Journal of International Development
J. Int. Dev. (2020)
Published online in Wiley Online Library
(wileyonlinelibrary.com) DOI: 10.1002/jid.3476

THE RELATION BETWEEN PROPERTY RIGHTS, FARM SIZE AND TECHNICAL EFFICIENCY FOR THE DEVELOPING COUNTRIES' AGRICULTURAL SECTOR

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Abstract: Previous studies have shown that the quality of property rights, farm size and market imperfections significantly affect agricultural efficiency. This article investigates the interaction between the quality of property rights and size when the countries are heterogeneous in degree of market imperfection, using a multilevel statistical approach for a sample of 84 developing countries. The results show a positive relation between technical efficiency and quality of property rights and a negative relation between farm size and quality of property rights. Furthermore, the results reject the regularly stated inverse relation between farm size and technical efficiency. In addition, the results show that market imperfections significantly affect the relations between technical efficiency and the explanatory variables. According to the results, increasing the farm size in countries with well-defined property rights reduces agricultural efficiency. On the other hand, in the majority of developing countries with low quality of property rights, the relation between farm size and technical efficiency is statistically significant and positive. © 2020 John Wiley & Sons, Ltd.

Keywords: agricultural efficiency; property rights; market imperfection; farm size; developing countries
JEL Classification: Q15; O30; L52

1 INTRODUCTION

As a component of economic growth, improvement of agricultural efficiency usually accompanies poverty reduction strategies, food security policies and life quality plans

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(Luh, Chang, & Huang, 2008; Devkota & Upadhyay, 2013 and Baldos & Hertel, 2014). Previous studies have shown that little advances in technical efficiency can significantly increase the developing countries' total agricultural production (Mochebelele & Winter-Nelson, 2000; Tzouvelekas, Pantzios, & Fotopoulos, 2001 and Chen, Huffman, & Rozelle, 2009). However, the developing countries' agriculture sector is still significantly inefficient.

According to the theoretical fundamentals and empirical evidence, there are various reasons for agricultural inefficiencies. Previous studies have examined the effects of different factors on agricultural inefficiency, but their results are inconsistent across countries. For example, some studies indicate the enlargement of farm size as a potential source of inefficiency (Heltberg, 1998; Benjamin & Brandt, 2002; Assuncao & Ghatak, 2003; Rahman & Rahman, 2009; and Manjunatha, Anik, Speelman, & Nuppenau, 2013). In contrast, some other studies show a positive relationship between farm size and efficiency (Kalaitzandonakes, Wu, & Ma, 1992; Helfand & Levine, 2004; Rios & Shively, 2016).

The heterogeneous nature of institutional situation of the developing countries, such as quality of property rights, inefficiency of domestic markets and degree of trade restriction, could be the source of these inconsistent results. The developing countries have different farm size, financial institutions and property rights, and it is likely that the interaction between these factors affects agricultural efficiency differently.

Researchers have investigated the effects of some of those factors on agricultural efficiency (e.g. Alvarez & Arias, 2004; Halkos & Tzeremes, 2007 and Baráth & Fertő, 2015). For example, empirical evidence demonstrates that market imperfection and weakness of property rights can significantly reduce agricultural efficiency (Lio & Hu, 2009; Michler & Shively, 2015). However, researchers have rarely studied the interactions between quality of property rights, farm size and market imperfections and the effects of those interactions on the agricultural efficiency of developing countries.

In this study, we investigate the interactions between these factors and their impact on the developing countries' agricultural efficiency. Specifically, we investigate the interactions between heterogeneous degrees of market imperfection such as quality of property rights, technical efficiency and farm size for a sample of 84 developing countries. The results show that market imperfections significantly affect the relations between technical efficiency and the explanatory variables in the model.

2 LITERATURE REVIEW

While various factors could affect the efficiency of agriculture, this article focuses on the interaction of three effective sources of inefficiency in the developing countries' agriculture sector: quality of property rights, market imperfection and farm size. Previous studies have regularly investigated the direct effects of these factors, but the interaction between these factors (indirect effects) remains vague.

