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Abstract

This paper considers the structural and institutional determinants of investment activity in selected African countries within a neoclassical framework. Generalized method of moments and a family of panel data estimation techniques are utilized in addition to nonparametric kernel regression techniques to uncover the relationship. Three main findings emerge; (i) financial openness and institutional quality are reasonably robust structural and institutional determinants of investment activity in Africa respectively, (ii) there is evidence of nonlinearity in the relationship and there exist a threshold level of financial openness that achieves the highest level of investment, (iii) using interaction terms, the inhibiting effect of financial openness is potentially less in countries with higher levels of institutional quality, (iv) promoting institutional quality is an effective policy towards facilitating investment activity in Africa.

Keywords; Investments, financial openness, institutional quality, nonparametric regression, GMM

JEL Classification; E22; O16; O38.

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1 Introduction

As shown in a recent World Bank study, the cross-country variation in investment activity and returns is widening and the variation is even more pronounced in Africa. Between 1980 and 2010, the rate of gross capital formation ranged between 1 and 90 percent of production worldwide (see Lim, 2014). This widening variation in investment activity is mostly due to the different kinds of frictions present in different economies which prevents a normalization of the returns from investment activities across countries. This eventually, inhibits the potential for regional integration and investment competitiveness. In order to facilitate efforts towards regional integration in Africa, it is important to correctly identify the factors that are responsible for the investment related frictions in African economies. Hence, in this study, we endeavour to provide answers to questions such as, what are the determinants of the relative investment activity in Africa, how do structural and institutional factors influence investments and what are the possible interactions.

Addressing this question in the African context generally requires a slightly broader approach than is used in the literature (see for examples Ndikumana, 2005; Love & Zicchino, 2006). This is particularly because of the greater diversity that exists in the region in terms of political and institutional frameworks which is different from the relative homogeneous characteristics of developed economies in Europe and America. The proposition we make is that in addition to the traditional economic factors that determine investment frictions and activity, there exist a wider set of factors including political, security, legal and institutional dimensions that should be accounted for in understanding the dynamics of investment activity and competitiveness in Africa.

The objective of this study is to empirically identify the broad set of factors that explain the differences in investment activity and competitiveness in Africa in the last three decades. The study is particularly different from others in the literature because it considers a broader set of structural and institutional determinants that are important to characterize the problem in the African context and does not lump developed and developing countries together in a panel.

To preview the results, we find that among the structural variables considered, financial openness appears to be the robust structural determinant of investment activity in Africa. On the other hand, institutional quality appears to be the robust determinant of investment among the institutional variables considered. We also find evidence of nonlinearities in the relationship, suggesting that there are turning points after which the observed effects of the structural or institutional variable is reversed. There is also weak evidence that the potentially inhibiting effects of financial openness is dampened at higher levels of institutional quality.

The rest of the paper is organized as follows; section 2 collects some of the relevant literature, section 3 highlights the empirical strategy used along with the data sources,

section 4 contains results from the parametric and nonparametric regression analysis, while section 5 is the conclusion with recommendations for policy.

2 Relevant literature

The theoretical and empirical literature on investment behaviour is quite established and robust. The key references that provide detailed review of the theoretical and econometric literature on investment behaviour can be found in Jorgenson (1971) and Clark, Greenspan, Goldfeld, and Clark (1979). The major theoretical formulations used to define investment behaviour can be classified under (i) simple accelerator theory, (ii) liquidity theory, (iii) expected profits theory, (iv) Tobin's Q theory and (v) the neoclassical theory (see Oshikoya, 1994).

The neoclassical flexible accelerator theory is often the most utilized model in the literature especially for empirical tests using data from industrially developed economies. In the past, data availability and structural diversity have limited the application of this class of models for the establishment of the empirical investment relations in Africa and other developing regions. This is particularly because key assumptions of the neoclassical theory such as the existence of perfect capital markets, little or no public investments among others are often not satisfied in this regions. These limitations among others have narrowed the focus of most studies on investment behaviour in developing countries to concentrating on explaining the causes of variations and the determinants of private investments (see Oshikoya, 1994, for example)

Economic size, (i.e GDP) and economic growth are hypothesized to be positively related to investments. This relation is mostly derivable from the flexible accelerator model which assumes that there is a fixed relationship in the production function between the desired capital stock and the level of output (see Fry, 1980). Bank credits are also hypothesised to be have a positive impact on investment activity. The effect on investments works directly through the the stock of credit available to firms. This positive impact have been found in many studies for developing economies (see Levine, 2002; Fry, 1980)

The impact of government spending and consumption on investment activity is theoretically ambiguous. The reason is because there are at list two known possible channels through which public expenditure could affect investment activity. On the one hand, public sector spending that results in high fiscal deficits may crowd out private investments through high interest rates, credit rationing and higher current and future tax burdens. On the other hand, if most of government spending is concentrated on infrastructure (such as transportation, communication, security, etc.), then government expenditure and investments is likely to be complemetary with private investments (see Blejer & Khan, 1984, for early evidence in the literature)

Recently, Lim (2014) has shown that in addition to traditional macroeconomic variables, it is also important to consider structural and institutional variables to understand the variation in worldwide investment variation. The paper uses data from 129 developed and developing countries to show that financial development and institutional quality are reasonably robust determinants of cross-country investment variations. Our study is closely related to the study by Lim (2014) in a broad sense, although we focus on Africa and try to address some of the potential shortcomings arising from the common practise of estimating the relationship using instrument based techniques like GMM. Here, we address this problem by considering nonparametric regression techniques.

3 Empirical strategy and data

3.1 Parametric specification

The empirical strategy adopted in the study is theoretically motivated from a standard neoclassical growth formulation (see Lim, 2014, for a similar application), where production is constant returns to scale and given by the Cobb-Douglas specification

$$Y_{it} = e^z K_{it}^{\alpha} L_{it}^{1-\alpha} \tag{1}$$

Where Y_{it} is level of output in country i, e^z is technology which is subject to a stochastic AR(1) shock process thus; $z_t = \rho z_{t-1} + \epsilon$. While K_{it} and L_{it} are the capital and labour used in production in country i and α is the share of capital in output. Where capital stock evolves according to the following equation of motion

$$K_{i,t+1} = (1 - \delta)K_{it} + I_{it} \tag{2}$$

The optimal capital stock in country i at time t is given as the weighted ratio of real output Y_{it} and the cost of capital R_{it} hence

$$K_{it}^{*} = \frac{\alpha Y_{it}}{R_{it}^{\sigma}} \tag{3}$$

where σ is the substitution elasticity of capital. Using the familiar result from neoclassical growth theory that in steady state with a balanced growth path μ, the growth rate of output, capital and consumption are equal, we can plug in the optimal level of capital (3) into the steady state equation of motion for (2) to obtain an expression for investment as

$$I_{it} = \frac{\alpha(\delta + \mu)Y_{it}}{R_{it}^{\sigma}} \tag{4}$$

By taking the logarithm of both sides of (4), we obtain an estimable equation for investment given as

$$\ln I_{it} = \ln \alpha + \ln(\delta + \mu_{it}) + \ln Y_{it} - \sigma \ln R_{it} \tag{5}$$

