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Regulatory Constraints to Agricultural Productivity

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Abstract

The economic thinking around the role of agriculture for development has evolved since the 1950s. Over the past decades, the agriculture sector has been rediscovered as a sector with great potential for triggering growth, reducing poverty and inequality, providing food security, and delivering environmental services. This paper contributes to the literature on the determinants of agricultural development by investigating the role played by laws and regulations. First, the paper proposes new measures of regulatory quality and regulatory efficiency in agriculture. Second, the paper employs cross-section data to test the relationship of the proposed measures with agricultural performance. The results indicate that agricultural productivity is on average higher where transaction costs imposed by regulations are lower and where countries adhere to more regulatory good practices. This relationship is stronger when low transaction costs and regulatory good practices are combined.

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Regulatory Constraints to Agricultural Productivity

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I. Introduction

The economic thinking around the role of agriculture for development has evolved since the 1950s. Classical economists viewed economic development as the relocation of factors of production from a traditional agricultural sector to a more productive, modern industrial sector (Lewis, 1954). This structural transformation has been described as the process that marks the change from an agrarian society to an industrial one, and from artisanal manufacturing to mass production. As economies grow and urbanize, services from commerce, finance, and the state become increasingly important (Clark, 1951, Kuznets, 1957, Chenery and Syrquin, 1975). Such literature looked at agriculture as a mere source of underutilized cheap labor, and has paid little attention to the development of the sector itself.

A new view emerged in the 1960s – largely thanks to the success of the Green Revolution in Asian economies – highlighting agriculture's central role as a driver of growth, especially in the early stages of industrialization (Johnston and Mellor, 1961). This branch of the literature did not oppose agriculture's relative decline in size, but rejected the notion of its marginality with regards to the development process (Trimmer, 1988). Scholars emphasized agriculture's modernization potential, in contrast with the traditional view of agriculture as an inherently less productive sector (North, 1959; Schultz, 1964; Hayami and Ruttan, 1985). Others called attention to agriculture's growth linkages and multiplier effects to highlight the sector's importance for broader economic development (Adelman, 1984; Mellor, 1998; Hsieh and Sadoulet, 2007).

Recent years witnessed a renewed interest in agriculture's role for development. The adoption of the Millennium Development Goals by the United Nations began to shift the development debate from achieving growth per se to promoting pro-poor – or "shared" – growth (Ravallion and Chen, 2003; Kraay, 2006). Some economists have stressed agriculture's new role as the result of globalization, technological and institutional innovations, and environmental constraints. They see agriculture as a key sector for this new development framework thanks to its potential to accomplish multiple functions: triggering growth, reducing poverty and inequality, providing food security, and delivering environmental services (Byerlee, De Janvry and Saudolet, 2009; Christiaensen, Demery and Kuhl, 2011).

Table 1. Agriculture's contribution to employment and GDP

	GDP (%)		Employment (%)	
	1980-99	*2000-15*	*1980-99*	*2000-15*
East Asia and the Pacific	17.4	11.2	37.2	25.3
Europe and Central Asia	9.7	5.3	17.3	12.6
Latin America and the Caribbean	11.0	7.1	19.4	15.7
Middle-East and North Africa	12.5	9.1	16.7	17.1
North America	1.3	1.2	2.9	1.6
South Asia	28.6	19.2	50.6	42.0
Sub-Saharan Africa	19.1	15.4	47.6	43.5
High income	4.5	2.7	9.9	5.5
Upper middle income	15.1	7.8	28.8	22.2
Lower middle income	24.1	16.9	39.9	35.1
Low income	32.8	28.9	75.0	71.4
Total	**12.9**	**8.3**	**24.1**	**19.1**

Source: Authors' calculations based on World Development Indicators.

From a development perspective, two main reasons constitute our rationale for focusing on agricultural productivity. The first reason is agriculture's relevance in the short run given its size. The figures on agriculture's contribution to the economy validate the idea that the sector is far from being marginal to the development process. Between the last two decades of the 20th century and the first 15 years of the 2000s agriculture's contribution has declined globally both in terms of GDP and employment (Table 1). In the latter period agriculture accounted only 2.7% of the GDP and 4.5% of total employment in high-income economies. The picture is however quite different for less wealthy nations. Since 2000, agriculture averaged 28.9% of the GDP of low-income[†] economies and 71.4% of total employment. Even among upper-middle income countries where agriculture downsized from 15.1% to 7.8% of GDP, the sector is still responsible for over one-fifth of total employment. Agriculture's relative decline in terms of contribution to employment and GDP as countries graduate to higher levels of income is a remarkable empirical regularity. Nonetheless, the sector's relevance for development is not to be questioned. While it may be trivial in high-income economies, agriculture's contribution is still substantial in most of the developing world.

