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Institutions and other Determinants of Total Factor Productivity in Sub-Saharan Africa

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Abstract

The primacy of factors of production, such as labour and capital, over Total Factor Productivity (TFP) in stimulating economic growth, has long been a contentious subject in discussions on the underlying causes of economic growth. While the roles of labour and capital have been exhaustively explored, TFP still has room for further exploration, more specifically in sub-Saharan Africa (SSA). This study empirically examines the link between institutions and TFP in SSA, while controlling for other frequently explored variables, for example, research and development, human capital, infrastructure and financial development. The estimations provided in the study are based on a panel of 26 sub-Saharan African countries over the period 1990–2011. We find that, while some of these factors affect TFP in the long-run, there is a consistent relationship with institutions as well. We also find that market-based institutions play a more prominent role than the more frequently explored political institutions.

Keywords: Total Factor Productivity (TFP), economic growth, sub-Saharan Africa, market-based institutions, human capital, financial development.

1 Introduction

Total factor productivity (TFP) is often considered in tandem with other factor inputs as drivers of growth. In sub-Saharan Africa (SSA) and other parts of the world, productivity growth is an avenue that has often been explored as a possible source of growth. This becomes even more pertinent when trying to decipher the sources of positive or negative growth, especially in the light of growth spurts experienced by many developing countries between 1990 and the

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mid-2000s. In the case of SSA, the available evidence suggests that other elements beyond mere factor accumulation most likely contribute to these growth patterns in terms of TFP at the aggregate level (Acemoglu & Zilbotti, 1999; Devarajan *et al.* 2003; Fosu, 2012). This suggests some saliency of TFP relative to normal factor productivity in SSA.

Factor productivity is often higher in more developed countries than in their less developed counterparts. Hall & Jones (1999) reported that workers in the USA had 35 times the output of workers in Niger. Not much has changed since then, as many developing and sub-Saharan African countries are still considerably less productive than their developed counterparts. The importance of total factor productivity as a stimulant in the performance of an economy is agreed upon in most of the literature on economic growth (Solow, 1956; Kydland & Prescott, 1982; Romer, 1990; Agion & Howitt, 1992). What is not always agreed upon is its importance relative to factor accumulation. Total factor productivity is defined as that portion of a country's output which is not accounted for in the corresponding level of inputs employed in production. In other words, while the optimal utilisation of labour and capital is very important in any country, the degree of efficiency with which they are employed is what constitutes total productivity. This is also often referred to as technological progress. In simplistic terms this can be explained by extracting, from a production function, those changes in total output that are not solely due to increases in the corresponding production factors. Thus TFP indicates how efficiently production factors are being used in production. As such, the aim of any functional economic system should be to maximise efficiency in production through continued technological progress or growth in total factor productivity.

In the past, the standard neoclassical approach to economic theory viewed this phenomenon as exogenous to the system, thereby failing to create the necessary incentives for countries to seek ways to improve it (Ramsey, 1928; Solow, 1956; Samuelson, 1958). However, this idea has been challenged successfully and it is now generally accepted that total factor productivity is, in fact, endogenous to a country's production (Schumpeter, 1978; Romer, 1986; Lucas, 1988). It is therefore not surprising that, primarily as a consequence of the seminal work of Romer (1986), a number of studies have explored both the role of total factor productivity on growth, and the determinants of total factor productivity. While empirical evidence supporting the importance of the former has been quite conclusive, the same has not been true in terms of the latter. Exploring this aspect of TFP is therefore of great importance to many developing countries that continue to suffer as a result of the inefficient usage of resources. Accordingly, this study aims to explore the determinants of total factor productivity and their contribution to overall economic growth in greater depth. Some of these determinants have, in fact, been explored in the literature, and these include innovation, research and development incentives or subsidies, the abundance of skilled labour, changes in the size of the market, etc. (Romer, 1990; Aghion & Howitt, 1992; Hall & Jones, 1999; Comin, 2006; Akanbi, 2011). These determinants are not always mutually exclusive. For example, the link between innovation and institutions is a well-researched empirical area (Schum-

peter, 1934; Park & Ginarte, 1997; Acemoglu 2008; Park 2008). This study however focuses on institutions as a possible determinant of TFP growth in Africa.

Along with other developing countries, the analysis of the role of institutions in SSA countries (and of other developing countries) by researchers have often used the rather broad but inadequate definition of institutions coined by North (1990), in which institutions are defined as humanly devised constraints that shape human interaction. In less formal terms, institutions are considered as rules of the game within a society aimed at structuring incentives in human exchange. While generally accepted, this broad definition highlights one of the primary obstacles encountered when analysing institutions, namely the failure to clearly indicate which specific institutions are being addressed in terms of the range of possible institution types (Aron, 2000). The research by Acemoglu *et al.* (2001, 2005 & 2012), and Glaeser (2004), appropriately highlighted the flawed approach taken by some empirical studies by failing to recognise the endogeneity of institutions and the need to unbundle institutions into more understandable segments. For example, many studies simply capture a particular country's institutional environment as a composite of institutions (both political and economic/market) with several sub-categories. Because of this oversimplified clustering of many different types of institutions into one composite measure, it becomes virtually impossible to draw meaningful inferences from the evidence presented. Given these concerns, it would be useful to explore institutions from a narrower and more readily interpretable perspective, rather than to make use of a composite measure,[1] even if this is at the risk of capturing only certain features of the institutional environment of a country.

For this study to make a significant contribution towards understanding the dynamics of TFP in SSA, the development of an adequate measure of the two variables of interest becomes very important. Once we have identified ideal proxies for institutions and for TFP, we will then be able to explore the significant role of institutions as one possible determinant of TFP growth in SSA. Accordingly, this study seeks to address two pertinent questions, namely: Do institutions play a significant role in determining TFP in SSA? And, how does the role of institutions compare to other core determinants found in the literature, such as human capital, research and development, infrastructure, financial development, macroeconomic stability, etc.

These questions contribute to the body of literature, especially in the case of SSA. It is particularly surprising that these questions have not yet been explored in any great depth, especially given the fact that, in the past decade, many African countries have experienced high growth spurts similar to that experienced by some Asian countries between 1980 and 2010. The majority of studies on TFP explored the possible role of TFP and its determinants in these growth spurts, but most have focused on Asia. The reason for the lack of empirical inquiry into the SSA environment is partly due to the lack of adequate

[1] For example, it becomes quite difficult to pinpoint which of the measures within the composite index is the source of the observed variation.

data on variables such as labour force participation, research and development, and institutions. Additionally, even though the relevant data is now being collected by multilateral institutions such as the IMF and World Bank, the period of coverage is still very limited, thus severely restricting the capacity for empirical inquiry. Moreover, the role that institutions play has been examined within many different contexts on the continent.[2] Despite these studies there are many other aspects of the role of institutions within various contexts that still need to be appropriately categorised, TFP being one of them. The link between institutions and some of the core determinants of TFP, such as financial development, research and development, and GDP, has been well documented in the literature on institutions (Lynn *et al.* 1996; Nelson & Nelson 2002; Chinn & Ito, 2006; Acemoglu, 2008; Jones & Romer, 2010). This paper therefore fills an important gap in the literature.