Where $\ln \alpha$ is the constant term and $\ln(\delta + \mu_{it}) \equiv g_{it}$ is the depreciation-adjusted growth rate in country i. To account for the additional structural and institutional variables which the neoclassical growth theory abstracts from, we include additional economic and structural variables in the vector $\mathbf{X}_{it}$ and institutional variables in the vector $\mathbf{Z}_{it}$, plus an error term ϵ_{it} so that the complete econometric estimation equation becomes

$$i_{it} = \beta + \rho i_{i,t-1} + \phi g_{it} + \varphi y_{it} - \sigma r_{it} + \mathbf{\Omega'X_{it}} + \mathbf{\Psi'Z_{it}} + \epsilon_{it} \tag{6}$$

Where the lower-case letters indicate the logarithms of the variables and bold letters are vectors. Further, an investment smoothing term $i_{i,t-1}$ is also introduced to account for partial-adjustment behaviour in capital formation observed in the literature (see Eberly, Rebelo, & Vincent, 2012)

The baseline regression equation in (6) is primarily estimated by system generalized method of moments (GMM) with robustness tests conducted using pooled regression and standard instrumental variable (I.V) techniques. The main advantage of using the system GMM technique is to enable us exploit the efficiency gains that arise from considering the instrument set as a system especially given that the number of cross section identifiers are less than the time series (i.e N<T). This method also allows us to take care of potential endogeniety problems.

3.2 Nonparametric specification

The GMM specification highlighted in the previous section is often robust when there are obvious concerns about endogenity and one is able to obtain relevant and valid instruments that correctly identify the parameters of interest. Often, researchers are not always blessed with instruments that satisfy these conditions. Further, the GMM specification may be very restrictive in the sense that it presupposes the existence of a linear relationship with monotonicities.

In this section, we consider a class of models that are less restrictive in terms of specifying the form of the relationship and at the same time capable of handling problems of endogeniety in the relationship between structural and institutional variables on investment in Africa. Specifically, we consider nonparametric regression techniques in the spirit of Racine, Hart, and Li (2006). However, to justify the application of this technique we first test a parametric version of the model to determine whether the relationship is nonlinear and non-monotic.

To achieve this, we employ Hsiao, Li, and Racine (2007)'s nonparametric and consistent test for correct specification of parametric model. Our choice of this method is because it admits the mix of continuous and categorical data types. Using this approach, the null hypothesis can be stated as follows: $H_O : E(Y|x) = m(x, \gamma_0)$, for almost all x and for some $\gamma_0 \in \mathcal{B} \subset \mathbb{R}^p$. Where $m(x, \gamma)$ is a known function with γ being a $p \times 1$ vector of unknown parameters which includes a linear regression model as a special case and $\mathcal{B}$ is a compact subset of $\mathbb{R}^p$. The alternative is the negation of H_O, that is $H_1 : E(Y|x) \equiv g(x) \neq m(x, \gamma)$ for all $\gamma \in \mathcal{B}$ on a set with a positive measure. The studentized version of the test statistic from this test is denoted by J_n.[1] For our application, we use the computed J_n test statistic with $i.i.d$ draws generated from 399 bootstrap resampling with bandwidths selected by cross-validation. As we will show latter in the results section, the significance test for the parametric model is not satisfied, hence the need for a nonparametric specification which is outlined hereunder.

The generic specification for the nonparametric regression is given thus;

$$y_{it} = g(\mathbf{X}_{it}, \mathbf{Z}_{it}) + \epsilon_{it}, \quad i = 1, 2 \dots N, \quad t = 1, 2, \dots T \tag{7}$$

where $g(.)$ is assumed to be a smooth and continuous but unknown function. $\mathbf{X}_{it}$ is a vector of the economic controls while $\mathbf{Z}_{it}$ is a vector of the institutional and structural variables of interest. Since the GMM and hence parametric specification in (6) is a special case of the nonparametric specification, it means that (7) is capable of automatically capturing linear and nonlinear effects including interaction and potential endogenity effects in the relationship without the need for a manual search.

Nonparametric econometric estimation techniques are often computationally involved, and in addition to the computational involvement, nonparametric multiple regressions techniques suffer from two major obstacles. First is the "curse-of-dimensionality" and second is the "difficulty of interpretation". The curse-of-dimensionality arises due to the deterioration of the rates of convergence of kernel methods as the number of regressors increases, which could lead to imprecise but consistent estimation of the object of interest. However, as Huynh and Jacho-Chávez (2009) have shown, this "curse" appears to be a "blessing" in this kind of setup. The reason is because by the nature of the construction of the institutional variables which is often by unobserved component model, their precision is dominated by the overall slow rate of convergence of the nonparametric estimators, and therefore no correction of standard errors is required.

We use the `np` package in `R`, developed by Hayfield and Racine (2008) to estimate the nonparametric model. In the data frame, we cast the variable $country_{it}$ as an categorical factor variable and $year$ as a ordered factor variable, while the control variables in the X_{it} and Z_{it} vectors are the continuous variables. This is a typical case of nonparametric

[1] Interested readers may want to see Racine (2008; 63-64) for more details.

regression with mix regressors.[2]

3.3 Data and Variables

The data set covers 22 African countries [3] over the period 1980-2011. The main sources are the World Bank's World Development Indicators (WDI) and the Polity IV database published by Systemic Peace. Other data were retrieved from Chinn and Ito (2012) and the Penn World Table (PWT) version 8.0. More specifically, output and output growth are measured by real GDP and real GDP growth rate from the WDI. Variables for economic control; government consumption, inflation and trade openness are sourced from the WDI. For robustness we alternate measures of investment using fixed investment rate (fixed capital formation share of GDP) from the WDI and the real capital stock. The cost of capital measured by real interest rate is obtained from the WDI. Financial openness index is obtained from Chinn and Ito (2008, updated). The human development index is retrieved from the PWT and it represents the index of human capital per person based on years of schooling as in Barro and Lee (2013) and returns to education as in Psacharopoulos (1994).

We measure financial development using domestic credit to private sector share of GDP retrieved from the WDI. We proxy institutional quality and institutional structure using scores of executive constraint and scores of democratic accountability respectively and are obtained from polity IV database. These variables are hypothesised to be important in the sense that the quality and structure of institutional mechanisms such as rule of law, contract enforcement, property right and judicial system can influence aggregate investment through altering incentive for new investment (Besley, 1995), or by increasing the sensitivity of investment to technological shocks at the macroeconomic level (Cooley, Marimon, & Quadrini, 2004). To capture business environment we use polity scores from polity IV project dataset. Full details of data sources and description are given in Appendices.

4 Results

4.1 Descriptive statistics

In Table 1 the summary statistics of the variables used in the analysis are presented. An interesting point to note is the relative sizes of the standard deviation of the structural and

[2] A gentle description of these estimation strategies can be found in the Racine (2008). Nonparametric Econometrics: A Primer.