[†] Low-income economies are defined as those with a GNI per capita, calculated using the World Bank Atlas method, of $1,005 or less in 2016; lower middle-income economies are those with a GNI per capita between $1,006 and $3,955; upper middle-income economies are those with a GNI per capita between $3,956 and $12,235; high-income economies are those with a GNI per capita of $12,236 or more.

The second reason is that, despite its decline in relative size, agriculture continues to play a crucial role in ensuring a successful structural transformation of the economy in the long run. In non-industrialized countries agriculture is the only source of government revenue. A sharp and sustained increase in agricultural productivity is a precondition for industrial development. All of today's high-income countries kick started industrialization by taxing their reformed agricultural sectors.[‡] In the subsequent early industrialization phases, a productive agricultural sector becomes a key contributor to overall growth by stimulating demand for industrial products, containing urban wages by producing affordable food and ensuring foreign currency inflow through agricultural exports. As agriculture integrates with the rest of the economy, capital and labor progressively shift towards uses with higher returns in manufacturing and services. This triggers a convergence in the labor productivities – and therefore incomes – of the two sectors, but important gaps persist to the present in rich countries (Table 2).

Table 2. Average labor productivity by income group, 2000-15 (thousand US$ per worker)

	Agriculture	**Manufacturing and Services**	**gap**
High income	39.0	74.5	47.7%
Upper middle income	6.9	18.8	63.3%
Lower middle income	2.5	6.4	61.5%
Low income	0.5	3.5	85.9%
Total	**21.5**	**43.1**	**50.1%**

Source: Authors' calculations based on World Development Indicators.
Notes: Labor productivity is calculated as the ratio between the GDP and the number of workers in each sector. The labor productivity gap is calculated as the labor productivity in agriculture expressed as a share of that in manufacturing and services.

Significant imbalances between urban and rural incomes generate political tensions in response to which governments tend to protect the agricultural sector from international competition and ultimately provide direct income subsidies to farmers (Lindert, 1991). Even for industrialized countries – most of which severely subsidize their farmers – raising agricultural productivity is key to contain the distortionary and budgetary costs of agricultural protection (Timmer, 1988).

Despite what is discussed above, much of the economic literature has treated agriculture as a marginal sector, leaving many questions around the drivers of agricultural development

[‡] Small states with no or minimal agriculture, such as Singapore or Hong Kong SAR, China, represent clear exceptions.

unanswered. In an attempt to fill part of this gap, our research focuses on the role of regulation in determining economic performance in agriculture. Our research follows the argument of Hayami and Ruttan (1985), which emphasizes poor institutions as the major constraint to agricultural performance over resource endowments and technological availability. Unlike capital and technology, policies and regulations are characterized by high spatial stickiness: they cannot flow easily across countries. This puts high responsibility in the hands of policy makers across developing countries to enact an enabling policy and regulatory environment for agriculture.

The remainder of this paper is organized as follows. Section II summarizes the existing literature around the relationship between regulation and agricultural transformation. Section III presents new data on agricultural regulation and proposes some measures of regulatory quality. Section IV proposes an empirical analysis of the relationship between business regulations and productivity in agriculture. Section V draws some concluding remarks.

II. Regulation and Agricultural Transformation

The structural change literature studies how countries reallocate their economic activities from agriculture to other sectors as they develop. A less obvious, though no less important, transformation occurs within the agricultural sector itself (Timmer 2009). Agricultural transformation has been shaped by increases in productivity, a shift towards cash crops and high-value/high-risk varieties, as well as an increased integration with the rest of the economy (Divanbeigi, Paustian and Loayza 2016). The extent of this transformation has often been dramatic. From 1960 to the present, agricultural output per hectare has expanded by over 250 percent (Alston, Babcock and Pardey 2010). In some cases, this expansion has been led by developing countries. Cereal yields in East Asia have risen by an impressive 2.8 percent per year, much more than the 1.8 percent growth in industrial countries (World Bank 2007).

Progress towards agricultural transformation has however been far from homogeneous. Economists have thus attempted to identify specific factors behind transformational success. They identified the success of the Green Revolution (1966 to 1985) and the two decades that followed as the result of a combination of high rates of investment in crop research, market development and policy support (Pingali 2012; Hazell 2010). Researchers also recognized public goods provision such as transport and irrigation infrastructure (Dercon and others 2009; Lipton,

Litchfield and Faurès 2005). Regulatory improvements also contributed to the transformation of agriculture, though research in this area has been limited. Sustained trade liberalization over the past five decades also supported agricultural transformation by expanding opportunities for exporters of agricultural products. In the past 50 years, exports of agricultural products from developing countries have multiplied eight-fold while those of agriculture-based manufactured products increased ten-fold. Studies found that regulation impacts the development of key agricultural markets such as seed (Gisselquist and Grether 2000; Langyintuo et al. 2010), machinery (Gisselquist and Grether 2000) and fertilizer (Freeman and Kaguongo 2003; Kormawa, Munyemana and Soule 2003).