The results obtained from the empirical estimations show that the two different types of institutions considered in this study show an important long-run link with TFP. However, it appears that market-based economic institutions feature stronger than political institutions in terms of economic growth. The results further suggest that, in the absence of institutions in the empirical models, some of the other core determinants of TFP appear to have inflated elasticities, but this diminishes in magnitude once institutions are controlled for. Finally, while not being the most strongly linked determinant to TFP, institutions do surface as one of the stronger determinants of TFP in the long-term.

The remainder of the study is arranged as follows: The next section discusses the theoretical framework underlying the study. Sections 3 and 4 contain the analysis of the data and a discussion of the empirical approach respectively, while section 5 analyses the results. The final section (6) contains our concluding remarks.

2 Theoretical framework

Classical growth theory has always identified capital and labour as the main sources of output in an economy, while other sources of production were considered to be exogenous to the system. In essence, all factors, such as institutions, technological progress, total factor productivity, etc., were considered to be exogenous. In the neoclassical framework, however, growth is viewed as stemming from two possible sources namely, the accumulation of factors such as labour and capital, as well as from growth in productivity. The combination of these two sources of growth comprises the notion of total factor productivity referred to in this analysis. In the past the issue of which of the two sources would be more important for economic growth, has been a point of contention. This study does not follow the same approach. The key point here is the determination of productivity. Whereas the relationship between factor accumulation and economic growth is well understood, the relative contribution of productivity

[2] This includes the role of institutions in determining economic growth, conflict, foreign direct investment, and many other phenomena.

to growth is not a well understood and theorised relationship. Furthermore, in terms of the primary focus of this study, total factor productivity is not readily measured in the literature.

Unlike theoretical support for determinants of TFP, the relationship between institutions and economic performance has been well theorised (North, 1989, 1990; Knaack & Keefer, 1995; Acemoglu *et al.* 2001; Glaeser *et al.* 2004). Similarly, the relationship between TFP and economic growth has been equally well examined (Solow, 1957; Fare, Grosskopf, Norris, & Zhang *et al.* 1994; Chen, 1997; Baier, Dwyer & Tamura, 2006; Griliches, 2007; McMillan & Rodrik, 2011). However, the relationship between institutions and total factor productivity has not been explored much. This relationship can be viewed as an expansion of the relationship between innovation, technological progress and economic performance. In this particular approach, institutions are viewed from the perspective of patent laws which govern ownership, and the ability to extract returns from research and development. This is in harmony with North's (1989) approach in which institutions are viewed from a transactional perspective[3].

Mehlum et al (2006) extends North's institutional approach by categorising institutions into two types: producer-friendly institutions and grabber-friendly institutions. In the former case, production complements rent seeking in the economy (i.e. investment), while in the latter, production competes with rent seeking (i.e. loans/debts). In this parlance, political institutions are viewed as elements of a market system that either complement productivity or compete with it. An application of this relationship is found in the interdependence between innovation, technological progress and institutions. Firms need to be assured of their ability to regain profits from the investments into research and development through the institutional environment. Innovating firms will then have the assurance that the rule of law will protect the use, by other parties, of their intellectual property rights, thus creating an environment where the benefits of innovation and new technological developments would contribute to their earnings. This will encourage continued investment in R&D, which, in turn, leads to technological progress and increased productivity in the economy.

Many other determinants of TFP have been examined in the literature, and the findings support the empirical evidence for the existence of a host of other macroeconomic variables that equally influence TFP in SSA. This includes variables such as trade openness, external debt, macroeconomic stability, policy syndromes, human capital, financial sector development, governance, economic growth, infrastructure, and research and development, among others (Edwards, 1998; Miller & Upadhyay, 2000; Olson *et al.* 2000; Akinlo, 2006; Bronzini & Piselli, 2009; Akanbi, 2011; Fosu, 2012). Given the large variety of macroeconomic variables linked to productivity, it is important to pinpoint those variables that feature consistently in the majority of these studies, and are relevant within the context of our study.

While the link between institutions and TFP is the primary focus in this

[3] In terms of North's discussion, interactions between individuals are riddled with high levels of uncertainty, and as such necessitate the creation of institutions that would then ensure high levels of trust and confidence and low levels of uncertainty during interactions.

study, this does not imply that the link with other potential determinants is of less importance. The role of R&D in enabling TFP growth has often been highlighted in endogenous growth models (Romer, 1990; Grossman & Helpman, 1991). However, the premise here is that increased R&D activities would serve to promote the diffusion of knowledge and innovation, which, in turn, would drive productivity growth. Likewise, human capital is believed to enhance productivity growth because higher levels of education will increase the ability to use and improve pre-existing technologies more efficiently (Lucas, 1988). When considering the link between public infrastructure and productivity growth, it goes without saying that better quality roads and road network systems would lead to greater productivity, or that improved access to electricity would enable manufacturing companies to be more productive. However, the empirical evidence underlying these supposedly obvious conjectures remain controversial, and contrary to what might be expected, there seems to be very little consensus on this. This could be because the need for improved infrastructure in most developed countries is minimal in comparison to the majority of SSA countries where there are substantial gaps in the availability of infrastructure. Thus, despite the apparent lack of consensus, public infrastructure remains an important potential determinant worthy of consideration in the empirical analysis of the determinants of TFP growth in SSA. Against this background, the following model of the TFP is adopted in this study:

$$tfp_{it} = f[gdp_{it}, pl_{it}, govt_{it}, trade_{it}, pop_{it}, ms_{it}, \inf ra_{it}, hc_{it}, rd_{it}, inst_{it}] \quad (1)$$

where tfp_{it} is the total factor productivity, gdp_{it} is the gross domestic product, pl_{it} is the price level (proxy for macroeconomic stability), $govt_{it}$ is the total government expenditure (proxy for fiscal discipline), $trade_{it}$ is the trade openness (measured by the sum of exports and imports divided by GDP), pop_{it} is the total population, ms_{it} is the M2 money supply (proxy for financial development, measured as a ratio of GDP), $\inf ras_{it}$ is the physical infrastructure index, hc_{it} is the index for human capital as measured in world Penn tables, rd_{it} is the level of research and development (measured by the total number of journals published), $inst_{it}$ is the level of institutions measured in terms of the polity index and the Fraser Institute property rights index, and $i\&t$ are the cross-sections and time periods respectively.

3 Data analysis

The data used in this study – from 26 SSA countries and covering the period 1990 to 2011 – were obtained from the World Bank Development Indicators databank and the World Penn Tables respectively. All data were measured in real terms (2005 prices) and in US dollars. All variables are expressed in natural logarithms. In cases where variables have negative values, a general transformation (i.e. adding each series by a constant) was performed and thereafter the natural logarithm was taken. The time period covered is based on data availability. The data from most SSA countries are more reliable from 1990 onwards,

and the time period was limited to 2011, based on the latest updated data from the Penn World Tables from which the variables human capital, price level, and government spending were obtained.

Furthermore, given the paucity of data that cover extended periods of time in SSA, it is important to identify proxies that are both long-term and would still capture the macroeconomic phenomena relevant to this study. This requires narrowing down the variables of interest for our analysis, to those with available proxies, ample data points, and which are generally adequate for analysis in the context of the institutional determinants of TFP. The determinants we control for include the most common determinants of TFP as highlighted in the empirical literature.

Based on the above, the following provides a detailed explanation of how some variables used in the study were generated.