[3] The list of countries are: Botswana, Burundi, Cameroon, Congo, Equatorial Guinea, Gabon, The Gambia, Kenya, Ghana, Malawi, Mauritius, Mozambique, Nigeria, Sierra Leone, South Africa, Swaziland, Tanzania, Uganda, Zambia, Egypt, Morocco, Rwanda

institutional variables compared with the economic controls. For example, the standard deviation of financial development a structural variable is 25.28 which is relatively large compared to some of the economic controls such as interest rates 13.24, inflation 22.23 and GDP 2.30. This provides preliminary support for the argument that structural and institutional variables may have non-trivial effects on investments.

In the Appendix section, Table 8 contains the pairwise correlation matrix for the variables. The interesting combinations are the correlation between the structural and institutional variables. We observe that financial openness a structural variable is weakly correlated with the institutional variables. As we obtain correlation coefficients between financial openness and institutional quality of $\rho = 0.10$, for institutional structure it is $\rho = 0.18$ and $\rho = 0.11$ for business environment although the relationships are statistically significant. This therefore suggest that the relationship between these set of variables are sufficiently weak enough to justify their just inclusion as conditioning variables in the empirical models.

Table 1: Descriptive statistics

Statistic	N	Mean	St. Dev.	Min	Max
Fixed Investments	678	19.96	10.63	−2.42	113.58
Investments	689	92.78	189.12	0.09	1,224.88
Financial Openness	696	0.29	0.29	0.00	1.00
LGDP	689	26.65	2.30	21.36	30.72
Business Environment	671	−1.55	6.46	−10	10
Institutional Quality	671	3.38	2.02	1	7
Interest rates	606	5.76	13.24	−53.44	60.69
Inflation	646	14.67	22.23	−17.64	200.03
GDP growth	685	4.28	6.97	−50.25	71.19
Human Development	640	1.83	0.41	1.13	2.85
Trade openness	688	71.81	38.07	6.32	275.23
TFP	458	1.55	3.56	0.57	29.67
Institutional structure	671	2.60	3.44	0	10
Financial development	665	21.38	25.21	1.54	167.54
Stock market	241	8.08	22.42	0.00	148.77

4.2 Benchmark GMM results

The benchmark results for the GMM specification in Equation 6 are reported in Table 2. We adopt an incremental approach whereby, we start with the baseline explanatory variables suggested by neo-classical theory and then incrementally include economic, structural and institutional variables to the right hand side respectively. We start by considering diagnostic tests for the overall model specification. First, the joint significance of the

variables included in each of the regressions in Table 2 is given by the Wald χ^2 statistic which is statistically significant for all the regressions. Secondly, tests for over-identifying restriction and instrument validity for the included instruments as captured by Hansen's J statistic cannot be rejected at the 5% level.

A caveat is however important at this point since as noted by Parente and Silva (2012) tests of overidentifying restrictions are not very informative about the validity of the moment conditions implied by the underlying economic model, and are therefore not reliable at identifying the parameters of interest. Further, the z-statistic test for Arellano-Bond AR(2) for second-order autocorrelation in the residuals show that there is no second-order autocorrelation, thereby justifying the non inclusion of more lags of the dependent variable on the right hand side.

Table 2: GMM regressions with fixed investment as dependent variable

	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10
Fixed invest$_{t-1}$	0.72***	0.96***	0.83***	0.83***	0.85***	0.77***	0.67***	0.51***	0.78***	0.58***
	(0.16)	(0.21)	(0.17)	(0.17)	(0.17)	(0.15)	(0.15)	(0.18)	(0.15)	(0.19)
LGDP	0.06	0.45	0.12	0.15	0.05	0.04	0.01	0.08	0.02	0.25
	(0.39)	(0.43)	(0.51)	(0.44)	(0.71)	(0.68)	(0.82)	(0.81)	(0.44)	(1.15)
GDP growth	0.42	1.01**	0.76*	0.78*	0.91**	0.73**	0.46	0.09	0.55	0.32
	(0.50)	(0.52)	(0.40)	(0.40)	(0.39)	(0.35)	(0.32)	(0.40)	(0.34)	(0.54)
Interest rate	-0.43*	-0.75**	-0.93***	-0.90***	-0.84***	-0.76***	-0.90***	-0.90***	-0.48***	-1.15*
	(0.22)	(0.33)	(0.27)	(0.26)	(0.31)	(0.25)	(0.29)	(0.27)	(0.16)	(0.67)
Inflation		0.24*	0.33**	0.31**	0.29**	0.17	0.08	0.00	0.12	0.14
		(0.14)	(0.13)	(0.13)	(0.13)	(0.11)	(0.21)	(0.25)	(0.08)	(0.37)
Govt. consumption			0.82**	0.77**	0.68**	0.75**	0.98**	1.09**	0.41**	0.85*
			(0.36)	(0.34)	(0.32)	(0.33)	(0.46)	(0.51)	(0.20)	(0.51)
Financial openness				-2.79	-2.52	-2.67	-4.73	-5.50	-3.40**	-6.89
				(2.66)	(2.72)	(2.55)	(3.54)	(4.00)	(1.69)	(4.35)
Trade openness					0.02	0.02	0.00	-0.02	0.05	-0.01
					(0.04)	(0.04)	(0.05)	(0.05)	(0.04)	(0.09)
Financial development						-0.03	-0.03	-0.02	0.01	-0.00
						(0.04)	(0.05)	(0.06)	(0.02)	(0.06)
Institutional quality							-0.23	0.59	0.41	0.31
							(0.57)	(1.54)	(0.77)	(1.49)
Institutional structure								-0.52	-1.99	0.16
								(1.06)	(1.64)	(1.54)
Business environ									0.93	-0.20
									(0.83)	(0.59)
Human cap. dev.										2.31
										(5.41)
Constant	6.21	9.20	-12.78	-9.97	-11.92	-11.83	-10.48	-7.81	-0.71	-10.46
	(10.25)	(11.63)	(17.38)	(14.63)	(20.13)	(19.85)	(24.43)	(26.47)	(13.06)	(27.05)
N	537	508	508	508	508	490	461	461	429	421
Hansen's J	5.55	1.79	1.86	1.87	1.88	2.07	2.03	2.60	5.86	1.00
Wald χ^2	253***	105***	194***	198***	196***	278***	270***	975***	2211***	227***
AR(2) z	0.99	1.12	0.58	0.61	0.73	0.75	0.38	0.24	0.92	-1.22
Instruments	9	7	8	9	10	11	12	14	17	15

Robust standard errors are reported in parenthesis. Significance symbols on coefficients are; *, ** and *** for the 10, 5 and 1% levels respectively.

Column (M1) in Table 2 contains the specification that represents the baseline neoclassical theory which posits that investment is a function of economic size (LGDP), economic

growth and cost of capital (interest rate). In columns (M2) and (M3) we introduce economic controls; inflation and government expenditure respectively. The first category of structural variables we introduce in columns (M4) and (M5) are the open-economy effects measured by financial openness and trade openness which have been shown to be significant determinants of medium term investments (see Loayza, Chong, & Calderon, 1999; Chinn & Prasad, 2003).

