Spring 5-19-2017

Financial Sector Development and Agricultural Productivity

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May 2017

Thesis Submission in fulfillment for the award of Master of Science Degree in International and Development Economics

Abstract: Global concern is rising about the performance of the agricultural sector in view of its integral role in poverty alleviation, economic development and meeting an ever-increasing nutritional demand. At the epicenter of the concern is declining productivity due to poor financial inclusion of the sector leading to low investment and returns to agriculture. A cursory examination of the existing literature on the subject reveals quite varied dimensions to the analysis of agriculture productivity-financial development nexus. Focusing on the role of financial sector development as a catalyst to agricultural productivity, we employ panel data and advances fixed-effects econometrics approach to empirically investigate the linkage between agricultural productivity and financial sector development. Results from the analysis suggests that while financial sector development contributes positively to agricultural productivity, the magnitude of the effect is however statistically insignificant. This result is robust to multiple specifications and controls for institutional quality, economic size, agro-environmental factors, level of infrastructure, human capital, as well as year and country fixed effects. Additionally, agriculture credit has a positive and significant effect on productivity across sample of 75 developing countries, but positive and insignificant for developed economies. In view of the foregoing, it is imperative that policies targeted at boosting agricultural productivity are predicated upon creating incentive system that channels greater credit to boost agricultural investment. In this sense, financial sector development is not an end itself, but a means to an end.

Key words: *Agricultural productivity, Financial sector development, economic growth, econometrics, Robustness checks*

*I would like to thank my advisor, Suparna Chakraborty, my professors Alessandra Cassar, Sunny Wong, Mike Jonas, J.A. Hughes, A.G. Katz; my internship supervisors Sarah Lowder, Rafaele Bertini and Brian Carisma of the Food and Agriculture Organization (FAO) of the United Nations, Rome, University of San Francisco's MS International and Development Economics class of 2017, and many others for useful inputs and assistance with the data collection. Funding from Nigeria's Petroleum Technology Development Fund and the University of San Francisco is gratefully acknowledged. All errors are mine.

1. Introduction

Agriculture has served as one of the oldest form of human economic activity over time, spanning and evolving across many generations. Emphasizing the significance of the sector across most developing countries of the world, (IFAD, 2007) reports that approximately 75% of the poor live in rural areas and most depend on agriculture for their livelihoods. More so, the Global Agriculture and Food Support Program (GAFSP) and (World Bank, 2007a), estimates that Agriculture growth is two to four times more effective at reducing poverty than growth in any other sector. To this end, the imperatives of research, policies and interventions targeted at promoting agriculture productivity can simply not be overemphasized. In view of the proposition of the Malthusian model that the longer a society has been into agriculture, the higher the population density and the lower the income per capita, increased population and dietary requirements could potentially offset such gains. As stated in the SOFA (2016) report, promoting agricultural productivity has become even more imperative given modern global realities and growth whereby a combination of micronutrient deficiencies, undernutrition and over-nutrition has become rampant both at the household level and within many nations.

This cross-country analysis underscores the strength of the financial sector as a catalyst to agricultural productivity, and hence, economic growth by examining the various linkages among agricultural productivity and the financial markets. Do countries with more advanced financial sector exploit agricultural resources more efficiently? The above question is not novel and the literature largely suggests the affirmative. However, very little attention has been paid to the possible financial sector development transmission mechanism that leads to productivity at the broad national level. Hence, the magnitude and direction of the effects in the productivity-financial development nexus remains largely ambiguous. Disentangling this relationship and possible endogeneity at the country level is imperative in formulating policies and interventions targeted at maximizing the strength of the financial sector in a way that entrenches a more productive agricultural sector within and across countries.

Thus, there is abundant theoretical frameworks and evidence in support of the assertion that financial systems are important for productivity growth and development e.g. country level empirical studies such as those of King and Levine (1993a, b), Beck et al. (2000a, b) and Levine et al. (2000).

Analyzing the roles of different types of financial institutions, Levine and Zervos (1998) show that stock markets and banks provide different services, but both stock market liquidity and banking development positively predict growth, capital accumulation, and productivity improvements. Industry-wise, Rajan and Zingales (1998) find that the state of financial development reduces the cost of external finance to firms, thereby promoting growth. Combining industry and country level data, Wurgler (2000) shows that even if financial development does not lead to higher levels of investment, it seems to allocate the existing investment better and hence promotes economic growth. However, the efficacy of these theory may largely depend on sectoral priorities of the domestic economy, the attitudes of financial institutions towards lending to agricultural firms. Given the time lag in returns to agricultural investment, along with potential impacts of climate and rainfall variability resulting from increasing level of global warming, it becomes imperative to channel efforts towards overcoming financial constraints to agricultural production.

2. Conceptual Overview

The literature and theoretical framework on the nature and nurture of agriculture has evolved over time, just as the art and science of agriculture itself, dating back from the times of hunting and foraging. Agriculture can be traced back to the Holocene and thus an industry that is a foundational economic activity in human civilization.

To put the subject matter into proper conceptual context, Agricultural productivity may simply be defined as the ratio of the value of total farm outputs to the value of total inputs used in farm production (Olayide & Heady, 1982). Other earlier definitions viewed productivity as a physical relationship between output and the input which gives rise to that output (Quoted in Saxon, 1965); as well as the "ratio of index of local agricultural output to the index of total input used in farm production" (Shafi, 1984). Indeed, many measures of agricultural productivity abound, ranging from, agriculture value-added, total factor productivity, yields per hectare, etc.

Financial development has been measured and defined in various ways by different scholars. Alfaro et al. (2004), in determining the nexus between FDI and Economic growth through local financial markets, explored five different measures, e.g. value of credits by financial intermediaries to the private sector as a ratio of GDP, while measuring it in terms of ratio of liquid liabilities of the financial sector. At cross country level, there is a causal link between

financial development and agricultural productivity. A 1% increase in private credit/GDP increases value added per agricultural worker by 1%-1.7% (Nathan Associate, 2015).

2.2 Review of Literature

The literature paving way for our understanding of the nature and impact of the synergy between financial sector development and agricultural productivity has room for further contribution, hence this study extends the frontiers of the existing knowledge on the subject matter.

