Agricultural Productivity in Cuba after a Decade of Reforms

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Abstract
Agricultural reforms are one of the principal elements of Cuba's efforts to "update" its socialist economy since 2007. As in other post-socialist transition economies, these reforms have directly impacted agricultural output and yields. This paper analyzes the evolution of agricultural yields in Cuba during the 2007-2017 period. Our analysis demonstrates that Cuba's agricultural yields declined during the first five years after the implementation of the reforms, but recovered during the following five year period. While the agricultural reforms introduced in Cuba since 2007 represent a transition towards a more decentralized (and efficient) agricultural model, the recovery of Cuban agriculture requires more profound, far-reaching, institutional and structural reforms, particularly in key areas such as property relations, foreign investment, and the roles of the market and the state.
Keywords: Cuban agriculture, agricultural productivity, agricultural reforms

Introduction

Agricultural reforms are at the forefront of Cuba's efforts to "update" its socialist economy. Despite accounting for only about 3.7 % of Gross Domestic Product (GDP), and the expansion of the services sector in recent years, agriculture plays an important role in the Cuban economy. By many measures, Cuba intrinsically remains an agricultural country.

Table 1. *Cuba: Gross Domestic Product (GDP) by Economic Activity, at Constant 1997 Prices, Milllion Pesos (CUP)*

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Gross Domestic Product (GDP)	**43.883**	**45.690**	**46.353**	**47.461**	**48.791**	**50.262**	**51.643**	**52.184**	**54.500**	**54.780**	**55.757**
Agriculture	1.747	1.757	1.815	1.722	1.807	1.817	1.902	1.945	1.993	2.113	2.083
Fishing	139	139	79	60	52	55	58	59	61	60	60
Mining	278	278	278	298	303	309	302	300	294	283	279
Sugar industry	194	225	222	193	203	218	235	245	289	283	279
Manufacturing industries (excluding sugar industry)	5.849	6.134	6.195	6.294	6.540	6.673	6.798	6.534	6.916	6.597	6.478
Construction	2.780	2.848	2.864	2.651	2.458	2.734	2.951	2.883	3.374	3.531	3.849
Electricity and water	653	657	662	651	669	698	724	729	760	769	779
Transportation, warehousing, and communications	3.769	4.019	4.118	4.224	4.377	4.648	4.796	5.002	5.328	5.507	5.708
Commerce	8.654	8.363	8.374	8.537	9.004	9.485	9.837	10.158	10.712	10.449	10.519
Hotels and restaurants	1.967	2.167	2.385	2.559	2.790	2.932	3.001	3.094	3.374	3.780	4.068
Financial intermediation	1.167	1.228	1.244	1.251	1.266	1.272	1.287	1.339	1.393	1.430	1.406
Enterprise services, real estate activities	1.310	1.336	1.342	1.424	1.473	1.684	1.727	1.815	1.884	1.926	1.968
Public administration, national defense, social security	1.716	1.772	1.888	1.921	1.950	1.949	1.972	1.961	1.921	1.962	2.006
Science, innnovation, and technology	147	183	203	218	235	252	262	262	255	261	244
Education	3.564	3.676	3.731	3.899	3.692	3.552	3.475	3.370	3.300	3.390	3.339
Public health, and public assistance	6.850	7.722	7.984	8.432	8.721	8.756	8.917	9.095	9.204	9.183	9.497
Culture and sports	1.766	1.787	1.799	1.939	1.904	1.900	1.990	2.038	1.955	1.918	1.927
Other activities, communal services, personal associations	681	689	727	726	738	732	764	780	836	853	821
Import rigths	652	698	443	462	609	596	645	575	654	535	449
Sources: ONEI, 2010, 2013,and 2018.											

Source: Oficina Nacional de Estadísticas e Información (ONEI), 2010 and 2018.

The agricultural sector's contribution to the national economy exceeds that of other important sectors such as financial intermediation, public administration, culture and sports, and communal services (Table 1). The agricultural sector is an important source of direct and indirect employment. Even though agricultural employment declined by 11.6% between 2007 and 2017, its share of total employment remained virtually unchanged at around 18% during this period.

Table 2. *Cuba: Employment by Economic Activity, Thousand workers*

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Total Employment	**4.867,7**	**4.948,2**	**50,7**	**4.984,5**	**5.010,2**	**4.902,2**	**4.918,8**	**4.969,8**	**4.860,5**	**4.591,1**	**4.474,8**
Agriculture, cattleraising, silviculture, and fishing	912,3	919,4	945,6	921,5	986,5	944,2	915,2	939,0	898,5	877,9	806,7
Mining	25,7	26,7	27,0	33,7	40,2	39,0	32,9	27,6	28,9	22,0	21,8
Manufacturing industries (including sugar industry)	523,3	543,1	530,8	486,6	507,6	608,5	469,0	393,0	406,2	373,2	361,1
Construction	243,7	245,2	239,1	224,5	219,2	210,0	244,9	249,9	268,2	266,3	262,3
Electricity and water	85,0	79,8	90,3	101,6	94,5	83,1	98,9	99,8	82,2	77,6	83,1
Transportation, warehousing, and communications	289,3	301,4	297,1	304,5	310,1	286,3	305,5	319,4	305,8	309,4	295,9
Commerce, hotels, and restaurants	613,6	610,2	628,2	641,9	647,3	683,3	740,4	755,5	770,4	745,6	753,3
Financial intermediation, insurance, enterprise services, real estate	111,4	123,0	118,5	116,2	125,2	103,1	102,2	102,2	96,8	103,2	95,8
Communal, social, and personal services	1.858,9	1.945,5	2.063,4	2.099,7	2.195,8	2.195,8	2.009,8	2.014,4	1.948,5	1.797,6	1.744,4

Source: Oficina Nacional de Estadísticas e Información (ONEI), 2010 and 2018.

