Measuring regional competitiveness through agricultural indices of productivity

The Peruvian case

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Abstract

Purpose – The purpose of this paper is to incorporate factors that characterize the agricultural activity as productivity indices to compute the agricultural competitiveness of regions in order to rank the regions, and compare the results with those obtained by applying other commonly used social and economic indicators.

Design/methodology/approach – The authors identify regional factors related to the use of water, soil, production, revenues, and rural population, which conform a total of six productivity indices, that the authors then employ to calculate the regional agricultural competitiveness index.

Findings – The agricultural-related indices are informative in supporting the regional ranking related to resources and technology utilization. The results reveal that the coastal regions are the most competitive when compared to the regions located in the highlands and the jungle. Nevertheless, in contrast with other existing competitiveness rankings, the present study identifies the regions with the greatest potential for agriculture.

Research limitations/implications – The authors identify the regions which have a higher potential of development considering the natural resources and agricultural production. The authors hope that this paper can assist regional and national policymakers in their endeavor to improve regional and national competitiveness.

Practical implications – The authors identify the regions with a higher potential of development considering natural resources and agricultural production and the possibilities to improve their competitiveness.

Social implications – The study also bears social implications, given that the rural activities in Peru are carried out by approx. 7 million inhabitants, whose contribution to the gross domestic product (GDP) is as much as 7 percent, making use of about 94 percent of the available water.

Originality/value – The originality of the present paper resides in the attempt to compute a regional competitiveness index by taking agricultural resources as determinant factors. The authors rank the regions based on their agricultural competitiveness.

Keywords Productivity, Competitiveness index, Economic growth, Regional competitiveness

Paper type Research paper

Introduction

With today's increased globalization of the world economy, coupled with the rising income inequality, the social and political turmoil, low trade, and low growth, among others, competitiveness has become ubiquitous. But what exactly is competitiveness and in what sense can one talk about regional competitiveness? Although the term competitiveness is rather clear when applied to firms – being a measure of the degree in which firms can compete with other firms – it is more difficult to define and measure when applied to regions and countries. Despite this, the concept of competitiveness of regions within a country bears similarities

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with the concept of competitiveness of countries. In this sense, the existing literature on competitiveness of countries may be applicable to the competitiveness of regions within a country, as well (Budd and Hirmis, 2004; Camagni, 2002; Gardiner *et al.*, 2004; Malecki, 2002).

Briefly stated, the concept of regional competitiveness, although widely studied, has no single accepted framework or definitions, nor strong agreement on its measurement, being an often-debated issue (Békés, 2015). A more accepted view is that regional competitiveness has to do with the degree (and success) with which regions compete with one another over shares of national and global export markets (Gardiner *et al.*, 2004), being viewed as a derivation of the macroeconomic competitiveness, defined at national level (Békés, 2015).

Enhancing competitiveness, both at the national and regional levels, is a popular target in economic policy-making, given its connectedness with economic growth and societal progress. The competitiveness of regions can be computed based on the application of indices of technology, economic environment, business development, innovative capacity, physical infrastructure, facilities, capital markets, competition, trade and monetary policies, the pool of skilled labor, and education and health, among others. Other aspects, also, such as the level of education, production services, and communication channels, are considered in the current measurements of competitiveness.

Nevertheless, despite its relevance to the different facets of the economic analysis, the empirical measurement of competitiveness faces certain constraints which arise from the very lack of a unique definition of the concept and the insufficiency of disaggregated indicators that adequately capture the wide range of factors relevant to competitiveness (Crespo Rodriguez *et al.*, 2011). As such, the existing enhancers of the economic efficiency do not show the factors which are directly related to the agricultural activity and, therefore, they miss to consider the activities which may exist in vast areas of the country. In this sense, for example, few indicators are available to assess, monitor, and evaluate changes in the quality of land resources (Pieri *et al.*, 1995).

We address this gap by proposing productivity indices that reflect the rural activities and apply them to the case of Peru. As such, the purpose of the present paper is to incorporate factors that characterize the agricultural activity as productivity indices to compute the agricultural competitiveness of regions in order to rank the regions of Peru, and compare the results with those obtained by applying other commonly used social and economic indices.

Such endeavors would bear substantial implications for practice, given that the rural activities in Peru are carried out by approx. 7 million inhabitants, whose contribution to the gross domestic product (GDP) is as much as 7 percent, making use of about 94 percent of the available water, a resource that is a matter of concern due to the recent climatic changes. In this sense, we also aim to identify the potential for improvement in the agricultural activity, which should be of interest in guiding management decisions for investments at the regional and country level, which will further lead to the improvement of competitiveness in each region and, ultimately, in the entire country. We hope to be able to advance the knowledge on the topic.

The remainder of the paper is organized as follows: the next section develops the topic of regional competitiveness, highlighting the most important aspects of its definition and measurement. This is then followed by the methodology section, wherein we introduce the indices of agricultural productivity. Further, we briefly describe the situation of the natural resources and the agriculture sector in Peru, data based on which we proceed to calculate the proposed indices, followed by the computation of the regional agricultural competitiveness index (ACI). The following sections describe the findings of the study and compare the results (ranking) with those reported by other existing studies. The last section concludes the paper, with additional insights regarding policy implications.

Regional competitiveness

Generally, the concept of competitiveness is associated with productivity (Porter, 1990), being often viewed as an indicator of the success or failure of policy (European Commission, 1999).

The European Commission (1999) defined competitiveness as "the ability to produce goods and services which meet the test of international markets, while at the same time maintaining high and sustainable levels of income or, more generally, the ability of (regions) to generate, while being exposed to external competition, relatively high income and employment levels" (p. 75).