Overview of the agricultural sector

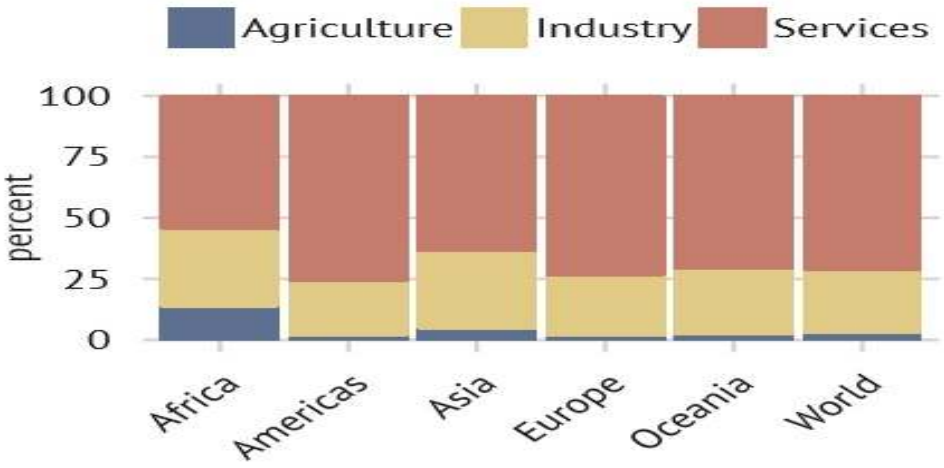
The regions of the world where hunger and extreme poverty are most widespread today – South Asia and sub-Saharan Africa – have seen flat or declining rates of investment per worker in agriculture over the past thirty years. Agricultural finance is a catalyst for Agricultural productivity, and hence, food security, job creation, and overall economic growth (GPFI, 2015). Despite this evidence, global efforts targeted at boosting productivity of this important sector have fallen short of expectations, both at the public and private level. The sector has witnessed consistent decline in terms of investment and share of contribution to GDP over time, with many economies paying greater attention to the services and manufacturing sectors.

To achieve the United Nations SDGs goals of ending hunger, achieving food security, improved nutrition, and promoting sustainable agriculture by 2030 (World Econ. Forum), agriculture requires greater level of investment to drive productivity to match an increasing global population. More so, Global food demand projected to increase by over 60% for estimated 9 billion people.

Despite this evidence, global efforts targeted at boosting agricultural productivity have fallen short of expectations, both at the public and private level. The graph presented below reflects the global realities in the sector and the extent of deficit that must be addressed to achieve optimal agricultural productivity.

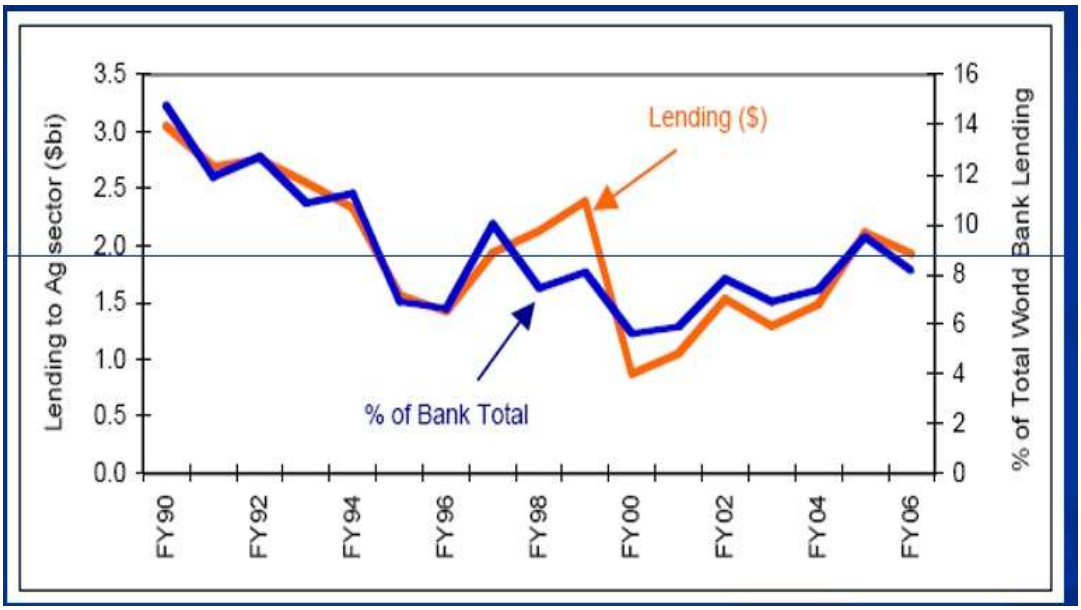
Fig. A: Value added by agriculture, industry and services sector

Value added by agriculture is comparatively lower than those from industry and services across all regions of the world. However, the sector is more significant in Africa and Asia compared to other economies. This is further explained in terms of figure A below.



Source: Source: FAO, Stat Book 2015

Fig. B: declining lending to agriculture (1990-2006)



Source: World Development Report, 2008

Figures above that when compared with other sectors such as industry and services, agriculture suffers from gross inadequacy of investment globally.

The nexus between agricultural productivity and financial markets

The quest for improvement in agricultural productivity has been a mirage since the emergence of agriculture and remains so even in the face of the technological advancement. While other sectors of the global economy such as mining, services, and manufacturing has witnessed tremendous advancement, most developing countries are still faced with low agricultural productivity. Tracing back to foundational theories on the foregoing, Ricardo (1815) opined "That great improvements have been made in agriculture, and that much capital has been expended on the land, it is not attempted to deny; but, with all those improvements, we have not overcome the natural impediments resulting from our increasing wealth and prosperity". This goes to show the level of impediments facing the agricultural sector, chief among them being poor financial resources to engage in commercial production, adoption of more efficient production techniques and improved seedlings that enhances productivity, purchase of crop insurance to provide safety net for large scale production, amongst several others, typically in developing countries. Indeed, finance is the heart beat of agriculture, which greatly influence the incentive to produce. The important role of the sector across most developing countries becomes evident since GDP growth in agriculture has been shown to be at least twice as effective in reducing poverty as growth originating in other sectors (World Bank, 2007a). More so, empirical evidence suggests that the availability of credit is more important than subsidized interest rates, whereby the expansion of banking had a larger impact on output through expanding fertilizer use than through increased investments (Binswanger, et.al 1993). This lay credence to the argument that greater investment in the agriculture is capable of significantly enhancing the welfare of most of the world populace.