What we see is that there is evidence of persistence in inflation as the coefficient on the lagged term ranges between 0.51 and 0.96 and is statistically significant in all the regressions. Also, the estimated signs on economic size, economic growth and interest rate are in line with the apriori expectations. However, although economic size is not significant in all the regressions, we find that the effect of economic growth is statistically significant in some regressions and economically significant in all the regressions. The interesting part about this category of variables is the result on interest rate which is negative and statistically significant. This is interesting because although this is what neoclassical theory postulates, the extant literature has struggled to establish this relationship empirically, and this could be because those studies generally neglect the additional institutional variables which this study accounts for (see Caballero & Engel, 1999; Lim, 2014, for examples).

The coefficient on inflation surprisingly assumes a positive sign and is statistically significant in some of the regressions contrary to the apriori expectation. Government consumption is positive and statistically significant in all the regressions. In our benchmark regression-column (M5), the coefficient is 0.77. Hence a one percent increase in the ratio of government consumption to GDP could on average lead to around 0.77 percent increase in the level of investment in the economy. This result is not very surprising as the public sector in most African economies are significantly large.

We get negative and non-trivial coefficients on the financial openness variable although the coefficients are not significant in all the regressions. The expected effects of financial openness on investments is not obvious a priori. However, the negative effect observed here could be interpreted in different ways. First, it implies that `ceteris paraibus`, more financially open economies seem to experience lower levels of investments. This would be the case if foreign direct investments crowd out domestic investments (see Agosin & Machado, 2005, for empirical evidence). In other words, foreign direct investments flows substitute and displace domestic investments more than one-for-one. Another possible explanation provided in Lim (2014) is that if returns to investments are higher abroad, then greater financial openness could lead to net capital outflows which reduces the level of domestic savings available for domestic investments. Another explanation could be the financial contagion effect in which case, financial openness could allow for the transmission of financial crises which could lead to investment contractions in the domestic economy. To pin down the effect that is operative in the African context would be beyond the scope of the present study.

Table 3: GMM regressions with gross level of investment as dependent variable

	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
Investments_{t-1}	0.97***	0.97***	0.97***	0.98***	0.98***	0.98***	0.98***	0.98***	0.95***	0.97***
	(0.01)	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)
LGDP	0.53	0.23	0.19	0.14	0.23	0.23	0.23	0.38	0.95*	0.67
	(0.40)	(0.22)	(0.25)	(0.27)	(0.33)	(0.31)	(0.36)	(0.24)	(0.57)	(0.84)
GDP growth	0.03	0.26	0.22	0.20	0.29	0.22	0.17	0.16	0.36	0.03
	(0.15)	(0.24)	(0.37)	(0.38)	(0.23)	(0.28)	(0.29)	(0.17)	(0.25)	(0.52)
Interest rate	-0.19	-0.04	0.01	0.01	0.05	0.02	0.01	-0.01	0.10	-0.20
	(0.29)	(0.15)	(0.25)	(0.26)	(0.19)	(0.21)	(0.24)	(0.20)	(0.15)	(0.69)
Inflation		-0.12	-0.11	-0.10	-0.09	-0.20	-0.22	-0.21	-0.16	-0.20
		(0.15)	(0.19)	(0.20)	(0.17)	(0.26)	(0.25)	(0.22)	(0.15)	(0.34)
Govt. consumption			0.02	0.04	0.07	0.14	0.14	0.12	0.03	-0.05
			(0.16)	(0.17)	(0.15)	(0.13)	(0.12)	(0.13)	(0.15)	(0.51)
Financial openness				1.54	1.47	1.41	1.12	1.09	-0.21	2.12
				(1.61)	(1.72)	(1.62)	(1.92)	(1.81)	(2.87)	(1.99)
Trade openness					-0.01	-0.02	-0.02	-0.02	0.02	-0.03
					(0.03)	(0.04)	(0.04)	(0.02)	(0.01)	(0.05)
Financial development						-0.00	-0.01	-0.01	0.03	0.00
						(0.02)	(0.03)	(0.03)	(0.03)	(0.04)
Institutional quality							0.30	1.56**	1.04	1.32*
							(0.28)	(0.76)	(1.22)	(0.72)
Institutional structure								-0.79	-1.79*	-1.12*
								(0.54)	(1.06)	(0.64)
Business environ									0.59	0.23
									(0.56)	(0.23)
Human cap. development										-0.12
										(2.94)
Constant	16.65	10.11*	8.05	5.73	8.24	8.94	8.70	10.82	29.99	24.07
	(13.17)	(6.12)	(9.18)	(10.33)	(13.96)	(14.12)	(15.77)	(10.64)	(21.30)	(37.35)
N	549	521	519	519	519	501	472	471	434	425
Hansen's J	7.19	0.58	0.65	0.63	0.62	0.52	0.60	2.22	5.51	0.79
AR(2) z	-1.85	-1.30	-1.35	-1.32	-1.40	-1.26	-1.20	-1.14	-1.07	-0.71
Instruments	9	7	8	9	10	11	12	14	17	15

Robust standard errors are reported in parenthesis. Significance symbols on coefficients are; *, ** and *** for the 10, 5 and 1% levels respectively.

For financial development, just like results available in the literature, it is difficult to make strong conclusions about the effects of financial development on investments, however, this result will be revisited in other specifications consider in the paper. When we include additional structural and institutional variables in columns (M6, M7, M8, M9, M10), we observe inconsistency in the signs of the variables and besides that, they are all statistically not significant. This inconsistency may be arising from the problems inherent in the estimation technique used here. It is possible that the instruments mechanism used for the institutional variables are weak. Besides, it could also be the case that the problems of endogenity we are accounting for may not be a serious concern here. In the sections that follow, we also present results from alternative estimation techniques.

4.3 Robustness to GMM benchmark

In this section, we consider the robustness of the benchmark results to alternative measurement of the dependent variable. In the previous section we used the ratio of gross

fixed capital formation to GDP which is a flow measure of the value of acquisitions of new or existing fixed assets by the business sector, governments and households. To offer a variant to the conceptualization of investments, we use the gross level of investments (inclusive of inventory accumulation) which is a stock variable as an alternative measure of the dependent variable.

The results for gross investment as dependent variable are reported in Table 3. Again, overall model diagnostic tests reveal that the instruments used are valid as we cannot reject the null of Hansen's J test of overidentifying restrictions for the instruments. Also, there is no evidence of second-order serial autocorrelation, hence it is sufficient to use only the first period lags as part of the right hand side variables. The Wald χ^2 test also reveals that the variables included in all the regressions are jointly significant although the results are not reported in the table for the sake of space.

For the robustness results, we focus on column (R10) as the benchmark. The quantitative coefficients from the robustness regressions are not directly comparable to those in Table 2, but the qualitative effects are comparable. We observe that there is even higher persistence in the gross levels of investments as the coefficient ranged between 0.95 and 0.98 in the different robustness regressions. Further, the qualitative signs on the baseline variables of economic size, economic growth and interest rates are preserved although they are mostly not significant. The economic controls here assume the expected sign as inflation enters with a negative sign and government consumption enters with a positive sign though again both are not statistically significant.