Regulation and economic performance

Regulations are sets of rules that constrain the actions of economic agents with the objective of achieving social goals such as safety, job security or health. The theory of regulation emerged in the nineteenth century and it encompasses a vast collection of literature.[§] Regulations are justified by structural market failures arising from informational asymmetries, economies of scale in production, fragmented markets and externalities. In their presence, economic agents do not internalize the social costs and benefits of their actions, and therefore adequate regulation can raise social welfare (Pigou 1938). However, the political economy that characterizes regulations is complex and social goals typically compete with interest groups that distort regulations to capture economic rents. Industry incumbents can acquire regulations that create rents for themselves thanks to lower information and organization costs than dispersed consumers (Tullock 1967; Stigler 1971). Politicians and bureaucrats themselves use regulation both to create rents and to extract them through campaign contributions, votes, and bribes (McChensney 1987; De Soto 1990; Shleifer and Vishny 1998).

Over the past decade, a branch of the literature has studied how business regulations affect economic performance (Djankov, McLiesh and Ramalho 2006; Jalilian, Kirkpatrick and Parker 2007; Loayza and Servén 2010). This depends on the balance between the market failures that regulations are able to correct and the costs they impose on economic agents. Part of this literature concentrated on identifying transmission channels through which specific regulations impact economic performance. They found that obstacles imposed by excessive regulation – e.g. high

[§] For extensive reviews see Laffont and Tirole (1993) and Levy and Spiller (1994).

business registration costs – prevent firms from investing and push them to the informal sector (Bruhn 2011; Branstetter et al. 2014). Overregulated labor markets also lead to a large informal economy and high unemployment because they increase barriers to formal employment and make markets too rigid to adjust to changing conditions (Amin 2009). Another channel through which regulation affects firms is by reducing uncertainty. Effective judicial courts, credit markets, bankruptcy laws and investor protection mechanisms ensure easier contract enforcement and higher debt recovery rates, shorten debt recovery suits and strengthen the rights of lenders to recover assets of defaulting borrowers (Visaria 2009). Higher predictability puts companies in a better position to optimize their productive decisions. Regulations also impact transaction costs for firms. Several studies show that regulations that make import and export processes more burdensome significantly decrease trade volumes (Djankov, Freund and Pham 2010; Hoekman and Nicita 2011). Others highlight the negative effects of high entry-costs on economic output and productivity across firms (Barseghyan 2008). Similarly, overly strict financial regulations limit access to financial services and disproportionally penalize smaller firms (Love, Martinez-Peria and Singh 2016).

Regulation in agriculture

The relationship between regulation and agriculture is far less explored by the literature. The studies cited above focus mainly on the impact of regulations on manufacturing. But does regulation play a role in promoting (or hampering) agricultural development? And does this role differ for different kinds of regulations? Obtaining empirical evidence to answer these questions is challenging due to the lack of comparable data on both agricultural regulations and production activities.

From a theoretical standpoint, two arguments motivate us to extend to agriculture the conclusions drawn by the general literature referenced. The first one is that several components of a supportive regulatory environment are not sector-specific. Like manufacturing firms, farming businesses benefit from secure property rights, efficient taxation, increased access to finance and the balanced entry and operational standards offered by a supportive investment climate.

The second argument is that the above-mentioned channels through which regulation affects economic performance are critical in agriculture. Externalities are predominant in agriculture, justifying regulation in a number of areas including biosafety, food safety, grades and standards,

intellectual property protection, agricultural input quality, groundwater extraction, and environmental protection. Due to agriculture's importance for human health and food security, political stability and environmental sustainability, it is not unusual for governments to implement more stringent agricultural regulations (Diaz-Bonilla 2014).

Another example concerns informality. In general, when the cost of compliance is higher than the benefits of legality firms may move to the informal sector. As agricultural production involves less complex processes than services or manufacturing, legal protection and contract enforcement become less valuable. Consequently, firms in agriculture are more sensitive to regulations with high costs of compliance, and consequently more prone to avoiding them by remaining (or becoming) informal (Loayza, Servén and Sugawara 2009).

As discussed, effective regulations reduce uncertainty by setting clear and easily enforceable rules. Predictability is critical in the farming business where risk is typically inherent. Farmers face considerable risk due to their susceptibility to exogenous elements such as weather, plague of insects, and diseases. Moreover, production decisions are made before knowing the market price of their crops. Uncertainty is further exacerbated by the inherent volatility of agricultural markets (Aimin 2010).

Transaction costs represent another dimension where regulatory efficiency is key in agriculture. Transport costs can make up one-third of the farm gate price in some Sub-Saharan African countries (World Bank 2007) and prevent farmers from specializing in the goods where they have a competitive advantage (Gollin and Rogerson 2010). High marketing costs due to isolation from markets and roads, lack of means of transport or inefficient transport services often discourage farmers from commercializing their production (Gebremedhin and Jaleta 2012). Finally, credit is often rationed in rural areas and financial services are often low quality and do not respond adequately to the demand of producers (Hoellinger 2011).