Empirical evidence indicates that administrative features, particularly the quality of property right, affect the inefficiency of farms (e.g. Helfand & Levine, 2004; Awasthi, 2009; Rahman & Rahman, 2009; Kandulu, Bryan, King, & Connor, 2012; Di Falco & Bulte, 2013; Manjunatha *et al.,* 2013; and Koirala, Mishra, & Mohanty, 2016). In traditional approach, researchers usually measure the efficiency of farms and then compare the efficiency scores of private farms with the efficiency scores of non-private

DOI: 10.1002/jid

farms (e.g. Helfand & Levine, 2004). This approach can appropriately reveal the average differences between different farms; however, it ignores a significant part of the data. Because management is a heterogeneous factor, in dimensions other than property rights, such approaches are unable to determine why the efficiency varies across farms.

In order to explain the significant causes of inefficiency, researchers focused on the quality of property rights as a source of heterogeneity. Jensen and Meckling (1976) argued that the differences in qualities of property rights cause dissimilarity in efficiency. Bonin, Hasan and Wachtel (2005) and Wang and Feng (2014) argue that transferring resources from government to the private agents cannot increase efficiency by itself and an improvement in quality of property rights is essential to increase efficiency. Consonant with the theory of property rights, empirical evidence demonstrates that the quality of property rights significantly affects efficiency (e.g. Strappazzon *et al.,* 2003 and Arnason, 2007). However, findings of Jensen and Meckling (1976) do not imply that the quality of property right is the single source of heterogeneity.

Property right, as a multidimensional phenomenon, consists of four components: permanence, exclusivity, security and transferability (Arnason, 2007). Jensen and Meckling (1976) argue that the exclusivity of private property causes private firms to be more efficient than state firms. On the other hand, Davies (1980) believes that security of tenure is the main cause. Likewise, one can assign efficiency enhancements to each component. Because the quality of property rights is an increasing function of all of its components (Arnason, 2007), a progress in each of these components improves the efficiency. This article uses an indicator of property rights protection as a proxy for the quality of property rights.

Furthermore, both theoretical and empirical research demonstrate that farm size affects agricultural efficiency. However, there is no any agreement in terms of direction and strength (Sheng, Zhao, Nossal, & Zhang, 2015). Some authors have reported an inverse relationship between farm size and technical efficiency (Sheng *et al.,* 2015). They usually argue that decreasing returns to scale is the major explaining reason for this relation. Some researchers considering various sources of heterogeneity try to explain both together. For example, Helfand and Levine (2004) argue that the relationship between farm size and efficiency is non-linear. They focus on Brazil and discuss that efficiency first falls with farm size and then rises. However, their statement may not hold for other developing countries because the threshold point may differ across countries.

Moreover, the correlation between farm size and efficiency is not limited to the direct effects. According to some empirical studies (e.g. Gorton & Davidova, 2004; Wollni & Brümmer, 2012 and Wang & Feng, 2014), the quality of property rights interacts with farm size. This interaction is referred to as an indirect effect of farm size (Halkos & Tzeremes, 2007). Because weakness of property rights, non-market institutions and inefficient state institutions tend to characterize developing countries (Benjamin & Brandt, 2002), the indirect effects of farm size may appear as a source of agricultural inefficiency in developing countries. However, previous studies do not clarify the details of these indirect effects.

In addition, in the efficiency literature, highly cited work of Fama (1980) highlights the significance of market imperfections. When markets are perfectly competitive, competition forces firms to increase efficiency. In this circumstance, firms regularly increase efficiency to maximize profit, and if a firm cannot compete, it will be forced out (Arnason, 2007). This is due to the direct effect of market imperfection on efficiency. According to Fama (1980), market imperfection potentially decreases inefficiency. However, in an

DOI: 10.1002/jid

empirical analysis, Henderson (2015) shows that the market competitiveness is not a sufficient condition to increase the efficiency of agriculture. Similar to farm size, market imperfection can have an indirect effect too. Davies (1980) argues that market imperfections prevent the improvement of the quality of property rights to increase efficiency. In any case, these studies do not clarify the indirect effects of market imperfection on the efficiency of the agricultural sector, and the details of this matter remain vague.