3.1 Measuring TFP

The issue of total factor productivity estimation has been the focus of many studies on factor productivity, thus providing a sound basis for further empirical investigation. For this reason not much attention is given in the present study to the estimation of productivity. Our primary aim here is to adopt the direct measurement approach and focus on the determination of TFP instead. In the past the residual approach was the more common measurement technique. The residual approach, formally known as the Solow residual, was developed by Solow in his seminal paper Solow (1957). However, this measurement approach requires that growth rates for factor inputs be accurately measured. Additionally, it can only be analysed in the presence of perfectly competitive factor markets within a neoclassical framework. In essence, accurately capturing TFP using the Solow residual approach is conditional upon some requirements that are difficult to accomplish in most sub-Saharan African countries.

To circumvent this problem, subsequent studies introduced an alternative approach to the growth accounting Solow residual approach. This approach involves the use of a direct measurement technique by extracting the "A" component from the traditional neoclassical production function. This measurement approach avoids many of the assumptions and conditions that are attached to the Solow residual approach. Studies which have employed it include works by Nadiri (1996), Hall & Jones (2002), and Fedderke & Bogetic (2009). In these studies, the subject of concern is often the relationship between TFP and economic growth.

To capture TFP, we used the simple endogenous production function and solve for A, which in the past, from the perspective of the classical growth theory, was often considered to be an exogenous factor. Consider the simple Cobb-Douglas production function:

$$Y = Af(K^{\infty}L^{1-\infty} \tag{2}$$

Solving for the changes in output not due to changes in factors inputs, we

solve for the parameter A, which gives:

$$A = \frac{Y}{K^{\infty} L^{1-\infty}} \tag{3}$$

To calculate this for SSA, we need to obtain values for the coefficient of capital and labour in equation (2). In doing so, the production function was estimated for each country, and the estimated coefficients of capital and labour were then used to calculate "A" in equation (3). We used gross fixed capital information from the World Bank data bank as a measure for capital stock. In the absence of labour force data, the labour force participation rate was multiplied by the adult population in order to derive a proxy for employment. Given that the labour force participation data in Africa only becomes consistent post 1997, an extrapolation was carried out to obtain the rates for the year 1990 and onwards.[4]

1. Measuring institutions

Institutions are important for economic growth, and this has been proven without reservation. Although such a consensus exists, questions pertaining to the type of institution, its nature and whether or not it is viewed as a 'good' or 'bad' institution, still abound. Furthermore, is a good or bad institution consistently good or bad in absolute terms across all different countries, regions and economic systems the world over? Moreover, the nature of institutions under consideration is often not clearly stated or consistently inferred, which leads to vagueness in the results obtained. Many previous institutional analyses were flawed due to these inherent ambiguities. These are pertinent issues that need consideration when analysing the role of institutions within any subject area. The lack of a clear stance on these subjects, make the accuracy of the inferences made from the empirical outcomes questionable. Although the focus on this study is mainly on the role that institutions play in determining productivity, we also attempt to address some of these concerns.

Admittedly, the institutions investigated in this study cover a wide spectrum (political and economic), and as such, we do not focus on any particular aspect of these institutions. A common problem when dealing with a wide array of institutions is to decide what constitutes a 'good' or a 'bad' institution, and the answer to this question would vary significantly across different regions, countries, customs and economic systems. This can be problematic for empirical analysis as results may show institutions to be negatively linked with TFP and growth, which is contrary to what has been concluded in much of the growth literature. However, such an outcome would not be entirely implausible. For example, Kahn (2012) touched on this subject in a comprehensive analysis of various institutions and highlighted the differences in the dynamics observed when comparing developed and developing countries. The study suggested,

[4] Data on labour force participation from ILO and the World Bank are mostly available post 1996 and later for most of the countries in the data set. We intrapolate the data available back to 1970, but only use data from 1990 onwards for our analysis.

for example, that some 'good' institutions in the west may, in fact, have a detrimental impact on developing countries. This premise is based on the fact that institutions in developing countries, even though they appear good on paper, are prevented from operating efficiently due to the lack of the necessary infrastructure.

We allow for the possibility of such an outcome in this analysis. A common example from many SSA countries over the past decade can be seen in the interplay of democracy, voting rights and rotating governance. The rationale is that administrative changes in the polity are good for a good institutional environment. However, what has played out in some SSA countries such as Rwanda and the Seychelles, among others, is the voting (in free and fair elections) into power over several terms of the same administration ¯ something the global community often takes exception to. If viewed as a valid and democratic procedure, the outcome would be perceived as positive. However, it will most likely be construed as "bad" for the institutional environment, since it may be viewed as impacting negatively on institutions. From the local voters' perspective, however, it is seen as a positive institutional outcome.

To accommodate some of these concerns, we use three different measures of institutions to capture both political and market-based institutions. We employ the often-used Polity series and the Freedom House index as proxies for political institutions, and the property rights indices from the Fraser Institute to capture market-based institutions. The Polity IV index ranges from -10 to 10, with -10 signifying a complete absence of a fully democratic and free political system and 10 signalling the presence of such a system. The Freedom House index scale ranges from 1 to 7, with 7 representing the lowest degree of political freedom, and 1 representing the highest. As such, a negative coefficient on the Freedom House index for political rights would indicate a positive relationship between political rights and TFP. The Fraser Institute index, on the other hand, ranges from 0 to 10, with 0 representing the lowest level of freedom, and 10 representing the highest.

We decided on these three measures of institutions as they cover a relatively long time period for most SSA countries, while providing a proxy to examine both the political and the economic aspects of institutions, as well as the respective roles they play in determining TFP. Taking into account some of the findings in the literature, we expect to find a positive link between TFP and both the Polity IV and Fraser Institute indices. We also anticipate a negative sign on the coefficient linking the Freedom House index and TFP.[5]

3.2 Measuring infrastructure

In order to capture infrastructure in a broader context and not to depend on single infrastructure stock alone, the study further generated a composite Physical Infrastructure Index (PII), which is based on three infrastructure stocks,

[5] A negative coefficient on the institutional factor is still a plausible outcome, given the previous explanations i.e. (the backlog of infrastructure development which inhibits the ability to take advantage of sometimes positive institutional outcomes)

namely roads, telecommunications and electricity. Following the lead in Akanbi (2015, 2013), Calderón and Servén's (2004) approach was adopted in building an aggregate index that combines the three infrastructure stocks. Calderón and Servén's idea was premised on the fact that many of the variations in a particular infrastructure stock across countries are explained by differences in these countries' geographic and demographic characteristics. Therefore, to construct the PII, the first step was to take the residuals from the regression of a particular infrastructural stock[6] and to measure each infrastructural stock respectively as the total road network per 1 000 km, the electricity generation per 1 000 people, and the number of telephone subscribers (main lines and mobile phones) per 1 000 people.

To aggregate the residual series derived from each regression, the Principal Component Analysis (PCA) was adopted and the first eigenvectors (loading matrix) from the principal component analysis were used as the required weights. This produced the following linear combination:

$$PII = \alpha_1 X_1 + \alpha_2 X_2 + \alpha_3 X_3 \tag{4}$$

where α_1, α_2, and α_3 are the eigenvectors (weights) from the PCA, and X_1, X_2, and X_3 are the three synthetic infrastructure stocks (see detailed explanation in Akanbi 2015).

