditToPrivateSector</td>
<td>0.0016</td>
<td>0.0014</td>
<td>1.1326</td>
<td>0.2612</td>
</tr>
<tr>
<td>lackOfPrimaryEdu</td>
<td>0.0005</td>
<td>0.0006</td>
<td>0.8666</td>
<td>0.3891</td>
</tr>
</tbody>
</table>

Source: Own calculations.

In order to explain the lack of the impact of the overall net ODA provided by DAC countries to Sub-Saharan Africa in the studied period we refer to the concepts of humanist interpretation and public choice theory. Both of these theoretical frameworks assume rationality of agents in realization of their goals (Buchanan & Tullock, 1962; Kmita, 1991). Generally, aid policies tend to be motivated by donor interests rather than recipient needs (Dreher et al., 2016). Hence, limited effects of aid are in fact consistent with the development cooperation policy. Only by changing the motivation of the system, aid effectiveness may be increased. However, positive impact of technical aid on productivity detected in the period 1995-2014 suggests, that direct actions may be less affected by the general malfunctions of the development cooperation system. Well-designed instruments may avoid syndromes described i.a. by Moyo (2009) or Fosu (2013). Technical cooperation which involves person to person relations, appeared to be more productive, than the financial aid transfers administrated by both donors and beneficiary.
bureaucratic structures. It seems that the individuals are motivated by utility-maximizing considerations in the technical projects realization. Successful projects create an opportunity for mutual gains for the agents (project employees and local community) in the field project operations (Buchanan & Tullock, 1962).

It seems that the grass root level of “trading” aid assets may contribute more to the overall economy, than the state level allocation of financial assets where bureaucratic interests and top-down planning overwhelm markets and fail. This is consistent with Malunga (2014), who claims that it is the clarity of the issues of culture, identity, and spirituality that enables people to articulate their agenda and the type of development they want. This issue is especially pivotal while engaging in relations with external entities, often stronger parties, like aid donors. Technical cooperation, as a type of intervention involves human interactions, which can evolve in time. People working on projects get more involved and find it rationale to engage in aid activities. They gain the advantage of a local perspective, over the “European office” perspective. Effectiveness of technical cooperation may be further explained in the light of the results of Walley & Cushing (2013) research'. They indicate that development aid directed at activities which enhance knowledge accumulation and skills development of the work force are more likely to improve productivity and long-run growth in Sub-Saharan African countries. Therefore, technical aid is an instrument likely to empower local communities, which are involved in project realisation.

At the end we want to stress that there are several limitations of this study, especially the data availability for the countries from Sub-Saharan Africa. It would be very interesting to analyse the impact of sectoral aid on productivity. However, the data on decomposed aid is available only from 2005. Also, due to data unavailability not all Sub-Saharan African economies were included in the study (see Table 2). Next, net ODA is itself aggregated and technical aid flows are included in this aggregate. Similarly, the data on loans received is also of aggregated nature - the loans may be received for various purposes - not only to stimulate productivity.

6. Conclusions

The goal of the study was to assess the empirical influence of OECD DAC aid flows on productivity growth in Sub-Saharan Africa over the period 1995-2014. 24 countries from the region were included in the study. Based on the dynamic panel model estimation we found that - regardless of the model specification - technical aid flows are significantly linked to increased productivity in the region. Thus, we suppose that technical cooperation spurs technological progress in Sub-Saharan Africa. This may suggest that the ongoing criticism of aid may have resulted in some types of aid activities.

Based on the development cooperation experiences from the 20th century in Sub-Saharan Africa, not many scholars (nor politicians) expect development aid to actually work. Therefore we decided to check if the declarations of DAC countries to improve aid effectiveness in the New Millennium were implemented in recent aid practice. Despite the initial optimism, the GMM panel analysis of the impact of aid flows on productivity in 24 Sub-Saharan countries suggests, that indeed the aid system generally does not work. However, based on our results, we claim that technical cooperation is the exception. A positive and significant effect of technical cooperation on productivity in the studied period suggests, that actions which are oriented directly towards technical progress in
recipient countries create better effects for productivity than other aid instruments. Hence, we suppose that the mechanisms of aid distribution and the degree of agents’ involvement in the process are crucial for aid effectiveness. This is valid in the context of the rent seeking phenomena in the recipient and the donor countries and the problem of subordination of aid agenda to foreign policy and personal gains. We argue that it is vital to reflect over aid practice rather than compromise it a priori.

Some policy implications may be formulated based on the results of this study. First, decreasing the poverty gap by short-term aid initiatives is unlikely. The effectiveness of technology transfer via development aid channels requires establishment of long-term mechanisms for knowledge, know-how and technology absorption. Second, growing threat of terrorism, social exclusion, and illegal economic migrations prove, that refusing to admit aid subjection to donors’ economic and geostrategic policies has backfired. If not for good reasons, then at least from common-sense, aid system should be concentrated on recipients’ needs and aimed especially at development of productivity-oriented technology. Fostering the capacity of aid recipients to develop on their own technology may initiate the indispensable structural changes of their economies. Based on the evidence presented in this paper, the adjustment of foreign impact to local demand and capacity appears to be indispensable to translate technology into productivity increase in the recipient country.

Some states are more independent in shaping their policies, while others depend on foreign entities (transition countries in Central Europe being a clear example of that) (Berglof, 2015). In the case of the low- and middle-income African countries, their policies were under a strong influence of international financial institutions and the DAC community in the modern history. Development assistance system was exploited instrumentally for that purpose (Chauvet & Collier, 2009). However lately, the hegemony of Western thought has been destabilized under growing pressure of China presence in Africa. The idea of economic liberalization without democracy grows to be as an alternative for Sub-Saharan states and their leaders. The dominance of the Western type of thinking in international economics in the following years is threatened and there appears temptation to use the aid as a tool of interests (not as a development driver). Development cooperation once again may play an important role in the international geopolitics, not in poverty fight.