As mentioned above, quality of property rights, farm size and their interactions affect agricultural efficiency. In addition, these relationships could be influenced by market imperfections. To investigate this idea, this article uses a multilevel (MLV) statistical approach for 84 developing countries that have been recently studied by Mekonnen, Spielman, Fonsah and Dorfman (2015). In this research, the agricultural technical efficiency score is considered as the dependent variable and class-specific technical efficiency scores are used for the 5th and 6th Mekonnen tables. Quality of property rights, farm size, the interaction between farm size and quality of property rights, as well as some additional variables such as institutional factors represent the set of explanatory variables.

3 DATA DESCRIPTION

The data used in this study are similar to the one used by Mekonnen *et al*. (2015). The sample covers 84 low-income and middle-income developing countries for the period 2000–2013, with a total of 633 country-years observations. According to Mekonnen *et al*. (2015), countries are divided into two relatively low efficient (RLE) and relatively high efficient (RHE) groups based on production technology and then market imperfection examined as the source of heterogeneity. Table 1 represents the variable symbols, indicators, components, data set and corresponding averages of the variables. The dependent variable, technical efficiency, is the one reported by Mekonnen *et al*. (2015).[1] Class-specific technical efficiency scores are used for the 5th and 6th Mekonnen tables.

The independent variable 'farm size' is the total agricultural land in million hectares collected from the World Bank database (2015). Other independent variables' data were collected from the Fraser Institute (2015) database.

The indicator of government size measures the independence of decisions regarding allocation of resources, goods and services in the political process. The countries with the highest levels of government consumption, highest transfers and subsidies, highest share of government enterprises and investment out of the total and highest top marginal tax rates earn lowest scores. The indicator of quality of property rights measures legal protections, and countries with the highest levels of legal protection earn higher scores. The indicators judicial independence and integrity of the legal system imply the independence and integrity of the legal system. The countries with the best legal systems earn higher scores.

[1]The common approach suggests estimating the technical efficiency scores via a stochastic frontier model. However, this model does not allow including the role of market imperfections in a hierarchical structure. Thus, we decide to implement a hierarchical model with their reported scores as a proxy for real scores of technical efficiency.

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Table 1. Variables and sample description

Symbol	Variable and subcomponents	Sources	Averages		
			RHE[a]	RLE	Total
TE	Technical efficiency	Mekonnen *et al*. (2015)	60.85	43.43	52.61
S	Size	FAO database (2015)	6.624	15.8	11
G	Government size	Fraser institute database (2015)	6.55	7.00	6.77
	Government consumption				
	Transfers and subsidies				
	Government enterprises and investment				
	Top marginal tax rate				
P	Quality of property rights		4.73	5.00	4.86
J	Judicial independency		3.62	4.28	3.94
I	Legal system integrity		5.46	5.33	5.40
T	Trade openness		6.85	6.81	6.83
	Tariffs				
	Regulatory trade barriers				
	Black-market exchange rates				
	Controls of the movement of capital and people				
L	Labour market regulation		6.26	6.09	6.18
	Hiring regulations and minimum wage				
	Hiring and firing regulations				
	Centralized collective bargaining				
	Hours regulations				
	Mandated cost of worker dismissal				
	Conscription				
C	Credit market regulation		8.39	8.24	8.32
	Ownership of banks				
	Private sector credit				
	Interest rate controls				
B	Business regulation		5.68	5.67	5.68
	Administrative requirements				
	Bureaucracy costs				
	Starting a business				
	Extra payments/bribes/favouritism				
	Licensing restrictions				
	Cost of tax compliance				

Source: Research finding
[a]Mekonnen *et al*. (2015) classify the countries into two groups with country averages of gross national income per capita, gross capital formation as a share of GDP, precipitation, agricultural land and dummy variables for geographic location.