3.3 Other determinants

To capture some of the more common determinants such as research and development, human development and financial development, we used journal publications, the human capital index and broad money respectively. We anticipate that the relationship between the three variables and TFP will be a positive one, given the findings in recent literature on the subject (Miller & Upadhyay, 2000; Olson *et al.* 2000; Akinlo, 2006; Bronzini & Piselli, 2009; AW *et al.* 2009; Akanbi, 2011).

4 Empirical approach

In determining the ideal empirical approach for the analysis, a number of decisions had to be made. Given that we are dealing mainly with aggregated macroeconomic observations, the noise accompanying the macroeconomic data could potentially disturb the outcome. Additionally, issues of endogeneity are also relevant and had to be addressed. In this particular study, endogeneity could surface from a number of areas. Given the fact that the model uses the Cobb-Douglas production function, and that macroeconomic variables make up the parameters, it is probable that several variables in the system may be jointly determined. For example, it is possible that a factor such as "good institutions"

[6] Each infrastructural stock (i.e. roads, telecommunications and electricity) is regressed on the labour force, urbanisation ratio and land area.

could be jointly determined with macroeconomic stability, and the same can be said for increases in government spending and the resultant changes in GDP. Therefore, in a model where variables are captured at the macro level and are therefore all endogenous, the possibility of bias due to endogeneity becomes very high. Consequently, many of the explanatory variables may be correlated with the error term. This means that the results obtained from estimating the production function using, for example, the OLS approach, may result in inconsistencies due to endogeneity emanating from simultaneity bias. Moreover, there is also the possibility of reverse causality arising from the performance of the explanatory variables due to changes in productivity. It has been shown that growth itself has a reinforcing impact on productivity (Olson *et al.* 2000).

With these concerns in mind, it was important to determine the best estimation technique for our purpose. A possible estimation technique would be to use an instrumental variables technique to account for all the endogenous variables, or any other technique that allows for the instrumentation of endogenous variables. The challenge arising from using any of these estimation techniques resides in the paucity of alternative measures to capture certain variables. This is a challenge peculiar to SSA. Obtaining adequate orthogonal proxies to instrument for all the endogenous variables would not be plausible in this case.

Given these considerations, an appropriate estimation of the elasticities of TFP requires the use of an estimator that accounts for the stated concerns without requiring instrumentation for the endogenous variables. Accordingly, we used an estimator that accounts for endogenous regressors, namely the Fully-modified OLS (FMOLS) estimation technique. This technique was developed by Pedroni (1996, 2000). The main strength of this technique is its ability to control for the endogeneity of the explanatory variables. Additionally, it allows for heterogeneity across cross-sectional units. The approach in this estimation technique is to use cointegrating vectors in dynamic panels, in panel unit root and within a panel cointegration framework. An added advantage of this approach is its ability to selectively pool the long-run information contained in the data, while at the same time being able to tease out short-run dynamics and heterogeneous fixed effects between the cross-sectional units.

FMOLS estimation can either be pooled "within" or "between" dimensions of the panel. In our particular study, we were interested in the "between" dimensions of the panel, as this has been shown to help lower the distortion when dealing with small samples. Since our time period only covers 1990-2011 for (most of[7]) the 26 SSA countries, an FMOLS estimation approach more suited to small samples, seemed to be the better option. The FMOLS is constructed by adjusting for endogeneity and serial correlation in the original OLS estimator. Consider the OLS estimator for β:

[7] Some of the data for some of the countries will be lost during the process of obtaining cointegrating vectors.

$$\hat{\beta}_{OLS} = \left[\sum_{i=1}^{N}\sum_{t=1}^{T}(x_{i,t}-\bar{x}_i)(x_{i,t}-\bar{x}_i)'\right]^{-1} \left[\sum_{i=1}^{N}\sum_{t=1}^{T}(x_{i,t}-\bar{x}_i)(y_{i,t}-\bar{y}_i)\right], \quad (5)$$

where $y_{i,t}$ is the fixed effects panel regression, and $x_{i,t}$ are M x 1 integrated processes, integrated of order one, for all i, where $x_{i,t} = x_{i,t-1} + \varepsilon_{i,t}$. In addition, $\bar{x}_i = (^1/_T)\Sigma_{t=1}^{T} x_{i,t}$ and $\bar{y}_i = (^1/_T)\Sigma_{t=1}^{T} y_{i,t}$. The presence of endogenous variables in the system means that there is the possibility of inconsistent estimates due to the simultaneity bias. The fully modified estimator takes care of this problem by correcting for endogeneity and serial correlation in the OLS estimator above. The process of this correction is detailed in Pedroni (1996) and Kao et al (1999). Accordingly, the fully modified OLS estimator obtained is of the form:

$$\hat{\beta}_{FMOLS} = [\Sigma_{i=1}^{N}\Sigma_{t=1}^{T}(x_{i,t}-\bar{x}_i)(x_{i,t}-\bar{x}_i)']^{-1} [\Sigma_{i=1}^{N}\Sigma_{t=1}^{T}(x_{i,t}-\bar{x}_i)\hat{y}_{i,t}^{+} - T\hat{\Delta}_{\varepsilon u}^{+}], \quad (6)$$

where $\hat{y}_{i,t}^{+}$ and $\hat{\Delta}_{\varepsilon u}^{+}$ and the endogeneity and serial correlation correction terms respectively.

4.0.1 Panel attributes

Prior to embarking on the estimation, it was necessary to explore the properties of the panel data set, which would help to determine both the long-run memory and co-movement attributes of the data. The first step entailed testing the data set for unit roots. While unit root tests in panel analysis are not as accurate and consistent as unit root tests in time series, some unit root tests have, however, been developed and are generally accepted in empirical studies related to economics. For this particular study we employed four different unit root tests in view of the risk of obtaining varying results from unit root tests.[8] The unit root tests we employed included the Augmented Dickey-Fuller approach, on which most other unit root tests are based. Specifically, we incorporated the Levin, Lin and Chu (LLC) unit root test developed by Levin et al (2002), and the Im, Pesaran and Shin unit root test developed by Im et al (2003). These two unit root tests are normally distributed. The two other unit root tests utilised are the Augmented Dickey-Fuller Fisher (ADF Fisher) unit root test developed by Maddala and Wu (1999), and the Fisher-Perron and Phillips (PP-Fisher) unit root test.[9] The last two Unit root tests have a chi-square distribution. All four Unit root tests test the null hypothesis of non-stationarity, which is the presence of a unit root. The only difference between these tests relates to the fact that

[8] This is a common practice in empirical economics.

[9] This was first provided in the Eviews 5 econometric package.

the Levin, Lin and Chu test, tests for the presence of a common unit root, while the others test for the presence of an individual unit root.

To take advantage of the long-run dynamics of the series, one would need to explore the cointegration attributes of the data and test whether or not any form of long-run relationship exists between the series. Ideally, to test for the existence of cointegrating vectors between the variables considered, the traditional Pedroni approach would be the best option. This approach was developed by Pedroni et al (1999, 2004). The issue with this approach is the inherent limitation on the number of series that can be considered simultaneously for the existence of cointegration, which is 7. In this particular study the model had more than 7 series, and would therefore not be applicable. The Kao's cointegration testing approach proved to be more suitable. This method is based on the cointegration testing technique originally developed by Engel and Granger (1987, 1991). This approach was developed by Kao (1999).