The interesting aspect of the robustness regressions is that the effect of institutional variables have now become obvious, and they are mostly consistent and statistically significant. The coefficient on institutional quality is bound by [0.3 and 1.56] and is quite quantitatively significant. Specifically, a one percent improvement in institutional quality could translate into increase in investments of around 1.56%. By contrasting the negative impact of institutional structure and the positive impact of business environment, it is possible to say something about the importance of institutions in fostering broad based economic opportunities and competition dynamics as highlighted in the influential work by Acemoglu and Johnson (2005). Overall, the regressions with gross level of investments as dependent variable reaffirms the quantitative and qualitative results obtained in the benchmark regressions and also provides some evidence on the effects of institutional variables.

4.4 Interactions between structural and institutional variables

In this subsection, we examine the interaction effects of structural and institutional variables on fixed investments. This exercise is to help us obtain further insight into the conditions under which institutional variables may influence investment patterns, given

Table 4: Fixed investments regressions with interaction terms

	T1	T2	T3	T4	T5	T6
Fixed invest$_{t-1}$	0.71***	0.69***	0.70***	0.70***	0.69***	0.68***
	(0.12)	(0.13)	(0.12)	(0.13)	(0.13)	(0.13)
LGDP	0.05	0.07	0.08	0.08	0.14	0.17
	(0.49)	(0.48)	(0.47)	(0.48)	(0.47)	(0.50)
GDP growth	0.11	0.08	0.09	0.08	0.11	0.09
	(0.28)	(0.29)	(0.30)	(0.30)	(0.28)	(0.30)
Interest rate	-0.57***	-0.55***	-0.56***	-0.56***	-0.55***	-0.55***
	(0.16)	(0.14)	(0.16)	(0.17)	(0.15)	(0.15)
Inflation	0.14***	0.09	0.13**	0.14***	0.10	0.10
	(0.05)	(0.09)	(0.05)	(0.05)	(0.08)	(0.07)
Govt. consumption	0.45**	0.49**	0.46*	0.48*	0.45*	0.47*
	(0.20)	(0.24)	(0.25)	(0.26)	(0.24)	(0.25)
Financial openness	-2.80*	-2.87**	-2.89*	-2.71*	-3.45**	-3.10**
	(1.46)	(1.45)	(1.57)	(1.58)	(1.64)	(1.53)
Trade openness	0.01	0.01	0.01	0.01	0.01	0.01
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
Financial development		-0.01			0.11	0.07
		(0.03)			(0.16)	(0.08)
Institutional quality			-0.03		0.47	
			(0.35)		(0.48)	
Institutional structure				-0.09		0.21
				(0.25)		(0.31)
Financial opn. × inst.qlty					-3.66	
					(3.66)	
Financial opn. × instruc						-1.96
						(1.89)
Constant	-7.40	-7.02	-7.73	-8.10	-10.71	-10.98
	(13.74)	(13.71)	(13.51)	(13.79)	(14.99)	(15.16)
N	438	434	433	433	429	429
Hansen's J	7.38	7.11	6.76	6.22	6.39	6.30
Wald χ^2	996***	999***	1031***	1129***	1579***	1489***
AR(2) z	0.78	0.78	0.74	0.74	0.73	0.73
Instruments	17	17	17	17	17	17

Robust standard errors are reported in parenthesis. Significance symbols on coefficients are; *, ** and *** for the 10, 5 and 1% levels respectively.

the structural conditions. Specifically, we interact the main structural variable in the model (i.e. financial openness), with two of the institutional variables used.

From the results which are reported in Table 4, column (T5) and (T6) are the results for the interaction between financial openness with institutional quality and financial openness with institutional structure respectively. From column (T5) we see that the sign on the interaction coefficient between financial openness and institutional quality is negative. We can interpret this result to mean that the potential negative effect of financial openness on investment is less in countries with higher levels of institutional quality. This relationship is also true for institutional structure. This conclusion should be taken only as indicative at this point since the coefficients are not statistically significant. This relationship will be revisited when we consider the non-parametric regressions.

Table 5: Regression results from parametric models

	Pooled OLS	Fixed effect	Random effect
Constant	-9.26**		-23.12***
	(4.48)		(7.37)
Log(GDP)	0.83***	0.54	1.2***
	(0.15)	(1.48)	(0.26)
GDP growth	0.09	0.01	0.04
	(0.07)	(0.05)	(0.05)
Interest rates	-0.01	0.12***	0.06**
	(0.03)	(0.02)	(0.02)
Inflation	-0.08***	-0.01	-0.03*
	(0.02)	(0.02)	(0.02)
Government consumption	0.26***	0.19***	0.21***
	(0.06)	(0.05)	(0.05)
Financial Openness	0.02	2.3**	1.74*
	(0.94)	(1.03)	(0.91)
Trade openness	0.07***	0.13***	0.11***
	(0.01)	(0.02)	(0.01)
Financial development	-0.01	-0.02	0
	(0.01)	(0.02)	(0.02)
Business Environment	0.27	-0.83***	-0.71***
	(0.21)	(0.24)	(0.2)
Institutional Quality	2***	1.86***	1.85***
	(0.48)	(0.43)	(0.43)
Institutional structure	-1.19***	0.73*	0.58
	(0.38)	(0.44)	(0.37)
Human Development	-2.35**	-5.86**	-5.53***
	(0.99)	(2.62)	(1.16)
R^2	0.29	0.35	0.34
Effect	None	Two-way	Individual

Robust standard errors are reported in parenthesis. Significance symbols on coefficients are; *, ** and *** for the 10, 5 and 1% levels respectively.

4.5 Non-parametric results

In this section, we begin by justifying the use of nonparametric regression estimation techniques by presenting the results from alternative parametric specifications and conducting a nonparamteric test for correct model specification. In Table 5 the results for three alternative parametric models are reported including; pooled OLS, panel fixed effect and random effect.

By concentrating on the results from the fixed effect regression which has the highest R^2 value among the alternatives, we observe that apart from a few differences, most of the results obtained corroborate the results from the instrument based GMM estimation in Table 2 and Table 3. The advantage we have here is that more variables are additionally

statistically significant. Particularly interesting are the coefficients for trade openness, business environment and human development index. Without banging on the results from this class of parametric regression since they have been discussed in a previous section, we move straight to consider the results from Hsiao et al. (2007)'s nonparametric and consistent model specification test for this class of models.

The J_n statistic for the null of correct model specification with 399 IID bootstrap replications is 9.33 with a 0.00 p-value. Therefore the null of correct model specification for all the parametric models are rejected at the 1% level. Some of the implications of these result are as follows. First, a linear specification for the investment relation in Africa maybe too restrictive as it implies that the relationship is constant over time and it ignores potential nonlinearities in the relationship. Secondly, it implies that the conclusions and perhaps policy implications derivable from any parametric specification of this relationship will be sensitive to the kind of model used. In other words, results are likely to be different with different estimation techniques. This is confirmed by the differences in the results obtained from the GMM and panel based estimation techniques reported. These limitations of parametric specifications for the investment relation in Africa motivates our estimation of the computationally involved nonparamteric relationship between investment and structural and institutional variables.