The indicator of trade openness measures the ease of free trade for the private sector. The countries that have few restrictions on the capital flows, a flexible exchange rate currency, a well-organized customs and low tariffs earn higher scores (for details, the reader can refer to Fraser Institute, 2015).

The three remaining indicators indirectly measure the imperfections of the labour market, capital market and overall goods and services markets. The indicator of labour market regulation measures the imperfection of the labour market. Countries with the highest level of regulations earn the lowest scores. Countries that permit market forces to determine wages and set up transparent hiring and firing contracts earn high scores.

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Similarly, the indicator of credit market regulation measures the credit market imperfections. Countries that allow the private banking system to allocate credit to private sector and avoid controlling interest rates earn higher scores. Finally, the indicator of business regulation measures the overall imperfections of the goods and services markets. Countries that allow markets to determine prices of goods and services earn higher scores (for more details, see Fraser Institute, 2015).

4 STATISTICAL METHOD

In order to investigate the relationship between property rights, market imperfections and technical efficiency, this study uses the following two levels model:

$$\begin{aligned} TE_{kt} &= a_0 + a_1 S_{kt} + a_2 P_{kt} + a_{12} P_{kt} S_{kt} + a_3 J_{kt} + a_4 I_{kt} \\ &\quad + a_5 T_{kt} + a_6 G_{kt} I_{kt} + a_7 G_{kt} j_{kt} + u_{hkt} + \varepsilon_{kt} \\ u_{hkt} &= f(L_{hkt}, C_{hkt}, B_{hkt}), \end{aligned} \tag{1}$$

where TE_{kt} is the technical efficiency of agricultural production, a_0 a constant term, S_{kt} the total land used by the agriculture sector, P_{kt} the quality of property rights, $P_{kt}S_{kt}$ the interaction between the size and quality of property rights, J_{kt} the independence of the judicial system, I_{kt} laws' integrity, T_{kt} trade freedom, $G_{kt}I_{kt}$ the interaction of government size and laws' integrity and $G_{kt}j_{kt}$ the interaction of government size and independence of the judicial system. ε_{kt} are the residuals, u_{hkt} random effect, L_{hkt} labour market regulation, c_{hkt}Credit market regulation and B_{hkt} business regulation. k is the country ID, t the year ID and h is the country class (analogous to Mekonnen *et al.,* 2015).

Equation 1 specifies technical efficiency of the agriculture sector as a linear function of farm size, quality of property rights and the institutional indicators. The error term of Equation 1 includes two random effect variables, u and ε. The component ε represents the regular disturbance in common regression equations. The other component, u, is the random difference between technical efficiency of the two groups, RLE and RHE, specified by the second line as a function of each country regulations. The component u helps to estimate the coefficients of the equation more efficiently by taking into account the variance of the heterogeneity between the groups and their constituent factors (herein, the institutional factors).

Furthermore, Equation 1 estimates the technical efficiency coefficient of the agricultural sector as a function of size, quality of property rights and institutional indicators. The error component in this equation consists of two parts, e and u. The component e represents the same component of common error in the regression models. The component u shows the random effects generated by the grouping.

To estimate Equation 1, we estimate both lines simultaneously. In this case, an MLV estimator is more efficient than the ordinary least square. Compared with ordinary least square, the MLV model has two key advantages: first, the MLV model includes a random component for structuring the variance and remedying group heteroscedasticity. Second, the model allows the intercept and the coefficients of the regulation indicators varying across groups. Following Goldstein (2011), if u is orthogonal to ε, then the block-diagonal covariance matrix of Equation 1 is denoted as

$$\text{var}\begin{bmatrix} u \\ \varepsilon \end{bmatrix} = \begin{bmatrix} G & 0 \\ 0 & \sigma_\varepsilon^2 I_n \end{bmatrix}. \tag{2}$$