The WEF's World Competitiveness Report (2016), on the other hand, defined competitiveness as: "the set of institutions, policies, and factors that determine the level of productivity of an economy, which in turn sets the level of prosperity that the country can achieve" (p. 4). The IMD's (2012) *World Competitiveness Yearbook* defined competitiveness in a similar manner, as "a field of economic knowledge, which analyses the facts and policies that shape the ability of a nation to create and maintain an environment that sustains more value creation for its enterprises and more prosperity for its people" (p. 502).

An economy is said to be competitive if the firms in that economy bear lower costs per unit than firms in other economies (Charles and Zegarra, 2014). Porter (1979) evolved the notion of competitiveness into a framework that conceptualizes the forces which drive industry competition. These forces, defined as the bargaining power of the suppliers, the threat of new entrants, the threat of substitute products, the bargaining power of the buyers, and the degree of rivalry, are designed to help develop an edge over rival firms.

Every economy counts with a series of individual attributes that contribute to its uniqueness. The classical theories of international trade argue in favor of the comparative advantage of nations, which resides in the factor endowments that the nations naturally have. Porter (1990), however, proposed his now famous diamond-shaped framework (composed of firm strategy, structure, and rivalry; factor conditions; demand conditions; and related and supporting industries) to illustrate the determinants of national advantage, arguing that a nation is capable of creating new factor endowments.

The concept of competitiveness of regions within a country, as previously mentioned, bears similarities with the concept of competitiveness of countries. According to Huggins *et al.* (2013), "regional competitiveness can be usefully defined as the capacity and capability of regions to achieve economic growth relative to other regions at a similar overall stage of economic development, which will usually be within their own nation or continental bloc." (p. 155).

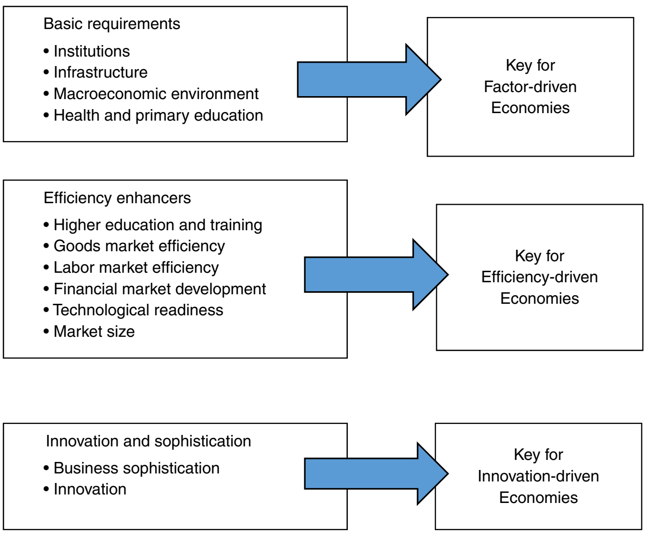
In time, many institutions have developed models to measure the competitiveness of nations – in this sense, we have, for example, the *World Competitiveness Yearbook*, developed by the International Institute for Management Development (IMD) and the Global Competitiveness Report, developed by the World Economic Forum (WEF).

Table I, retrieved from the preliminary document prepared for the Inter-American Development Bank by Andrew Warner (Warner, 2003), presents the competitiveness indices of both the WEF and the IMD, but also of the Heritage Foundation. It includes the Global Competitiveness Index (GCI) of the WEF's Global Competitiveness Report, which weighs the macroeconomic, institutional, and technological development conditions (Figure 1 highlights The GCI Framework). In addition, the current competitiveness index (CCI) of the Global Competitiveness Report has three components: the quality of the local business environment, the quality of operations, and corporate strategies. The "competitiveness index," published in the IMD's *World Competitiveness Yearbook*, has four sub-indices: economic performance, government efficiency, business efficiency, and infrastructure. Finally, the Index of Economic Freedom of the Heritage Foundation (EF) is based on ten quantitative and qualitative factors, grouped into four categories of economic freedom, i.e., rule of law, limited government, regulatory efficiency, and open markets.

World Economic Forum (WEF)[a]		Institute for Management and Development (IMD)[b]	The Heritage Foundation[c]
Global competitiveness index (GCI)	Current competitiveness index (CCI)	Competitiveness index (IMD)	Economic freedom index (EF)
Technology and supporting infrastructure index	Operations and business strategy index	Economic performance	
Public institutions index		Government efficiency	
Macroeconomic environment index	Business environment quality index	Business efficiency	
		Infrastructure	
Sub-indices			
	Physical infrastructure		Property rights
	Administrative infrastructure		Freedom from corruption
	Human resources		Fiscal freedom
	Technology		Government size/spending
	Capital markets		Business freedom
	Conditions of demand		Labor freedom
	Complementary industries		Monetary freedom
	Competition		Trade freedom
			Investment freedom
			Financial freedom

Notes: [a]Global Competitiveness Report (GCR), www.weforum.org; [b]World Competitiveness Yearbook, www.imd.ch/wcy/; [c]Heritage Foundation, www.heritage.org/research/features/index/

Table I. Competitiveness indices



Source: World Economic Forum, available at: http://reports.weforum.org/global-competitiveness-report-2015-2016/methodology/

Figure 1. The Global Competitiveness Index framework

The sub-indices of the IMD's competitiveness index are set to measure a series of aspects that can show how nations and enterprises alike are managing the totality of their competencies to achieve increased prosperity (IMD, 2016). These aspects refer to the economic performance (macroeconomic evaluation of the domestic economy, domestic economy, international trade, international investment, employment, and prices), the government efficiency (public finance, fiscal policy, institutional framework, business legislation, and societal framework), the business efficiency (productivity and efficiency, labor market, finance, management practices, and attitudes and values), and the infrastructure (basic infrastructure, technological infrastructure, scientific infrastructure, health, environment, and education).