Agriculture also enjoys strong linkages with other key sectors of the Cuban economy and has considerable spillover effects (Nova González, 2018; Nova González and González -Corzo, 2015; Spadoni, 2014). The agricultural sector is a leading source of intermediate and finished products, provides renewable energy, and manages a large share of the country's infrastructure and transportation and rail networks (Nova González, 2013; Spadoni, 2014).

Cuba's agricultural sector is divided into the state and non-state sectors. The state sector is comprised of state-owned agricultural enterprises, and the non-state sector includes agricultural cooperatives, private farmers, and usufruct farmers.1 As in most of the former socialist countries of Asia, Central and Eastern Europe (CEE), and the former Soviet Union (FSU), the Cuban non-state agricultural sector is more efficient than the state sector (Brada and King, 1993). Even though they only hold about 24% of the country's agricultural surface, private farmers and Credit and Services Cooperatives (CCS) are the most efficient agricultural producers in Cuba; collectively, they account for close to 60% of domestic agricultural production (Nova González, 2018). The efficiency gap between Cuba's non-state and state agricultural sector has widened since the introduction of agricultural reforms in 2007.

In recent years, Cuba's agricultural sector has been affected by a series of challenges and limitations that have limited its productive capacity and impacted its efficiency. The most significant include: declining productivity, insufficient access to essential inputs (e.g., fertilizers, equipment, machinery, pesticides, spare parts, etc.), the lack of economic incentives to stimulate efficiency and production, excessive state intervention through price controls, control of procurement, distribution and taxation, inadequate access to diversified forms of financing, the inexistence of input markets, a fragmented and inefficient supply chain, state restrictions on property rights and the concentration of wealth, a dilapidated infrastructure, logistical challenges, relatively high levels of external sector dependency, and the effects of the U.S. embargo (González -Corzo, 2013, 2017; Mesa-Lago and Pérez-López, 2015; Nova González, 2012; Spadoni, 2014).

To address these challenges, improve agricultural efficiency and production, and substitute imports, Cuba has implemented a series of agricultural reforms since 2007 (Mesa-Lago and Pérez-López, 2015; Nova González, 2018; Riera and Swinnen, 2016). The most important include: increases in the prices paid by the state to producers of selected agricultural products, the reorganization of the state's agricultural administrative apparatus, the introduction of a new tax system, decentralized commercialization for selected agricultural products, microloans for non-state agricultural producers, and the expansion of usufruct farming rights (González -Corzo, 2019; Nova González, 2018).

Starting in 2007, in an attempt to incentivize agricultural production and improve efficiency, the state-run agricultural procurement agency, Acopio, raised the prices paid to producers of essential staples such as beef, milk, potatoes, and rice (Nova González, 2012). By 2013, the price paid by Acopio for beef had increased by 263.3%; similarly, the prices paid for milk, potatoes and rice were raised by 478.9%, 20%, and 226.5%, respectively (Spadoni, 2014). After the approval of Resolutions 238 and 239 in 2015, Acopio increased the price paid to beef producers by 45.8%; the price of milk was raised by 80%; and potato prices were increased by 44.4% (Gaceta Oficial de Cuba 18, 2015).

Another important reform was the reorganization of the state administrative and regulatory apparatus in charge of sugar and non-sugar agricultural production (González-Corzo, 2013; Nova Gonzalez, 2018). Law 287, approved in 2011, transferred the administrative functions related to sugarcane agriculture from the Ministry of the Sugar Industry (Ministerio de la Industria Azucarera, MINAZ) to the Ministry of Agriculture (Ministerio de la Agricultura, MINAGRI) , while Decree-Law 294, also approved in 2011, replaced the MINAZ with a state-owned holding company known as Grupo Azucarero AZCUBA (Gaceta Oficial de Cuba 37, 2011). Starting in 2011, the administration and management of the sugar agro-industry was divided between the MINAGRI and AZCUBA, with the later focused primarily on all industrial aspects of sugar production such as processing, packaging, marketing, and logistics (or distribution) (Gaceta Oficial de Cuba 37, 2011).2

The introduction of a new agricultural tax regime after the approval of Law 113 in 2012 was another important reform measure. All natural persons and legal entities are required to pay land taxes, sales taxes, and income taxes (Gaceta Oficial de Cuba 53, 2012). Land taxes are levied on agricultural land, idle land, forested areas, and pastures, and the amount levied depends on the official classification of such land, with higher quality (i.e. more productive) land paying higher taxes (Gaceta Oficial de Cuba 53, 2012). Natural persons pay a minimum sales tax of 5% and also pay income taxes based on a progressive scale, with annual rates ranging from 10% to 45% (Gaceta Oficial de Cuba 53, 2012). Cooperatives are given preferential treatment with regards to income taxes (and the applicable deductions). They pay taxes on their per capita income, ranging from 5% on per capita income up to 10,500 Cuban pesos (CUP), 12.5% on per capita income between 10,501 CUP and 46,500 CUP, and 17.5% for any amount above 46,500 CUP (Gaceta Oficial de Cuba 53, 2012).

The decentralization of the distribution of selected agricultural products in Havana and the two neighboring provinces of Artemisa and Mayabeque has been another important agricultural reform. The first step in this process was the authorization of direct sales of agricultural products at roadside kioks (operated by individual farmers and cooperatives) after the approval of Agreement 6853 in 2010 (González-Corzo, 2013). This was followed by the approval of Resolutions 90, 122, and 369 in 2011, which for the first time since the 1959 revolution permitted direct sales of agricultural products (by non-state producers) to the growing (state-run) tourism sector (González-Corzo, 2013).