The role of institutions

The quality of institutional systems within countries can mitigate negative impact climate variability and ease financial burden on farmers. Several studies find that certain threshold of intuitional quality is required. Further emphasis on the need for robust formal and informal institutional framework to enhance agricultural productivity and sustainability could be found through the works of Francis and Youngberg (1990) who argued that agricultural systems should maintain agricultural productivity and promote economic viability, reduce environmental degradation, and sustain rural communities and enhance the quality of life. Ikerd (1990) opines

that for a sustainable agriculture, farming systems should be commercially competitive, resource conserving and environmentally sound, and socially supportive. Such lofty goals can only be attained through formulation and implementation of policies that takes these factors into account and entrench more inclusive institutions in developing countries that ensures that benefits accruing from productive process better the lots of farmers who are highly reliant on agriculture as main source of livelihood.

The economic literature infers that the relationship between agriculture and financial systems are often marked by a difficult history. For financial institutions, agriculture is a sector that pays poorly because it has long protected by the State, resulting in substantial bad debts and deterioration of attitudes in relation to credit. To farmers, financial institutions are often seen as a rapacious industry applying prohibitive interest rates. In the new approach, all financial institutions are engaged in market logic, with primal motive of achieving financial autonomy and provide resources for their development. It thus provides the incentive to channel efforts towards the most profitable and secure sectors, thereby crowding out the agriculture. More so, a sound financial infrastructure is needed to support an efficient financial system. A key component is a strong prudential regulatory and supervisory capacity for the financial system (Meyer, 2003). This ensures that the both financial institutions and farmers are provided with the right incentive to access and grant credits respectively.

Hornbeck (2012) reflects that the value of land over time is a function of the broadly defined technological frontier and the environment. Hence, increasing agricultural productivity also leads to land savings, with less land being required for production.

While productivity in agriculture is predicated upon other important factors such as finance, human and physical capital, etc., it is immediately clear that rainfall variability does indeed pose the most fundamental impediment to productivity than could have been anticipated in time past. Hence, the need for adoption of climate smart agriculture and other discretionary policies targeted at curbing human factors that negatively affects the climate and environment cannot be over-emphasized. More so, climate, soil, geographical factors influence yields per hectare cross different countries and regions of the world, meaning that global yields are unevenly distributed. While technology can be used to improve productivity, the effects of adverse temperatures and rainfall variability means that land fertility limits potential positive impacts, considering that the stock of land can also not be increased. Agriculture productivity is highly predicated upon variation in rainfall, hence much attention is being given to

understanding climate change impact on agricultural productivity by institutions and policy makers.

Of great concern is the view widely held in several empirical findings that even though the mean level of global production is not projected to change significantly over the next three decades, certain regions are likely to experience higher climate variability and extreme weather shocks over the coming years (IPCC 2007, Rosenzweig & Tubiello, 2006), even as third U.S. National Climate Assessment forecasts that such climate disruptions to agriculture have been increasing and are projected to become more severe over this century. More so, Lobell et al. (2009) in their study of the potential impact on crop production in 12 regions of the world currently suffering from high level of food insecurity and finds that climate change could significantly impact agricultural production and food security by the year 2030. Hence, it is estimated that parts of South Asia and Sub-Saharan Africa could witness a decline in agricultural productivity between 15-35% (Cline 2007; IPCC 2007; Fischer et al. 2005).

In concluding, evidence from our extensive review of the theoretical and empirical framework on the agricultural productivity-financial sector nexus suggests that the latter is a fundamental imperative in the achieving the former. Thus, it suffices to note that financial development of an economy may only be a means to an end and not an end itself.

3. METHODOLOGY

3.1 Data, Model and Hypothesis

Our empirical analysis is predicated upon the measurement of agricultural productivity in terms of its agriculture value-added expressed as a ratio of GDP and crop yields measured in kilograms per hectare., with both data obtained from the World Development Indicators (WDI) for 115 countries from 1991-2013.

Constructing accurate and comparable measures of financial services data for a broad cross-section of countries over several decades is highly complicated. This study follows the precedence of Alfaro et al. (2004), advanced from the efforts of King and Levine (1993a), Levine and Zervos (1998) and Levine et al. (2000), which have constructed several financial market series, ranging from the stock market to the volume of lending in an economy. Accordingly, we employ two different measures of financial development. Deducing from the approach of Alfaro et al. (2004),

the first approach measures private sector credit (PRIVCR): equals the value of credits by financial intermediaries to the private sector as a ratio of GDP. This measure differentiates between the end users of the claims of financial intermediaries, i.e. whether the claims are in the public or the private sector and excludes funds from the development banks and the Central Bank to better capture the ability of intermediaries to research and identify profitable ventures, monitor and control managers, ease risk management, and facilitate resource mobilization (Beck et, al. 2000). Secondly, Bank Credit (*BANKCR*) equals credits by deposit money banks to the private sector as a share of GDP (excluding non-bank credits to the private sector).

To control for other factors that affects agricultural productivity across the sample of 115 countries besides the level of financial sector development, controls are made for level of infrastructure, institutional quality, economic growth, investment, agro-environmental factors and human capital. Data has been obtained from World Governance Indicators (WGI) for corruption Index. Controls for infrastructure includes mobile subscription per 100 people has been obtained for the same period from World Development Indicators (WDI). To investigate whether FSD impacts productivity mainly through investment in Agriculture, a proxy for investment entails factoring in the ratio of credit to agriculture as a ratio of total credit. This data has been obtained from the FAOSTAT, the database of Food and Agriculture Organization of the United Nations (FAO). For Robustness checks, I shall employ yields (kg per hectare) as an alternative measure for agricultural productivity against the same explanatory (RHS) variables. Data is obtained from the database of the World Bank for all countries.

Measure of human capital to reflect the absorptive capacity of the total population is measured using the educational attainment as a ratio of returns to education, obtained from Barro and Lee (2010) series. Additionally, inflation, measured as the percentage change in the GDP deflator is employed to obtain real values of key macroeconomic indicators. This measure can be obtained from the database of World Bank (2000a, b). It is important to note that most of the variables in the model are measured either in percentages or ratios to account for the different scales and characteristics of the various economies being considered in this study.

3.2 Research Questions

i. Does financial sector development (FSD) lead to higher levels of agricultural productivity? If so, are the impacts direct?
ii. Otherwise, what are the possible transmission mechanisms?

3.3 Overview of Empirical Strategy and Model

This study empirically investigates the financial development-agricultural productivity nexus at the broad macro level across multi-country employing fixed effects regression, clustering at country level. Year and country fixed effects are carried out to control for country-specific and time-invariant characteristics in the panel regression. Robust standard errors adjustment is carried out to correct for heteroscedasticity and autocorrelation in the model. To determine whether fixed effects regression is preferred over random effects, Hausman test is carried out to test whether the errors (U_i) are correlated with the regressors. After running each model, the null hypothesis that they are not is tested. The test statistics shows that random effects are biased, hence fixed effects provides more efficient estimates than random effects.