Gallup *et al.* (1998) suggested a two-way relationship: a direct relationship with economic productivity through the effects of transport costs, agricultural productivity as the production of specific crops, population density, resources provision, and health conditions and an indirect relationship that acts through the impact of geography on policy decisions. Policies are influenced by the spatial distribution of the population, the morphology of the territory, and the geographical location of the country or region.

The differences in the provision of resources can also result in diverse orientations of the economic activity and in different levels of GDP growth. The Heckscher-Ohlin model (Ohlin, 1933) suggests that the regions or countries with different factors can generate more goods and specialize in the production of those for which the required factors of production are relatively abundant locally.

With regard to geography and development, Sachs and Warner (1995), based on a sample of countries for the period 1970-1989, concluded that the countries with an abundance of natural resources register less economic growth than the economies with fewer resources. This allegation should be cautiously considered since the referred condition offers a great potential for production. On the other hand, Gavin and Hausmann (1998) stated that the availability of natural resources and growth have a negative relationship with the GDP. This might mean that the dependency on natural resources would not necessarily conduce to economic growth.

In Colombia, Sánchez and Núñez (2000) concluded that agriculture is not important for large regions, in which industry and services are more significant for their economic structure, although the greatest part of the rural population of Colombia is concentrated in the more economically developed areas, between 1,000 to 1,200 MOSL, with favorable conditions for the cultivation of coffee. The same authors reported the influence on agricultural productivity of the soil quality, such as the depth of the soil, the density of topsoil, the amount of organic matter, soil moisture, the erosive processes, as well as the weather conditions. At municipal level, with less than 40,000 inhabitants classified as rural, a correlation was found between the agricultural GDP per capita and the Moisture Index. Another study applied to the Colombian territory is that of Galvis Aponte (2001), who identified that the geographical conditions of a country or region have an impact on its economic performance through the agricultural productivity and the population's health. Galvis Aponte applied an econometric model estimating that, for 1997, more than 80 percent of the variability in the agricultural productivity levels is explained by the quality of the soil and by climatic factors.

In Ecuador, Castillo (2013) noted that productivity is measured by land unit or employed persons. He highlighted the work methodology for data search: interviews with the experts in each type of crop and representatives of key public institutions in the agricultural sector.

In Mexico, the Secretariat of Agriculture, Livestock, Rural Development, Fisheries, and Food (FAO-MEXICO, 2008) studied the competitiveness of agri-food chains, in which one production system constituted the main input or raw material for other production systems in the group; the competitiveness of the chain was shown to depend on the competitiveness of each of the production systems that comprised it.

With regards to Peru, the National Plan of Competitiveness of Peru (MEF, 2008) defined competitiveness as the "interrelationship of various elements that determines the increase in the productivity of businesses and the context that surrounds them that allows the efficient use of the factors of production, such as the human resources, fixed assets, financial resources, and technology." This definition "includes the strengthening of institutions to create a favorable business climate, within a stable macroeconomic framework, which enables a proper functioning of the factors, goods, and services markets." At the regional level, the Regional Competitiveness Index (MEF, 2008; CNC, 2013) is measured by using the indicators that show the inhabitants' quality of life and the conditions for attracting investment. The index is developed using a combination of eight factors: infrastructure; economic performance; health; education; business climate; innovation; natural resources and environment; and institutions and governance.

Benzaquen *et al.* (2010) proposed a Regional Competitiveness Index for Peru (IRCP), for the 26 regions. The Metropolitan Lima area was considered separate from the Department of Lima known as "Lima Provinces." Taking few years' data as a basis, CENTRUM Católica (2014) considered five pillars for the calculation of the index: economy, businesses, government, infrastructure, and people. For each pillar, five factors were considered to measure their behavior, and a set of 90 variables were designated to validate the results. A national survey was conducted among entrepreneurs in order to assess the businesses. The "People" pillar included education and health. It is to be mentioned that the selection of the variables followed closely the methodology proposed by the WEF and IMD. In this sense, also, the competitiveness indices were derived following a non-optimization approach, in an absolute sense, wherein pillars were given an equal importance in terms of weights. It was in 2014 that Charles and Zegarra overcame these methodological barriers by means of proposing an optimization-based model, that is, data envelopment analysis (DEA), to compute the regional competitiveness index (Charles; 2016; Charles and Zegarra, 2014); furthermore, in 2016, Charles and Diaz proposed a non-radial variant of the DEA model to avoid the traditional pitfalls of DEA-based composite indices, while also extending the applicability of the DEA method to comparisons across multiple years.

Rojas and Sepúlveda (1999) noted that "the overall objective of competitiveness is the economic dimension, whose interaction with the social, environmental, and political-institutional dimensions constitutes the sustainable development process." They defined competitiveness as the ability of a country to create, produce, and distribute products or services in the international trade, maintaining increasing profits for their resources, considering the rural spaces, the agri-food chains, and the interaction between them.

Santa Cruz *et al.* (2006) identified that the territorial inequality of geographical, ecological, and topographic nature – as the base for competitiveness – impact on human development and, hence, they underlined the need to design public policies that recognize the diversity of the peasant economy. They also emphasized that the departments unaffected by El Niño climate phenomenon and droughts, such as the Amazonas, Cajamarca, and Huánuco, showed GDP growth. This provided information on crops acclimatized by regions, considering, for example, the Northern Coast, Central Coast, Southern Coast, North Center, and South Highlands.

Finally, Vela Meléndez and Gonzales Tapia (2011) applied Porter's Diamond Model and found a low level of agricultural competitiveness and profitability in Peru, an unsustainable use of natural resources, a limited access to basic services for the small agricultural producer, and a weak institutional development of the sector.

In general, the studies on agricultural productivity do not count with indicators of regional agricultural competitiveness based on which regions could be ranked; Peru is not an exception – in this sense, it does not have any proposals to include quantitative indices to guide the development of the rural sector and to rank its regional agricultural competitiveness.

