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Country Risk and Agricultural Productivity: An Efficiency Study

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Abstract: Do the social, economic and political environment in a country affect agricultural efficiency? We address this question by estimating a stochastic frontier model of agricultural productivity in 138 countries from 1984 to 2013. By observing how the business condition, level of social harmony and quality of government in a country affect agricultural inefficiency, we find there to be a positive effect. However, land quality as quantified by percentage of land irrigated, and openness to global trade have a more positive effect on decreasing agricultural productivity. We also find that consistent with literature, former British colonies exhibit higher technical efficiency.

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1. Introduction

Agriculture accounts for approximately 2.8% of overall world income (World Bank, 2012) which, considering other sectors, is not monumental. However, in the context of development economics, it is important to not overlook the impact the agricultural sector could have in changing many lives, poverty alleviation and improving overall economic well-being.

Globally, employment in agriculture has declined drastically but steadily over the past decades. In 1991, 42% of the world's total population were involved in agriculture but as of 2017, that number has decreased to approximately 29% (World Bank, 2018). The decline in agricultural participation, however, is mainly driven by developed nations as they transition from agricultural economies to industrialized economies. However, certain regions have seen growth in agricultural employment. Between 1999 to 2009, growth in agricultural employment accounted for 50% of total employment growth in Sub-Saharan Africa, agricultural employment growth accounted for 33% of total employment growth in South Asia (FAO, 2012). This shows that many developing countries are largely agrarian. 70% of total participation in agriculture, approximately 1.3 billion people, are from low-income countries where agriculture is their primary source of livelihood.

Therefore, given that many of today's developing countries are largely agrarian with a majority of the population depending on agriculture for food and employment, growth in productivity has become a major focus. In addition, productivity growth is essential to meet the demand of the steady rapidly increasing population in terms of food and raw materials (Coelli & Rao, 2005). Past literature has shown that growth in agricultural productivity plays a major role in meeting the ever-increasing global demand for food and in improving food security (Griliches, 1957; Piesse and Thirtle, 2010; Alston and Pardey, 2014; Fugile and Toole, 2014 etc.).

Thus, many interventions targeting the increase in productivity have taken place. Most importantly was the inclusion of technological advancements, especially during the green revolution in the 1960s, which saw a large increase in productivity. This success was attributed to high rates of investment in proper irrigation, fertilizer, seed development, crop research, infrastructure and market development as well as crop genetic improvements. Between 1960 to 2000, developing countries saw an increase in wheat yield of 208%, rice was 109%, maize 157% and continued high yields in other crops with China and other Asian countries experiencing stronger yield growth (Pingali, 2012).

There is strong evidence that agricultural research and development has a large impact on productivity growth and that it has the most consistent influence on observed multifactor productivity growth (Griliches 1973; Kendrick and Grossman 1980; Sveikauskaus and Sveikauskaus 1982). However, these global aggregates, as shown in Figure 1, mask the underlying geographic disparities between countries. Thus, the purpose of this paper is to explore the main causes of the discrepancies we see in productivity, especially in middle to low income countries. Most of these countries are largely agrarian with a large portion of their population dependent on agriculture. Yet we consistently observe low food production growth per capita in Sub-Saharan African countries compared to other economies.

Several studies have analyzed the cross-country differences in agricultural productivity (Hayami and Ruttan, 1970 and 1971; Kawagoe et al. 1985; Fulginiti and Perrin, 1993, 1997, 1998, 1999; Lusigi and Thirtle, 1997; Coelli and Rao, 1998 etc.). Each study uses different econometrical methods and yet the results seem to be consistent in showing global increases in total factor productivity and aggregate increases in efficiency. Moreover, they also show significantly large changes in total factor productivity (TFP) in Asia, mainly due to China, compared to very small changes in Sub-Saharan Africa. Coelli and Rao (2005), perform a cross-country examination of TFP growth and show that Asia performed best with annual TFP growth of 2.9% while growth in Sub-Saharan Africa was only 0.6%. This is shown in Figure 2.

Past literature has chalked this discrepancy to the late introduction of private research programs in Africa, or the lag in breeding efforts of plants that were of relative importance to African farmers (Pingali 2012). While some others have blamed it on low labor productivity in the region (Lusigi and Thirtle 1997; Piesse and Thirtle 2010).

In addition, the primary focus of past research has been in increasing productivity. This approach assumes that farmers are already producing at their maximum capacity. It also assumes that there is uniformity in technology and agricultural inputs such as land, labor, livestock and machinery. However, given the discrepancies we see in productivity, we cannot make these bold claims.

This paper instead, looks at the factors that keep farmers from reaching their maximum capacity, given their level of input and technology. What makes them less efficient. Efficiency studies on agricultural productivity have been carried out by authors such as Belbase and Grabowski (1985) and Abdulai et. al (2013).

However, Fulginiti et al. (2004) look at how institutions affect agricultural efficiency in Sub-Saharan Africa. They conclude that former UK colonies exhibit higher productivity gains, while former Portuguese colonies show net reductions in productivity (Fulginiti et al. 2004). This view that historical institutions (colonial heritage etc.) in a country could explain the discrepancies we observe in agricultural productivity is the main motivation behind this paper. However, instead of looking at historical institutions, we look at present day institutions in the form of country risk indicators.

To provide a wider understanding of the literature of institutions and agricultural productivity, we will first discuss the literature on agriculture and economic productivity and afterwards look at how that knowledge has been applied to agricultural productivity.

1.1 Institutions and Economic Outcomes

North (1990) defines institutions as "rules of the game in a society or, more formally, the humanly devised constraints that shape human interaction". In their paper, The Role of Institutions in Growth and Development (2008), Acemoglu and Robinson borrow from North's (1997) definition of institutions clarifying that the major effect of institutions is through incentives. Therefore, they state that since these institutions are key determinants of incentives, then they should have major effects on economic outcomes including growth and development, inequality and poverty (Acemoglu and Robinson, 2008).

This notion has been proven by many cross-country studies that have looked at various institutional indicators and their effect on economic outcomes. For example, Knack and Keefer (1997) look at the effect of social capital, measured in trust and civic cooperation, on economic performance (GDP and investment). They find that trust and cooperation is stronger in countries with low inequality, high literacy rate and institutions that restrain government and chief executive officers. Their results show that institutional factors such as a well-developed financial sector, secure property rights, reliable contracts etc. are important for a productive economy.

Similarly, Mauro (1995) looks at the impact of corruption on economic growth and finds that corruption negatively impacts investment and therefore, economic growth. Djankov et al. (2002) look at the regulation of entry for new firms across different countries and find that countries with stricter entry barriers have lower institutional quality. They find that the stricter regulations are usually associated with higher corruption, large inequality rates and more unofficial economies. They also found that less democratic countries, countries with less restraints on political ruling, with interventionist governments, tend to have strict barriers to entry. Other studies have looked at the impact of education on economic outcomes as well and have found a positive correlation (Barro and Lee, 2001; Aghion et al., 2009; Hanushek and Woessmann, 2010).

Thus, correlation observed between specific institutional factors and economic outcomes, have led many economists to believe that the political, economic and socio-economic build of a nation could have a significant impact on growth and development.