Baseline Model and hypothesis 1: The impact of financial development on agricultural productivity

$$AgProd_{it} = \beta_0 + \beta_1\, Finance_{it} + \beta_2\, AgCredit_{it} + \beta_3\, (Finance * AgCredit)_{it} + \beta_4\, (Finance * Corruption)_{it} + \delta\, X_{it} + \gamma + \varepsilon_{it}$$

Where:

$AgProd = \ Agricultural\ Productivity, defined\ as\ crop\ yields\ kg\ per\ hectare$

$\beta_0 = constant\ term\ or\ agriculture\ productivity\ intercept$

$Finance_{it} = Private\ Sector\ credit\ ratio\ to\ GDP\ (PRIVCR)\ and\ bank\ credit\ ratio\ of\ GDP\ (BANKCR)$

$\delta X_{it} = vector\ of\ controls\ for\ economic\ growth, human\ capital, infrastructure,$

$population\ growth\ \&\ agro - environmentl\ factors$

$AgCredit_{it}$

$=$ Credit to Agriculture, fishery and forestry

γ_{it} = Country and time fixed effects

Hypothesis

$H_0: \beta_1 = B_2 = B_3 = 0$
$H_A: \beta_1 \neq B_2 \neq B_3 \neq 0$

Baseline Model and hypothesis 2: The impact of agricultural credit on agricultural productivity. Financial development is excluded in this specification.

$$AgProd_{it} = \beta_0 + \beta_1\, AgCredit_{it} + \beta_2\, (gCredit * Corruption)_{it} + \beta_3\, (Corruption)_{it} + \delta\, X_{it} + \gamma + \varepsilon_{it}$$

3.4 Robustness Checks

We employ an alternative measure of agricultural productivity- agriculture value added divided by GDP is regressed against the same explanatory (RHS) variables with BANKCR as an alternative measure of FSD.

$$AgProd_{it} = \beta_0 + \beta_1\, BANKCR_{it} + \beta_2\, AgCredit_{it} + \beta_3\, (BANKCR * AgCredit)_{it} + \beta_4\, (Finance * Corruption)_{it} + \delta\, X_{it} + \gamma + \varepsilon_{it}$$

Where:

$AgProd_{it}$ = agrculture value added divided by GDP

$\beta_0 = constant\ term\ or\ agriculture\ productivity\ intercept$

$BANKCR_{it-1} = Bank\ credit\ as\ ratio\ of\ GDP$

$\delta X_{it} = vector\ of\ controls\ for\ economic\ growth, human\ capital, infrastructure, population\ growth\ \&\ agro - environmentl\ factors$

$H_0: \beta_1 = B_2 = B_3 = 0$

$H_A: \beta_1 \neq B_2 \neq B_3 \neq 0$

The hypothesis is tested at three different levels: developing countries, developed and full sample of all 106 countries. The World Bank income classification is employed with ratings from 1-5. Following the precedence of Hnatkovskay et. al., (2014), countries with income ratings between 1-3 are classified as developing, whereas those in the range 4-5 are classified as developed countries.

4.1 Empirical Results and Analysis

The panel regressions are presented in terms of tables 1-4 of appendix A, with robust standard errors in parenthesis, correcting for autocorrelation while also controlling for country and year fixed effects. Financial markets measure is interacted with agriculture credit and level of corruption quality respectively, in addition with simultaneously controlling for infrastructure, institutional quality, economic size, and other agro-environmental factors that affects productivity. The analysis is also presented for both developed and developing countries to investigate whether there is a differential impact of financial development on productivity, conditional on income level of a country.

Panel A and B in tables 1, 2 and 3 employs cereals yield per hectare to measure agricultural productivity. To ensure robustness of the relationship between financial development and agricultural productivity, an alternative measure of productivity is provided in column C, using agricultural agriculture value added as ratio of GDP. Similarly, two different measures of financial sector development are employed as regressors in terms of tables 1-4 of appendix A, employing private credit ratio of GDP and bank credit ratio of GDP (Alfaro et. al 2009). The investigate whether financial development leads to greater resource mobilization in agriculture, real credit to agriculture, fishery, and forestry is interacted with financial markets. As a first step, we investigate whether the level of financial development in the host country affects the agricultural productivity positively. Consequently, we ask whether the effects of financial markets are direct or conditional on agriculture credit and institutional quality.

To get an estimate of how important the financial sector has been in enhancing the productivity effects of agricultural credits, one can ask the hypothetical question of how much a one standard deviation increase in the financial development variable would enhance the agricultural productivity rate of a country receiving the mean level of credits in the sample. If we use the private credit variable as measure of financial development and define agriculture productivity in terms of cereals yields per hectare, (i.e. panel A), it turns out that having better financial markets impacts positively on productivity, while the impact is negative and insignificant when productivity is measured in terms of value added by agriculture ratio to GDP as shown in panel C. This result perhaps suggests that developed financial markets impacts positively on crop yields/ha but not through agriculture value-added. The mechanism of transmission of the impact of financial productivity may be more effective through drivers of productivity that leads to direct production process such as fertilizer usage, high yield seedlings, and land productivity as opposed to broad drivers of productivity involving the overall production process. This result is consistent across sample of developing countries in the sample (table1) and developed countries (table 2), as well as in the full sample as presented in table 3 of appendix A.

The robustness of the results obtained is confirmed by also employing an alternative measure of financial development, defined in terms of bank credit as ratio of GDP in terms of panel C in sub-sample of developing countries (table 1), developed countries (table 2) and full sample (table 3). Hence, the regressions in panel C employs crop yield per hectare as dependent

variable against the same measures bank credit as financial development and the same vector of controls for agricultural credit, infrastructure, economic growth, population growth, level of human capital, agro-environmental factors and institutional quality. As was the case with the previous measure of financial development, the impact of financial sector development on agricultural productivity is positive but insignificant across sub-sample of 75 developing countries, 15 developed countries and the full sample of 90 countries in terms of panel C of tables 1, 2 and 3 respectively.