Indicators of productivity and regional agricultural competitiveness

The model proposed in this study to compute regional competitiveness is based on productivity indicators that characterize the agricultural activity of each and every region; in this sense, the model is built based on information regarding the rural population, the availability and use of essential natural resources for the agricultural activity (e.g. water and soil), as well as the volume and the gross value of the agricultural production resulting from the agronomic practices and the level of technology used.

Indicators of productivity

We consider six productivity indicators: two of them are related to the water production and water-related income, two are related to the water and soil and the production obtained from the soil, and the last two are related to the gross profit per rural inhabitant and the weighted production of the annual harvest per capita.

Water production index (WPI). The WPI relates the annual production (kg) (PT) of all the crops that are produced in a region to the water volume (m^3) available for irrigation in each region (VAU). Hence, the achieved crop yields can be compared considering the use of water and knowing whether all the available water would be used or not:

$$\mathrm{WPI} = \frac{\text{Total Production (kg)}}{\text{Available water volume (m}^3\text{)}} = \frac{\mathrm{PT}}{\mathrm{VAU}} \left(\mathrm{kg}/m^3\right) \tag{1}$$

Economic index of water (EIW). The EIW relates the revenue in Soles (PEN) or in American Dollars (USD) (BEB) obtained from the sale of the production to the water volume (m^3) available in each region (VAU):

$$\mathrm{EIW} = \frac{\text{Gross profit}\left(\mathrm{S/.}\right)}{\text{Available water volume(m}^3\text{)}} = \frac{\mathrm{BEB}}{\mathrm{VAU}}\left(\mathrm{PEN}/m^3\right) \tag{2}$$

Water and soil use index (WSUI). The WSUI, as an indicator of the utilization of these resources, relates the water available for agricultural purposes to be used by regions (VAU) to the agricultural area available for irrigation (SR):

$$\mathrm{WSUI} = \frac{\text{Available water volume }\left(\mathrm{m}^3\right)}{\text{Irrigation surface (ha)}} = \frac{\mathrm{VAU}}{\mathrm{SR}} \left(\mathrm{m}^3/\mathrm{ha}\right) \tag{3}$$

Soil production index (SPI). The SPI, as an indicator of the performance achieved with a certain technological level used during the agricultural year, sets a production value for the surface suitable for irrigation:

$$\mathrm{SPI} = \frac{\text{Total production (kg)}}{\text{Irrigation surface (ha)}} = \frac{\mathrm{PT}}{\mathrm{SR}}\left(\mathrm{kg}/\mathrm{ha}\right) \tag{4}$$

Rural inhabitant's financial profit (RIFP). The RIFP is an indicator of the gross profit per capita.

$$\mathrm{RIFP} = \frac{\text{Gross profit }\left(\mathrm{S/.}\right)}{\text{Rural population (inhabitants)}} = \frac{\mathrm{BEB}}{\mathrm{PR}} \left(S/.\text{/inhabit.}\right) \tag{5}$$

Labor production index (LPI). The LPI is an indicator of the weighted production of the annual harvest per capita:

$$\mathrm{LPI} = \frac{\text{Total Production (kg)}}{\text{Rural population (inhabitant)}} = \frac{\mathrm{PT}}{\mathrm{PR}}\left(\text{kg/inhabit.}\right) \tag{6}$$

Agricultural competitiveness index by region (ACI). Finally, we compute the regional ACI, which is calculated as the average of the normalized n productivity indices defined above:

$$\mathrm{ACI} = \sum_{i}^{n} \frac{\mathrm{Indices}}{n} \tag{7}$$

Situation of natural resources and the agro in Peru

According to Coronado (2014), the coast of Peru is narrow, widening toward North with 53 rivers that discharge an annual average of 1,098 m^3/s. The cordillera has high mountains and the rivers flow parallel to the coast, dividing the territory into a western basin and an eastern basin or the Amazon jungle with 63,380 m^3/s, along with the Titicaca lake basin with 323 m^3/s, thus producing a total of 64,800 m^3/s. A total of 70 percent of the water on the coast discharges during the rainy season from December to March – a quite remarkable number with high relevance given that agriculture is the activity that consumes more water (Table II).

With about 5,000 wells, the underground water provides 1,500,000,000 m^3 annually, which is mostly used during the dry season.

Peru has 71 percent of the tropical glaciers in South America affected by the climatic change; it is reported that the Cordillera Blanca shows a reduction of 21.8 percent of the occupied area.

The average annual rainfalls in the highlands range from 500 to 800 mm. In the lowland jungle, they rise up to 2,000 to 4,000 mm, while on the coast they reach up to only 100 mm.

The total area of Peru is 128 million hectares and only 1.5 million are irrigated, most of which are located on the coast. Additionally, there are 10.9 million hectares with irrigation potential, with 50 percent of the hectares located in the jungle, precisely where the water is available (Table III).

Nowadays, the agricultural activity is the main source of income for 2.3 million families, accounting for about 30 percent of the Peruvian households; it generates approximately

Use	Volume MCM	(%)	Use type (%)	Total annual runoff MCM
Consumptive				
Agricultural	23,059.00	94.40	64.50	2,059,799.30
Livestock	87.70	0.40		
Industrial	946.90	3.90		
Mining	206.60	0.80		
Non-consumptive				
Energy	13,352.70	100.00	35.50	
Total	37,652.90		100.00	

Note: USE-Runoff Volume Relation, 1.80

Table II. Use of water in Peru

Region and surface	Irrigated land	Rain-fed land	Total (irrigated and rain-fed land)	Irrigation potential
Coast	0.9		0.9	3.5
Highlands	0.5	1.3	1.8	1.9
Jungle	0.1	0.5	0.6	5.5
Agricultural surface			3.3	10.9
Natural grass			27.6	
Agricultural area			30.6	
Total area of the country			128.02	

Table III. Land resources in Peru (million hectares)

7.6 percent of the GDP (Emanuel and Escurra, 2010; MINAG, 2010), showing a great dynamism resulting from the development of the agro-export.