1.2 Institutions and Agricultural Outcomes

Although many studies have looked at the effect of institutions on economic outcomes, there has been little empirical analysis done on the specific institutional qualities that affect agricultural outcomes. As stated earlier, agriculture is important to development as many of the world's poorest are employed in the sector and rely on it, not only for income, but also for food. Thus, this study, much like other correlational studies, seeks to look at the specific institutional qualities that affect agricultural outcomes. The results could help inform policy by identifying the specific institutional factors lead to the discrepancies we observe in agricultural productivity.

There have been several conceptual and theoretical analysis on the impact of institutions on agricultural development (Slangen, 2001; Leach et al. 1999; Pretty and Chamber,1993). Zylberstajn (2009), in his paper, found that with the increase in technological advancement in Brazil, having a strong government system that fosters deeper interaction between local governments, multinational corporation and stakeholder groups is essential to further development. Cloete (2013), in his study of institutions and agricultural development in South Africa, also found that having a strong governance structure is essential to agricultural development. He emphasizes the need for public-private partnerships, water user associations, proper rural finance systems, equity sharing and better human capital through education.

In his conceptual study on the impact of institutions on agriculture in ancient France, Hoffman (1988) looks at how the political society in the old regime worked to the detriment of agriculture. He compares the productivity of land and labor in France with England's productivity and finds that the political system, including the weak French legislation at that time, to be the main cause for the failure in agriculture.

These studies point to the role of institutions on agricultural productivity, however they are theoretical in nature. Fulginiti et al. (2004), take on a more empirical view of the subject however, drawing from Acemoglu and Robinson's (2001, 2005 and 2013) view on institutions. Acemoglu and Robinson (2001) argue that the political, economic and socioeconomic institutions we see today are themselves products of historical institutions such as colonial rule and former political structures. The authors argue that these could explain the current institutions at play today which could explain the different economic outcomes we observe. Following this theory, Fulginiti et al. (2004) look at how colonial history, conflicts and democratic quality affect agricultural outcomes for countries in Sub-Saharan Africa. Fulginiti et al. (2004) through empirical analysis, find that former UK colonies exhibited higher productivity gains compared to other countries, while former Portuguese and Belgium colonies showed reduction in productivity. They also find that there is a significant reduction in productivity during conflicts and wars and countries with better political rights and democratic quality exhibited higher productivity.

For this study, we will be following Fulginiti et al.'s (2004) empirical analysis, however we will be looking at what present day economic, political and socioeconomic factors affect agricultural productivity performance. To accomplish this, we divide the ICRG variables into three groups; Business Conditions, Social Harmony and Government Quality. We look at these indicators separately and together, controlling for exogenous factors such as land quality, labor quality, openness to trade and environmental conditions, all consistent with Fulginiti et. al (2004). The results show that on their own, these institutional indicators are negative and significant which indicates that they decrease inefficiency. However, when we combine them together, they lose their significance and we find a stronger effect in the land quality variable, Irrigation. This strong significance in irrigation, supports the findings by Block (1994), Frisvold and Ingram (1995), Thirtle et al. (1995), Chang-Kang et al. (1999) and Fulginiti et al. (2004).

Following this introduction, Section 2 of our paper presents a description of our analytical approach; the stochastic production frontier model. Section 3 presents our data and empirical specification. Section 4 examines our main empirical results, and we summarize and present conclusions in section 5.

2. Analytical Approach: The Stochastic Production Frontier Model

Productivity is measured by output per unit of input. Following Fulginiti et al. (2004), we adopt the production function approach as pioneered by Solow and Griliches. Griliches (1998) used the Cobb Douglas production function to estimate total factor productivity, while introducing a variable, that represented the effect of research and development. Aigner et al. (1997) and Meeusen et al. (1977) modified the production form however, to reflect technical inefficiencies, thus the standard neoclassical production function became a stochastic production frontier.

In this study, we analyze countries' technical inefficiency to identify the institutional factors that explain the discrepancies we observe in productivity between countries. The stochastic production frontier model estimates the maximum output level for a country based on a given set of production inputs. Thus, the difference between the country's maximum output and its actual output is defined as the technical inefficiency. Following Battese and Coelli (1995) the general specification of the frontier model is:

$$lnY_t = lnX_{it}\beta + (v_{it} - u_{it}) \quad (1)$$

where subscripts *i* and *t* are country and year indices respectively. *Y* represents the real output of the country, *X* is an N x 1 vector of production inputs and is a vector of coefficients. is the error term in equation (1) consisting of the random error, which is assumed to be normally distributed i.i.d. *N*(0,).

The technical inefficiency estimated by , is a non-negative random variable, with a truncated normal distribution with mean i.i.d. *N*(μ,). The mean as defined by Wang and Wong (2012) is represented as a linear function of certain determinants:

$$\mu_{it} = Z_{it}\delta = \delta_0 + \sum_{m=1}^{M} \delta_m z_m \quad (2)$$

where is a 1 x p vector of variables that could affect the efficiency of a country, and is a p x 1 vector of unknown parameters, the coefficients to be estimated. This variable measures technical inefficiency across production units, the inefficiency effects are assumed to be independently distributed for different countries and years (Wang and Wong, 2012). This variable accounts for heterogeneity across countries that can cause deviations from the maximum potential output.

Thus, technical efficiency (TE), defined as the ratio of actual output to the maximum output is calculated as in equation (3) and takes on values of 0 and 1, 1 indicating full technical efficiency.

$$TE_{it} = E[exp(-u_{it})\,|\varepsilon_{it}] \quad (3)$$

For interpretation sake, as the model estimates how far a country's actual output is compared to its maximum output. The smaller the coefficient in equation (2), the more efficient the country is. This tells us that the distance between the maximum output level and actual output level is small. This illustrated in Figure 3.

3. Data and Empirical Specification

3.1 Data

The research question we are addressing in this paper is what economic, political and socioeconomic factors affect agricultural productivity. To answer this question, we will be looking at 138 countries with varying institutional qualities, ranging from high income to low income countries, over the last three decades (1984-2013). To estimate the maximum production function, we use panel data on output from USDA-ERS (2013) and conventional agricultural inputs; land, labor, fertilizer, machinery (tractors) and livestock from FAOSTAT (2018). The descriptive statistics for the dataset are available in Table 1.

Agricultural output is the quantity of agricultural production in millions of constant 2004-2006 U.S dollars. Agricultural land is measured as the sum of arable land and permanent crops, as defined by FAOSTAT (2018) in thousand hectares. Agricultural labor is measured as the number of people who are economically involved agriculture. Fertilizer is the quantity of fertilizer plant nutrient in use (N, P_2O_5, and K_2O) measured in metric tons. Farm machinery is he number of agricultural tractors in use. The livestock variable is the number of animals on farms, measured in thousands.

Following Fulginiti et. al (2004), we use two different types of efficiency changing variables in our analysis, those that allow for qualitative input differences, which are used as controls and those that capture institutional differences across countries. We use four input quality measures: (1) labor quality, proxied by school attainment taken from Barro-Lee(2015), (2) land quality, proxied by percentage of land irrigated taken from FAOSTAT (2018), (3) Drought, which controls for environmental changes, measured by the number of occurrences in a country for a given year taken from CRED EM-DAT (2009). Lastly, we include an openness variable, not included in past literature, this is meant to capture any effects of trade policy within a country, data was calculated by the GDP share of imports and exports taken from World Bank (2018). The openness variable is also used to represent any variation we may observe from a country's openness, such as foreign investments and to a lesser degree research and development.