Considering the combined error term Zu + ε is multivariate normal with mean Xβ and n × n variance–covariance matrix:

$$V = ZGZ' + \sigma_\varepsilon^2 I_n. \tag{3}$$

In addition, defining ? as a vector of unique elements of G, the log likelihood function is denoted as

$$L\left(B, \theta, \sigma_\varepsilon^2\right) = -\frac{1}{2}\left\{\text{nloglog}(2\pi) + \text{loglog}|V| + (y - XB)'V^{-1}(y - XB)\right\}, \tag{4}$$

maximized as a function of B, ? and σ_ε^2. There are several algorithms to estimate the MLV model in Equation 1: maximum likelihood, iterative generalized least squares, restricted maximum likelihood, restricted iterative generalized least squares, and so on (for details, see Goldstein, 2011). The present article uses an expected version[2] of maximum likelihood.[3]

Because the efficiency scores are limited to the range of 0 to 100, using an unlimited dependent variable model seems problematic unless the limits do not hit their real values. In this case, a censored Tobit regression model is often considered (Jacobs, Smith, & Street, 2006; Ma *et al.,* 2014). To avoid mistakes in the statistical inference, a Tobit regression model compared a fixed effect version of Equation 1 using Fisher's test. Corresponding *F* statistics with 9 and 520 degrees of freedom is 0.62, indicating that the parameters of Tobit model are not significantly different from the estimated fixed effect model. In addition, a chi-squared test is applied for comparing the fixed part of Equation 1 and the corresponding fixed effect model. Corresponding chi-squared statistics with 8 degrees of freedom is 0.58, indicating that the fixed part of the MLV model is not significantly different from the pure fixed effect model. However, the random effect of the model is still significant. The technical efficiency scores are fractions, and as such, a fraction response model is more appropriate; however, it should be noted that estimators for fractional models may not always be available. In this study, we used 13 bundle software packages.

5 EMPIRICAL RESULTS

We used a Fisher-type test to investigate the unit roots of the time series variables. Similar to the Dickey–Fuller and the Philips–Peron tests, the null hypothesis is the existence of a unit root in all panels. Rejection of the null hypothesis does not imply stationarity of the time series in all panels. However, it is still sufficient for the purpose of this study.[4] As shown in Table 2, all variables are integrated of order zero.

[2]For details about expected maximum likelihood, see Raudenbush and Bryk (2002).
[3]Goldstein (2011) emphasizes that the maximum likelihood procedure produces biased estimates of the random parameters. However, the restricted version of maximum likelihood produces unbiased estimates. We estimated both restricted and unrestricted versions of maximum likelihood with expectation algorithm; we achieved similar results.
[4]The Fisher's test performs a unit root test on each panel's series separately and then combines the probability values to obtain an overall test of the unit root. Thus, rejection of null hypothesis implies that the series are stationary in the majority of the panels.

DOI: 10.1002/jid

Table 2. Unit root test

Variables	Pm[a]	p value
Technical efficiency	−7.35[b]	0.000
Government size	14.85	0.000
Quality of property rights	80.27	0.000
Judicial independency	5.05	0.000
Legal system integrity	34.10	0.000
Trade openness	11.54	0.000
Labour market regulation	38.08	0.000
Business regulation	22.12	0.000
Size	5.09	0.000
Residual	8.22	0.000

Source: Research findings
[a]Drift term included
[b]Modified inverse chi-squared statistics is used to adjust the bias of the short-length time series in proportion to the sample size (reader can refer to Choi, 2001).

Table 3 represents the estimation results of Equation 1. The first section of Table 3 embodies the corresponding parameters of explanatory variables. The second section embodies the estimation results of the random part. The third section of Table 3 represents the results of a wide range of normality tests containing Skewness–Kurtosis test, Shapiro–Wilk test, Shapiro–Francia test, Rayan–Joiner test, Kolmogorov–Smirnov test and Anderson–Darling test. None of them rejects the hypothesis of normality. The fourth section of Table 3 represents three statistics of goodness of fit. Wald statistics implies that the model is significant in total. In addition, the overall likelihood ratio test compares the estimated model versus ordinary least squares. The corresponding statistics is significantly in favour of the estimated model. The final section of Table 3 represents pseudo and adjusted pseudo R^2 statistics. Both indicate simultaneously that the model can explain about 90% of agricultural efficiency changes across those countries over time.

