Faculty of Agricultural Sciences
Institute for Social Sciences in Agriculture
Chair of Communication and Advisory Services in Rural Areas
Prof. Dr. Andrea Knierim

Agricultural Education in Honduras

-

Return on Investment, Quality, and Efficiency

Dissertation

Submitted in fulfilment of the requirement for the degree of

"Doktor der Agrarwissenschaften"

(Dr. sc. agr.)

Presented by

MARIA FLORES

Born in Matagalpa, Nicaragua

- November 2019 -

This thesis was accepted as a doctoral dissertation in fulfillment of the requirements for the degree “Doctor of Agricultural Sciences” (Dr. sc. agr.) by the Faculty of Agricultural Sciences at the University of Hohenheim.

Date of oral examination: 06 May 2020

Examination Committee	
Supervisor and Reviewer:	Prof. Dr. Andrea Knierim
Examiner:	Prof. Dr. Perry den Brok
Examiner:	Prof. Dr. Manfred Zeller
Head of the examination committee:	Prof. Dr. Stefan Böttinger

Table of Content

Executive Summary

The Agri-food sector, like any other economic sector, requires competent workers and entrepreneurs able to maximize productivity and cope with the various challenges the sector is facing. Agricultural education prepares these actors to acquire knowledge, identify options that optimize their productivity, and adapt to changing environments. However, the importance of agricultural education is declining in education policies, and nowadays, it is no longer an attractive field of study for the youth. There is a need to re-invent agricultural careers to the new demands of the agri-food and labor market sectors.

As there is a limited number of studies available that analyze agricultural education in Latin-American and other developing countries, this research provides new insights by examining the determinants for return to investment, quality, and efficiency of agricultural education, taking Honduras as a case study.

The present dissertation encompasses three interrelated studies. The first study addresses the research question on how the educational attainment on agricultural education, years of experience, age, sex, geographical region of residence, and work sector, affect the graduate's earnings. This study computes the return to agricultural education by educational level, using several econometric techniques, such as the instrumental variables, Heckman’s two-step procedure, and the multinomial logit to tackle endogeneity of education, sample selection bias, and selection bias for choosing this field of study, respectively. The results show that regardless of the economic activity in which the individuals work, graduates from agricultural educational programs receive positive returns on their investment in education. High school graduates from these programs, have higher earnings within the economic activity of agriculture than non-graduates. At the university level, the graduates' competencies are better paid in economic activities outside agriculture than inside, for example, in fields of manufacturing, public administration, and education.

The second study addresses the question of what competencies employers require from graduates of agricultural education programs. Interviews and workshops were conducted, addressing employers from agricultural value chains, purposely selected, and using maximum variation sampling. The results show that graduates perform at an intermediate level in technical competencies. Of the 20 competencies identified, graduates perform poorly in at least six areas of competence, which requires immediate action.

Although the analysis of academic curricula shows that the competencies included are relevant for employers to cope with the challenges faced by the agri-food sector, there is room for improvement.

Finally, the third study addressed the question about the level of efficiency of the public institutions delivering agricultural educational programs, and the factors influencing it. This study computes the efficiency using the non-parametric approach data envelopment analysis (DEA). The model used is output-oriented, variable return to scale, and two-stage where controllable and non-controllable inputs are included in the first and second stages, respectively. This study follows a double bootstrapping procedure to avoid the caveats of the conventional DEA analysis. The evidence showed that none of the agriculture education centers in the sample is considered a full efficient entity. However, there is a potential to improve the usage of the current resources. It is possible by expanding the outcomes in a range of 1% to 50% without changing the existing resources.

In summary, the findings of this dissertation provide compelling evidence that each additional level of agricultural education in Honduras is a worthwhile investment, and that graduates from both education levels, secondary and tertiary levels, are necessary to support Honduras' economy. Nevertheless, improvements should be made in terms of the quality and the resources used in the provision of agricultural education.

Based on the research findings, it is recommended to revise the academic curricula, with the aim of better matching education and labor market requirements. Secondly, a closer analysis of the implementation of the educational processes is necessary in order to enhance the competencies requested and identify better management of the resources available. Finally, setting formal collaboration mechanisms between the education centers, authorities, and the private sector could strongly improve agricultural education systems' contribution to the performance of the sector. To further refine this research, it would be beneficial to increase the sample sizes to expand further the techniques used.