Additionally, we ask what the impact of financial development would be on productivity conditional on level of credit advanced to agriculture. The literature suggests that financial development seem to improve access to finance. This assertion is investigated by interacting the two financial development indicators with credit to agriculture. The interaction term between private credit and agriculture credit to GDP ratio in panel A of tables 1, 2 and 3 employs crop yield as measure of productivity. To ensure that the interaction term does not proxy for investment or the level of development of financial markets, all the latter variables were also independently included in the regression. The effect of financial development on productivity, conditional on credit to agriculture is negative across developing, developed as well as the full sample as shown in tables 1, 2 and 3 respectively of appendix A. Panel B of the same tables presents the analysis employing bank credit as ratio of GDP to measure financial development. The result is also consistent with the previous result. An indication that even with developed financial markets, impact on productivity is not positive due to poor lending to the agriculture sector by the financial system. However, direct credit to agriculture positively and significantly enhances productivity at the 1% level across developing countries (table 1) relative to developed countries which derives increased productivity but negative in terms of value added by the agriculture sector. The effect in the overall sample follows the precedence of the developing countries, an indication that the result is largely driven by the nexus between financial development and agricultural productivity across developing countries. This may be due to the more significant role of the sector in the former than the latter. This ambiguous effect of financial markets and the role of local conditions underscores the motivation for this ongoing research.

Empirical evidence also suggests that the impact of financial development on agricultural productivity is conditional on a threshold of institutional quality (Dhrifi, 2014). To verify this possibility, we interact financial sector development (FSD) with corruption to ascertain the

partial effect of financial development on productivity conditional on level of institutional corruption.

The results in panel C of table 1 suggests that the partial effect of financial development on productivity, given a unit increase in corruption level is negative and significant at the 10% level. The reverse is the case for developed countries as shown on panel C of table 2, as well as the full sample in terms of panel C of table 3. (See appendix A). These results confirm certain findings in the literature: FSD by itself does exert a robust positive impact on productivity. The interaction provides mixed results, with negative impact in the case of developing countries with weaker institutions and higher corruption levels, but positive across developed countries the presence of stronger institutions with lower corruption, an indication of the role of institutions.

equation 2 of the model is employed to run fixed effects regression to investigate the effect of agriculture credit on productivity in the absence of financial sector development in terms of table 4 of appendix A. Real credit to agriculture ratio of GDP is hereby employed as a regressor, controlling for institutional quality, infrastructure, population, economic growth, proportion of total land area that is arable and the level of human capital. Panels A and B of table 4 presents the differential effects for developed countries, C and D for developing countries whereas E and F accounts for the full sample effect. We find mixed result for developed countries, where the effect of credit to agriculture on productivity is negative in term of crop yields but positive when value added by agriculture is considered as shown on panels A and B of table 4 respectively. Developing countries fare significantly better, with results of panel C and D of table 4 suggesting positive and significant effect of agriculture credit on productivity. Across the full sample presented in panel E and F, the effect follows the precedence of developing countries. While this suggests that global agricultural productivity growth is largely driven by developing countries, it does also show the credit gap in developing countries. Hence, the aim of boosting productivity could be effectively achieved by channeling greater credits to agricultural sector, especially in highly agro-allied economies which are predominantly developing countries. The interaction of agriculture credit with institutional quality suggests that agriculture credit given increasing level of corruption impacts productivity negatively across both developed and developing countries, with the impact being statistically significant in the full sample as shown on panel F of table 4 (See appendix A).

4.2 Conclusion

In this paper, we have extensively examined the effect of financial markets (FSD) on agricultural productivity, and whether these effects are predicated upon threshold level of institutional quality, infrastructure, or investment through direct credits to agriculture, fishery and forestry globally. The most significant conclusion of this paper is that while finance matters for agricultural productivity, it is not a significant driver of productivity in the absence of quality institutions and greater credits to agriculture.

Credit to agriculture appears to be the main channel through which countries enhance productivity from the financial markets. Financial sector development contributes positively to agricultural productivity and through direct crop inputs but negative through value-added by agriculture as ratio of GDP. This result is robust to multiple specifications and measures of productivity and controls. These results are consistent with the recent findings in the literature that show the important role of well-developed financial markets. More so, the regressions consistently show that credit to agriculture positively impacts productivity, aligning with vast body of literatures asserting the role finance as the "brain of the economy" by enhancing access to credit, reducing cost of production and doing business, as well as in channeling resources efficiently towards competing ends (Carkovic, M. & Levine, R., 2005; World Bank, 2001).

FSD can play an important role in agricultural productivity by broadening access to finance and reducing cost of finance, but the magnitude of such gains may depend on the absorptive capacity of the domestic economy, the quality of institutions, investment in human capital, infrastructure and technology in agricultural sector. Other more prudent policies might involve eliminating barriers that prevent farmers from establishing adequate linkages, improving local farmers' access to inputs, technology and financing, and broadening the markets for outputs. More policy implication of the results would entail creating the desired level of institutional incentive required to encourage the financial system to advance greater levels of credits to agriculture.

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APPENDIX A: Panel Fixed Effects Regression Results

Table 1: Financial Development & Agricultural Productivity: Developing Countries

Variables	(A) Crop Yield	(B) Crop Yield	**(C) Agric. Value Added_GDP**
Agriculture Credit/GDP	10.70**	6.936*	16.38***
	(3.830)	(3.397)	(0.659)
Agriculture Credit/GDP X Private Credit/GDP	-0.118		
	(0.103)		
Private Credit/GDP	0.002		-0.003
	(0.002)		(0.002)
Arable Land	-0.007	0.004	-0.008
	(0.005)	(0.003)	(0.006)
Mobile Subscription per 200 people	0.0001	-0.001	-0.002**
	(0.001)	(0.001)	(0.001)
Lag LnGDP	-0.015	-0.053	0.057
	(0.057)	(0.051)	(0.053)
Lag Population	0.524	0.046	0.153
	(0.305)	(0.178)	(0.340)
Corruption	0.069	0.168***	0.0437
	(0.068)	(0.046)	(0.072)
Corruption X Private Credit/GDP			-0.005*
			(0.003)
Agriculture Credit/GDP X Bank Credit/GDP		-0.051	
		(0.076)	
Bank Credit/GDP		0.001	
		(0.001)	
Lag Human Capital		0.022	
		(0.136)	
Constant	6.668***	7.845***	-0.039
	(0.837)	(0.503)	(0.666)
Observations	961	824	942
R-squared	0.128	0.191	0.273
Number of Countries	88	75	89
Country FE	YES	YES	YES
Year FE	YES	YES	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 2: Financial Development and Agricultural Productivity: Developed Countries