Estimated parameters show a positive correlation between agricultural efficiency and quality of property rights in both RHE and RLE group countries. The corresponding parameter of quality of property rights (P) implies that an increase in quality of property rights significantly increases the technical efficiency of developing countries' agriculture sector. In addition, corresponding parameters of judicial independence indicator (J), indicator of integrity of the legal system (I), interaction between government size and integrity of the legal system (GI) and interaction between government size and judicial independence (GJ) indicate that agricultural efficiency is an increasing function of the health of the legal system. All the three parameters are consistent with the theory of property rights and previous research including Di Falco and Bulte (2013), Bonin *et al*. (2005), Helfand and Levine (2004), Kandulu *et al*. (2012) and Wang and Feng (2014). Note that this is the direct effect of property rights.

The positive parameter of farm size significantly rejects the commonly assumed inverse relationship between efficiency and size. However, positive correlation between farm size and technical efficiency is common in the literature for the developing countries' agricultural sector (e.g. Fan & Chan-Kang, 2005). Similar to property rights, the total effect of size depends on both direct and indirect effects. Negative interaction between efficiency and quality of property rights implies that the enlargement of size reduces the

DOI: 10.1002/jid

Table 3. Estimation of hierarchical model

Symbol	Coefficient	Z	χ^2
Symbol	Multilevel	Fixed effect	Tobit
Constant	19.867	18.744***	20.500***
Quality of property rights	2.972***	2.347**	2.781**
Size × quality of property rights	0.751***	0.854***	1.150***
Quality of property rights	−0.114***	−0.126***	−0.172***
Judicial independency	3.558	2.694	4.612
Legal system integrity	3.775***	3.897	2.716
Trade openness	5.798**	8.086***	7.980***
Government size × legal system integrity	−0.687	−0.731**	−0.596
Government size × judicial independency	−0.609	−0.447	−0.703
Random effects		χ^2	
Constant	28.484	73.88***	
Labour market regulation	4.240	54.78***	
Credit market regulation	5.32*10–9	72.26***	
Business regulation	0.862	71.14***	
Overall		80.80***	
Normality tests			
Skewness–Kurtosis	Pr (Skewness)	Pr (Kurtosis)	Adjusted χ^2
Statistic	0.59	0.16	0.32
W–V tests	W	V	Z
Shapiro–Wilk	1.00	1.54	1.04
Shapiro–Francia	1.00	1.53	0.94
Other test	RJ	KS	AD
Ryan–Joiner test	1.00		
Kolmogorov–Smirnov test		0.04	
Anderson–Darling			0.69
Goodness of fitness statistics			
Wald (8)	143.81***		
LR test	131.52***		
Deviance	4561.10		
R^2			
Pseudo R^2	89.92%		
Adjusted pseudo R^2	89.77%		

Source: research findings
*10% significance level.
**5% significance level.
***1% significance level.

performance of the current set of property rights and vice versa. Formerly, Wang and Feng (2014) reported a positive interaction between property rights and the size. They argue that the larger firms enjoy more benefits from improvements in quality of property rights. However, present findings show positive interaction between size and property rights. In addition, the results imply that by increasing size, the efficiency–size relationship tends to decrease and become more negative. This finding is in contrast to Helfand and Levine (2004).

The results indicate the critical value of quality of property rights to be about 6.58. The coefficients obtained for the quality of property rights and size are both positive, but in order to obtain a more precise conclusion regarding the effects of these two variables on the efficiency, it is necessary to consider their interconnection. In Equation 1, it is clear from the size and quality of property rights that the final effect of these two factors on

DOI: 10.1002/jid

→-------------------------Reducing government size------------------------→

Independence of the legal system	Improving property right	Agricultural trade liberalization
	Enlarging size	

→---------------------Deregulation of domestic markets -------------------→

Figure 1. Policy ordering for agricultural efficiency improvement programmes

performance is affected by their interaction influence. The coefficient obtained for the interaction of these two variables is −0.114, which shows that one unit increase in each of these two factors will reduce the final contribution to agricultural productivity by 0.114. According to the figures in Table 3, for an increase in size leading to increased efficiency, the index of property rights is more than 6.58.