Zusammenfassung

Der Agrarsektor benötigt wie jeder andere Wirtschaftszweig kompetente Arbeitskräfte und Unternehmer, die in der Lage sind, Herausforderungen zu bewältigen und die Produktivität zu maximieren. Landwirtschaftliche Bildungs und Ausbildungsangebote bereiten diese Akteure darauf vor, Wissen zu erwerben, Optionen zur Optimierung ihrer Produktivität zu identifizieren und sich an veränderte Rahmenbedingungen anzupassen. Allerdings nimmt die Bedeutung der landwirtschaftlichen Ausbildung in der Bildungspolitik ab, und es ist für viele Jugendliche oft kein attraktives Studienfach mehr. Es ist daher notwendig, die landwirtschaftlichen Ausbildungsgänge weiter zu entwickeln, um den neuen Anforderungen im Agrar- und Ernährungssektor und dem Arbeitsmarkt gerecht zu werden. Es gibt nur eine begrenzte Anzahl von Studien, die die landwirtschaftliche Bildung in Lateinamerika und anderen Entwicklungsländern analysieren. Daher, untersucht die vorliegende Studie die Determinanten für die Rentabilität, Qualität und Effizienz der landwirtschaftlichen Ausbildung von Honduras als Fallstudie.

Die vorliegende Dissertation umfasst drei zusammenhängende Studien. Die erste Studie beschäftigt sich mit der Forschungsfrage, wie sich der Bildungsabschluss in der landwirtschaftlichen Ausbildung, der zeitliche Umfang an Berufserfahrung, das Alter, das Geschlecht, die Wohngegend und der Arbeitsbereich auf das Einkommen des Absolventen auswirken. Diese Studie berechnet die Rentabilität der landwirtschaftlichen Ausbildung nach dem Bildungsniveau unter Verwendung verschiedener ökonometrischer Techniken, wie z.B. der instrumentellen Variablen, des zweistufigen Verfahrens nach Heckman und des multinomialen Logits, um der Endogenität der Bildung, der Verzerrung der Stichprobenauswahl und der Verzerrung durch die Auswahl des Studienbereichs zu begegnen. Das Ergebnis ergab, dass Absolventen landwirtschaftlicher Bildungsprogramme unabhängig von ihrer wirtschaftlichen Tätigkeit positive Renditen für ihre Investitionen in Bildung erzielen. High-School-Absolventen dieser Programme erbringen bessere Leistungen bei ihrer wirtschaftlichen Tätigkeit in der Landwirtschaft. Universität-Absolventen werden in wirtschaftlichen Tätigkeiten außerhalb der Landwirtschaft besser entlohnt als innerhalb, z.B. in der Industrie, der öffentlichen Verwaltung und im Bildungswesen.

Die zweite Studie beschäftigt sich mit der Frage, welche Kompetenzen Arbeitgeber bei Absolventen von landwirtschaftlichen Bildungsprogrammen erwarten. Es wurden Interviews und Workshops mit Arbeitgebern aus landwirtschaftlichen Wertschöpfungsketten durchgeführ. Die Stichprobe wurde bewusst und mit maximaler Variation ausgewählt.

Die Ergebnisse zeigen, dass die Absolventen bei technischen Kompetenzen auf einem mittleren Niveau abschneiden. Von den 20 identifizierten Kompetenzen schneiden die Absolventen in mindestens sechs Kompetenzbereichen schlecht ab, was ein sofortiges Handeln erfordert. Obwohl die Analyse der akademischen Lehrpläne zeigt, dass die vermittelten Kompetenzen für die Arbeitgeber relevant sind, um die Herausforderungen des Agrar- und Ernährungssektors zu bewältigen, gibt es Verbesserungsmöglichkeiten.