Table 6: Optimal bandwith selection

Variable	Bandwith
L.GDP	0.0185
GDP growth	28.674
Interest rate	7.168
Inflation	41.097
Government consumption	3.105
Finiancial openness	0.9988
Trade openness	18.313
Financial development	2.525
Business environment	11823203
Institutional quality	88815043
Institutional structure	5877867
Human development	0.7205
Factor.Country	0.0531
Factor. Year	0.4915

Notes: Results are based on local regressions and bandwidths are selected by least squares cross validation. Objective function value is 9.04 achieved on 2 multistarts. For continuous explanatory variables, we use second-order Gaussian continuous kernel. For the factor variable, we use Aitchison and Aitken kernel method, while Li and Racine kernel method is used for the ordered variable.

To estimate a nonparametric regression model, we need to obtain the optimal bandwidth

for each of the regressors and since the baseline model is cast in a panel data framework, we are faced with a situation where we have regressors of mixed data type. That is, we have continuous variables which are all the controls in Equation 7, a categorical variable which are the countries and an ordered variable which is time. The results for the optimal bandwidth selection for each of the variables is presented in Table 6. The results are based on local regressions and bandwidths are selected by least squares cross validation. The objective function value is 9.04 achieved on 2 multistarts.[4] For continuous explanatory variables, we use second-order Gaussian continuous kernel. For the factor variable, we use Aitchison and Aitken kernel method, while Li and Racine's kernel method is used for the ordered variable.

Table 7: Non-parametric Kernel regression significance tests

Variable	P-values	
	IID	Wild-Rademacher
L.GDP	0.84	0.96
GDP growth	0.86	0.9
Interest rate	0.77	0.45
Inflation	0.62	0.72
Government consumption	0.73	.03**
Finiancial openness	0.42	0.71
Trade openness	0.28	0.7
Financial development	0.63	0.25
Business environment	.002**	0.00***
Institutional quality	0.27	.00***
Institutional structure	0.86	0.92
Human development	0.91	0.47

IID indicates that the p-values are obtained by paramteric bootstrap resampling from the normal distribution, whereas, Wild-rademacher will use a wild bootstrap transformation with Rademacher variables. This approach has the advantage of controlling for heteroscedasticity of unknown form on the DGP

4.5.1 Nonparametric significance test for kernel regression

Nonparametric regressions do not produce point parameter estimates, thus the standard t-testing approach used to identify significant parameters does not apply here. However, there is still a sense in which the significance of the regressors could still be tested. We implement univariate nonparametric significance tests for mixed data type based on Racine et al. (2006) and Racine (1997) to all the regressors. This test is comparable to the t-test in parametric regression. The class of tests formulated by Racine et al. (2006) are

[4]It is often recommended that at least 5 multistarts be used to achieve the objective function value when computer performance is high. However, due to the many hours it takes to run this, we have decided to use 2 multistarts as this does not compromise the results in any significant way.

known to be robust to functional misspecification among the class of twice continuously differentiable functions. Also, the null-distribution of the test has correct size and the test has power in the direction of the class of twice continuously differentiable alternatives see Racine (1997). To conduct this test, partition the vector of explanatory variables say W into two parts. The variable whose significance is to be tested $W_{(j)}$ and all other conditioning variables $W_{(-j)}$ excluding $W_{(j)}$. The partitioned matrix of conditioning variables (continuous and dummy) is written as $W = (W_{(-j)}, W_{(j)})$, where $W_{(-j)} \in \mathbb{R}^{p-j}$ and $W_{(j)} \in \mathbb{R}^{j}$. If the conditional mean $E(Y|W)$ is independent of a variable or group of variables of interest, then the true but unknown vector of partial derivatives of the conditional mean of dependent variables with respect to these variable is zero. That is, the test is formulated to detect whether a partial derivate equals 0 over the entire domain of the variable in question. The null hypothesis is stated in terms of the vector of partial derivates of the conditional mean thus;

$$H_O; \frac{\partial E(Y|W)}{\partial W_{(j)}} = 0 \qquad \text{for all } w \in W$$

$$H_A; \frac{\partial E(Y|W)}{\partial W_{(j)}} \neq 0 \qquad \text{for some } w \in W$$

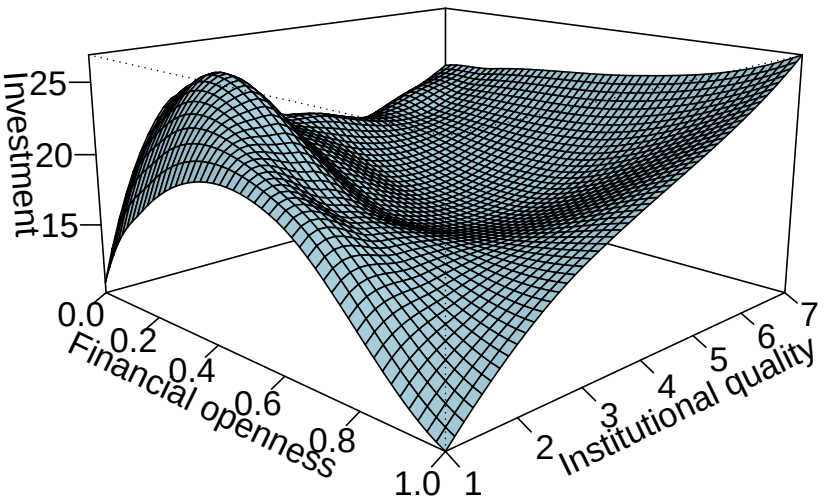
where $W_{(j)}$ is the regressor we are testing for and W is the vector of all regressors continuous and dummies.

The results for the significance test are reported in Table 7. The p-values are obtained by bootstrapping because the relevant distributions under the null and alternative hypothesis are non-standard. Column two contains the results for IID bootstraps which shows that only business environment is statistically significant. Too much cannot be said about this result because it does not account for potential heterogeneity of unknown form in the data generating process. This motivates the consideration of the alternative bootstraping technique using "wild" bootstraping schemes with Rademacher variables. The results are reported in column 3 of Table 7. We find that with heteroskedasticty accounted for government consumption, business environment and institutional quality have statistically significant p-values.