The quality of property rights indicator for the majority of developing countries is below the critical point. Consequently, the correlation between size and efficiency is positive. On the other hand, the indicator for the remaining developing countries[5] is above the critical point, indicating that the correlation between size and efficiency is negative. Similarly, by differentiating Equation 1 with respect to the quality of property rights, the critical value of size is about 26.1 million hectares. For the majority of developing countries, total agricultural land is below 26.1 million hectares. Consequently, the total impact of property rights is positive. However, for a number of countries, including Kazakhstan, Pakistan, Ukraine, Nigeria, Argentina, Brazil, China, Russia and India, size is above the critical value.

The estimated random component of the model reveals two facts. First, differences between the technical efficiency of RHE and RLE countries depend on the structural variables that are not included into the model (Mekonnen *et al.,* 2015). Second, and more importantly, the imperfections of domestic labour market, domestic capital market and domestic markets for the goods and services significantly affect the relationship between efficiency and other explanatory variables. This result is consistent with Davies (1980) and Assuncao and Ghatak (2003). However, this study considers the imperfection of domestic output markets as well as input markets. The results show that the domestic markets of the RHE countries are more competitive than the domestic markets of the LHE countries. Thus, consistent with previous studies, we find a negative correlation between market imperfections and agricultural efficiency. This is in contrast to Fama (1980). However, he refers to the direct effect of market imperfection on efficiency, while the above statements refer to the indirect (or structural) effects. Nevertheless, one can consider the corresponding parameter of trade openness as the direct effect of market imperfection. The positive parameter of trade openness, as a proxy for market imperfection and consistent with Fama (1980), indicates that market imperfection significantly reduces agricultural efficiency of developing countries.

[5]Including Chile, Malta, Namibia, Jordan, Mauritius, Saudi Arabia, Estonia, Oman, Bahrain, Rwanda, Iceland, Malaysia, Belgium, South Africa, Taiwan and Qatar. One may generalize this finding for developed countries. However, this article does not include them, and generalization should be adequately cautious.

DOI: 10.1002/jid

6 CONCLUSIONS

The literature on agricultural efficiency demonstrates that the quality of property rights, the size and market imperfections, all significantly affect technical efficiency. However, the interactions between these factors remain vague. Using an MLV statistical approach, this article investigated the interactions between the quality of property rights, size and market imperfections. Following Mekonnen *et al*. (2015), the article partitioned a sample of 84 developing countries into two groups: 42 countries with higher efficient agriculture and 42 countries with lower efficient agriculture. In agreement with previous studies, this article finds a positive relation between technical efficiency and size and a positive relation between technical efficiency and quality of property rights. In addition, this article finds that market imperfections significantly affect the relationship between technical efficiency and all the other explanatory variables in the model.

According to the estimated parameters, the regularly stated inverse relationship between size and technical efficiency was rejected. However, interaction between the quality of the property rights and size clarified some hidden aspects of this subject. Corresponding parameters demonstrated that the interaction between size and quality of property rights is significant and negative. This finding clarifies the empirical dissimilarities in various studies. According to the results, increasing the size in countries with well-defined property rights reduces agricultural efficiency. On the other hand, in the majority of developing countries that have low quality of property rights, the relation between size and efficiency is significant and positive.

From the viewpoint of policy implications, the estimated parameters emphasize the significance of improving the quality of property rights, enlargement of farm size, trade liberalization and deregulation of developing countries' domestic markets. According to the results, this article proposes a policymaking scheme represented in Figure 1. The beginning point of efficiency improvement programmes is independence of the legal system. This is an important issue where ignoring it delays improvements in the quality of property rights. The second step is improving the quality of property rights, simultaneously with enlarging farm size through a parallel set of programmes. After these two steps, developing countries are ready to benefit from trade liberalization and foreign market access. In addition, deregulation of domestic markets and reduction of government size and intervention start with the first stage and continue to the end of the final stage.

Data availability statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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