We also include a variable for the numbers of years since each country has been independent. This allows for exogenous variation in the model and strengthens our institutional analysis. Although Fulgniti et al. (2004) find no significance, we find there to be an effect when paired with social harmony. This suggests that the longer the country has been independent, the more efficient it is in agricultural productivity. This data was retrieved from Hensel (2014).

The institutional variables are taken from the International Country Risk Guide (ICRG, 2018). The ICRG rating provides 22 variables for political, financial and economic sub-categories. However, we use the Political Risk Rating sub-category as it contains measures across each category, covering both political and social risk ratings. The Political Risk Rating comprises of twelve variables where the minimum number of points for each component is zero and the maximum number of points depends on the fixed weight each component is given in the overall political risk assessment. (PRS Group, 2012). The data is interpreted as the lower the risk rating, the higher the risk and the higher the risk rating, the lower the risk. Thus, the twelve variables are Government Stability, Socioeconomic Conditions, Investment Profile, Internal Conflict, External Conflict, Corruption, Military in Politics, Religious Tensions, Law and Order, Ethnic Tensions, Democratic Accountability and Bureaucracy Quality. Table 2 shows each risk component, their maximum points and summary statistics of the risk component in our data.

For simplification in our analysis, we group the twelve variables into three main institutional indicators; Business Conditions, Social Harmony and Government Quality. Table 3 shows the grouping system. Although, we do not find any formal analysis done with this type of grouping, in their cross-country analysis, Hellman et. al (2000) point to the effect bureaucracy quality and corruption have on the business environment. We include investment profile as this is strongly linked to business environments and socioeconomic conditions as well. We link the conflict variable to social harmony, the assumption is that internal (ethnic or religious) and external conflicts affect the ability for people to coexist and thrive hamoniously. Rothstein and Teorell (2008) in their study of government quality state democracy, rule of law and efficiency in government as three concepts of quality of governance which we follow in our paper. Table 4 shows the descriptive statistics of these three institutional variables. These institutional ratings across countries is displayed in Figure(s) 4, 5 and 6.

3.2 Empirical Specification

We model the production function (1) with a flexible trans log functional form. This functional form, as opposed to the Cobb-Douglas functional form does not impose constant elasticity of substitution. (Wang and Wong, 2012). The log-linear trans log production function is thus:

$$ln[Output]_{i,t} = \beta_0 + \sum_{j=1}^{5} \beta_{1j}\, lnx_{ijt}$$
$$+ \sum_{j=1}^{5} \beta_{2j}\, lnx^2{}_{ijt}$$
$$+ \sum_{j=1}^{5} \sum_{k>j}^{5} \beta_{3_{jk}}\, lnx_{ijt} lnx_{ikt}$$
$$+ \sum_{j=1}^{5} \beta_{4j}\, lnx_{ijt} T$$
$$+\beta_5 T + \beta_5 T^2 + v_{ijt} - u_{ijt} \quad (4)$$

Where i is from 1 to 138 representing the countries, and j is from 1 to 5 representing the agricultural inputs (Land, labor, fertilizer, machinery and livestock) and the inputs represent the inputs at each time period t from 1 to 30.

is the agricultural output, x's are inputs and T is the time from 1 to 30, which is used as a proxy for technical change. is the one-sided technical inefficiency measure, assumed to be truncated at zero and normally distributed i.i.d. *N*(μ,), capturing the heterogeneity across countries which will help explain the differences we observe across countries. We also allow for idiosyncratic error by including the random error , i.i.d. *N*(0,) which is independent of .

The technical inefficiency term is specified using the efficiency changing variables and is estimated simultaneously with equation (4) as:

$$u_{ijt} = \delta_0 + \sum_{m=1}^{5} \delta_m\, z_{m,ijt}$$
$$= \delta_0 + \delta_1 Institutional\ Variables_{ijt}$$
$$+ \delta_2 Irrigation_{ijt}$$
$$+ \delta_3 School\ Attainment_{ijt}$$
$$+ \delta_4 Drought_{ijt}$$
$$+ \delta_5 Openness_{ijt} \quad (5)$$

Where each variable is given for each country i, at time t, tested for each input j.

The simultaneous maximum-likelihood procedure was made up of four sets of specifications. Each of the institutional variables (Business Conditions, Social Harmony and Government Quality) were tested on their own, using the qualitative input variables as controls. The fourth test was of all the institutional variables combined in the model.

4. Results

Empirical results are provided for each of the institutional variables, each containing four regressions as the qualitative inputs are added to the model. As this is an efficiency study we only include the technical inefficiency results.

Result 1 shows the results for Business Conditions on its own. The coefficient is small and negative across all specifications which indicates that the increase in business conditions leads to less inefficiency in agricultural productivity. In columns (2) to (4) we observe significance in the irrigation and openness values as well. These values show stronger significance as compared to the Business Conditions variable.

Result 2 shows the results for Social Harmony on its own. The coefficients here are also small and negative. However, we only find significance in the first three columns (1) to (3) without the Independence variable. Column (4) shows that when we include the variable for years since independence, the effect of social harmony is not statistically significant. However, irrigation, openness and school attainment are negative and significant.

Result 3 shows the results for Government Quality on its own. Here we observe significance across all specifications (1) to (4). In columns (1) to (3), the coefficients are small and negative which indicates that the quality of governance reduces agricultural inefficiency. However, when we include years since independence, we observe that the coefficient on government quality is positive but significant. Which indicates that better government quality contributes to agricultural inefficiency. We believe that this is because of the fall in productivity in most developed countries which coincide with better governance. Here as well, irrigation, school attainment and openness are small and significant.

Result 4 shows the results for all institutional variables combined and all efficiency changing qualitative inputs included. Here we observe negative and small coefficients for both Business Conditions and Social Harmony. Still we see that better governance correlates with less efficiency. However, we observe significance in the irrigation variable for columns (1), (3) and (4).

The significance we find in irrigation is consistent with the findings by Block (1994), Frisvold and Ingram (1995), Thirtle et al. (1995), Chan-Kang et. al (1999) and Fulginiti et al. (2004). However, our results show drought to not be significant which is also consistent with the above literatures but the coefficients on the value are small and negative, indicating that drought decreases inefficiency. An explanation for this could be found in Rockstrom et al.'s

(2002) study looking at rainwater management in drought prone environments. The authors find that there are no agro-hydrological limitations to productivity even in drought prone environments as farmers adopt more risk aversion strategies. The significance we observe in the openness variable tells us that according to our study, open trade policies contribute to decreasing agricultural inefficiency, as the flow of information and technology across borders, bringing in innovations from research and development, this leads to more efficiency. We use the openness variable as a proxy for research and development.

Result 5 shows the results of all institutional variables at different crop levels. These categories were classified according to FAOSTAT (2018). Here we find that for almost all crops our three institutional variables are not very significant. However, Figure 8 shows that beverages and spices have the highest yield across all regions, and we see significance in the land quality variable, percentage of land irrigated.

Figure 6 shows technical efficiency across all regions using the TE function in equation (3) estimated with the composite political risk variable (all 12 institutional indicators). We find that North America has had the most consistent and high level of efficiency, close to 1. We also find that technical efficiency in Sub-Saharan Africa has been quite high, close to 1. Across all regions, we see a sharp decrease in technical efficiency coinciding with the years 2008-2010. In their study of decisions made by agricultural and non-agricultural banks pre-recession, Li et al. (2018) confirm the impact the recession had on efficiency in the agricultural sector which is shown in the graph. In addition, we test out Fulginiti et al.(2004)'s result that show higher technical efficiency for former British colonies. We find this to be true as evidenced in Figure 8.