The prevalence of externalities, uncertainty, informality and high transaction costs implies that regulation matters for agricultural performance. What is more, it suggests that regulations affect agriculture through dimensions that are peculiar to the farming business. These include regulations of agricultural input markets such as seed, fertilizer, land and water, as well as regulations that enable small-scale and remote farmers to access financial services. Moreover, they include product quality, sanitary and phytosanitary standards as well as licenses regulating trucking services (Cullinan 1999; Hafeez 2003; Alternburg and von Drachenfels 2007; Goldstein and Udry 2008;

Christy et al. 2009; Das 2012; Dethier and Effenberg 2012; Mobarak and Rosenzweig 2013; Diaz-Bonilla et al. 2014).

Our research investigates the role played by laws and regulations for agricultural development. We contribute to the existing literature by employing a new data set that covers regulatory areas that are specifically relevant for agricultural businesses. We propose new measures of quality and efficiency for business regulations in agriculture and analyze their relationship with agricultural productivity.

III. Measuring Regulation in Agriculture

Designing regulations that can pursue social objectives without imposing excessive costs on firms or other undesired economic effects is no easy task. In the agricultural sector, more balanced regulations that foster well-functioning markets while ensuring transparent and strong protections for consumers are needed (Swinnen et al., 2015). Economic research is key in guiding evidence-based policy making towards more effective regulations. This relies critically on the availability of firm-level data as well as on data on the quality and efficiency of regulatory practices. To build our measure of business regulations for agriculture, we use a new data set produced by the World Bank Group (WBG), Enabling the Business of Agriculture (EBA), which provides benchmarks on regulations that impact firms along the agricultural value chain.

Data description

EBA indicators cover 62 economies in their 2017 edition.[**] The data are standardized through case-study assumptions which allow robust comparison of a country's regulations with those of others. EBA data collection is primarily survey-based and the data are validated through a direct analysis of the relevant legislation. Questionnaires are completed by private and public sector experts as well as civil society organizations in each target country.

The EBA project collects primary data focusing on legal barriers for businesses operating in agriculture attempting to quantify the transaction costs of dealing with government regulations. EBA indicators cover a wide range of regulatory domains that are relevant to firms operating in

[**] See Annex I for the list of countries included in the EBA sample. The 62 countries are chosen to represent all country groups based on income level, geographical position and role of the agricultural sector as defined by World Bank (2007). For full information on EBA data and underlying methodology see World Bank (2016a).

agriculture (Table 3). The data set features two types of indicators. Q*uality* indicators reflect the text of laws and regulations. They assess their conformity with several global regulatory good practices aimed at correcting market failures. For example, requirements on registration, labeling and monitoring of new fertilizers are important. They ensure that farmers have full information on the fertilizer they plan to use on their crops and protect them from purchasing low-quality products. Inadequate nutrients, heavy metals or other residues found in fertilizer products can contaminate crops, animals and humans (Sartain et al., 2004). Farmers should be given assurance that the products they use will not contaminate their crops and the environment.

Table 3. List of topics covered by EBA indicators

Topic	Indicator
Fertilizer	Required procedures to register a new fertilizer product
	Labeling requirements, legislation on the sale of mislabeled and open fertilizer containers, and practices in monitoring fertilizer quality
	Statutory requirements for fertilizer import
	Time to comply with processes required to register a new fertilizer product
	Cost to comply with processes required to register a new fertilizer product
Finance	Regulations for deposit-taking microfinance institutions and credit unions
	Entry and operational requirements for agent banking and non-bank electronic money issuers
	Regulations on the use of agricultural commodities as collateral
ICT	Regulations on the provision ICT services in rural areas
Machinery	Suitability testing of agricultural tractors, licensing requirements, warranties and post-sale services
	Operational safety and performance standards of tractors
	Required procedures to import agricultural tractors and harvesters
Markets	Legal obligations applicable to domestic pest management
	Regulation of farmers' cooperatives, contract farming arrangements and related disputes resolution
	Time to comply with processes required to export agricultural products
	Cost to comply with processes required to export agricultural products
Seeds	Time to comply with processes required to commercialize a locally-developed seed variety
	Cost to comply with processes required to commercialize a locally-developed seed variety
Transport	Licensing and inspection regulations
	Statutory restrictions to cross-border transport and regulations on carrier's liabilities
Water	Regulations on integrated water resource management
	Regulations on individual water use for irrigation

Further, e*fficiency* indicators measure the transaction costs that firms have to bear to comply with national regulations on the ground. Transaction costs are expressed in time or monetary units, like the time and cost needed to comply with requirements on agricultural exports. Regulatory bottlenecks exporting agricultural products – such as special licenses, registration and export

documentation – can raise transaction costs associated specifically with exports and discourage private investment in marketing and storage capacity (World Bank, 2012; Pannhausen and Untied, 2010). Delays in obtaining mandatory export documents can reduce overall export volumes due to damage or deterioration, especially for time-sensitive agricultural products (Djankov, Freund and Pham, 2010).