The national production is developed over nearly 3.3 million hectares, out of which 80 percent is made of transitory crops and the remainder of fruit trees. On the other hand, 64 percent of the gross value of the livestock production are chickens (45 percent), living the cattle with a percentage of 18 percent. The available land in Peru is 0.11 ha/capita, representing the lowest ratio in Latin America, which clearly calls for improvement in productivity and an increase of the irrigated land. It should be noted that Peru has vast lands suitable for irrigation in the Amazonas region, where, as mentioned, there is also plenty of water available.

Production situation

The predominant crops in Peru are essentially composed of rice, potato, hard yellow maize and amylaceous maize, alfalfa, sugarcane, bananas, citrus products, as well as products destined for export, such as asparagus, mango, avocado, grape, coffee, and cocoa (MINAGRI, 2012). Table IV shows the main crops, by region, beginning with the crop with the higher production in metric tons.

Rice is produced over a surface of 380,000 ha, out of which 60 percent is located on the north coast and lowland jungle, 33 percent is concentrated in the jungle, and 7 percent is located in the Southern part of the country; the rice production reaches approx. 2,600,000 metric tons per year, with 69 percent being produced on parcels of 20 ha maximum, which results in an average production of 7.6 metric tons/ha. In Arequipa, this production is doubled; the price of the paddy rice in 2012 ranged from S/.0.79/ kg in the Amazonas region to S/.1.13/ kg in Arequipa. The rice production represented 4.5 percent of the gross national product related to agriculture and livestock and generated 44.7 million jobs.

Table IV. Relation of major crops by regions

Region	Main crops
Tumbes	Rice, banana, cassava, lemon
Piura	Rice, lemon, mango, banana, grape, hard maize
Lambayeque	Sugarcane, rice, alfalfa, maize, lemon, mango, avocado
La Libertad	Sugarcane, potato, rice, alfalfa, asparagus, maize, wheat
Cajamarca	Potato, alfalfa, rice, cassava, coffee, maize, bananas
Amazonas	Rice, banana, cassava, coffee, maize, potato
Ancash	Sugarcane, alfalfa, maize, potatoes, avocado, wheat
Lima	Sugarcane, alfalfa, maize, tangerine, avocado, potato
Ica	Alfalfa, asparagus, tomato, grape, onion, maize, potato
Huánuco	Potato, banana, cassava, maize, ullucus, peas
Pasco	Potato, banana, cassava, coffee, maize
Junín	Orange, tangerine, alfalfa, coffee, barley, maize, cocoa
Huancavelica	Alfalfa, peas, potato, wheat, avocado
Arequipa	Alfalfa, sweet potato, onion, potato, rice, sugarcane
Moquegua	Alfalfa, avocado, onion
Tacna	Alfalfa, olives, onion, avocado
Ayacucho	Potato, alfalfa, maize, barley, wheat, ullucus
Apurímac	Potato, alfalfa, maize, ullucus, wheat, beans
Cusco	Potato, alfalfa, maize, coffee, ullucus, banana, orange, oca, cocoa
Puno	Potato, alfalfa, quinoa, barley, oca, orange, pineapple
San Martin	Rice, banana, oil palm, maize, coffee, cocoa, potato, coconut
Loreto	Cassava, banana, oil palm, maize, pineapple, coconut
Ucayali	Banana, cassava, oil palm, papaya, potato, maize
Madre de Dios	Banana, rice, cassava, papaya, maize

Sources: MINAGRI (2012), Authors' compilation

Peru counts with 4,200 varieties of potato, the largest variety in the world, harvested almost entirely in the highlands, from over about 270,000 ha; 40 percent of the Canchán variety and 600,000 metric tons per year are produced in Puno and Huánuco, and more than 400,000 metric tons are produced in Cusco and Junín, with an average annual crop performance of 13.3 metric tons/ha. Junín is located in the central highlands, with an average performance of 17.5 metric tons/ha/year. The farm prices range from S/.0.66/ kg in farms in Junín to S/.1.32/ kg in Puno. The cost of production represents 60 percent of the revenues.

Alfalfa is a crop that is mainly harvested in Arequipa and in Puno, which are livestock regions. In 2012, a production of more than 3,139,000 metric tons with an annual crop yield of more than 75 metric tons/ha on 41,851 ha was achieved in Arequipa, whereas in Puno, with 18,716 ha, the annual crop yield was a little more than 21 metric tons/ha. However, the average farm price in Puno was S/. 0.30/ kg, three times higher than the price in Arequipa. Moquegua obtained the second largest crop yield, with 56 metric tons/ha/year and a farm price similar to the one in Arequipa.

Another relevant crop is the sugarcane, which is harvested from over more than 180,000 ha, with crop yields that exceed 140 metric tons/ha/year in La Libertad, as well as in Lima. Table V shows the relevant data with regards to the discussed above; additionally, it provides data regarding the coffee production.

The performance of the crops, for almost all the crops, is relatively low. Among the main causes of such phenomenon, we can find: the use of non-certified seeds (in this sense, e.g. only 1 percent of the potato seeds are being used, in spite of counting with the presence of the International Potato Center, a renowned international institute, concerned with delivering sustainable solutions to the problems of hunger, poverty, and the degradation of natural resources) and the limited agronomic management and control of pests and diseases, as it has been lately appreciated with the coffee rust and the small size of the farms, which limits the credit.

The applied technological level is low and in the best case is average, except for the case of the limited extensions which are dedicated to producing crops dedicated for exports. There are private associations that support the production of crops, such as the Committee of Rice, Coffee, and Asparagus producers.