5. Summary and Conclusion

The aim of this study was to see if the differences in agricultural productivity across countries could be explained by institutional indicators. To accomplish this, we use a stochastic production frontier model to estimate a maximum output level and using efficiency changing variables, including the institutional variables, we run tests to see if these variables decrease or increase inefficiency.

We use a panel dataset with 138 countries over 30 years with output as the measure of productivity and include five conventional input variables (land, labor, fertilizer, machinery and livestock) to estimate the production function. For our inefficiency function, we use the institutional variables and four qualitative input variables; irrigation, as a proxy for land quality, school attainment as a proxy for labor quality, drought for environmental conditions and openness for trade policy. The institutional variables we use are made up of ICRG's Political risk ratings and are Business Conditions, Social Harmony and Government Quality.

Our results show that on their own, each of the three institutional indicators are small, negative and significant which indicates that they could decrease inefficiency, meaning that they increase efficiency. However, when we include years since independence, we find that no significance in Government Quality. This result coincides with the decrease in agricultural productivity we find in high income countries with better government quality. We also see significance in the openness and irrigation variables when we aggregate crop yields. This leads us to conclude that the flow of information, ability to trade and access to global markets contributes to decreasing inefficiency. In addition, land quality matters. We find there to be strong evidence for better land quality having a positive impact on efficiency.

While the consistency we observe in the significance of the irrigation variable is consistent with previous literature, it also indicates that there are other factors that impact the efficiency of agricultural productivity beyond institutional reasons which could explain the cross-country differences we observe. Omitted variable bias is a major concern in this model as we cannot possibly include every single variable that affects efficiency, a missing measure we are most concerned with is research and development.

There is strong evidence that agricultural research and development has a large impact on productivity growth and that it has the most consistent influence on observed multifactor productivity growth (Griliches 1973; Kendrick and Grossman 1980; Sveikauskaus and Sveikauskaus 1982). Additionally, economic studies have shown that research and development contribute to approximately 0.3 percent annually to productivity growth (Griliches, 1980).

However, due to data limitations we could not include a measure for agricultural research and development. However, we include openness and school attainment to capture the impacts of research and development. The assumption we make here is that the more open a country is to trade, the more we would observe increases in technological adoption which should reflect in the output. Likewise, a more educated labor force could lead to a more advanced approach to agriculture which should also reflect in the output. However, both variables were not significant. The coefficient on school attainment is small and negative but openness is positive.

Our study showed that while institutions are important in the efficiency of agricultural output, they may not necessary explain the differences in productivity we observe across countries. To explore this more, we recommend that further study be done including a measure of agricultural research and development.

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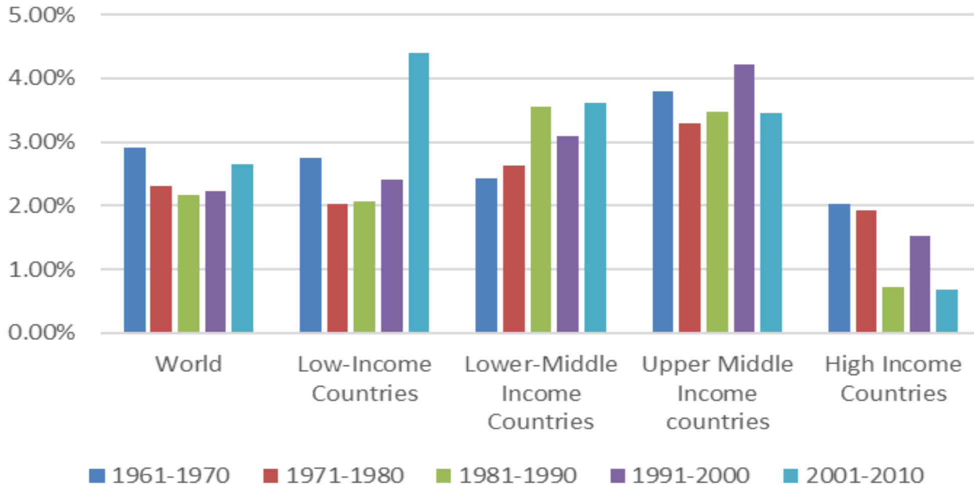
Appendix

FIGURE 1: AGRICULTURAL PRODUCTIVITY GROWTH



Note: Agricultural productivity growth across income levels

FIGURE 2: AVERAGE AGRICULTURAL OUTPUT

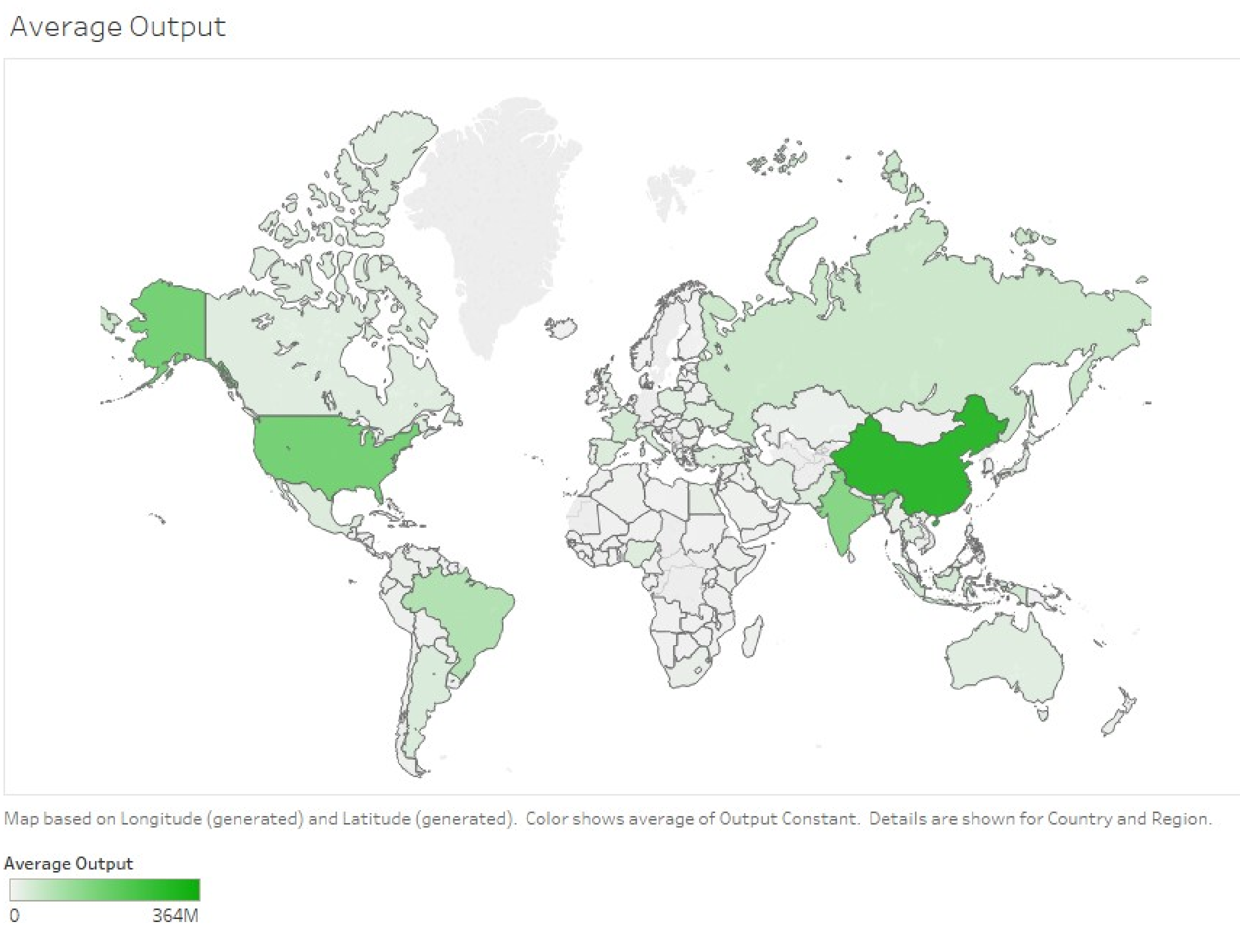
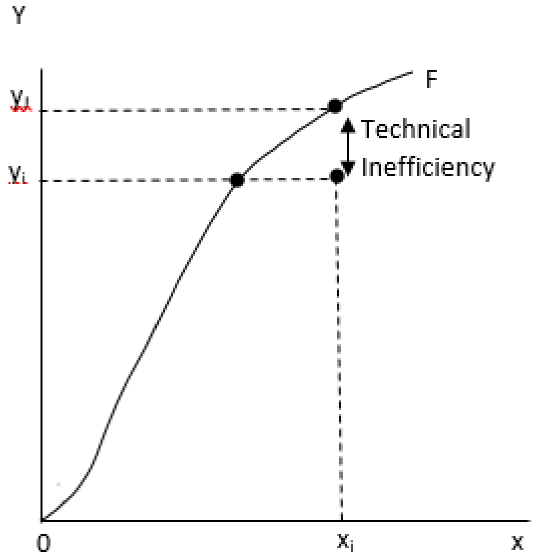