5 Empirical results and analysis

Since the time series properties of the variables were unknown, the empirical analysis began by conducting the above-mentioned panel unit root tests. The results of the unit root tests are presented in Table 1. For most of the variables, two or more of the four unit root tests accept the null hypothesis of unit root presence at the 5% significance level, with the exception of the Freedom House indicators. This means that traditional panel estimation techniques would likely suffer from spurious regression and thus provide uninterpretable results. A possible solution to this could be achieved by first differencing the series, and then estimate using an estimation technique such as OLS. There is substantial evidence to show that most of the series are stationary after taking their first difference, with the exception of human capital and population. However, first differencing the series before estimation, while avoiding spurious regression, would result in a loss of information on the long-run dynamics of the series.

The results of the cointegration tests are reported with the regression outputs in Tables 2, 3 and 4. The tests results suggest that cointegrating vectors do exists for all variables included in the regressions in Tables 2 and 3. In columns (1), (2), (3) and (4) of Tables 2 and 3, the results of the OLS estimates are presented. The first column is given without either the fixed or time effects; column (2) includes only time effects; column (3) includes only country effects, while the fourth column includes both time and cross-sectional fixed effects. These OLS results are expected to suffer from a simultaneity bias, and thus may lead to an overestimation of the elasticities. The results for the FMOLS estimation, as well as for the Kao cointegration test results are presented in columns (5) to (8) of the tables. The corresponding t-statistic of the Kao residual (cointegration test) is -3.782, which is well above the 1.98 95% critical value. This implies the existence of a long-run relationship between the explanatory variables and total factor productivity. In column (5) the FMOLS estimates of the model is

once again presented without including any time or cross-country fixed effects. According to Kao et al (1999), the OLS elasticity estimates are often larger and thus more often overestimated than the FMOLS estimates, which corrects for serial correlation and endogeneity. In this particular case, when comparing across the two estimations without any fixed or time effects, it does seem to be the case.

However, these results could be problematic as macroeconomic variables tend to increase over time, and an argument can be made that SSA countries are not completely homogenous (depending on the context of the analysis). As such, both time and fixed cross-country effects need to be included in the estimations to effectively analyse our data set. Column (6) includes a time effect, column (7) the fixed country effects, while column (8) includes both time and fixed effects. In Column (5) we see that all the explanatory variables have corresponding signs that agree with the literature, except for the trade category, which, according to the estimates, has a negative and significant long-run effect on TFP in SSA.

For comparison we also regress all the explanatory variables, with the inclusion of institutions on TFP. The regression output is presented in Table 3. We immediately observe that the signs in both cases (Tables 2 & 3) remain mostly consistent. Secondly, we notice a significant decrease in the elasticities for some of the variables involved. For example, the journal (R&D) coefficient was 0.444, 0.222, 0.394 and 0.060 for the regressions in columns (5) to (8) of Table 2 respectively. However, once institutions are controlled for in Table 3, we see a decrease to 0.004, 0.002, 0.004 and 0.002 in columns (5) to (8) respectively. This suggests that empirical analysis in the absence of institutions may overcall the overall impact of some explanatory variables on TFP. In some instances it seems that the effects of a few of the explanatory variables are underestimated. However, there generally seems to be more overestimation than underestimation. Additionally, we also see in column (7) of both tables, that some of the variables which did not impact TFP in the absence of institutions now seem to have a significant correlation with TFP in the long-run. This suggests that the omission of institutions in TFP analysis may misrepresent the role of some of the more prominent factors.[10]

If we revert to the main regression results in Table 3 and focus on Column (7), which incorporates fixed country effects in its analysis, the results indicate that, with the exception of government spending, all the explanatory variables have a significant long-run relationship with productivity growth. While most of the theoretically-backed variables, such as infrastructure, research and development, as well as human capital, have positive and significant elasticities, some of them have signs contrary to expectations. A few of the variables have a negative sign. For example, financial development, population, trade, and the price level all have negative and significant coefficients. While a negative coefficient on price level is expected, and a negative coefficient on population could be ambiguous depending on the quality of the population, a negative coefficient on trade and financial development is puzzling. The literature suggest that

[10] Infrastructure, R&D, human capital, financial development, etc.

trade and openness would have a positive impact on productivity (Melitz, 2003; Alcala & Ciccone, 2004; Melitz & Ottaviano, 2008; Topalova & Khandelwal, 2011).

A possible reason for this contrary result may be the fact that trade activities within and across SSA countries remain in the primary goods sector, with some found in the manufactured goods sector where actual productivity could be measured. Similarly, the development of the financial system has not yet benefitted the majority of SSA citizens. Access to credit remains very tight, especially to small business owners who operate mainly in the informal sector where the majority of the population is found.

The main focus of this analysis lies in the role played by institutions, in their different forms, in determining TFP in SSA. Overall, while GDP and population are important factors when it comes to explaining TFP, the institutional impact at 0.056%, is one of the larger elasticities among the core determinants of TFP, falling behind human capital at 0.443%, and trade at -0.068%, but ahead of research and development, as well as of infrastructure (see column (7) of Table 3). If we consider column (8), which assumes both a time effect as well as heterogeneity between countries, and thus include both fixed time and cross-country effects, we see many of the core determinants becoming insignificant. Surprisingly, human capital seems to exhibit a negative yet significant relationship with TFP growth.[11] This is quite puzzling, as the literature on TFP suggests that human capital would be an important facet of productivity improvement (Rauch, 1991; Maudos *et al.* 1999; Miller & Upadhyay, 2000; Shapiro, 2006; Ciccone & Papaioannou, 2009; Teixeira & Fortuna, 2010). However, it is possible that, over the years post-independence, during which most education and a human capital metrics increased, many SSA countries have also experienced high levels of deterioration in infrastructure, civil unrest, and political instability. All these factors might contribute to the low quality of human capital, thus not reflecting positively on TFP in SSA.

To explore this further, we also employed a different measure of institutions which captures property rights rather than political rights, and used this as a proxy for the state of institutions across SSA. The measure used in this case is the Fraser Institute property rights measure. This measure captures market-based institutions as opposed to the political institutions captured by the Fraser Institute (*Fi_Pr)* series. The results are presented in Table 4. The OLS estimates with fixed time effects, fixed country effects, and fixed time and country effects reported in columns (2) and (3), suggest that economic institutions have a negative and significant effect on TFP, whereas only R&D comes out as insignificant, while many of the other control variables are significant. On the other hand, examining the results derived from the FMOLS estimation, the regressions with fixed country effects, and fixed time and country effects in columns (7) and (8), show that market-based institutions are positively linked with TFP growth, while human capital is negatively linked with TFP in the long-run. Once

[11] Notice that the coefficient on human capital only becomes negative in the presence of fixed time (period) effects.

again, trade, price level and population remain negatively linked, as in the case of Polity IV approach shown in Table 3. The counterintuitive result from the human capital variable, indicates that the level of education (and other human development measures captured in the HC index) in SSA countries have not yet been fully utilised in the production sector and therefore reflects negatively in the total productivity growth

An interesting observation in the results is the magnitude of the two different types of institutions (political and economic institutions). If one considers the elasticities in Columns (7) and (8) of both Tables 3 and 4, we see that the magnitude for property rights exceeds that of political liberties in column (8), while the opposite is true in column (7).[12] To explore this further, we conducted a regression controlling for both measures of institutions. The challenge with this is the lack of adequate observations to perform a cointegration analysis. The OLS estimates are, however, presented in Table A of the Appendix. The output suggests that market-based institutions might be more relevant for TFP determination, although in a detrimental way (see column (2)). However, once either fixed country effects, or both fixed time or country effects are included in the regression, none of all the core explanatory variables, including institutions, is significantly linked with TFP determination in the long-run.