4.5.2 Investment profile curves, surface plots and contour maps

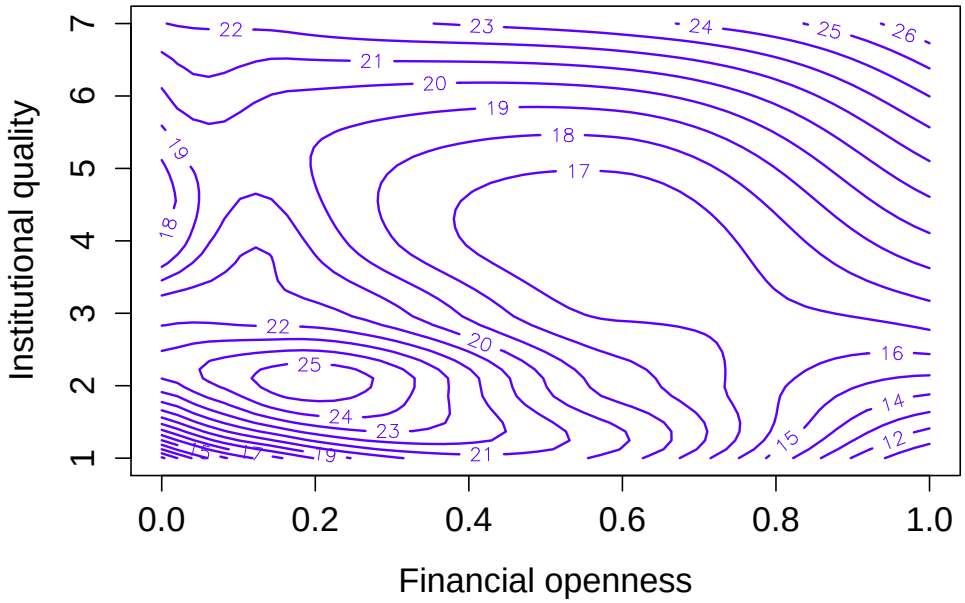
Since nonparametric regressions do not produce coefficients for the regressors, to see the results of nonparametric regression, we need to plot the profile curves, surface curves and or co-plots of the regressors. The investment profile curves with bootstrap standard errors are reported in Figure 5 and they give an isolated picture of the marginal effect of each regressor on investments. However, since we are specifically interested in the combined effects of structural and institutional variables, we focus on the surface plots

Figure 1: Fitted surface for kernel regression of investments on Finop. and Instqlty



and contour maps. We use institutional quality as the baseline institutional variable since it achieves significance in most of the models compared to the other institutional variables and then we alternate significant structural variables to understand their combined effects on investments.

Figure 2: Contour maps for kernel regression of investments on Finop. and Instqlty



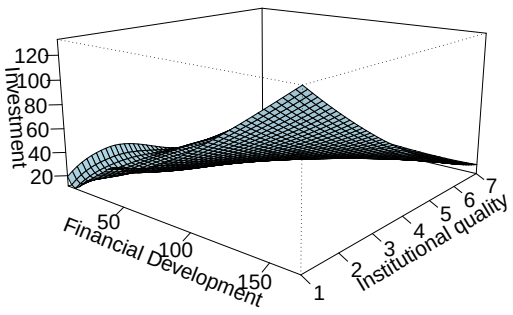
In Figure 1 the surface plot for the fitted values of the nonparametric regression of fixed investment on financial openness and institutional quality is reported. From the plot, we observe that the relationship of investments to financial openness and institutional

quality appears to be nonlinear, especially in the direction of financial openness. Also, the partial regression in the direction of each predictor does not appear to change very much as the other predictor varies, suggesting that the additive nonpararmetric model used is likely to be the appropriate specification.

Specifically, we observe from Figure 1 that at very low levels of financial openness, investment to GDP ratio is almost zero. However, as the level or index of financial openness increases, investments begin to rise and peaks when the level of financial openness is somewhere around 0.4, after which higher levels of the financial openness index leads to reductions in the level of investment. This result implies that there is a threshold level of financial openness that is best for these economies. Levels of financial openness less or greater than this threshold will be suboptimal and will lead to reductions in the level of investments. One possible explanation for this relationship could be the competing and crowding out effects that may be operative between FDI and domestic investments given the level of financial openness. When a country is relatively financially closed to the global financial market, investments are lower since financial mobilization only depends on domestic savings. On the other hand, an economy that is relatively too financially open will attract a lot of FDI which could crowd out domestic investments and with repatriation of funds by foreign investors, domestic investments will eventually shrink.

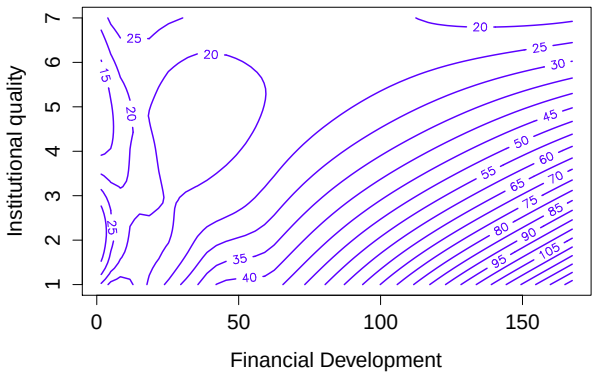
Further, we observe a seemingly linear and monotonically increasing relationship in the direction of institutional quality. In other words better and better institutions lead to more and more investments.

Figure 3: Fitted values and contour maps for investments on Findev and Instqlty



(a) Fitted surface for investments on Findev

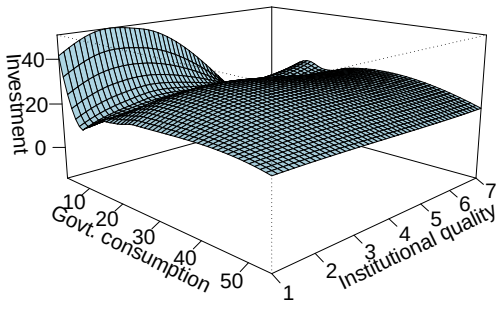
(b) Contour maps for investments on Findev



The contour maps are a cross-sectional representation of the three dimensional graphs. In specific terms, the contour maps presented here are two dimensional diagrams that connect specific points of the structural and institutional variable to the same estimated level of investment, i.e, they are Iso-investment lines. In Figure 2 we report the contour maps for the iso-investment given different levels of financial openness and institutional quality. We observe that there are two possibilities for the highest iso-investment curve

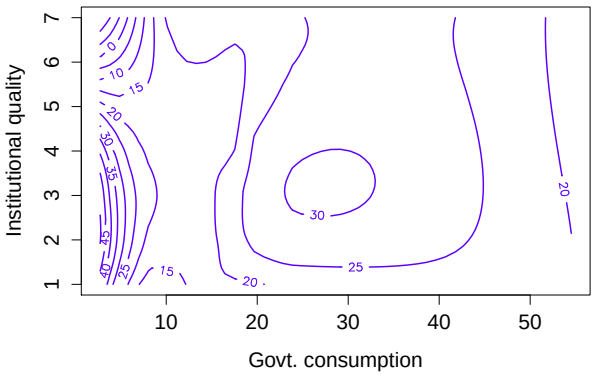
at 25. One is at the point where financial openness is low (around 0.2) and institutional quality is also low (around 2) and the other is when there is very high financial openness (around 0.8) and very high levels of financial quality around 6). This confirms the nonlinear relationship earlier observed and a lot more can be said about this.

Figure 4: Fitted values and contour maps for investments on Govtcon and Instqlty



(a) Fitted surface for investments on Gvtcon

(b) Contour maps for investments on Gvtcon.