FIGURE 3: EFFICIENCY MEASUREMENT IN STOCHASTIC PRODUCTION FRONTIER MODEL



Note: F represents the production function at the maximum output level, x_i represents country I whose actual output is y_i, thus, the technical inefficiency measures the distance between y_j (the maximum output level) and y_i (the actual output level).

TABLE 1: DESCRIPTIVE STATISTICS OF OUTPUT AND INPUT VARIABLES

Table 1: Descriptive Statistics						
VARIABLES		**N**	**Mean**	**S.D.**	**Min**	**Max**
y						
Output (Millions $)		873	342	838	0.22	5250
x (inputs)						
Labour (Millions Persons)		873	45.08	142.00	0.01	660.00
Fertilizer (Millions Tonnes)		873	12.62	53.47	0.00	426.00
Land (1000 Ha)		873	22.32	41.43	0.00	187.78
Animals (Millions Head)		873	736.00	1760.00	0.69	8940.00
Machinery (1000 in Use)		873	387.95	763.06	0.01	4592.55
μ (efficiency variables)						
Irrigation (1000 Ha)		859	5.55	13.61	0.00	64.50
Drought (Occurrence)		873	0.14	0.42	0.00	3.00
Openness		867	67.27	33.54	0.02	218.85
School Attainment		629	8.24	2.32	1.21	13.10
Independence		873	150	194	20	1070

Note: S.D refers to the Standard Deviation

TABLE 2: DESCRIPTIVE STATISTICS OF POLITICAL RISK ASSESMENT

COMPONENT	MEAN	S.D.	MIN	MAX (DATA)*	MAX (POSSIBLE POINTS) **
GOVERNMENT STABILITY	7.4	2.2	1	12	12
SOCIOECONOMIC CONDITIONS	4.8	1.7	0.5	10	12
INVESTMENT PROFILE	6.7	2.2	0	12	12
INTERNAL CONFLICT	8.0	2.4	0	12	12
EXTERNAL CONFLICT	9.4	2.1	0	12	12
CORRUPTION	2.5	0.9	0	6	6
MILITARY IN POLITICS	2.9	1.6	0	6	6
RELIGIOUS TENSIONS	4.3	1.4	0	6	6
LAW AND ORDER	3.0	1.1	0	6	6
ETHNIC TENSIONS	3.7	1.4	0	6	6
DEMOCRATIC ACCOUNTABILITY	3.3	1.3	0	6	6
BUREAUCRACY QUALITY	1.7	0.9	0	4	4
TOTAL	57.7	11.8	8.5	83.1	100

Note: S.D refers to the Standard Deviation

*This is the maximum points for our data

** This is the maximum points in the composite index by ICRG

TABLE 3: COMPONENTS OF MAIN INSTITUTIONAL VARIABLES

Business Condition	Social Harmony	Government Quality
Socioeconomic Conditions	Internal Conflict	Government Stability
Investment Profile	External Conflict	Law and Order
Corruption	Religion Tension	Democratic Accountability
Bureaucracy Quality	Ethnic Tensions	Military in Politics

TABLE 4: DESCRIPTIVE STATISTICS OF MAIN INSTITUTIONAL VARIABLES

Variables	N	Mean	S. D.	Min	Max
Business Condition	3,872	0.53	0.18	0.02	0.96
Social Harmony	3,872	0.72	0.17	0.04	1.00
Government Quality	3,872	0.62	0.17	0.04	0.97