As an additional test of the robustness of institutions in determining TFP, we employed one extra measure which captures political rights (Fh_Cl) index from the Freedom House. The Kao test for Fh_Cl reports a t-statistic of -1.35, and a corresponding p-value of 0.089. While this is not at the 5% level of significance, it is still within the 10% level of significance, and thus we can interpret the estimated elasticities with 90% confidence. The regression outcome is reported in Table B of the Appendix. For the most part, the OLS reports in columns (2) to (4) of all the different measures of institutions remain insignificant.

A comparison of the FMOLS output for the Fh_Cl estimates in Table B to those in Tables 3 and 4, reveals that on the whole, institutions continue to significantly affect TFP in the long-run (see column (7) across all the regression outcomes, while the results differ in column (8) of the regressions). The argument can be made for both homogeneity (column 6) and heterogeneity (columns 7 and 8). Similarly, many of the r-squared results reported for most of the OLS estimates, which included time (period) effects, are not much larger than those without, suggesting that the time effects might not be as important for the variables we employed, making a case for considering only fixed country effects. As such, we can consider both results of columns (6) to (8) as feasible representation of these economies.

6 Conclusion and policy implications

In this paper, we explored the determinants of Total Factor Productivity in sub-Saharan Africa. Special attention is given to the role played by institutions, in

[12] However, in a similar manner to the previous results, the core explanatory variables (human capital, R&D, and financial development) seem to be negatively correlated to TFP.

addition to other core determinants such as R&D, human capital, infrastructure, financial development, trade, government spending, population, price level and GDP.

The results indicate that institutions play an important role in determining TFP in SSA. We find that in some cases, the role of determinants previously determined in the literature (i.e. R&D, human capital, financial development) had elasticities that were quite large in the absence of institutions. However, in the presence of institutions, some of the elasticities had slightly lesser values, indicating a relatively lesser role in determining productivity in SSA than had previously been determined. An interesting result is the consistently negative role played by trade and some of the other explanatory variables in determining productivity. This is contrary to the evidence in the TFP literature, as "openness" and "trade" are expected to be positive and significant in determining productivity, as suggested by earlier studies carried out in Asia and other non-African economies. However, given the position of SSA in the context of a globalised world, it is possible that trade impacts productivity in a negative manner, given that the manufacturing and industrial sectors in many countries in SSA are relatively underdeveloped. As such, products imported are often finished products, which might mean that the link between trade and productivity, which includes the import of intermediate products used in the production of final products, may not be as positive in SSA as in other more developed nations. This can have a detrimental impact on productivity.

We also explored possible differences in the elasticities attached to different institutional measures and types. We differentiated between political institutions and market-based economic institutions. Our results suggest that market-based economic institutions (property rights), might play a more significant role in determining productivity changes in SSA. This is an interesting outcome, given that, in the past, more attention was given to political institutions in order to attain sustainable economic growth. Although political institutions remain a worthy cause, these results suggest that attention should also be given to market-based economic institutions as they may have an even more important role in improving productivity across SSA.

Finally, we are aware of the empirical and methodological concerns that come with such studies, for example, the use of FMOLS to counteract issues related to endogeneity which often limits the value of macroeconomic studies. Caution must therefore be taken in interpreting the OLS results, as well as the results obtained from the FMOLS estimates where the cointegration tests show a relatively low 90% level of confidence. In addition to this, this study gives an overview of the role played by institutions in determining TFP. The next step should be to conduct a country-specific analysis in which individual country characteristics can be well accounted for, thus allowing for more adequate country-specific policy recommendations.

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Table 1: Panel unit root tests

Variable	LLC	ImPS	ADF-Fisher	PP-Fisher	Variable	LLC	ImPS	ADF-Fisher	PP-Fisher
TFP	-1.656**	-1.474***	64.66	74.36**	ΔTFP	-2.612***	-7.449***	144***	432***
	(-0.049)	(0.07)	(0.112)	(0.023)		(0.005)	(0.00)	(0.00)	(0.00)
Polity	13.463	-0.193	40.48	301***	ΔPolity	12.224	-3.062***	67.56**	1072***
	(1.00)	(0.423)	(0.829)	(0.00)		(1.00)	(0.001)	(0.013)	(0.00)
Fh-Civil Liberties	-2.207**	-2.093**	20.84**	78.83***	ΔFH-Civil liberties	16.353	0.053	3.058	33.27***
	(0.014)	(0.018)	(0.022)	(0.00)		(1.00)	(0.521)	(0.548)	(0.00)
Fi-Property rights	-0.899	-0.028	35.00	75.57***	ΔFI_Property rights	0.254	-1.888**	56.07**	193***
	(0.184)	(0.489)	(0.769)	(0.001)		(0.60)	(0.030)	(0.047)	(0.00)
Hc	-6.230***	-0.325	45.27	178***	ΔHc	6.287	2.170	37.66	24.966
	(0.00)	(0.373)	(0.734)	(0.00)		(1.00)	(0.985)	(0.932)	(1.00)
M2	-0.595	0.396	60.936	99.56***	**Δ**MS	0.994	-3.914***	107.2***	502.1***
	(0.276)	(0.654)	(0.716)	(0.008)		(0.840)	(0.000)	(0.002)	(0.000)
R&D	0.915	4.109	44.23	37.61	Δinfrastructure	1.536	-7.334***	144***	1259***
	(0.82)	(1.00)	(0.769)	(0.933)		(0.938)	(0.00)	(0.00)	(0.00)
Infrastructure	-2.227**	1.031	43.75	60.99		-1.586*	-4.952***	107***	326***
	(0.013)	(0.849)	(0.785)	(0.184)		(0.056)	(0.00)	(0.00)	(0.00)
Trade	-1.936**	-2.114**	70.41**	101***	Δtrade	-3.976***	-8.439***	168***	717***
	(0.026)	(0.017)	(0.045)	(0.00)		(0.00)	(0.00)	(0.00)	(0.00)
GDP	-0.054	-0.125	84.060	72.584	**Δ**GDP	-9.826***	-5.387***	127.9***	389.0***
	(0.479)	(0.450)	(0.121)	(0.393)		(0.000)	(0.000)	(0.000)	(0.000)
Population	-0.509	4.593	87.08***	148***	ΔGDP	-2.443***	-4.005***	119***	64.42
	(0.305)	(1.00)	(0.002)	(0.00)		(0.007)	(0.00)	(0.00)	(0.116)
Price level	3.676	3.078	17.09	25.48	ΔPrice level	-3.105***	-4.090***	86.40***	311***
	(1.00)	(0.999)	(1.00)	(0.999)		(0.001)	(0.00)	(0.002)	(0.00)
Govt. Spending	-1.707**	-1.206	57.80	82.53***	ΔGovt. Spending	-2.217**	-5.978***	125***	417***
	(0.044)	(0.114)	(0.270)	(0.005)		0.013	(0.00)	(0.00)	(0.00)

Source: Authors' computation and analysis of results

Note: P-values in parentheses. *, **, and ***, denotes the 10%, 5% and 1% levels of significance respectively. FH-Civil Liberties and FH-Property rights are institutional indices from the Freedom House data set, while FI-Property rights is the property rights index from the Fraser Institute data series. HC stands for human capital, M2 for broad money. All the tests are carried out to include individual fixed effects and individual trends. The specified lags for all the variables are 2, except for the Freedom House and Fraser Institute indices, which are assigned a lag of 1, due to the lack of adequate data. In all the four different tests, the null hypotheses being tested is that of the presence of a unit root.