To provide non-state producers with additional sources to finance the acquisition of essential inputs and working capital, starting in 2011 Decree-Law 289 authorized the provision micro-credits by state-run banks (Gaceta Oficial de Cuba 40, 2011). These state provided micro-loans can range from 500 CUP to 10,000 CUP; the micro-credit can only be used to finance activities or transactions related to agricultural production; and contract terms are determined by the type of credit financing requested, the amount and type of collateral pledged by the borrower, and his or her credit profile (Gaceta Oficial de Cuba 40, 2011).

The most significant structural reform implemented in Cuba's agricultural sector since 2007 has been the expansion of usufruct farming. This process was initiated with the approval of Decree-Law 259 in 2008, which authorized the transfer in usufruct of up to 13.42 hectares (ha) of idle state-owned land to individual farmers for a period of 10 years and to cooperatives for a period of 25 years (Gaceta Oficial de Cuba 4, 2008). Usufruct farming was expanded further after the approval of Decree-Law 300 in 2012. This policy measure keep the amount of land that could be assigned to new usufructuaries unchanged, but increased the amount that could be assigned to existing usufructuaries from 40.26 ha to 67.10 ha; usufructuaries were allowed to build permanent structures covering up to 1% of the area granted in usufruct; and established compensation by the state for investments in such permanent structures in case of termination or cancellation of the usufruct contract (Gaceta Oficial de Cuba 45, 2012).

Usufruct farming was expanded again after the approval of Decree-Law 350 in 2018. This policy measure extended the duration of usufruct contracts from 10 years to 20 years for natural persons and from 25 years to an indefinite time period for legal entitities (Gaceta Oficial de Cuba 39, 2018). The amount of land that can be assigned to first-time usufructuaries doubled from 13.42 ha to 26.84 ha and usufruct rights can be given for raising cattle as long as usufructuaries grow their own animal feedstock (Gaceta Oficial de Cuba 39, 2018). Usufructuraries can build permanent structures covering up to 3% of the land area granted in usufruct; however, they are required to work on their land and manage it directly (without intermediaries) and the state can terminate the usufruct contract at any time if there are multiple violations of the conditions stipulated in the contract and, or, if the usufructuary fails to satisfy its social objectives (Gaceta Oficial de Cuba 39, 2018).

The agricultural reforms introduced in Cuba since 2007 have contributed to the development of a new agricultural model in which the non-state sector plays a greater role and there is a larger emphasis on crop diversification, the use of organic means to improve fertility and control pests, urban farming, and self-sufficiency in food and agricultural production (Chan and Freyre Roach, 2012; González-Corzo, 2019; Leitgeb et al., 2012; Nova González, 2013, 2018; Ponce Palma et al., 2015)). Cuba's agricultural reforms have also contributed to the redistribution of agricultural land from the state to the non-state sector and significant reductions in idle (non-productive) land (Gonzalez-Corzo, 2019). As in the former socialist countries of Asia, Central and Eastern Europe (CEE), and the Former Soviet Union (FSU), the agricultural reforms implemented in Cuba since 2007 have also impacted agricultural output and productivity, particularly agricultural yields.[3] Even though agricultural yields have recovered after their initial decline following the reforms introduced in 2007, they remain relatively low by historical standards, and Cuba depends on imports to satisfy a significant portion of its demand for food and agricultural products.

This paper analyzes the evolution of land productivity in Cuba after the introduction of agricultural reforms in 2007. The remainder of the paper is organized as follows. Section 2 reviews the literature on commonly-used measures of agricultural productivity. Section 3 discusses the sources of data and methodology. Section 4 presents the results of our analysis of evolution of agricultural output and land productivity in Cuba during the 2007-2017 period. Finally, in section 5 we present the conclusions and a series of policy recommendations to improve production and efficiency in Cuba's agricultural sector.

Literature Review

Agricultural productivity is generally defined as the ratio of agricultural output to the total inputs used in farm production (Anderson and Reynolds, 2016; Datt and Ravallion, 1998; Fulginiti and Perrin, 1998). It is an important source of economic growth and poverty reduction, particularly in lesser developed countries (LDCs) or emerging economies (Datt and Ravallion, 1998; Mellor, 1999; Thrittle, Irz, Jin, et al., 2001; Minten and Barret, 2008), and is considered one of the the essential indicators for agricultural development (Fermont and Benson, 2011). Increases in agricultural productivity over time are related to the choice and relative availability of inputs and to the techniques applied in the production process (Anderson and Reynolds, 2016).

The literature on agricultural productivity in transition economies emphasizes the importance of measures such as agricultural output, agricultural yields, labor productivity, and total factor productivity (TFP) (Johnston, 1970; Lerman, 2000; Lerman et al., 2003; Swinnen and Rozelle, 2006). 4 Increases in agricultural productivity are essential to the successful recovery of the agricultural sector after the initial shock experienced during the early stages of the transition process. Higher agricultural yields and labor productivity have a positive effect on the income of agricultural households linked to other sectors of the economy through its multiplier effect, thus increasing their demand for goods and services (Hanmer and Naschold, 2000; Mellor, 1999; Schneider, 2011, Irz, et al., 2001; Thritle, Lin and Piesse, 2003).5

Improved agricultural productivity has a direct effect on agricultural prices, 6 production costs, the international competitiveness of the agricultural sector, and contributes to changes in income for the households engaged in agricultural activities (Doward, et al., 2004; Dorward, 2013; Irz, et al., 2001; Schneider, 2011). Higher agricultural yields and increases in labor productivity also play a fundamental role in the long-term development and sustainability of agriculture (Mahadevan, 2003).