The large private investment in the agricultural sector located on the coast is concentrated on export products, such as asparagus and grapes in Ica and La Libertad, sugarcane in La Libertad and Lambayeque, mangos and avocado in Piura, and so on.

The High Jungle (Amazonas, San Martin, Huánuco, and Junín) offers great possibilities for the production of coffee, cocoa, citrus products, palm oil, sugarcane, and fruits (such as bananas and pineapples), as well as spices. This supports the need for investment in technology development with an adequate environmental management.

There is a free market policy, although it maintains a price band for several products, e.g. rice. A unique tax applies on the sale of products.

The Peruvian terrain conditions the transportation to the markets. The coast facilitates the transport throughout it. The highlands have mountains that exceed 5,000 meters above sea level (mamsl), making it difficult to mobilize crops from the highlands and the jungle because of the risk of landslides, a factor that is being considered in the countries' competitiveness ranking.

Table V presents the harvested area, the crop yields, and the price of the main products of the country.

Regional productivity, competitiveness indicators, and the regional ACI

Productivity indicators

Tables V and VI depict the information used in the calculations, as well as the computed indices, respectively. The overall data used for the computations were collected from the

Table V.
Basic information of the crops with greater harvested area in Peru

Region	Harvested area ha	Production metric tons/year	Average crop yield kg/ha	Average farm price PEN (S./) /kg
Alfalfa				
Arequipa	41,851	3,139,000	75,007	0.10
Puno	18,716	604,673	21,057	0.30
Huancavelica	11,081	153,487	13,852	0.16
Tacna	11,081	248,261	22,404	0.19
Lima	10,721	425,732	19,669	0.25
Moquegua	10,673	506,997	55,935	0.08
Rice				
Piura	65,374	607,547	9,196	0.91
San Martin	85,095	575,558	6,764	0.81
Lambayeque	46,180	421,038	9,117	0.92
La Libertad	31,769	306,560	10,542	0.89
Amazonas	37,891	296,289	7,556	0.79
Arequipa	18,071	241,328	13,364	1.13
Potato				
Puno	51,429	567,612	11,006	1.32
Huánuco	37,506	566,968	15,117	0.70
Cusco	34,784	432,127	12,473	0.77
Cajamarca	28,201	309,724	10,583	0.64
Huancavelica	27,345	283,473	10,366	0.48
La Libertad	23,535	309,090	16,105	0.76
Junín	23,390	409,402	17,502	0.48
Coffee				
San Martin	80,174	68,712	857	5.34
Cajamarca	65,215	64,901	905	6.37
Amazonas	60,217	38,217	785	7.15
Cusco	58,546	35,710	610	6.48
Junín	55,504	76,714	800	6.41
Puno	10,202	7,304	722	9.75
Sugarcane				
La Libertad	37,040	5,234,476	141,307	
Lambayeque	25,710	2,767,051	107,625	
Lima	12,089	1,542,968	130,039	
Ancash	5,684	722,001	127,022	
Arequipa	500	622,380	104,000	

Source: MINAGRI (2012). Authors' compilation

National Institute of Statistics and Information of Peru (INEI) (INEI, 2013), the Ministry of Agriculture of Peru (MINAG) (Emanuel and Escurra, 2010; MINAG, 2010), the National Water Authority of Peru (ANA), the National Weather Service and Hydrology of Peru (SENAMHI), and the Cuanto Institute (Webb and Fernández Baca, 2014). The information related to the production and the areas correspond to the year 2012 (INEI, 2012) and may be used as a good approximation for the last years, as is the case of the data taken from INEI corresponding to 2013 with respect to the production tonnage (INEI, 2013). The average annual water discharged, by regions, was obtained from SENAMHI and ANA. For rivers that discharge in more than one region, each river was given a proportionate percentage. The six productivity indices are presented in Table VI, while Table VII provides the ranking of the regions based on both the computed productivity indices and based on the derived normalized ACI.

Region	WPI	EIW	RIFP	WSUI	SPI	LPI
Amazonas	0.599	0.463	3,477	61,501	29,852	3,644
Ancash	0.802	0.264	1,197	7,052	5,247	4,477
Apurímac			1,165		4,282	2,558
Arequipa	0.594	0.217	7,512	59,156	35,166	41,677
Ayacucho			1.375		8,849	3,012
Cajamarca	0.386	0.414	1,399	25,755	9,950	1,304
Callao						
Cusco			1,216		10,602	1,977
Huancavelica			573		13,682	1,835
Huánuco			1,254		26,746	2,318
Ica	0.515	0.394	11,645	9,673	4,982	15,207
Junín			2,113		28,503	4,419
La Libertad	2,058	0.542	4,858	13,029	26,818	18,421
Lambayeque	1,394.	0.207	2,433	11,070	15,435	16,380
Lima	0.472	0.461	20,052	18,518	8,734	20,531
Loreto			1,397			3,172
Madre de Dios			3,483			1.949
Moquegua	1,538	0.284	4,687	13,358	20,553	
Pasco			1,932			2,849
Piura	0.300	0.165	1,760	17,603	5,286	3,203
Puno	0.405	0.286	1,558	247,532		2,201
San Martin			2,779			7,044
Tacna	1250	0.845	10,075	4,293	5,368	14,902
Tumbes	0.075		3,548	173,993	13,610	13,164
Ucayali			2,592			5,923
Total			2,674			

Table VI. Productivity indices calculated for each region

The productivity indices are ranked from 1 to 24, where the value of "1" is assigned to the highest index value and the value of "24" is assigned to the lowest index value – except for the water volume used per hectare (or WSUI), in which case the lower the index value the higher the productivity indicator. It is to be noted that the region of Callao was excluded from the ranking, given that it is an urban area.