Data aggregation: Quality and Efficiency

As discussed, the debate on the impact of regulation evolves around both quality and efficiency arguments. It depends on the balance between the market failures it is able to correct and the costs it imposes on businesses. In this context, EBA indicators are of particular interest as they provide information on both dimensions. Based on the nature of each EBA indicator *i* we compute our quality or efficiency scores for economy j as follows:

$$x_{i,j}^{QUAL} = \frac{GP_{i,j} - GPmin_i}{GPmax_i - GPmin_i} \quad (1) \qquad x_{i,j}^{EFF} = 1 - \frac{TC_{i,j} - TCmin_i}{TCmax_i - TCmin_i} \quad (2)$$

where *GP*, *GPmin* and *GPmax* are the observed, minimum and maximum number of regulatory good practices; *TC*, *TCmin* and $TCmax_i$ are the observed, minimum and maximum transaction cost amounts in the sample. After multiplying them by 100, we obtain scores that are normalized between 0 and 100, with 100 representing the best practice and 0 the worst. To avoid outliers, transaction costs that exceed the 99th percentile are assigned a value of 0.

A first aggregation is obtained at the topic level by averaging for each economy all normalized scores for each regulatory area. Topic regulatory scores represent the overall quality of regulations in a specific area, and can combine efficiency and quality indicators (Table 4).

Table 4. Correlations between EBA indicators

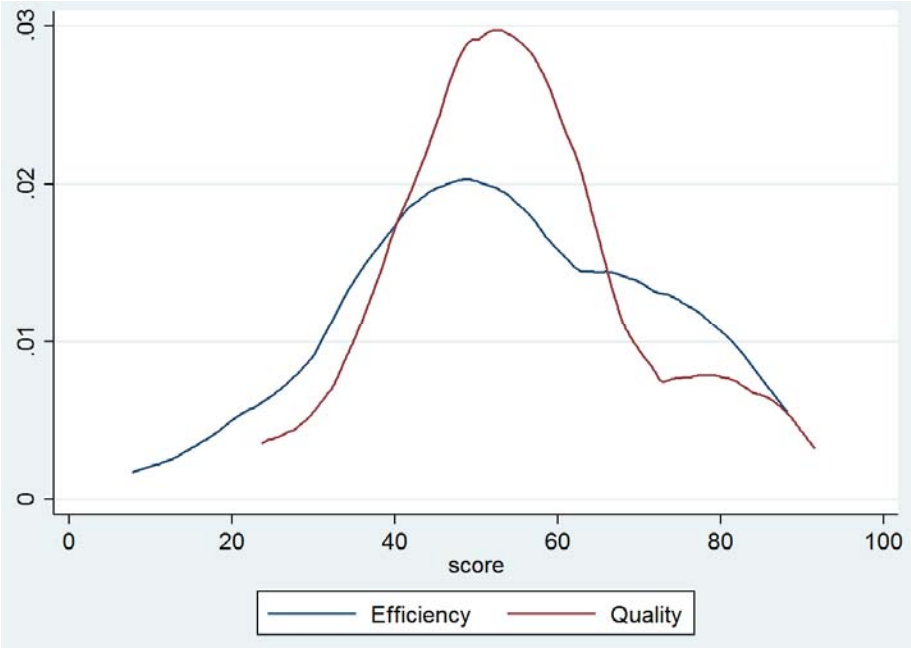
	Fertilizer	Finance	ICT	Machinery	Markets	Seed	Transport	Water
Fertilizer	1							
Finance	0.21	1						
ICT	0.51	0.50	1					
Machinery	0.43	0.14	0.43	1				
Markets	0.60	0.27	0.60	0.40	1			
Seed	0.48	0.35	0.68	0.45	0.50	1		
Transport	0.24	0.31	0.39	0.25	0.36	0.47	1	
Water	0.33	0.43	0.55	0.39	0.57	0.51	0.54	1

Source: Authors' calculations based on Enabling the Business of Agriculture indicators.

Topic-level scores display a moderate positive correlation. The lowest correlation (0.14) is found between Machinery and Finance regulations, while the highest (0.68) is found between Seed and

ICT regulations. Further, aggregate measures for regulatory efficiency and quality are obtained by averaging all efficiency and quality indicators for each economy. The quality and efficiency components are then averaged to build a measure of overall regulatory quality. Both regulatory good practices and transaction costs display large variation across the sample. This derives from the diversity of regulatory practices enacted by the countries in our sample. The measure of regulatory efficiency appears more dispersed, while countries are more clustered around the mean when it comes to regulatory quality. This may be in part driven by construction, given that efficiency measures are based on continuous variables while quality ones are categorical. On both dimensions, the right tail of the distribution is widened by a number of good performers (Figure 1).