Increases in agricultural productivity, resulting from the implementation of policies to incentivize the efficient use of the labor, capital, and other essential inputs, has a positive impact on national production and agricultural incomes, and contributes to the modernization, and recapitalization of the agricultural sector (Csáki, 1999; Lerman and Feder, 2004). Higher agricultural productivity can also contribute to poverty reduction, particularly in developing countries where agriculture accounts for notable shares of employment and GDP (Cervantes-Godoy and Dewbre, 2010; Schneider, 2011).7

Measuring agricultural productivity is a complex process, which involves the analysis of the relationship between inputs and outputs in agricultural production. The literature on the measurement of agricultural productivity includes partial productivity measures (e.g., yield by area harvested and area planted, agricultural labor productivity, production value, and technical efficiency), which relate a single input or group of inputs to total output, as well as total factor productivity measures (e.g. the Malmquist Index or Coelli Method and net farm income) (Anderson and Reynolds, 2016; Belloumi and Matoussi, 2009; Trueblood, 1996; Thompson, 1926).

Partial factor productivity measures focusing agricultural yields (or land productivity) are divided into two categories: (1) yields by area harvested and (2) yields by area planted. 8 The first category includes gross yield, harvested yield (or common crop yield), and economic yield, for which area harvested represents the principal input, while the second only consists of yield by area planted for which the latter is the only input considered (Anderson and Reynolds, 2016).

Gross yield (also known as biological yield) is calculated by dividing the total quantity produced before harvest or post-harvest loss by the total area harvested. Harvested yield, which is the most commonly-used yield measure reported in the literature (Fermont and Benson, 2011), is calculated by taking the ratio of the total quantity harvested before any post-harvest loss to the total area harvested. Economic yield, which considers harvest-related losses and post-harvest losses (e.g., losses caused by rodents, spoilage, losses experienced at different points in the supply chain, etc.), is calculated by dividing the total quantity of output available for use before any post-harvest loss by the total area harvested.

The yield by area planted is another partial measure of factor productivity used in agriculture (Fermont and Benson, 2011); this measure of land (or crop) productivity is similar to the harvested yield except for the fact that it is estimated by dividing the total quantity harvested before post-harvest losses by the total area planted (Anderson and Reynolds, 2016; Fermont and Benson, 2011). Agricultural productivity can also be measured by estimating the production value per area harvested (or planted). This partial measure of factor productivity is calculated by dividing the total gross value of the quantity harvested by either the total area harvested or the total area planted (Anderson and Reynolds, 2016).

Another important partial factor productivity measure is technical efficiency (also known as the Stochastic Frontier Method), which compares the observed and optimal amount of output and input of a production unit (Lovell, 1993). Technical efficiency can be expressed as follows:

$$y = f(x)e^{u+v} \tag{1}$$

The variable *Y* represents the farmer's observed output, *f* is the production function frontier, *x* is the vector of input levels, *f(x)* represents the maximum output, *u* is the systematic deviation of output from potential output – which takes into account socioeconomic factors that can impact a farmer's technical efficiency, and *v* represents the error term (Diagne, 2002).

There are two approaches to measure technical efficiency: (1) the input-oriented approach, which measures technical efficiency as a proportional increase in input use holding output constant, and (2) the output-oriented approach, which measures technical efficiency as a proportional increase in output, holding input constant (Farrell , 1957). To achieve optimality, farmers that fail to operate on the efficient production frontier can improve their levels of technical efficiency by either increasing output, while holding input levels constant, or by reducing input use, while holding production levels unchanged (Fischer, et. al., 2009).

Agricultural labor productivity (ALP) is another important measure of partial factor productivity (Dharmasiri, 2012). As Shafi (1965) indicates, agricultural labor productivity is measured the ratio of total product (TP) to the labor input (L), measured in total man-hours, as shown in Equation (2):

$$\pi = \frac{TP(L)}{L} \tag{2}$$

The term π represents agricultural labor productivity, *TP* is total product (or total output), and *L* represents the labor input.

It is worth noting, however, that the efficiency of the labor input (i.e., agricultural labor productivity) should not be directly equated with agricultural efficiency. There are several reasons for this. High levels of labor productivity may be caused by utilization of relatively large quantities of capital inputs; agricultural labor may be more productive in regions with more favorable conditions; and labor productivity may be affected by workers' abilities, their attitudes towards work, and the intensity of their efforts (Borjas, 2016).

The general characteristics of the labor force in terms of educational attainment, accumulated experience, social capital, workplace training, and specialization can also impact agricultural labor productivity (Polyzos and Arabatis, 2006; Zioganas and Nikolatis, 1995). Other important determinants of agricultural labor productivity include the adoption of new technologies and innovation (Beeson, 1987; Porceddu and Rabinge, 1997; Sasaki, 1985), the use of chemical fertilizers and pesticides (Polyzos and Arabatis, 2006), public sector investments in infrastructure (Mamatzakis, 2003), favorable climatic conditions, land fertility, and irrigation (Zioganas, 1999), and proximity to major urban centers (Polyzos and Arabatis, 2006).

Several studies have used a production function approach to quantify agricultural productivity (Dharmasiri 2009, 2012; Gokskel and Ozden ,2007; Kawagoe et al., 1985; Saran, 1965; Trueblood,1996; Yuan ,2011). Equation (3) presents the Cobb-Douglas production function developed by Yuan (2011) to conduct an input-output analysis of agricultural production in China's Hebei Province using inputs such as cultivated land area (*Ac),* cultivated area under irrigation (*Ai*), rural electricity consumption (*Ce*), agricultural machinery power (*Pm*), usage of chemical fertilizer (*Fc*), and rural manpower (*Mr*) :

$$y(t) = A\,Ac(t)^{\alpha}\ Ai(t)^{\beta}\ Ce(t)^{\gamma}\ Pm(t)^{\delta}\ Fc(t)^{\lambda}\ Mr(t)^{\varphi} \tag{3}$$

The terms α, β, γ, δ, λ, and φ represent the output elasticies of the agricultural inputs used in the Cobb-Douglas production function shown in Equation (1) and $0 < \alpha, \beta, \gamma, \delta, \lambda, \varphi < 1$ (Yuan, 2011).