VARIABLES	(A) Crop Yield	(B) Crop Yield	(C) Agric. Value Added_GDP
Agriculture Credit/GDP	10.42	4.924	-0.471
	(12.480)	(6.211)	(0.741)
Agriculture Credit/GDP X Private Credit/GDP	-0.074		
	(0.084)		
Private Credit/GDP	0.002		-0.009*
	(0.004)		(0.004)
Arable Land	-0.051	-0.082	0.009
	(0.044)	(0.065)	(0.017)
Mobile Subscription per 200 people	-0.001	-0.002	-0.006***
	(0.001)	(0.003)	(0.001)
Lag LnGDP	0.830	1.183	-0.321
	(0.584)	(0.888)	(0.206)
Lag Population	2.778***	2.673***	0.496*
	(0.137)	(0.218)	(0.227)
Corruption	-0.428*	-0.508*	-0.899*
	(0.183)	(0.249)	(0.417)
Corruption X Private Credit/GDP			0.004
			(0.002)
Agriculture Credit/GDP X Bank Credit/GDP		-0.045	
		(0.054)	
Bank Credit/GDP		0.001	
		(0.005)	
Lag Human Capital		-0.869	
		(1.431)	
Corruption X Bank Credit/GDP			0.000
			(-0.000)
Constant	-6.267	-8.459	4.795*
	(6.470)	(7.244)	(2.181)
Observations	159	146	144
R-squared	0.670	0.678	0.694
Number of Countries	16	15	17
Country FE	YES	YES	YES
Year FE	YES	YES	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3: Financial Development & Agricultural Productivity: Full Sample

VARIABLES	(A) Crop Yield	(B) Crop Yield	**(C) Agric. Value Added_GDP**
Agriculture Credit/GDP	9.221***	7.694**	10.19**
	(2.964)	(2.927)	(4.745)
Agriculture Credit/GDP X Private Credit/GDP	-0.068***		
	(0.022)		
Private Credit/GDP	0.004		-0.001
	(0.002)		(0.002)
Arable Land	-0.020*	-0.014	0.007
	(0.009)	(0.011)	(0.011)
Mobile Subscription per 200 people	0.001	0.001	-0.002**
	(0.001)	(0.001)	(0.001)
Lag LnGDP	-0.095	-0.133	0.052
	(0.090)	(0.088)	(0.047)
Lag Population	1.783**	1.693*	0.211
	(0.737)	(0.837)	(0.315)
Corruption	0.0665	0.111	0.002
	(0.0620)	(0.071)	(0.053)
Corruption X Private Credit/GDP			-0.005**
			(0.002)
Agriculture Credit/GDP X Bank Credit/GDP		-0.061**	
		(0.023)	
Bank Credit/GDP		0.004	
		(0.003)	
Lag Human Capital		-0.126	
		(0.252)	
Corruption X Bank Credit/GDP			0.001
			(-0.000)
Constant	5.178***	5.348***	-0.345
	(1.223)	(1.556)	(0.675)
Observations	1,120	970	1,086
R-squared	0.267	0.297	0.233
Number of Countries	104	90	106
Country FE	YES	YES	YES
Year FE	YES	YES	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 4: Differential Impact of Agricultural credit on Productivity

	Developed		Developing		Full Sample	
VARIABLES	(A) Crop Yield	(B) Agric. Value Added_GDP	(C) Crop Yield	(D) Agric. Value Added_GDP	(E) Crop Yield	(F) Agric. Value Added_GDP
Agriculture Credit/GDP	-8.162	4.083	15.95**	19.03***	3.102	19.50***
	(6.300)	(5.651)	(6.955)	(5.164)	(3.225)	(3.791)
Arable Land	-0.095	0.026	0.004	-0.009	-0.013	-0.009
	(0.069)	(0.018)	(0.002)	(0.014)	(0.011)	(0.011)
Mobile Subscription per 200 people	-0.003	-0.006***	-0.001	-0.002*	0.001	-0.002***
	(0.004)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Lag LnGDP	0.646	-0.288	-0.0567	0.081	-0.122	0.054
	(0.610)	(0.289)	(0.049)	(0.071)	(0.075)	(0.059)
Lag ln Population	2.869***	0.422	0.116	0.350	1.651*	0.223
	(0.191)	(0.269)	(0.164)	(0.538)	(0.892)	(0.309)
Lag Human Capital	-1.413		0.149		-0.101	
	(1.926)		(0.154)		(0.268)	
Corruption	-0.359	-0.346*	0.210***	-0.102**	0.146**	-0.120
	(0.245)	(0.180)	(0.033)	(0.045)	(0.062)	(0.080)
Corruption X Agric. Credit/GDP		-1.612		-4.799		-7.996***
		(2.169)		(8.044)		(1.669)
Constant	0.337	3.323	7.446***	-0.760	5.425***	-0.293
	(3.561)	(3.010)	(0.465)	(0.961)	(1.404)	(0.663)
Observations	161	154	839	956	1,000	1,110
R-squared	0.662	0.640	0.235	0.261	0.292	0.261
Number of Countries	15	18	75	89	90	107
Country FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Appendix B: Summary Statistics for full sample and sub-sample of developed vs developing countries

A: Full Sample

Variable	Obs.	Mean	Std. Dev.	Min	Max
Real AGVA_GDP	2,170	0.609	2.062	0.0002	20.785
Log crop. Yield	2,492	7.618	0.732	4.7014	11.215
rC2A_GDP	1,548	0.009	0.022	0.0000	0.290
PRIVCR	2,450	39.309	34.415	0.8739	261.481
BANKCR	2,450	37.114	31.301	0.8739	261.481
Arable Land	2,630	15.699	13.867	0.0840	72.098
Mobile Subs	2,329	41.688	47.095	0.0001	199.664
Human Capital	2,139	2.277	0.694	1.0335	3.718
Ln Real GDP	2,553	10.688	2.134	5.6809	16.600
Log Population	2,553	1.994	2.005	-3.1940	7.154
Reg. Quality	1,701	-0.045	0.832	-2.5301	2.247
Corruption	1,701	-0.128	0.897	-1.9138	2.462

B: Developed Countries

Variable	Obs.	Mean	Std. Dev.	Min	Max
Real AGVA_GDP	297	0.418	0.837	0.003	4.989
Log crop. Yield	359	8.287	0.670	5.099	11.215
rC2A_GDP	284	0.019	0.044	0.000	0.290
PRIVCR	405	85.495	40.057	25.712	261.481
BANKCR	405	76.548	34.424	25.712	261.481
Arable Land	428	14.299	11.465	0.419	37.209
Mobile Subs	426	63.475	50.207	0.029	199.664
Human Capital	391	2.975	0.448	1.986	3.718
Ln Real GDP	437	11.973	2.441	6.363	16.600
Log Population	437	1.603	2.257	-2.774	5.759
Reg. Quality	280	1.173	0.462	-0.082	2.247
Corruption	280	1.322	0.660	-0.252	2.462