Note: S.D refers to the Standard Deviation

FIGURE 4: CARTOGRAPHICAL ILLUSTRATION OF BUSINESS CONDITIONS

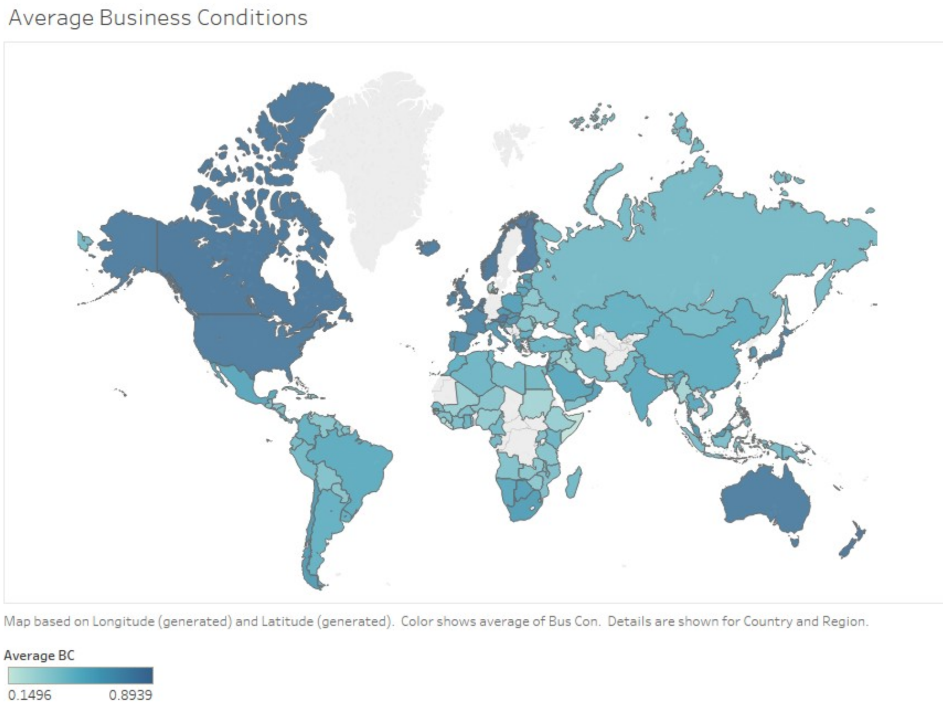


FIGURE 5: CARTOGRAPHICAL ILLUSTRATION OF SOCIAL HARMONY

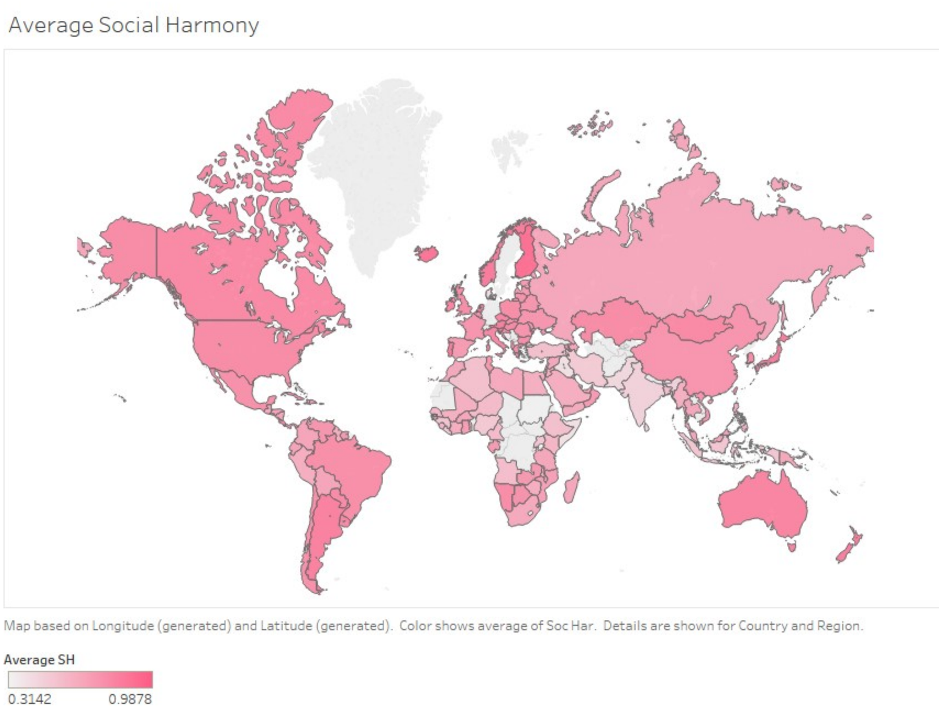


FIGURE 5: CARTOGRAPHICAL ILLUSTRATION OF GOVERNMENT QUALITY

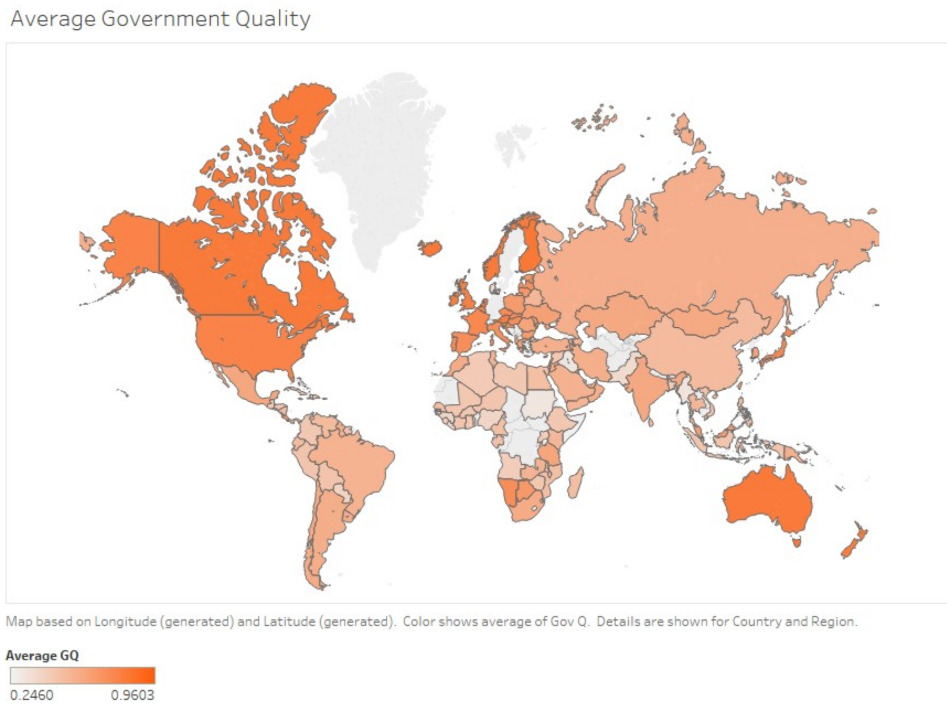


FIGURE 6: AVERAGE TECHNICAL EFFICIENCY ACROSS REGIONS

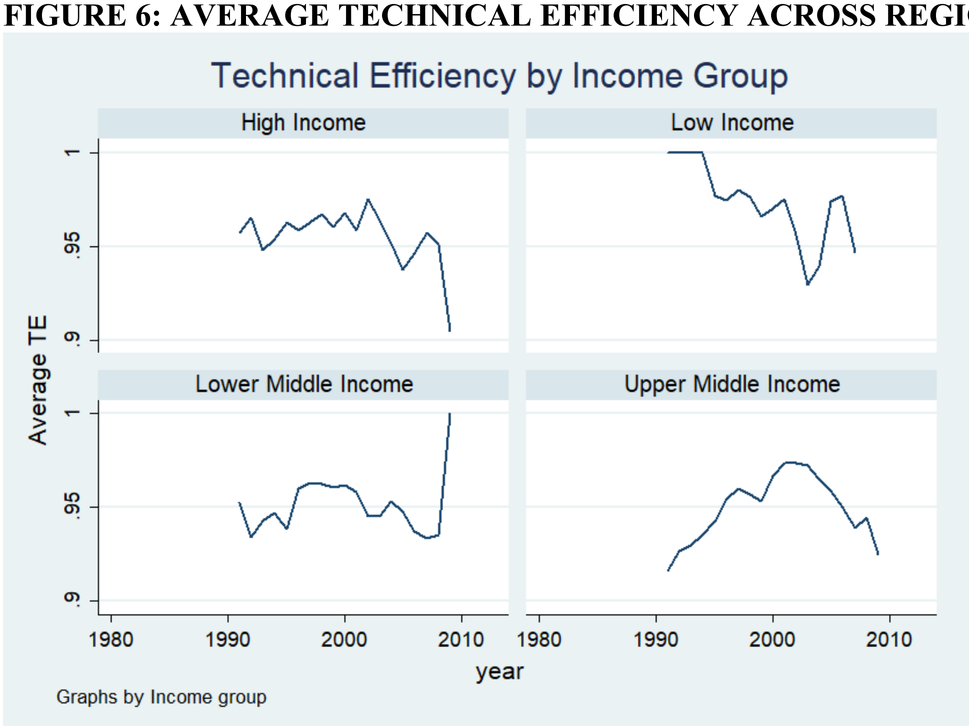


FIGURE 7: CARTOGRAPHICAL ILLUSTRATION OF TECHNICAL EFFICIENCY IN AGRICULTURE

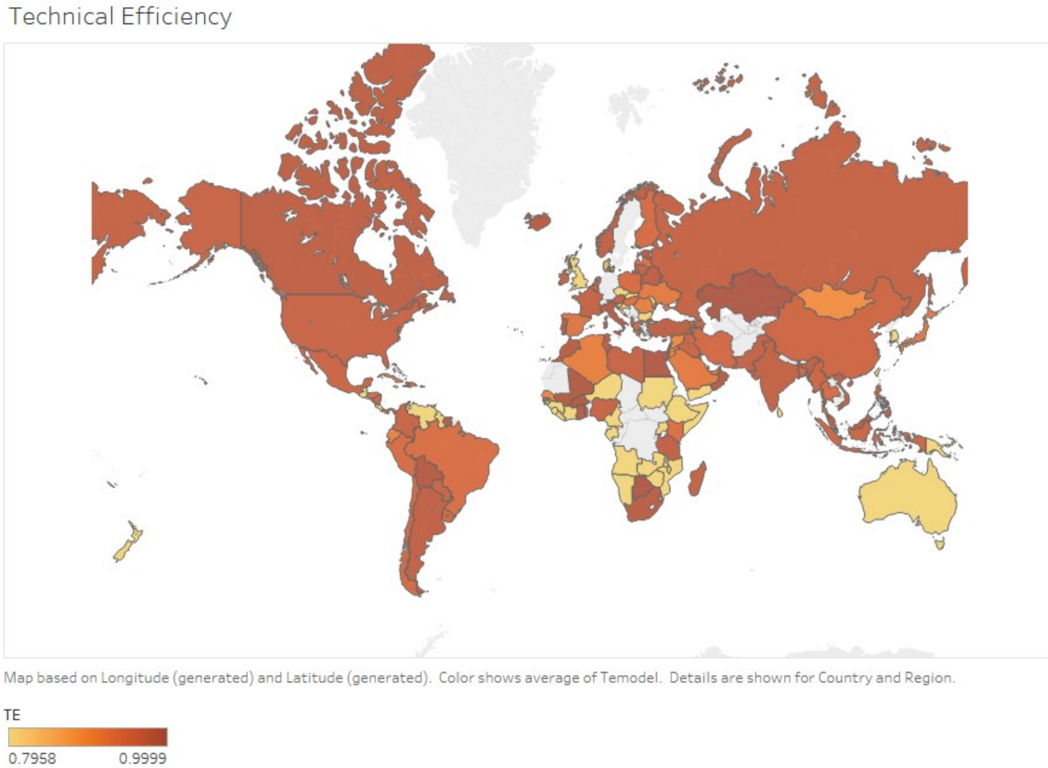
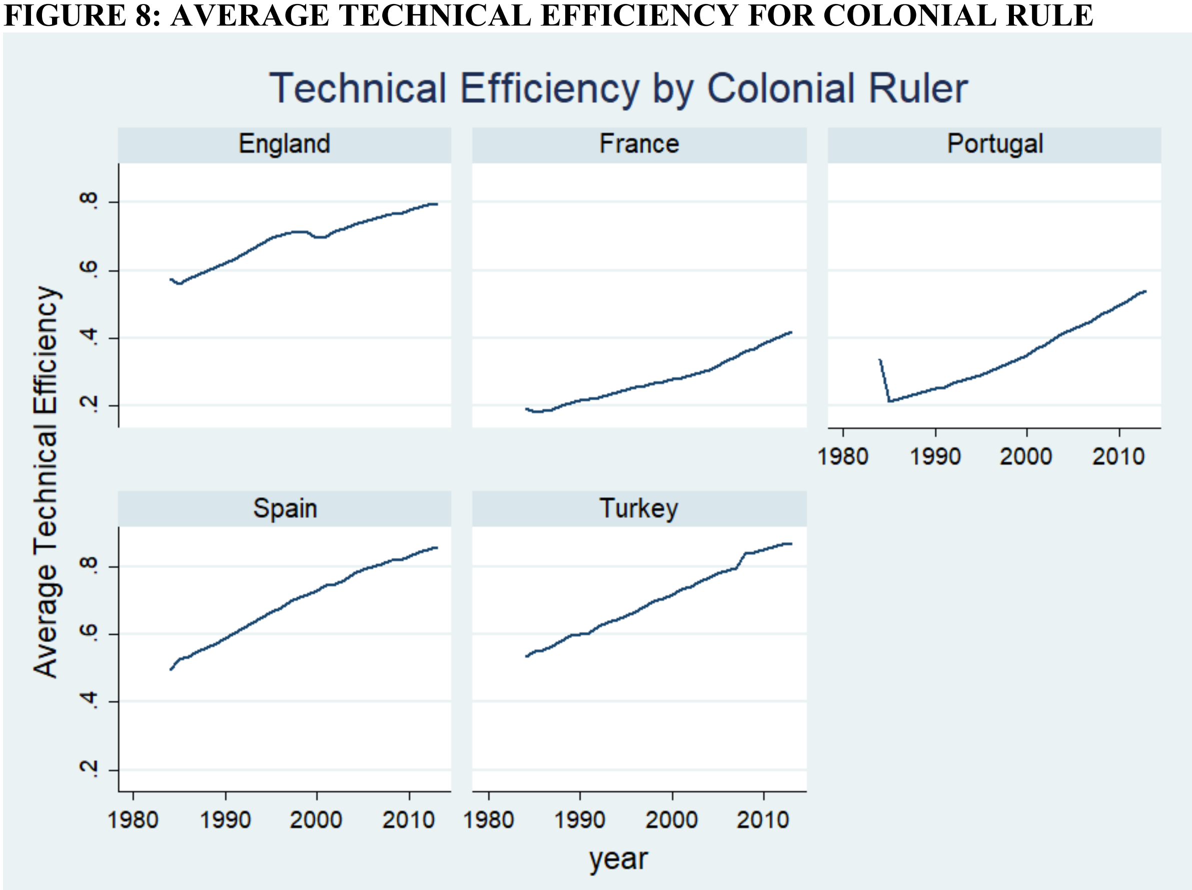


FIGURE 8: AVERAGE TECHNICAL EFFICIENCY FOR COLONIAL RULE



RESULTS FOR AGGREGATE OUTPUT

RESULT 1: TECHNICAL INEFFICIENCY ESTIMATES FOR BUSINESS CONDITIONS

VARIABLES	(1)	(2)	(3)	(4)
Business Conditions	-0.112***	-0.106**	-0.0957***	-0.0548*
	(0.0370)	(0.0419)	(0.0358)	(0.0324)
Irrigation	-0.0371**	-0.0402***	-0.0411***	-0.0378***
	(0.0146)	(0.0141)	(0.0139)	(0.00966)
School Attainment	-0.0380	0.00437	-0.00385	-0.0153
	(0.0611)	(0.0355)	(0.0345)	(0.0306)
Openness		-0.00112**	-0.00126**	-0.00126**
		(0.000449)	(0.000492)	(0.000523)
Drought			-0.0363	-0.0307
			(0.0241)	(0.0213)
Independence				-0.000180
				(0.000148)
Log Likelihood	1237.7	1245.0	1253.4	1288.0
Wald Chi-square	1652734.9	1998027.5	2661239.6	7493691.7
Country Fixed Effects	YES	YES	YES	YES
Observations	625	624	624	624