Other studies have attempted to measure agricultural productivity using parametric and non-parametric models focusing on Total Factor Productivity (TFP) (Banker, Charnes, and Cooper, 1984; Belloumi and Matoussi, 2009; Coelli et al., 1998; Färe et al., 1999; Farrell, 1957; Fuglini and Perrin, 1999; Trueblood, 1996). TFP is defined as the ratio of total output (e.g., crops, livestock, byproducts, etc.) to total inputs (e.g., land, labor, capital, etc.) (O'Donnell, 2008; Rezek, Campbell, and Rogers, 2011). As O'Donnell (2008) indicates, TFP can be expressed as:

$$TFP_{it} = \frac{Y_{it}}{X_{it}} \tag{4}$$

The term $Y_{it} \equiv Y(y_{it})$ represents total output; where $Y_{it} \in i\frac{M}{+}$ is a vector of output quantities, $X_{it} \equiv X(x_{it})$ represents aggregate inputs, and $X_{it} \in i\frac{N}{+}$ is a vector of input quantities (O'Donnell, 2008).

Belloumi and Matoussi (2009) employed the following non-parametric, output-based, *Malmquist Productivity Index (MPI)* to analyze changes in agricultural productivity in a selected group of Middle Eastern and North African (MENA) countries. The authors defined the MPI with respect to two time periods denoted as *t* and *t+1*. The MPI related to technology in any period *t* is given as:

$$Mt = \frac{dt(xt+1, yt+1)}{dt(xt, yt)} \tag{5}$$

The MPI with period *t+1* technology is given by:

$$Mt+1 = \frac{dt+1(xt+1, yt+1)}{dt+1(xt, yt)} \tag{6}$$

Equation (7) shows the output-oriented Malmquist Productivity Index (MPI) developed by Belloumi and Matoussi (2009):

$$Mt, t+1(xt, xt+1, yt, yt+1) = \left[\frac{dt(xt+1, yt+1)}{dt(xt, yt)}\ \frac{dt+1(xt+1, yt+1)}{dt+1(xt, yt)}\right]^{1/2} \tag{7}$$

Equation (7) is decomposed into two components: technical efficiency and technological change as shown in Equation (8) (Belloumi and Matoussi, 2009):

$$Mt, t+1(xt, xt+1, yt, yt+1)$$

$$= \frac{dt+1(xt+1, yt+1)}{dt(xt, yt)}\left[\frac{dt(xt+1, yt+1)}{dt+1(xt+1, yt+1)}\ \frac{dt(xt, yt)}{dt+1(xt, yt)}\right]^{1/2} \tag{8}$$

The term outside the square brackets represents the change in *technical efficiency* over the two periods (*t*, *t+1*) (Belloumi and Matoussi, 2009):

$$\Delta TE\ t+1 = \frac{dt+1(xt+1, yt+1)}{dt(xt, yt)} \tag{9}$$

Equation (10) shows the *technological change* over the two time periods (Belloumi and Matoussi, 2009):

$$\Delta TCt+1 = \left[\frac{dt(xt+1, yt+1)}{dt+1(xt+1, yt+1)}\frac{dt(xt, yt)}{dt+1(xt, yt)}\right]^{1/2} \tag{10}$$

The decomposition of TFP into TE and TC facilitates the analysis of their impact on the growth of TFP (Sabasi and Shumway, 2015; Stewart, Veeman, and Unterschutz, 2009). A value greater than 1 for either of these components (i.e., $\Delta TEt+1$ and $\Delta TCt+1$) represents an improvement; conversely, values lower than 1 represent the opposite (Belloumi and Matoussi, 2009; Yeboah et al., 2011).

Data Sources and Methodology

Due to existing data limitations and difficulties in the collection of data required to estimate agricultural labor productivity (ALP) and total factor productivity (TFP) in Cuban agriculture, this study solely focuses on agricultural yields (or land yields). Agricultural yields (or land yields) are calculated by taking the ratio of physical output to the area cultivated or harvested. Land is generally considered as the most fixed and permanent input in the agricultural production process; therefore, despite their limitations, agricultural yields (or land yields) are an important measure of efficiency in the agricultural sector (Anderson and Reynolds, 2016; Dharmasiri, 2012).[9]

Cuba's National Statistics Office (*Oficina Nacional de Estadísticas e Información, ONEI*) estimates agricultural yields for annual crops by dividing total output by the cultivated area dedicated to each crop (Oficina Nacional de Estadísticas e Información (ONEI), 2018). In the case of perennial crops, agricultural yield is calculated by dividing total output by the cultivated area under production (ONEI, 2018). For annual crops, agricultural yield is calculated by dividing total output by the area planted (ONEI, 2018). Data on agricultural yields is provided for sugar and non-sugar crops in the state and non-state sectors and it is published annually in the Statistical Yearbook (*Anuario Estadístico de Cuba, AEC*) (ONEI, 2018).

To analyze the evolution of agricultural yields for the ten (10) selected non-sugar crops in Cuba during the 2007-2017 period, we develop an index that sets 2007 values equal to 100.0.[10] We divide the 2007-2017 period into two (2) stages: (1) the first five years after the introduction of agricultural reforms (i.e., 2007-2012), and (2) the subsequent five year period (i.e., 2012-2017).

We applied the following equation to the raw data to construct the index of agricultural yields used in this study.[11]

$$y = \left(\frac{yt}{y0}\right).100 \qquad (2)$$

The variable *y* represents the new indexed value of agricultural yields, *y0* represents the value of agricultural yields in the initial time period (i.e., 2007), and *yt* represents the raw data in a given time period (t) ranging from 2007 to 2017.