C: Developing Countries

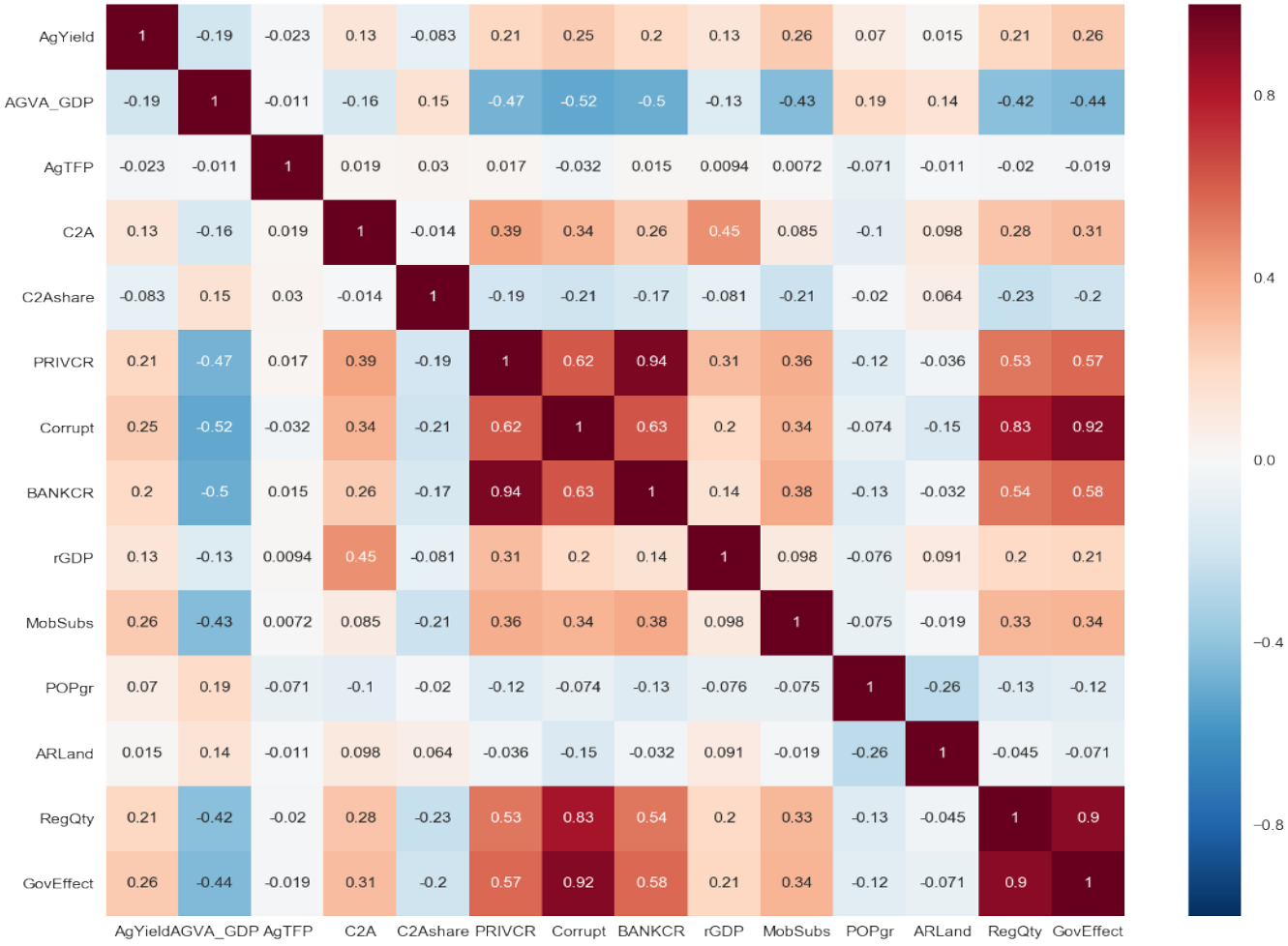
Variable	Obs.	Mean	Std. Dev.	Min	Max
Real AGVA_GDP	1,873	0.639	2.193	0.000	20.785
Log crop. Yield	2,133	7.506	0.680	4.701	10.227
rC2A_GDP	1,264	0.006	0.012	0.000	0.151
PRIVCR	2,045	30.162	24.403	0.874	165.860
BANKCR	2,045	29.305	23.886	0.874	165.860
Arable Land	2,202	15.971	14.274	0.084	72.098
Mobile Subs	1,903	36.810	44.960	0.000	185.822
Human Capital	1,748	2.121	0.642	1.034	3.649
Ln Real GDP	2,116	10.422	1.964	5.681	15.700
Log Population	2,116	2.074	1.940	-3.194	7.154
Reg. Quality	1,421	-0.285	0.661	-2.530	1.444
Corruption	1,421	-0.414	0.617	-1.914	1.358

Appendix C: List of Countries

Afghanistan	Costa Rica	Italy	Russian Federation
Albania	Cote d'Ivoire	Jamaica	Rwanda
Angola	Cyprus	Jordan	Senegal
Antigua and Barbuda	Czech Republic	Kazakhstan	Serbia
Argentina	Dominica	Kenya	Seychelles
Armenia	Dominican Republic	Korea, Dem. People's Rep.	Singapore
Aruba	Ecuador	Kyrgyz Republic	Sri Lanka
Australia	Egypt, Arab Rep.	Lebanon	St. Kitts and Nevis
Austria	El Salvador	Liberia	St. Lucia
Azerbaijan	Estonia	Malawi	Vincent & the Grenadines
Bahrain	Ethiopia	Malaysia	Suriname
Bangladesh	France	Maldives	Syrian Arab Republic
Barbados	Gabon	Mali	Tajikistan
Belarus	Gambia, The	Mexico	Tanzania
Belgium	Georgia	Moldova	Thailand
Belize	Germany	Morocco	Timor-Leste
Benin	Ghana	Mozambique	Togo
Bhutan	Greece	Namibia	Trinidad and Tobago
Bolivia	Grenada	Nepal	Tunisia
Bosnia & Herzegovina	Guatemala	New Zealand	Turkey
Botswana	Guinea-Bissau	Nicaragua	Uganda
Brazil	Guyana	Niger	Ukraine
Bulgaria	Honduras	Nigeria	United Arab Emirates
Burkina Faso	Hungary	Oman	United States
Burundi	India	Pakistan	Uruguay
Cabo Verde	Indonesia	Panama	Vanuatu
Cambodia	Iran, Islamic Rep.	Peru	Vietnam
Canada	Iraq	Philippines	Yemen, Rep.
Congo, Dem. Rep.	Israel	Qatar	Zambia