The results depict a very interesting phenomenon: the first half of the rank is dominated by the regions located on the coast (La Libertad, Tacna, Arequipa, Lima, Moquegua, Lambayeque, Ica, Ancash, Piura, and Tumbes) – the only exception is posed by the Amazonas region, which occupies the seventh position and is located in the jungle, and the Cajamarca region, which occupies the ninth position and is located in the highlands. In this sense, there is no coastal region to be found in the second half of the ranking. The second half of the ranking, on the other hand, is dominated by regions which are located both in the highlands and in the jungle, with the mention that the highland regions tend to concentrate in the first half of this second half of the ranking (this is the case of Junín, Huánuco, Huancavelica, Cusco, and Puno) – with the exception of Ayacucho, Pasco, and Apurimac, while the jungle regions can be found toward the bottom of the rank (San Martin, Ucayali, Madre de Dios, and Loreto). The least competitive region is, nonetheless, located in the highlands (i.e. Apurimac). This pattern may be due to the fact that the coastal regions are the greatest consumers of fertilizer, with the highlands and jungle following far behind (FAO, 2001).

Let us explore these results further. La Libertad, for example, ranks 1st in terms of agricultural productivity (with the best score being given to the WPI) – this might be explained by the fact that this region has received the largest public investments for irrigations (under the projects titled "Chavimochic" and "Jequetepeque Zaña"), thus ensuring water availability in areas where previously private investment was made by sugar

Region	Rank based on WPI	Rank based on EIW	Rank based on RIFP	Rank based on WSUI	Rank based on SPI	Rank based on LPI	Normalized ACI	Rank based on ACI
Amazonas	6	3	9	11	2	12	0.382	7
Ancash	5	9	21	2	16	10	0.222	10
Apurímac			22		18	17	0.020	24
Arequipa	7	10	4	10	1	1	0.538	3
Ayacucho			24		12	15	0.037	20
Cajamarca	11	5	17	9	11	22	0.260	9
Callao								
Cusco			20		10	20	0.052	16
Huancavelica			23		8	21	0.063	15
Huánuco			19		5	18	0.141	14
Ica	8	6	2	3	17	5	0.381	8
Junín			13		3	11	0.166	13
La Libertad	1	2	5	5	4	3	0.655	1
Lambayeque	3	11	12	4	7	4	0.431	6
Lima	9	4	1	8	13	2	0.502	4
Loreto			18			14	0.024	23
Madre de Dios			8			23	0.029	21
Moquegua	2	8	6	6	6		0.441	5
Pasco			14			16	0.027	22
Piura	12	12	15	7	15	13	0.190	11
Puno	10	7	16	13		19	0.051	17
San Martin			10			8	0.051	18
Tacna	4	1	3	1	14	6	0.584	2
Tumbes	13		7	12	9	7	0.183	12
Ucayali			11			9	0.045	19

Table VII. Ranking of the regions according to the six productivity indices and according to the computed normalized ACI

manufacturers, such as Casa Grande and Cartavio. Tacna, which ranks 2nd, might owe its position to the more efficient use of the limited water resources it counts with. Arequipa, which ranks 3rd, owes its position mainly to two indices: SPI and LPI. This result might be explained by the fact that Arequipa is best known for its farmers and their agricultural skills – in this case, it should be highlighted that numerous works have been carried out to help them, such as the Colca River regulation and the derivation of the Apurimac river for irrigation in Majes, which have contributed to enhancing this region's agricultural competitiveness. Another interesting case is that of the city of Lima, which ranks 4th and whose competitiveness may also as well have been supported by the water management works which have been carried out extensively both in the north and the south of the region, thus leading to a higher production (kg) per capita and a higher gross profit per capita. Moquegua is ranked 5th and just like Tacna, it displays a more efficient use of the limited water resources it has.

On a different note, Apurimac, which is located in the highlands, ranks last (24th position). The explanation for such result may go back as far as the early 1980s, when the political violence in the rural areas negatively impacted on the agricultural development of the region, leading to a lower agricultural profit. Ayacucho, which ranks 20th, counts with a similar situation.

The regions of Amazonas and Cajamarca are of particular interest, due to the fact that, as mentioned, they are located in the jungle and in the highlands, nevertheless, they enter the rank in the 7th and 9th positions, respectively. This may be due to the fact that both of these regions have vast areas apt for agriculture, which are also suitable for irrigation; with the Amazonas region having plenty of water available.

The investments in lands for irrigation improvement include the enhancement of the production technology. The WPI is directly related to the availability of water, which is currently related to the public investment; the EIW considers the prices, in this sense, for example, the lower farm prices for alfalfa in Arequipa – the largest producer of alfalfa in the country – is an indicator related to the market. The SPI is perhaps the most powerful performance indicator of the land use, while RIFP and LPI consider that the production and the gross profit have a direct relation with technology, prices, and the rural workers.

The significant differences in the indicators' values show that there is room for improvement, which can be achieved by means of promoting appropriate policies directed toward tackling the factors with a lower score.

Comparison among various competitiveness rankings

Table VIII depicts the rankings of the regions obtained by the Peruvian Institute of Economy (referred to by Cuanto Institute, Webb and Fernández Baca, 2014) and CENTRUM Católica (2014), which are furthermore contrasted with the ranking derived by the present study.

By evaluating the results in a more qualitative manner, it can be observed that, generally, for all of the models, the most competitive regions are located on the coast, while the regions in the highlands tend to be the worst performers, jointly with some of the jungle regions.