Results and Discussion

Table 3 presents the index of agricultural yields for the ten (10) selected non-sugar crops in Cuba during the 2007-2017 period.

Table 3. *Cuba: Index of agricultural yields of selected crops other than sugarcane, Tons per hectare.*

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Roots and tubers	100,0	92,0	82,4	80,5	93,1	98,6	89,6	100,6	104,8	102,7	102,7
Potatoes	100,0	134,6	150,0	148,4	151,1	138,0	145,1	139,5	152,7	146,0	146,1
Plantains	100,0	89,8	62,4	61,0	87,2	107,9	94,7	116,8	109,7	113,7	114,0
Vegetables	100,0	56,9	55,3	54,7	62,8	62,9	67,9	74,7	80,0	77,6	77,5
Tomatoes	100,0	61,4	71,8	69,8	72,4	75,3	82,7	67,0	91,6	79,6	79,4
Rice	100,0	91,6	85,4	84,2	89,0	103,4	111,1	111,4	121,9	119,9	117,6
Beans	100,0	139,7	100,8	97,8	147,0	141,0	148,4	142,5	163,0	152,0	153,4
Citrus Fruits	100,0	72,9	74,1	67,9	67,3	66,2	69,9	42,8	70,6	63,0	58,8
Other Fruits	100,0	163,5	150,0	144,6	185,9	223,3	203,7	193,2	231,1	212,9	212,3
Corn	100,0	108,2	64,1	61,7	106,0	100,7	102,7	99,2	104,3	101,7	101,7

Source: Oficina Nacional de Estadísticas e Información (ONEI), 2010 and 2018.

During the first five years after the introduction of agricultural reforms (i.e., between 2007 and 2012), the index of agricultural yields declined in 4 out the 10 non-sugar crops shown in Table 3:

1. *Roots and tubers:* The index of agricultural yields declined to 98.6 in 2012 (i.e., five years after the start of the reforms), reflecting an average annual growth rate of 0.2%; the index rose to 102.7 in 2017 (i.e. ten years after the reforms were initiated), and grew at an average annual rate of 1.1% between 2012 and 2017.
2. *Vegetables*: The index of agricultural yields fell to 62.9 in 2012, and grew at average annual rate of -6.4% during the first five years after the introduction of the agricultural reforms in 2007. During the following five year period (i.e., between 2012 and 2017), the index of agricultural yields for vegetables grew at an annual rate of 4.4%, reaching a value of 77.5 in 2017.
3. *Tomatoes*: The index of agricultural yields fell to 75.3 in 2012, recording an average annual growth rate of -3.3% during the 2007-2012 period. Between 2012 and 2017, it increased to 79.4, and grew at an average annual rate of 2.8% during this period.
4. *Citrus fruits*: The index of agricultural yields fell to 66.2 in 2012 (i.e., five years after the start of the reforms), and declined at an average annual rate of -7.3% between 2007 and 2012. It fell to 58.8 in 2017, reflecting an average annual rate of 2.9% during the 2012-2017 period.

Even though agricultural yields have recovered for the majority of the non-sugar crops shown in Table 3, Cuba remains highly dependent on food and agricultural inputs, and the agricultural sector is unable to meet the nutritional needs of the population (García Álvarez and Nova González, 2013; Messina, Stefanou, and Royce, 2016). Domestic agricultural production currently satisfies an estimated 20% of Cuba's demand for food and agricultural products and imports account for the remaining 80% (González-Corzo, 2019). Cuba imported an estimated $1.5 billion in food and agricultural products in 2007, representing 15.4% of total merchandise imports (ONEI, 2010). In 2017, food and agricultural imports reached an estimated $2.1 billion, representing 20.9% of the island's total merchandise imports (ONEI, 2018). In 2017, Cuba imported 64% of the rice, 52% of the beans, 68% of the corn, and 100% of the wheat flour, and vegetable oils consumed by its population (Nova González, 2018).

These trends can be explained by several factors. On the supply side, the area planted and under cultivation has decreased notably since 2007. The area planted and under cultivation fell from 2,988,500 ha in 2007 to 2,773,500 ha in 2017, representing a reduction of 8.5% during this period (ONEI, 2010, 2018). Agricultural production has also been affected by the exodus of administrative personnel, field workers, and qualified technicians to other sectors of the economy, particularly self-employment and other activities in the emerging non-state sector. Agricultural employment fell from 919,700 workers in 2007 to 782,900 in 2017, representing a decrease of 14.9% during this period (ONEI, 2010; 2018). Changes in the age distribution of the Cuban population, the displacement of labor to other sectors of the economy, and increases in outward migration have also impacted Cuba's agricultural production since 2007 (González-Corzo, 2019; Mesa-Lago, 2018; Nova González, 2018).

Other contributing factors include the limited scope of the agricultural reforms introduced since 2007, bureaucratic and regulatory constraints, restrictions on property rights, producer autonomy, and the concentration of wealth, prohibitions on foreign investment, an onerous tax system, insufficient access to essential inputs, logistical and supply chain difficulties, adverse climatic conditions, and the economic effects of the U.S. embargo (Feingberg, 2018; González-Corzo, 2019; Mesa-Lago, et al., 2018; Nova González, 2018; Spadoni, 2014).

On the demand side, the expansion of entrepreneurial activities and self-employment since 2010 has resulted in considerable increases in Cuba's demand for imported food and agricultural products (González-Corzo, 2014; González-Corzo and Justo, 2014; González-Corzo and Justo, 2017; Ritter and Henken, 2015). The number of self-employed workers grew from 391,800 in 2011 (the year after major self-employment reforms were introduced) to 583,200 in 2017, representing an increase of 48.9% during this period. Self-employed workers represented 13% of the occupied workforce in Cuba in 2017, compared to 3% at the onset of the self-employment reforms in 2010 (González-Corzo and Justo, 2017; ONEI, 2018).[12] The higher incomes earned by self-employed workers and the emerging entrepreneurial class, their changing preferences in favor of imported goods, and their higher living standards have been increased Cuba's demand for imported food and agricultural products in recent years (Mesa-Lago, et. al., 2016; Morales Dopico, 2017; Ritter and Henken, 2015; Spadoni, 2014).