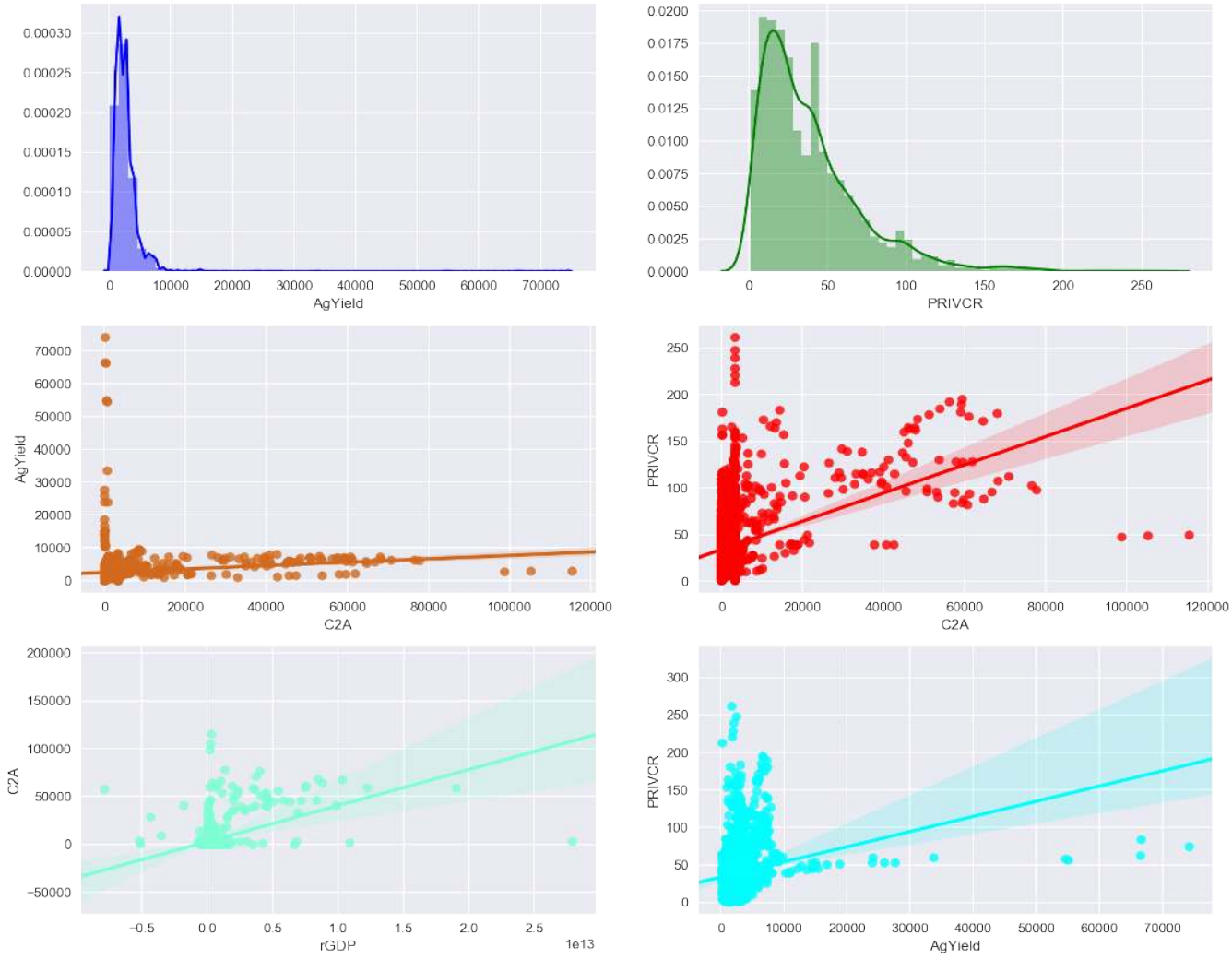
Appendix D

Correlation among key variables



Appendix E

Trend in global Agriculture Productivity, credit and financial development (1991-2013)



Source: generated by author from structured dataset using python machine learning

Appendix F

Construction and definition of Variables

Variable	Construction	Definition
lnrC2A	Credit to Agric. divided by GDP deflator	Real Credit to Agriculture, Fishery and Forestry (millions of USD)
Human Capital	Human capital generated based on Barro and Lee series	Educational attainment of proportion of the population 25+ years as ratio of returns to education
Cereals Yield	Cereal yield- measured as kg/ha of harvested land, includes wheat, rice, maize, barley, oats, rye, millet, sorghum, buckwheat, & mixed grains.	Partial measure of agricultural productivity
AGVA_GDP	Current Value Added/GDP deflator. Employed as a measure of agric. Productivity	Real agriculture value added per worker in millions of UDS taken as ratio of GDP- a measure of agricultural productivity
MobSubs	Mobile cellular subscriptions (per 100 people)- all mobile cellular subscriptions that offer voice communications. It excludes subscriptions via data cards or USB modems, subscriptions to public mobile data services & private trunked mobile radio	Employed as a control for technology in the regression equation, defined as the number of postpaid subscriptions, and the number of active prepaid accounts (i.e. that have been used during the last three months).
ARLand	Arable land (% of land area)-Employed as one of the vector of controls for productivity	land under temporary crops (double-cropped areas are counted once), temporary meadows for mowing or for pasture, land under market or kitchen gardens, and land temporarily fallow, excl. land abandoned for shifting cultivation.
Population	Population growth (annual %)-for year t is the exponential rate of growth of midyear population from year t-1 to t, expressed as a %.	Population is based on the de facto definition of population, which counts all residents regardless of legal status or citizenship.
Corruption	Reflects perceptions of the extent to which public power is exercised for private gain.	Including both petty and grand forms of corruption, as well as "capture" of the state by elites and private interests.
PRIVCR	Private credit by deposit money banks and other financial institutions to GDP.	Generated using the deflation method employing end of period CPI, average CPI and credit to private sector.
BANKCR	Bank Credit-equals credits by deposit money banks to the private sector as a share of GDP	Indicator excludes non-bank credits to the private sector. This provides a reflection of level of financial development of a country