Table 2: OLS and FMOLS estimation of TFP determinants - without institutions

	OLS					FMOLS			
Variable	1	2	3	4		5	6	7	8
R&D	0.146**	0.134**	0.006	0.005		0.007	0.005	0.007***	0.004
	(0.060)	(0.064)	(0.004)	(0.004)		(0.006)	(0.005)	(0.002)	(0.002)
Hc	-2.779***	-2.816***	0.316**	0.215		0.444**	0.222	0.394***	0.060**
	(0.485)	(0.501)	(0.132)	(0.152)		(0.206)	(0.372)	(0.058)	(0.136)
M2	-0.888***	-0.901***	-0.056***	-0.058***		-0.053**	0.015	-0.055***	-0.011**
	(0.144)	(0.153)	(0.016)	(0.018)		(0.025)	(0.023)	(0.007)	(0.008)
Infrastructure	0.410*	0.406*	0.004	-0.002		0.003	0.041	0.000	0.029
	(0.227)	(0.235)	(0.013)	(0.014)		(0.020)	(0.025)	(0.006)	(0.009)
TRADE	0.664***	0.647***	-0.068***	-0.069***		-0.078***	-0.105***	-0.066***	-0.087***
	(0.166)	(0.172)	(0.019)	(0.020)		(0.029)	(0.025)	(0.008)	(0.009)
POP	-0.055	-0.068	-0.792***	-0.907***		-0.817***	-0.515**	-0.790***	-0.398***
	(0.103)	(0.110)	(0.064)	(0.081)		(0.100)	(0.224)	(0.028)	(0.082)
GDP	0.449**	0.499***	0.700***	0.687***		0.704***	0.576***	0.672***	0.539***
	(0.211)	(0.234)	(0.040)	(0.042)		(0.060)	(0.076)	(0.017)	(0.028)
PL	0.768***	0.740*	-0.018	-0.045**		-0.042**	-0.024	-0.022***	0.004**
	(0.201)	(0.264)	(0.014)	(0.019)		(0.021)	(0.020)	(0.006)	(0.007)
GOVT	0.293*	0.302	-0.006	-0.010		0.005	-0.015	-0.006	-0.026
	(0.162)	(0.168)	(0.015)	(0.016)		(0.023)	(0.026)	(0.006)	(0.010)
Effects	None	Time	Country	Both		None	Time	Country	Both
R-squared	0.175	0.178	0.998	0.998		0.998	0.999	0.998	0.999
obs	548	548	548	548		513	513	513	513
Kao's Residual Test			t-stat:	-3.141	P-value:	0.001			

Source: Authors' computation and analysis of results

Note: *, **, and *** represent 10%, 5% and 1% significance levels respectively. Standard errors are in parentheses. Kao's residual is the panel cointegration test for the existence of cointegrating equations among the variables. Null hypothesis being tested by the cointegration test is no cointegration

Table 3: OLS & FMOLS estimation of TFP determinants, using polity as proxy for institutions

	OLS					FMOLS			
Variable	1	2	3	4		5	6	7	8
INST(Polity)	1.263	3.367**	-0.004	0.070		-0.039	-0.075	0.056***	0.007
	(1.003)	(1.562)	(0.060)	(0.092)		(0.101)	(0.069)	(0.020)	(0.020)
R&D	0.149**	0.136**	0.004	0.004		0.004	0.002	0.004***	0.002
	(0.062)	(0.066)	(0.004)	(0.004)		(0.007)	(0.005)	(0.001)	(0.001)
HC	-2.629***	-2.660***	0.308**	0.238		0.476**	-0.455	0.443***	-0.643***
	(0.506)	(0.520)	(0.142)	(0.165)		(0.236)	(0.401)	(0.046)	(0.114)
M2	-0.885***	-0.901***	-0.054***	-0.054***		-0.041	0.024	-0.048***	-0.004
	(0.152)	(0.161)	(0.018)	(0.019)		(0.029)	(0.026)	(0.006)	(0.008)
INFRA	0.315	0.326	0.010	0.005		0.021	0.005	0.019***	0.005
	(0.243)	(0.249)	(0.015)	(0.015)		(0.023)	(0.028)	(0.005)	(0.008)
TRADE	0.656***	0.637***	-0.074***	-0.075***		-0.091***	-0.117***	-0.068***	-0.084***
	(0.179)	(0.185)	(0.021)	(0.021)		(0.034)	(0.029)	(0.007)	(0.008)
POP	-0.102	-0.126	-0.794***	-0.890***		-0.840***	-0.611**	-0.808***	-0.562***
	(0.107)	(0.114)	(0.069)	(0.085)		(0.114)	(0.241)	(0.022)	(0.068)
GDP	0.474**	0.533**	0.716***	0.707***		0.723***	0.569***	0.685***	0.595***
	(0.221)	(0.244)	(0.043)	(0.048)		(0.068)	(0.086)	(0.013)	(0.025)
PL	0.764***	0.700**	-0.017	-0.047**		-0.032	0.014	-0.017***	0.022***
	(0.211)	(0.277)	(0.016)	(0.020)		(0.025)	(0.023)	(0.005)	(0.006)
GOVT	0.273	0.274*	-0.007	-0.020		0.006	-0.034	-0.003	-0.027***
	(0.166)	(0.172)	(0.016)	(0.015)		(0.025)	(0.028)	(0.005)	(0.008)
Effects	None	Time	Country	Both		None	Time	Country	Both
R-squared	0.166	0.178	0.997	0.997		0.997	0.998	0.997	0.997
obs	479	479	479	479		392	392	392	392
Kao's Residual Test	Null:	No cointegration	t-stat:	-3.782	P-value	0.000			

Source: Authors' computation and analysis of results

*, **, and *** represent 10%, 5% and 1% significance levels respectively. Standard errors are in parentheses. Kao's residual is the panel cointegration test for the existence of cointegrating equations among the variables. Null hypothesis being tested by the cointegration test is no cointegration

Table 4: OLS & FMOLS estimation of TFP determinants, using the Fraser Institute property rights as proxy for institutions