The influx of remittances from abroad has also contributed to increases in Cuba's demand for food and agricultural imports. Remittances are associated with higher levels of income, household consumption, and living standards (Economic Commission for Latin America and the Caribbean [ECLAC], 1998). They serve as a principal source of capital for new business formation and are also used to finance the expansion of existing small and medium enterprises (SMEs) (ECLAC, 1998). Remittances increased from $2.3 billion in 2011 (a year after the introduction of self-employment reforms, which expanded opportunities for small business formation) to $3.4 billion in 2016 (Morales Dopico, 2017). An estimated 70% of the Cuban population receives remittances on a regular basis and more than two-thirds of such remittances are spent on consumption (Morales Dopico, 2017).

Finally, Cuba's tourism sector has grown considerably since its initial opening in the early 1990s, and in recent years this strategically-important sector of the Cuban economy has emerged as a leading consumer of imported food and agricultural products (Feinberg and Newfarmer, 2016). The normalization of diplomatic relations with the United States in 2014 contributed to notable increases in the number of international tourists traveling to Cuba. The number of international visitors increased from 2,716,317 in 2011 to 4,653,559 in 2017, representing an increase of 71.3% during this period (ONEI, 2010; 2018). Gross tourism receipts rose from $2.5 billion in 2011 to $3.3 billion in 2017, representing a growth rate of approximately 32% during this period (ONEI, 2010; 2018).

Conclusions

Agricultural reforms are at the forefront of Cuba's recent efforts to "update" its socialist economy (Nova González, 2013, 2018). Cuba's recent agricultural transformations (initiated in 2007) have been characterized by gradual price liberalization (for selected agricultural products), reductions in state subsidies, the expansion of usufruct rights, a greater emphasis on agricultural cooperatives, decentralized commercialization of selected agricultural products, and microloans by state-run banks to non-state agricultural producers (González-Corzo, 2019; Mesa-Lago and Pérez-López, 2015; Nova González and Figueroa Alfonso, 2018;Spadoni, 2014) . The implementation of these reform policy measures has contributed to the emergence of new agricultural model in which non-state producers play a larger role, the redistribution of agricultural land from the state to the non-state sector, and notable reductions in idle land. Cuba's agricultural reforms have also impacted agricultural yields (García Álvarez and Nova González, 2013; González-Corzo, 2017; Nova González, 2018).

Agricultural yields declined in four (4) out of the ten (10) non-sugar crop categories included in our study during the first five years after the introduction of agricultural reforms in 2007. However, agricultural yields recovered in six (6) of the ten (10) non-sugar crop categories included in this study during the subsequent five year period (i.e., between 2012 and 2017).

After more than a decade since the introduction of agricultural reforms, Cuba's agricultural sector remains unable to achieve the output levels and yields required to satisfy domestic demand and the island imports a considerable share of the food and agricultural products consumed by its population. This situation can be attributed to several factors. The area planted and under cultivation has declined significantly since 2007; employment in the agricultural sector has decreased notably in recent years, mainly resulting from demographic changes, the exodus of labor to other sectors of the Cuban economy, and overseas migration. Agricultural production has also been affected by the limited scope of the reforms introduced since 2007, adverse climatic conditions (e.g., intense hurricanes and droughts), poor soil conditions (e.g., erosion and salinity), excessive bureaucratic and regulatory constraints, insufficient access to essential inputs, prohibitions on foreign investment, limitations on property rights and the concentration of wealth, an inefficient supply chain, and the deteriorated state of Cuba's infrastructure.

Despite ongoing efforts to substitute imports, Cuba remains highly dependent on imported food and agricultural products. The island's demand for food and agricultural imports has been driven by the expansion of self-employment and the non-state sector, the growth of international tourism, and increases in remittances from abroad.

The agricultural reforms introduced in Cuba since 2007 represent a transition towards a more decentralized agricultural model; however, despite some improvements, more profound structural and institutional reforms are required to achieve long-term progress in this strategically-important sector of the Cuban economy. A logical initial step to incentivize agricultural output and improve productivity would be market liberalization. This process generally involves the elimination of state controls over resource and output allocation. Market liberization includes important reform measures such as price and trade liberalization and the reduction or elimination of agricultural subsidies (Csaki, 1998; Trzeciak-Duval, 1999; Swinnen and Rozelle, 2006).

Reforming property rights is another important measure to improve agricultural output and productivity in Cuba. Land tenure and property rights (LTPRs) can be improved by increasing the size of usufruct plots and extending the duration of usufruct contracts as was done in China and Vietnam. The experiences of other developing and transition economies demonstrate that improved land tenure and property tend to have a positive impact on agricultural production and yields, incentivize long-term investments, alleviate poverty, result in notable increases in access to credit, contribute to the development of formal land and rental markets, and improve the living standards of rural households (Bandiera, 2007; Bellemare, et al., 2018; Fuentes Cordoba, 2017; Goldstein and Udry, 2008; Holden, Deininger, and Ghebru, 2011).