Acknowledgment

The research is supported by Polish Ministry of Science and Higher Education through the Project SONATA: 2013/\09/D/HS4/01849 (Mechanisms of technology absorption in Sub-Saharan Africa). The authors would like to thank the participants of the International Conference on Emerging Markets Economies – Euroconference 2016 (29.06-01.07.2016, Porto, Portugal) for the discussion and comments on the early version of this paper.

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Appendix

Table 9. Description of the data used in the study

<table>
<thead>
<tr>
<th>VARIABLE</th>
<th>DESCRIPTION</th>
<th>SOURCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>ctfp</td>
<td>TFP level at current PPPs (USA=1)</td>
<td>PennWorldTables</td>
</tr>
<tr>
<td>population</td>
<td>Population in millions</td>
<td>PennWorldTables</td>
</tr>
<tr>
<td>techODApc</td>
<td>Technical ODA received in constant US dollars (2015) – per capita</td>
<td>OECD</td>
</tr>
<tr>
<td>netODApc</td>
<td>Total ODA received in constant US dollars (2015) – per capita</td>
<td>OECD</td>
</tr>
<tr>
<td>netLoansPc</td>
<td>Net loans received in constant US dollars (2015) – per capita</td>
<td>OECD</td>
</tr>
<tr>
<td>PoliticalStability</td>
<td>Political Stability and Absence of Violence/Terrorism measures perceptions of the likelihood of political instability and/or politically-motivated violence, including terrorism. Estimate gives the country's score on the aggregate indicator, in units of a standard normal distribution, i.e. ranging from approximately -2.5 to 2.5.</td>
<td>World Government Indicators through the World Bank database. The WGI are produced by Daniel Kaufmann (Natural Resource Governance Institute and Brookings Institution) and Aart Kraay (World Bank Development Research Group). See also: <a href="http://www.govindicators.org">www.govindicators.org</a> and Kaufman et al. (2010)</td>
</tr>
<tr>
<td>CorruptionControl</td>
<td>Control of Corruption captures perceptions of the extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as &quot;capture&quot; of the state by elites and private interests. Estimate gives the country's score on the aggregate indicator, in units of a standard normal distribution, i.e. ranging from approximately -2.5 to 2.5.</td>
<td>World Government Indicators through the World Bank database.</td>
</tr>
<tr>
<td>PrimarySchoolEnrolment</td>
<td>Primary school enrolment (gross). Gross enrollment ratio is the ratio of total enrollment, regardless of age, to the population of the age group that officially corresponds to the level of education shown. Primary education provides children with basic reading, writing, and mathematics skills along with an elementary understanding of such subjects as history, geography, natural science, social science, art, and music.</td>
<td>United Nations Educational, Scientific, and Cultural Organization (UNESCO) Institute for Statistics.</td>
</tr>
<tr>
<td>TradeToGDP</td>
<td>Trade (the sum of exports and imports of goods and services) measured as a share of gross domestic product.</td>
<td>World Bank national accounts data, and OECD National Accounts data files.</td>
</tr>
<tr>
<td>AccessToElectricity</td>
<td>Access to electricity is the percentage of population with access to electricity. Electrification data are collected from industry, national surveys and international sources.</td>
<td>World Bank, Sustainable Energy for All (SE4ALL) database from the SE4ALL Global Tracking Framework led jointly by the World Bank, International Energy Agency, and the Energy Sector Management Assistance Program.</td>
</tr>
<tr>
<td>FinDepositsToGDP</td>
<td>Financial system deposits to GDP (%). Demand, time and saving deposits in deposit money banks and other financial institutions as a share of GDP. Raw data are from the electronic version of the IMF’s International Financial Statistics. Financial system deposits (IFS lines 24, 25, 44, 45, FOST and FOSD); GDP in local currency (IFS line NGDP); end-of period CPI (IFS line PCPI); and average annual CPI is calculated using the monthly CPI values (IFS line PCPI).</td>
<td>International Financial Statistics (IFS), International Monetary Fund (IMF)</td>
</tr>
<tr>
<td>DepositMoneyToGDP</td>
<td>Deposit money banks' assets to GDP (%). Claims on domestic real nonfinancial sector by deposit money banks as a share of GDP. Raw data are from the electronic version of the IMF’s International Financial Statistics. Deposit money bank assets (IFS lines 22, a-d, International Financial Statistics (IFS), International Monetary Fund (IMF).</td>
<td></td>
</tr>
</tbody>
</table>
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<table>
<thead>
<tr>
<th>VARIABLE</th>
<th>DESCRIPTION</th>
<th>SOURCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>FOSAG, FOSAOG, FOSAON and FOSAOP</td>
<td>GDP in local currency (IFS line NGDP); end-of period CPI (IFS line PCPI); and average annual CPI is calculated using the monthly CPI values (IFS line PCPI).</td>
<td></td>
</tr>
<tr>
<td>CreditToPrivateSector</td>
<td>Domestic credit to private sector (% of GDP). Domestic credit to private sector refers to financial resources provided to the private sector, such as through loans, purchases of nonequity securities, and trade credits and other accounts receivable, that establish a claim for repayment. For some countries these claims include credit to public enterprises.</td>
<td>World Development Indicators (WDI), World Bank</td>
</tr>
</tbody>
</table>

Source: Own elaboration.