Region	Peruvian Institute of Economy (S1)	CENTRUM Católica (S2) 2013	(S3) 2014	Present study (S4)
Amazonas (J)	21	25	23	7
Ancash (C)	10	14	12	10
Apurímac (H)	18	22	20	24
Arequipa (C)	3	3	2	3
Ayacucho (H)	17	23	21	20
Cajamarca (H)	20	24	22	9
Cusco (H)	11	10	8	16
Huancavelica (H)	22	26	24	15
Huánuco (H)	19	21	19	14
Ica (C)	4	6	5	8
Junín (H)	12	16	14	13
La Libertad (C)	8	7	6	1
Lambayeque (C)	9	8	7	6
Lima Metropolitan Area (C)		1		4
Callao (C)	1	2	1	
Lima Provinces (C)		9		
Loreto (J)	24	17	15	23
Madre de Dios (J)	6	12	10	21
Moquegua (C)	2	5	4	5
Pasco (H)	15	19	17	22
Piura (C)	13	11	9	11
Puno (H)	23	15	13	17
San Martín (J)	14	18	16	18
Tacna (C)	5	4	3	2
Tumbes (C)	7	13	11	12
Ucayali (J)	16	20	18	19

Notes: C, Coast; H, Highlands; J, Jungle. (S1) The competitiveness index considers the institutions, infrastructure, economic environment, health, education, and labor; (S2) (S3) The competitiveness index considers the government, infrastructure, economy, firms, and people; (S4) The competitiveness index considers the six proposed indices of agricultural productivity
Source: Authors' compilation

Table VIII. Comparison of the competitiveness ranking by regions

Nevertheless, at a closer look, a series of notable discrepancies in the ratings of the regions can be detected.

Amazonas, located in the jungle, is one of the regions that experience one of the most drastic changes in the competitiveness ranking, being ranked at the bottom of the rank by S1, S2, and S3; wherein S4 improves its position by ranking it 7th in terms of agricultural competitiveness. A similar pattern can be observed in the case of Cajamarca, located in the highlands and ranked 9th by S4, while S1, S2, and S3 rank it 20th, 24th, and 22nd, respectively. Huancavelica is generally considered to be the least competitive region (Charles, 2015a, b), being ranked 22nd by S1 and last by both S2 and S3; S4, however, highlights its agricultural competitiveness and agricultural potential by ranking it 15th. Huánuco's situation is similar to that of Huancavelica, being placed by S4 in the first half of the ranking, in the 14th position. Lastly, an interesting change is experienced by La Libertad, located on the coast, which although is ranked as one of the most competitive regions by all of the models, it is ranked 1st by S4, making it the best performer among all of the regions in the country.

On a different note, Cusco and Madre de Dios exhibit a deterioration in their competitiveness position, being ranked in the first half of the ranking by S1, S2, and S3, but ranked 16th and 21st, respectively, by S4.

Overall, it could be concluded that the competitiveness rankings of some of the regions is improved by incorporating agricultural productivity indices in the assessment of their competitiveness, while the position of other regions is weakened. The findings highlight that the regions with the greatest potential for agriculture are Amazonas and La Libertad.

Final discussion and conclusions

Given its connectedness with economic growth and societal progress, enhancing competitiveness is nowadays a popular target in economic policy-making. The competitiveness of regions can be computed based on various factors. Nevertheless, the existing methodologies to compute the regional competitiveness fail to capture the agricultural activity in their computations.

We address this gap by proposing productivity indices that reflect the rural activities, which we further use to compute a regional ACI to rank the regions in Peru. Thus, we propose a model with six indices of agricultural productivity: WPI, EIW, WSUI, RIFP, SPI, and LPI.

Such endeavors bear substantial implications for practice, given that, as mentioned before, the rural activities in the country are carried out by approx. 7 million inhabitants, whose contribution to the GDP is as much as 7 percent, making use of about 94 percent of the available water, a resource that is a matter of concern due to the recent climatic changes, that are aggravated by the global warming process, all of which have been affecting the main sources of irrigation water. As a matter of fact, Peru is recognized as one of the countries that are most vulnerable to climate change. The dependence on rains constitutes one of the sector's main vulnerabilities, directly influencing the seedtime of national agricultural products.

It is to be noted that although almost 100 percent of the agriculture on the coast and approximately 40 percent of the agriculture in the highlands is of irrigation (Zegarra and Orihuela, 2005), the percentage of regions adopting modern irrigation techniques is still considered to be very low. One of the main limitations for the adoption of modern irrigation equipment is the high cost relative to the national average agricultural production costs and the limited access of farmers to financial services (Peru Opportunity Fund, 2011).

Additionally, Peruvian farmers are mainly rural and 64 percent are located in the highlands, which is considered to be the poorest area of the country, with 36.7 percent of the poor and 59.8 percent of the extreme poor living here. In this sense, broadly stated, these farmers are poor, counting with limited access to the public water, drainage, and electricity (Peru Opportunity Fund, 2011).

In consequence, providing a snapshot of the ranking of the regions in terms of agricultural competitiveness may help policymakers concerned with improving the competitiveness of the regions to identify the potential for improvement, which can further assist them in orienting policies of investment in the rural areas and in endorsing policies that promote the use of a high technological level.

Findings suggest that the region of La Libertad is the best performer, which concurs with the agriculture-related dynamics in the region. Furthermore, the regions in which agriculture is deemed to lack potential received approximately the same ranking by both the present study and the available studies with which the present study is compared. Finally, low-value indicators in the present study confirm that there is room for improvement in the use of the factors. Future research can be directed toward designing specific lines of action, for every region, to improve their competitiveness. Another future direction of this study could be to refine the regional ACI by means of considering additional factors that might impact on the agricultural activity, such as science, technology, innovation, and R&D.

The main limitations for this study were threefold: the availability of the data for the same time periods; the distribution of the river discharges among the different regions; and the calculation of the rural population who is directly involved in the agricultural field work.

Currently, public investment in agricultural research is quite erratic in nature; there is, thus, a need for public investments to be more consistent, while also targeting a wider range of producers. We hope that this paper will set the first step and contribute in assisting relevant policymakers concerned with enhancing regional economic growth in their endeavor to design strategies and policies aimed at increasing regional competitiveness.

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