Another important step to transform Cuba's agricultural sector is reforming upstream and downstream operations (Liefert and Swinnen, 2002). Upstream operations include the processes related to the provision (or supply) of agricultural inputs, while downstream operations refer to storage and warehousing, transportation, logistics, processing, and distribution (Liefert and Swinnen, 2002). In the case of Cuba, a necessary policy measure to reform upstream operations is the creation and expansion of wholesale input markets where all types of agricultural producers would be able to procure essential inputs at market determined prices (Feinberg, 2018). As in other transition economies, the elimination of the state monopoly that regulates agricultural prices and the distribution of agricultural products, combined with the elimination of existing restrictions on private property and the concentration of wealth could have a positive impact on agricultural output and yields (Liefert and Swinnen). Greater levels of producer autonomy, the expansion of voluntary and truly independent cooperatives, and allowing foreign investment in agriculture can also have a positive impact on agricultural output and productivity (Feinberg, 2018).

To incentivize investments, attract labor, improve efficiency, and stimulate production in the agricultural sector, it is necessary to consolidate or unify the five (5) existing taxes (sales, labor, land value, income and idle land) preferably into a single sales tax (at an attractive rate that would not discourages production). The interim transition tax system should focus on improving and modernizing the tax administration and adopting internationally-recognized accounting practices (Martínez -Vazquez and McNab, 1999). Taxes that could be enforce with relative ease and efficiency (e.g., value-added taxes (VATs) and excise taxes), as well as those that can serve as more stable sources of revenue should be prioritized (McLure, 1991; Hussain and Stern, 1993).

Finally, Cuban agriculture would benefit from increases in the availability of credit. While agricultural production and productivity are influenced by other factors such as the availability of seeds, fertilizer, irrigation infrastructure, soil quality, and climatic conditions, improved access to credit financing, combined with modern technology and production methods, is an essential requirement to achieve higher output and productivity levels (Naidu, Sankar, and Surya, 2013). Improved access to credit financing can have a positive impact on agricultural output and efficiency by reducing farmers' financial constraints and provides strong incentives to increase productivity by investing in new technologies and applying modern production techniques (Feder, et al., 1990).

Implementing these policies will likely improve Cuba's self-sufficiency in agricultural and food production, reduce food and agricultural imports, and, similar to China, Vietnam, and other former socialist economies, improve the living standards of a significant portion of its population.

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Endnotes

[1] Cuba's agricultural cooperatives include: (1) *Cooperativas de Producción* Agropecuarias (CPAs) (Cooperatives of Agricultural Production), (2) *Cooperativas de Créditos y Servicios (CCS*) (Credit and Services Cooperatives), and (3) *Unidades Básicas de Producción Cooperativa (UBPCs*) (Basic Units of Cooperative Production). For more information about Cuba's agricultural cooperatives, see Nova González (2013).

[2] The replacement of the Ministry of Sugar (MINAZ) with AZCUBA in 2011 was part of the sugar agro-industry reorganization plan announced in 2002, which called for shutting down 76 of the 156 sugar mills operating at the time, the reassignment of some 600,000 hectares (ha) from sugarcane to non-sugar crops, repurposing 14 sugar mills (out of those that continued to operate) to concentrate on the production of molasses for animal feedstock, and transferring 100,000 workers to other sectors of the Cuban economy (Pérez-López, 2016).

[3] Due to the limitations and inconsistencies of official Cuban statistics, the impact of the agricultural reforms on labor productivity is excluded from this study.

[4] According to Lerman (2000), in the absence of reliable data to estimate TFP in transition economies, labor productivity and agricultural yields are acceptable measures to assess the impact and effectiveness of agricultural reforms.

[5] Since the majority of these goods and services are produced by other sectors of the economy, sales revenues and earnings in these sectors also increase as a result of the multiplier effect of the growth of agricultural productivity (Mellor, 1999; Hanmer and Naschold, 2000; Thritle, Lin and Piesse, 2003; Schneider, 2011)

[6] Datt and Ravallion (1998) demonstrate that the growth of agricultural yields contributed to the reduction of poverty in India through its (positive) impact on the prices of food and agricultural products. According to Staatz and Dembélé (2008), at the end of the 1990s food prices in Uganda dropped significantly as a result of increased agricultural yields, while in Ethiopia food prices increased dramatically during periods in which agricultural yields declined significantly (e.g., 1995-1996 and 1999-2000).

[7] Bravo-Ortega and Lederman (2005) estimate that agricultural productivity has a significant effect on the average income of the poorest countries and regions included in their study and plays an essential role in the reduction of poverty particularly in the poorest rural households.

[8] Yield measures of land productivity consider land as the sole input and crop production as the sole output; they provide an important measure of agricultural efficiency since land is the most permanent and fixed factor among the three input categories commonly in agriculture: land, labor, and capital (Anderson and Reynolds, 2016; Dharmasiri, 2012; Thomson, 1926). However, the use of crop yields faces many limitations; since crop yield uses land as the only input, it excludes other factors that affect production such as labor and other inputs; it ignores the effects of environmental damage and does not account for intercropping (Tittonell and Giller, 2013).

[9] As Tittonell and Giller (2013) indicate, there are three (3) principal limitations when using agricultural yields (or crop yields) to measure agricultural productivity (or efficiency): (1) other factors that influence output such as labor and capital are excluded, (2) the effects of intercropping are not included, and (3) agricultural yields (or crop yields) ignore the effects of environmental effects (or negative externalities) associated with agricultural production.

[10] As is customary with the use of indexed data, the data were normalized from the starting point in order to maintain the same percentage changes in the non-indexed series. In addition, subsequent values were calculated so that the percentage change is the same as the percentage change in the non-indexed series.

[11] The raw data used to construct these indexes was obtained from Cuba's Annual Statistical Yearbook (*Anuario Estadístico de Cuba)* for the years 2007, 2012, and 2017.

[12] According to Ritter and Henken (2015), there are an estimated four (4) unregistered self-employed workers for every self-employed worker that is legally registered in Cuba; this estimate suggests that the actual number of self-employed workers in 2017 would be 2,333,800, accounting for 52.2% of the total number of employed persons in the country for that year.