NOTE: Standard errors in parentheses
* p<.10 ** p<.05 *** p<.01"

RESULT 2: TECHNICAL INEFFICIENCY ESTIMATES FOR SOCIAL HARMONY

VARIABLES	(1)	(2)	(3)	(4)
Social Harmony	-0.152***	-0.150**	-0.157***	-0.0521
	(0.0417)	(0.0655)	(0.0460)	(0.0434)
Irrigation	-0.0450***	-0.0369	-0.0377***	-0.0540***
	(0.00770)	(0.0303)	(0.0129)	(0.00901)
School Attainment	-0.0437	0.0116	0.00861	-0.0781**
	(0.0286)	(0.0336)	(0.0349)	(0.0344)
Openness		-0.00102	-0.00105**	-0.00146***
		(0.000719)	(0.000453)	(0.000498)
Drought			-0.0355	-0.0226
			(0.0244)	(0.0220)
Independence				-0.000403**
				(0.000173)
Log Likelihood	1322.1	1247.9	1249.4	1287.7
Wald Chi-square	123008502.9	2580132.6	2372916.3	3203419.4
Country Fixed Effects	YES	YES	YES	YES
Observations	625	624	624	624

NOTE: Standard errors in parentheses
* p<.10 ** p<.05 *** p<.01"

RESULT 3: TECHNICAL INEFFICIENCY ESTIMATES FOR GOVERNMENT QUALITY

VARIABLES	(1)	(2)	(3)	(4)
Government Quality	-0.0508	-0.0793**	-0.0862**	0.111**
	(0.0777)	(0.0368)	(0.0409)	(0.0542)
Irrigation	-0.0299	-0.0289***	-0.0299*	-0.0518***
	(0.0327)	(0.00947)	(0.0177)	(0.0104)
School Attainment	-0.0511	-0.00337	-0.00832	-0.133***
	(0.128)	(0.0343)	(0.0339)	(0.0311)
Openness		-0.000891**	-0.000940	-0.00117***
		(0.000403)	(0.000603)	(0.000436)
Drought			-0.0318	-0.0147
			(0.0260)	(0.0355)
Independence				-0.000835
				(0.00147)
Log Likelihood	1255.8	1247.1	1246.2	1291.2
Wald Chi-square	7020042.2	1596220.8	2995715.7	1568481.8
Country Fixed Effects	YES	YES	YES	YES
Observations	625	624	624	624

NOTE: Standard errors in parentheses
* p<.10 ** p<.05 *** p<.01"

RESULT 4: TECHNICAL INEFFICIENCY ESTIMATES FOR ALL INSTITUTIONAL VARIABLES

VARIABLES	(1)	(2)	(3)	(4)
Business Conditions	-0.0792	-0.0555	-0.0665	-0.112**
	(0.0623)	(0.125)	(0.0594)	(0.0555)
Social Harmony	-0.126**	-0.120	-0.114*	-0.0848
	(0.0630)	(0.0731)	(0.0652)	(0.0751)
Government Quality	0.0359	0.0422	0.0233	0.0792
	(0.0873)	(0.194)	(0.0980)	(0.0792)
Irrigation	-0.0378***	-0.0394	-0.0384*	-0.0335***
	(0.0130)	(0.0450)	(0.0203)	(0.0122)
School Attainment	-0.0205	0.0192	0.0140	0.00410
	(0.0434)	(0.0305)	(0.0355)	(0.0419)
Openness		-0.00106	-0.00104**	-0.000614
		(0.000737)	(0.000482)	(0.000469)
Drought			-0.0346	-0.00838
			(0.0234)	(0.0332)
Independence				-0.000787
				(0.000590)
Log Likelihood	1240.9	1260.5	1251.3	1260.9
Wald Chi-square	1654459.4	2456512.4	2403785.8	1658555.0
Country Fixed Effects	YES	YES	YES	YES
Observations	625	624	624	624

Standard errors in parentheses
* p<.10 ** p<.05 *** p<.01"

RESULT 5: TECHNICAL INEFFICIENCY ESTIMATES: CROP LEVEL

VARIABLES	CEREAL	VEGETABLES	FRUITS AND NUTS	OILSEED CROPS	ROOTS AND TUBERS	BEVERAGES AND SPICES	LEGUMES	SUGAR CROPS	FIBRE
Business Conditions	0.177	-0.360***	-0.0303	-0.398	-0.489*	-0.128	-0.0849	0.583	-0.0597
	(0.207)	(0.136)	(0.0716)	(0.294)	(0.252)	(0.107)	(0.584)	(0.784)	(0.277)
Social Harmony	-0.287*	-0.0247	-0.0726	-0.0148	-0.464*	0.113	0.0272	0.520	-0.280
	(0.168)	(0.0857)	(0.0637)	(0.296)	(0.261)	(0.101)	(0.189)	(1.259)	(0.486)
Government Quality	-0.203**	0.0920	-0.0566	-0.494	0.331	-0.111	0.134	-0.529	-0.0233
	(0.0935)	(0.125)	(0.0599)	(0.325)	(0.245)	(0.0874)	(0.423)	(0.914)	(0.837)
Irrigation	-0.0172	-0.0626	-0.0150	-0.0558	-0.102**	-0.0813***	0.0376	-0.0351	-0.175
	(0.0329)	(0.0459)	(0.0316)	(0.0398)	(0.0434)	(0.0230)	(.)	(0.0479)	(0.301)
School Attainment	-0.185	0.182**	0.00967	-0.236	-0.119	0.185**	-0.0294	-0.258	0.376
	(0.194)	(0.0836)	(0.0566)	(0.181)	(0.130)	(0.0762)	(0.223)	(0.401)	(1.393)
Openness	0.00320*	-0.00211**	0.00160	0.00519**	-0.00400	-0.000722	0.00153	-0.00238*	-0.000351
	(0.00177)	(0.000853)	(0.00109)	(0.00207)	(0.00265)	(0.00123)	(0.00358)	(0.00133)	(0.0152)
Drought	0.00689	0.0459*	0.0155	-0.222	-0.120	-0.0222	0.0283	0.0381	-0.0349
	(0.0349)	(0.0253)	(0.0153)	(0.148)	(0.114)	(0.0275)	(0.0804)	(0.0353)	(0.0596)
Independence	-0.000133	-0.00180	-0.000157	0.0000262	0.00119**	-0.000742***	-0.00437	0.000513	-0.00103
	(0.000177)	(0.00134)	(0.000201)	(0.000446)	(0.000545)	(0.000233)	(0.00748)	(0.000504)	(0.00446)
Log Likelihood	328.9	483.1	427.2	310.2	281.2	298.1	270.4	292.9	241.0
Wald Chi-square	11530.1	3189784.0	6017.5	25424.0	83587.8	20643.3	30308.5	14051.5	40038.6
Country Fixed Effects	YES	YES	YES	YES	YES	YES	YES	YES	YES
Observations	295	295	295	295	295	295	290	277	268

Standard errors in parentheses
* p<.10 ** p<.05 *** p<.01"