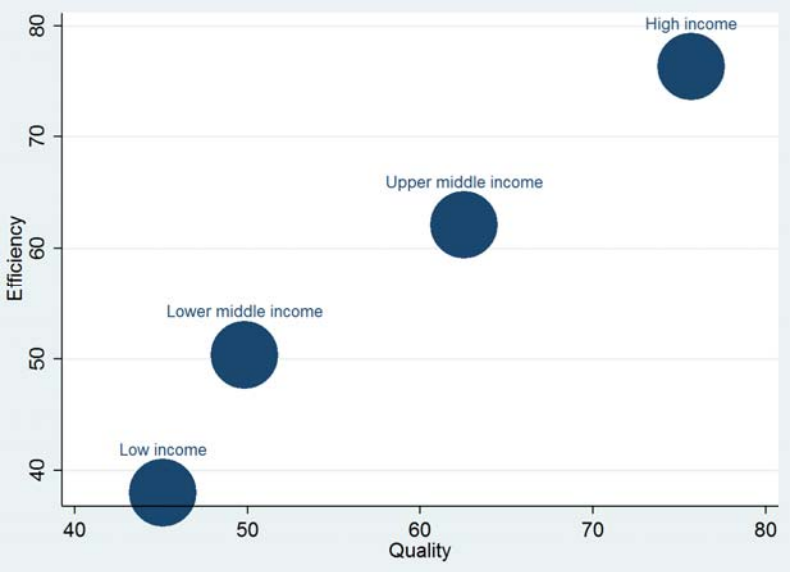
Figure 1. Kernel density functions for Efficiency and Quality indicators



Source: Authors' calculations based on Enabling the Business of Agriculture indicators

Averaging quality and efficiency, we observe a positive association between income levels and the supportiveness of countries' regulatory environment. Countries with higher income per capita have in fact more efficient and higher quality agricultural regulations (Figure 2).

Figure 2. Average regulatory scores by income group



Source: Authors' calculations based on Enabling the Business of Agriculture indicators
Notes: Average scores for each income group are reported in annex II

To explore further the relationship between regulatory quality and efficiency, we look at country-level scores on the two dimensions (Figure 3).

Figure 3. Regulatory efficiency VS quality

Source: Authors' calculations based on Enabling the Business of Agriculture indicators

These display a positive correlation (0.67), suggesting that countries with more regulatory good practices tend to impose lower transaction costs on agricultural businesses.[††] A number of

[††] This correlation is significant at the 99% level after controlling for GDP per capita.

countries combine low transaction costs with a high number of regulatory good practices. This points against the argument that improvements in regulatory quality involve high efficiency costs. Spain displays good practices across several regulatory areas. It enacts sound requirements on registration, labeling and monitoring of new fertilizers. Further, it ensures reliable pest management and control at the border through surveillance and pest reporting obligations, quarantine pest lists and risk-based border inspections, domestic containment and border quarantine procedures. At the same time, transaction costs that agribusinesses in Spain bear to register new fertilizer, commercialize new seed varieties and export agricultural goods are rather low. Conversely, other economies perform poorly in either dimension. Liberia, for example, lacks most mentioned good practices while imposing high transaction costs on agribusinesses. Finally, several countries display high scores in only one of the two dimensions while not performing as well on the other, showing potential for targeted regulatory improvement.

Correlations with other measures of institutional quality

The EBA overall score provides a synthetic measure of the quality of countries' regulatory environment for agriculture. To be effective, however, regulations need to be enforced. One potential critique to EBA indicators could be that, being largely based on law on the books, the good practices that they reward may not be observed in practice. In this case one would expect a negative association between our scores and measures of law enforcement. Conversely, EBA scores could be perfectly correlated with other measures of business regulation making them redundant.

To address these points, we look at the correlations between EBA scores and the following indexes: Rule of Law (RoL) from the Worldwide Governance Indicators database and the Ease of Doing Business (DB) from the World Bank's Doing Business data set. As expected, both correlations are positive and significant. The RoL index proxies the level of enforcement of laws and other societal rules. Its positive correlation (r=0.63) with the EBA score implies that where good regulatory practices are in place, laws also tend to be better enforced. On the other hand, the DB index measures the quality of a country's business regulations for the manufacturing and services sectors. EBA scores do not correlate perfectly with the DB index (r=0.74). This implies that our measure captures different and more agriculture-specific dimensions of overall regulatory quality.

IV. Results

The economic literature presented above argues that regulations can contribute to agricultural development through several channels, many of which are specific to the sector. Among these, they stress efficient input markets, secure water rights, effective rural ICT and transportation services, accessible irrigation systems, comprehensive financial infrastructure and sound sanitary and phytosanitary standards. In order to provide new evidence to this literature we investigate the relationship between regulation and productivity in agriculture.