In Figure 3 we report similar results for the case when we use an alternative measure of structural characteristic, here financial development. Again, we observe nonlinearities in the relationship between investment and financial development with institutional quality held constant (see Figure 3a). Specifically, we find that in spite of institutional quality, higher levels of financial development monotonically leads to higher levels of investment. This is interesting because it implies that even with weak institutions, it is still possible to have high levels of investments and this has generally been the case for many African countries like Nigeria which in-spite of weak institutions have still managed to attract significant investments especially in the private sector. The results are also similar when we use government consumption as the structural variable as reported in Figure 4

5 Conclusion

This paper endeavours to uncover the structural and institutional determinants of the variations in investments in Africa within a neoclassical framework. A simple neoclassical model that captures the apriori expectation is described and taken to the data using parametric and nonparametric regression techniques.

We obtain three main findings. First, we find that the main structural determinant of investment in Africa is financial openness, while the main institutional determinant is institutional quality. Secondly, we observe that there are nonlinearities in the relationship between investment and structural characteristics of an economy. Specifically, there is a threshold level of financial openness that guarantees high levels of investments. Thirdly,

when we interact the structural variable with the institutional variable, we find that the investment inhibiting effects of financial openness is less in countries with higher levels of institutional development.

The simple insight for policy arising from this paper is that in addition to the traditional policy areas such as a stable macroeconomic environment, the investment climate in Africa is characterized by the broader structural and institutional environment in which firms and businesses operate. These includes, financial openness, financial development, government consumption and the governance frameworks such as the control of corruption.

Figure 5: Investment profile curves with bootstrap error bands

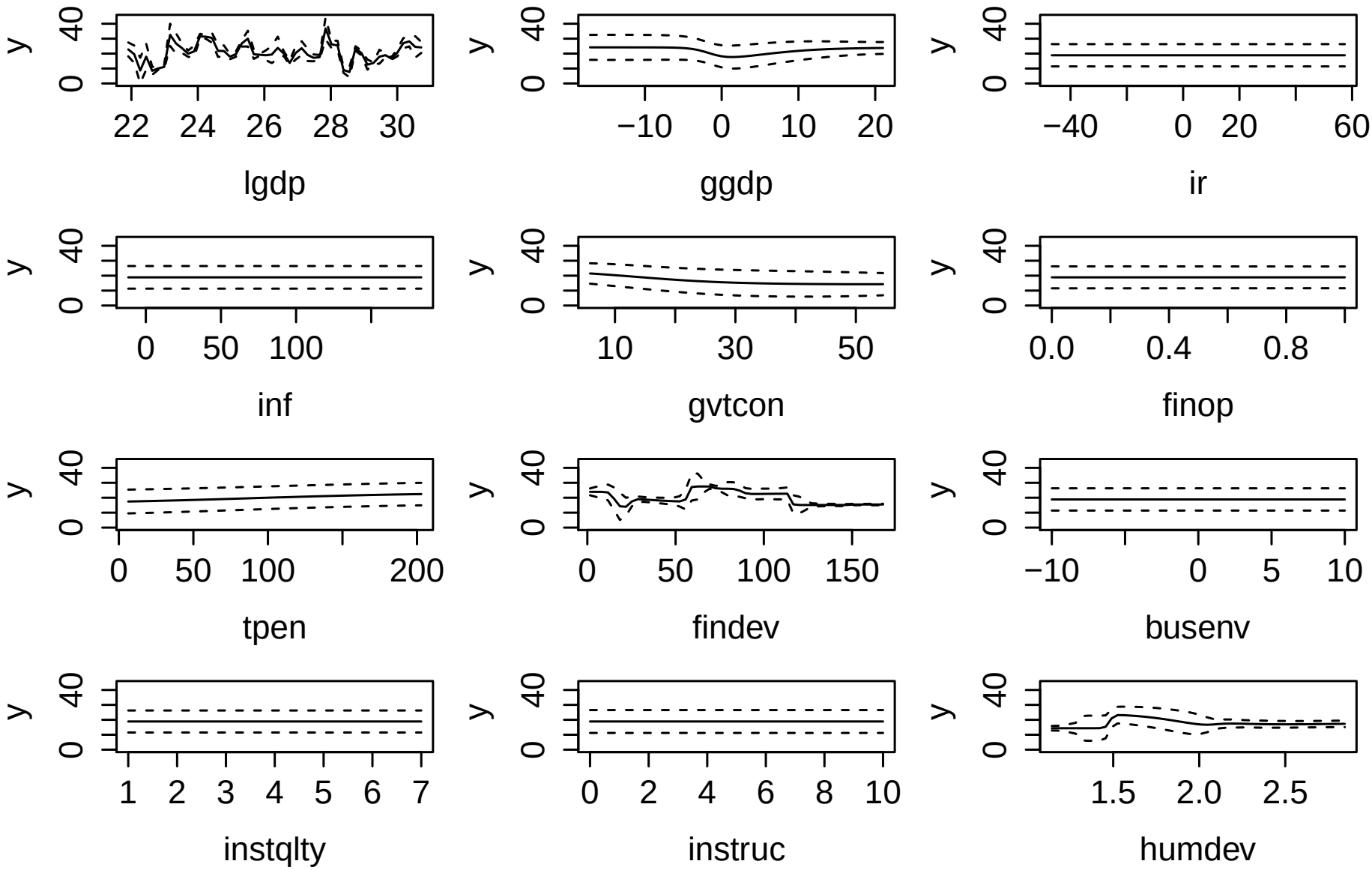


Table 8: Correlation with Bonferroni p-values

	Fix. Inv.	Ln.inv	Ln.GDP	GDP.g	Int. R.	Inf.	Gvt. Con.	Fin. Op.	Trd. Opn.	Fin. Dev	Inst. Qlty.	Int. strc.	Bus. Env.	Hum. dev.	TFP
Fixed Investment	1														
linv	-0.13*	1													
LGDP	0.03	-0.65***	1												
GDP growth	0.34***	-0.01	-0.02	1											
Interest rate	0.15*	-0.19***	-0.01	0.11	1										
Inflation	-0.19***	0.20***	-0.02	-0.08	-0.61***	1									
Govt. consumption	0.139*	-0.15**	-0.14*	-0.09	0.10	-0.07	1								
Financial openness	0.007	-0.13*	-0.01	0.03	0.22***	-0.16**	-0.05	1							
Trade openness	0.52***	-0.02	-0.31***	0.26***	0.12	-0.14*	0.208***	0.06	1						
Financial development	0.03	-0.07	0.02	-0.06	0.04	-0.16**	0.21***	0.07	-0.006	1					
Institutional quality	0.16	-0.06	-0.05	0.03	0.07	-0.06	0.20***	0.17***	0.10	0.44***	1				
Institutional structure	0.07	-0.04	-0.12	0.01	0.05	-0.03	0.24***	0.13*	0.18***	0.39***	0.93***	1			
Business environ	0.09	-0.04	-0.07	0.06	0.09	-0.02	0.16**	0.17**	0.11	0.31***	0.93***	0.963***	1		
Human cap. development	0.27***	0.05	0.04	0.04	0.08	-0.13	0.197***	0.28***	0.43***	0.42***	0.44***	0.41***	0.38***	1	

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

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