	OLS				FMOLS			
Variable	1	2	3	4	5	6	7	8
INST(Fi_Pr)	-1.915**	-2.335***	0.091	-0.041	0.308**	0.087	0.351***	0.210***
	(0.798)	(0.916)	(0.057)	(0.064)	(0.145)	(0.148)	(0.016)	(0.000)
R&D	0.041	0.041	0.015	0.014	0.015	0.031	0.015***	0.022***
	(0.140)	(0.144)	(0.010)	(0.010)	(0.025)	(0.020)	(0.003)	(0.000)
HC	-2.709***	-2.666***	-0.420***	-0.109	-1.455***	-0.970	-1.499***	-1.081***
	(0.714)	(0.727)	(0.165)	(0.183)	(0.490)	(1.100)	(0.055)	(0.000)
M2	-0.669***	-0.548**	-0.033	0.001	0.026	0.020	0.008	-0.051***
	(0.224)	(0.239)	(0.025)	(0.026)	(0.047)	(0.051)	(0.005)	(0.000)
INFRA	0.627**	0.561*	0.006	0.001	0.001	-0.018	-0.006**	-0.005***
	(0.314)	(0.323)	(0.015)	(0.015)	(0.027)	(0.038)	(0.003)	(0.000)
TRADE	0.772***	0.743***	-0.087***	-0.087	-0.121***	-0.089*	-0.131***	-0.063***
	(0.240)	(0.251)	(0.028)	(0.029)	(0.049)	(0.050)	(0.006)	(0.000)
POP	0.991***	0.809***	0.467***	0.503***	0.349***	0.359*	0.413***	0.546***
	(0.286)	(0.324)	(0.058)	(0.059)	(0.104)	(0.200)	(0.012)	(0.000)
GDP	0.260	0.329*	-0.446***	-0.202**	-0.042	-2.965*	-0.063**	-0.913***
	(0.160)	(0.186)	(0.079)	(0.104)	(0.239)	(1.700)	(0.027)	(0.000)
PL	0.950***	1.426***	-0.020	0.051	-0.066	0.069	-0.055***	0.069***
	(0.312)	(0.540)	(0.021)	(0.034)	(0.048)	(0.046)	(0.005)	(0.000)
GOVT	0.734***	0.800***	-0.021	-0.026	0.086*	0.023	0.061***	0.031***
	(0.270)	(0.278)	(0.023)	(0.023)	(0.048)	(0.048)	(0.005)	(0.000)
Effects	None	Time	Country	Both	None	Time	Country	Both
R squared	0.270	0.286	0.999	0.999	0.999	1.000	0.999	1.000
obs	299	299	299	299	208	198	208	198
Kao's Residual Test	Null:	No cointegration	t-stat	-2.114	P-value:	0.017		

Source: Authors' computation and analysis of results

Note: *, **, and *** represent 10%, 5% and 1% significance levels respectively. Standard errors are in parentheses. Kao's residual is the panel cointegration test for the existence of cointegrating equations among the variables. Null hypothesis being tested by the cointegration test is no cointegration

Appendices

Table A: OLS estimation of TFP determinants, using both Fraser Institute Property rights and Polity IV as proxy for institutions

	OLS			
Variable	1	2	3	4
INST(Polity)	1.105	3.944	-0.099	-0.180
	1.416	2.402	0.069	0.110
INST(Fi_Pr)	-1.651**	-2.292**	0.092	-0.023
	0.840	0.949	0.060	0.068
R&D	0.056	0.042	0.018	0.017
	0.151	0.153	0.011	0.011
HC	-2.759***	-2.618***	-0.460***	-0.170
	0.753	0.762	0.167	0.185
M2	-0.648***	-0.507**	-0.045	-0.019
	0.241	0.253	0.028	0.029
Infrastructure	0.782**	0.757**	0.014	0.009
	0.328	0.332	0.016	0.016
Trade	0.770***	0.708***	-0.081`***	-0.080***
	0.259	0.272	0.030	0.031
GDP lagged	0.959***	0.784**	0.484***	0.513***
	0.305	0.339	0.062	0.062
Pop	0.209	0.254	-0.470***	-0.241**
	0.172	0.196	0.079	0.105
Price Level	1.042***	1.426***	-0.007	0.061*
	0.335	0.551	0.023	0.035
Govt Spend	0.690**	0.707**	-0.022	-0.028
	0.282	0.288	0.024	0.024
Effects	None	Time	Country	Both
R squared	0.253	0.281	0.999	0.999
obs	265	265	265	265
Kao's Residual Test	Null:	No coint	t-stat	-9.943615

*, **, and *** represent 10%, 5% and 1% significance levels respectively. Standard errors are in parentheses. Null hypothesis being tested by the cointegration test is no cointegration

Table B: OLS & FMOLS estimation of TFP determinants, using Freedom House Property rights as proxy for institutions

	OLS				FMOLS			
Variable	1	2	3	4	5	6	7	8
INST(Fh_CL)	-0.160	-0.258	0.020	0.023	0.024	0.009	0.049***	0.033***
	0.225	0.349	0.012	0.018	0.052	0.043	0.008	0.006
R&D	0.137**	0.130*	-0.002	0.000	-0.005	-0.003	-0.012***	-0.011***
	0.069	0.075	0.005	0.005	0.015	0.012	0.002	0.002
HC	-1.942***	-2.054***	0.138	0.240	-0.387	-0.761	-0.535***	-1.311***
	0.550	0.573	0.158	0.177	0.665	1.458	0.104	0.215
Dom Credit	0.079	0.081	-0.035***	-0.034***	-0.024	-0.077*	-0.012**	-0.064***
	0.084	0.087	0.008	0.008	0.032	0.042	0.005	0.006
Infrastructure	-0.053	-0.032	0.022	0.020	0.049	0.022	0.029***	-0.020*
	0.269	0.279	0.015	0.015	0.048	0.080	0.007	0.012
Trade	-0.065	-0.080	-0.131***	-0.119***	-0.119	-0.088	-0.182***	-0.160***
	0.190	0.200	0.021	0.022	0.088	0.082	0.014	0.012
GDP lagged	0.197*	0.226*	0.572***	0.574***	0.656***	1.105***	0.538***	0.409***
	0.112	0.121	0.033	0.036	0.123	0.325	0.019	0.048
Pop	-0.324***	-0.354***	-0.657***	-0.699***	-0.532	-0.665	-0.276***	-1.673***
	0.118	0.125	0.075	0.093	0.331	1.725	0.052	0.255
Price Level	0.457**	0.345	-0.020	-0.036*	-0.038	-0.002	-0.015*	-0.003
	0.233	0.308	0.015	0.019	0.052	0.061	0.008	0.009
Govt Spend	0.308*	0.348*	-0.024	-0.018	0.012	0.028	-0.008	0.016
	0.176	0.183	0.016	0.016	0.058	0.077	0.009	0.011
Effects	None	Time	Country	Both	None	Time	Country	Both
R squared	0.076	0.095	0.998	0.998	0.998	0.998	0.998	0.999
Obs.	332	332	332	332	109	109	109	109
Kao's Residual Test	Null:	No cointegration	t-stat	-4.404997	P-value:	0		

*, **, and *** represent 10%, 5% and 1% significance levels respectively. Standard errors are in parentheses. Null hypothesis being tested by the cointegration test is no cointegration

Table C: List of Countries

Benin	Ghana	Rwanda
Botswana	Kenya	Senegal
Burundi	Lesotho	Sierra Leone
Cameroon	Malawi	South Africa
Central African Republic	Mauritania	Sudan
Congo, Republic	Mauritius	Swaziland
Cote d'Ivoire	Mozambique	Togo
Gabon	Namibia	Uganda
The Gambia	Niger	