The first data set used draws from the World Bank's World Development Indicators (2016) and covers agricultural total output and countries' stock of human capital. The agricultural total output is measured by agricultural value added in constant 2000 US dollars.[‡‡] The stock of human capital is measured by combining primary, secondary and tertiary gross enrollment ratios. Moreover, figures on main agricultural inputs (labor, land and livestock) are drawn from FAO (2016).[§§] Fertilizer use is measured as the sum of nitrogen, potash, and phosphate content of various fertilizers consumed, in metric tons. Labor is in thousands of economically active population in agriculture. Land is measured as thousands of hectares of arable land and permanent cropland. Livestock is measured in thousands of cow-equivalent livestock units, as calculated by Hayami and Ruttan (1970). To take the effect of climate conditions into account, we add the variable of average annual precipitation in the model. The data of this variable are provided by the WDI database. This variable is presumed to have positive impact on agricultural productivity as in other studies (Weibe, 2003). We use data from CIA (2016) to build a dummy variable for landlocked countries. Previous studies have found this geographical property to have negative impacts on a country's development (Faye et al., 2004).

Following the approach of Lio and Liu (2008), we estimate country i's aggregate agricultural production function as:

$$lnAGVA_i = \alpha_0 + \alpha_1 REGULATION_i + \alpha_2 INPUTS_i + \alpha_3 CountryControls_i + \alpha_3 Region_i + \varepsilon_i \quad (3)$$

[‡‡] Converting production value in domestic currency to US dollars may result in a downward bias for products relevant to developing countries. An alternative is using international dollars, but following Antle (1983) we prefer to use US dollars as purchasing power parity-adjusted values might overstate the agricultural production in developing countries.

[§§] Fertilizer was excluded from the analysis due to its high correlation with EBA indicators. This is due to the presence of several indicators relating to fertilizer regulation among our aggregate measures based on regulatory quality.

This specification allows us to study the association between regulation and agricultural output after controlling for agricultural inputs (labor, land, livestock, human capital), country characteristics (average precipitation, landlocked-ness) and regional fixed-effects. The available sample has 59 countries.[***] Following Huber (1967) and White (1980) we employ OLS regression with robust standard errors to address heteroskedasticity.

The adjusted R^2 for all OLS regressions exceeds 0.75, which suggests that the fitted regression outcomes explain the variation in cross-country agricultural outputs by a significant level. Table 5 displays the results of one baseline regression (OLS1) where we have excluded the regulatory measures to maximize sample size. Further, we report 3 estimations of our model performed using our overall (OLS2), quality (OLS3) and efficiency (OLS4) regulatory measures as explanatory variables.

Table 5. Estimates of the aggregate agricultural production function

	Dependent Variable: lnAGVA				
VARIABLES	OLS	OLS2	OLS3	OLS4	2SLS
lnEBA		1.064**			4.343***
		(0.397)			(1.421)
lnEBAEFF			0.676**		
			(0.260)		
lnEBAQUAL				0.973**	
				(0.456)	
lnLABOR	0.273***	0.226*	0.220	0.232*	0.216
	(0.0560)	(0.133)	(0.134)	(0.125)	(0.196)
lnLAND	0.498***	0.505***	0.508***	0.518***	0.407**
	(0.0701)	(0.130)	(0.135)	(0.128)	(0.165)
LIVESTOCK	6.53e-09***	4.81e-09*	5.46e-09**	3.78e-09	5.31e-09*
	(2.14e-09)	(2.60e-09)	(2.59e-09)	(2.83e-09)	(3.04e-09)
EDUCATION	1.093***	0.723*	0.792**	0.768*	0.0582
	(0.281)	(0.375)	(0.373)	(0.393)	(0.608)
RAIN	0.000226*	0.000239	0.000245	0.000165	0.000673
	(0.000127)	(0.000271)	(0.000282)	(0.000270)	(0.000435)
LANDLOCK	-0.354**	-0.592**	-0.617**	-0.621**	-0.310
	(0.163)	(0.243)	(0.241)	(0.249)	(0.327)
Constant	7.486***	5.452*	6.565**	5.621*	-3.422
	(1.530)	(3.003)	(2.843)	(2.941)	(5.267)
Observations	140	59	59	59	59
Adjusted R^2	0.860	0.723	0.721	0.712	0.411

Region fixed-effects included but not reported
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

[***] See Annex I for a detailed list of countries in the sample.

In all estimations inputs show the expected positive sign and achieve statistical significance. In OLS4 LIVESTOCK is not statistically significant. The coefficient of the LANDLOCK variable is negative and significant in all estimations, confirming a negative impact of countries' landlockedness on agricultural productivity. Our empirical results support the hypothesis that better agricultural regulation is associated with higher agricultural productivity. Regression OLS2 shows a positive and statistically significant coefficient for our overall measure of regulatory quality, indicating that a country with better agricultural regulations produces on average more agricultural output with the same amounts of agricultural inputs. Regressions OLS3 and OLS4 test our efficiency and quality measures separately and show a similar result: lower regulatory transaction costs and a higher number of regulatory good practices are associated with higher average agricultural productivity. Comparing the 3 proposed indicators, the overall measure displays a larger coefficient, indicating that quality and efficiency features display a stronger association with agricultural productivity when they are combined.

From these results, we cannot establish causality. In fact, while countries might be more productive thanks to better regulation, it could also be that regulation is better in more productive countries where more resources are available to improve business regulation. Moreover, there could be another variable that makes regulatory quality and agricultural output move together. Following La Porta et al (1998), we instrument business regulations with countries' legal origin.[†††] Table 5 reports the results of the two-stage least squared model (2SLS). The effect of more business-friendly regulation on agricultural productivity remains positive and significant.

V. Conclusions

The development of the agricultural sector has been considered a key priority for all developing countries. Economists and policy makers have devoted their attention to improving agricultural technologies, physical infrastructure and education. More recently, the interest on the role of institutions such as governance and regulations on economic development has increased. We propose new measures of regulatory quality and efficiency in agriculture. Employing these we explore the relationship between the heterogeneity in countries' agricultural productivity and their regulatory environment. We find some evidence to confirm the hypothesis that regulation

[†††] The legal origin variable used as instrument covers 5 groups: English, French, German, Nordic, and Socialist.

contributes to agricultural outcomes. Our results indicate that agricultural productivity is on average higher where transaction costs imposed by regulations are lower and where countries adhere to a higher number of regulatory good practices. In particular, this relationship is stronger when low transaction costs and regulatory good practices are combined. The outcome of our research is encouraging, but points at the need for improved agricultural data. Better coverage and quality of data on agricultural productivity and regulation are needed to measure their relationship with higher precision. In this regard, one limitation of our study is represented by its purely cross-sectional nature. A panel analysis is necessary to further test the robustness of our hypothesis and will be conducted once the necessary data are available.

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Annexes

Annex I. List of countries covered by EBA 2017 indicators

High income	Upper middle income	Lower middle income	Low income
Chile	Bosnia and Herzegovina	Armenia	Benin
Denmark	Colombia	Bangladesh	Burkina Faso
Greece	Georgia	Bolivia	Burundi
Italy	Jordan	Cambodia	Ethiopia
Korea, Rep.	Kazakhstan	Cameroon*	Haiti*
Netherlands	Malaysia	Côte d'Ivoire	Liberia
Poland	Mexico	Egypt, Arab Rep.	Malawi*
Spain	Peru	Ghana	Mali
Uruguay	Romania	Guatemala	Mozambique
	Russian Federation	India	Nepal
	Serbia	Kenya	Niger
	Thailand	Kyrgyz Republic	Rwanda
	Turkey	Lao PDR	Senegal
		Morocco	Tanzania
		Myanmar	Uganda
		Nicaragua	Zimbabwe
		Nigeria	
		Philippines	
		Sri Lanka	
		Sudan	
		Tajikistan	
		Ukraine	
		Vietnam	
		Zambia	

*excluded from OLS model estimations due to lack of data on other variables

Annex II. Average EBA scores by income group

	Overall	Efficiency	Quality
High income	76.00	76.32	75.68
	(11.61)	(12.21)	(12.68)
Upper middle income	62.32	62.09	62.54
	(9.82)	(12.61)	(11.33)
Lower middle income	50.09	50.37	49.82
	(8.42)	(13.33)	(9.32)
Low income	41.55	38.00	45.10
	(11.70)	(15.85)	(10.09)
All	**54.21**	**53.40**	**55.02**
	(15.16)	(18.41)	(14.68)

Source: Authors' calculations based on Enabling the Business of Agriculture indicators
Notes: Standard errors in parenthesis. T-tests confirm that High and Upper middle income have higher mean than the Low and Lower middle income group with 99% confidence level.

Annex III. Description of non-EBA variables

Variable	Definition	Source
AGVA	Agricultural value-added in constant 2000 US dollars	World Bank (2016b)
DB	Ease of doing business index (distance to the frontier)	World Bank (2016c)
EDUCATION	Education index: combined primary, secondary and tertiary gross enrollment ratios	World Bank (2016b)
LABOR	Thousands of economically active population in agriculture	FAO (2016)
LAND	Arable land and permanent cropland, in thousands of hectares	FAO (2016)
LANDLOCK	Dummy variable for landlocked countries	CIA (2016)
LIVEST	Thousands of cow-equivalent livestock units as calculated by Hayami and Ruttan (1970)	FAO (2016)
RAIN	Average precipitation (mm per year), 1966-2015	World Bank (2016b)
RoL	Rule of Law index	World Bank (2016d)

Notes: All variables refer to year 2014 where data is available. LAND data refers to 2013. Values for some countries are interpolated using most recent available observations.