Schließlich stellt die dritte Studie den Effizienzstandard der öffentlichen Einrichtungen, die landwirtschaftliche Bildungsprogramme anbieten, und die Faktoren, die sie beeinflussen, in Frage. Diese Studie berechnet die Effizienz mit dem nichtparametrischen Ansatz der Data Envelopment Analysis (DEA). Das verwendete Modell ist eine zweistufige, ausgangsorientierte, variable Skalenrückführung, die in der zweiten Stufe die nicht steuerbaren Variablen beinhaltet. Diese Studie folgt einem doppelten Bootstrapping-Verfahren, um die Nachteile der herkömmlichen DEA-Analyse zu vermeiden. Die Studie weist nach, dass keine der landwirtschaftlichen Bildungseinrichtungen in der Stichprobe voll effiziente ist. Jedoch besteht das Potenzial, die vorhandenen Ressourcen besser zu nutzen. Es ist möglich, die Ergebnisse in einem Bereich von 1% bis 50% auszubauen, ohne die aktuellen Ressourcen zu verändern.

Zusammenfassend lässt sich sagen, dass die Ergebnisse dieser Dissertation überzeugende Argumente dafür liefern, dass jedes zusätzliche landwirtschaftliche Bildungsniveau in Honduras eine lohnende Investition ist und dass Absolventen beider Bildungsebenen, auf High-School- und Universitätsniveau, notwendig sind, um Honduras' Wirtschaft zu unterstützen. Dennoch sollten die Qualität und Ressourcen, die für die Bereitstellung der landwirtschaftlichen Ausbildung verwendet werden, verbessert werden.

Auf der Grundlage der Forschungsergebnisse wird erstens empfohlen, die akademischen Lehrpläne im Hinblick auf eine bessere Abstimmung von Bildung und Arbeitsmarktanforderungen zu überarbeiten. Zweitens ist eine genauere Analyse der Umsetzung der Bildungsprozesse erforderlich, um die geforderten Kompetenzen besser zu vermitteln und einen besseren Einsatz der verfügbaren Ressourcen zu gewährleisten. Schließlich könnte die Festlegung formaler Kooperationsmechanismen zwischen den Bildungszentren, den Behörden und dem Privatsektor den Beitrag der landwirtschaftlichen Bildungssysteme zur Leistungsfähigkeit des Sektors erheblich verbessern. Um diese Forschung weiter zu verfeinern, wäre es vorteilhaft, die Stichprobengröße zu erhöhen, um die verwendeten Techniken weiter auszubauen.

List of Abbreviations and Acronyms

DEA	Data Envelopment Analysis
DMU	Decision Making Unit
EQF	European Qualifications Framework for Lifelong Learning
GDP	Gross Domestic Product
HHS	Honduras Households Survey
HIHP	High Importance and High Performance
HILP	High Importance and Low Performance
ISCED	International Standard Classification of Education
IV	Instrumental Variable
LIHP	Low Importance and High Performance
LILP	Low Importance and Low Performance
OLS	Ordinary Least Square
ROI	Return on Investment
ROIE	Return on Investment in Education
UNA	The National University of Agriculture
UNAH	The Honduras National Autonomous University
UNESCO	The United Nations Educational, Scientific and Cultural Organization

List of Tables

List of Figures

List of Appendices

Agricultural Education in Honduras: Return on Investment, Quality, and Efficiency

1. Introduction

Agriculture, like any other sector, requires a "more educated and skilled workforce capable of increasing productivity, developing high quality, specialized products competitive in international markets" (Rivera, 2008, p. 384), and managing the current challenges affecting the agri-food sector (Swan and Lay, 2014).

Agriculture is facing multiple challenges such as (i) globalization, (ii) rapid technological uptake, (iii) climate change, and (iv) environmental degradation. Furthermore, it must feed an ever-growing population that demands high quality, safe, and sustainable food (Tilman et al., 2001).

Coping with these challenges requires the acquisition of agricultural knowledge and innovation through research, extension, and education (Rivera et al., 2005). Education prepares future researchers, educators, farmers, and advisors, enabling these actors to create and use knowledge (Rivera and Alex, 2008). This knowledge allows farmers to seek and decode the information available, and to analyze and decide between several technical options that will help them to improve their productivity. In addition, it enhances farmers' ability to innovate and adapt to changing conditions (Welch, 1970).

The effects of education are evidenced in changes in productivity (Lockheed et al., 1980). Early studies on this issue found that education, along with research, infrastructure, and technology, increases agriculture's productivity (Antle, 1983; Mundlak et al., 1997). Recent studies suggest that one additional year of education of a developing country´s population increases its agricultural productivity by 3.2% (Reimers and Klasen, 2013). Furthermore, compared to their less educated peers, graduates from formal agricultural education are more equipped to make decisions on efficiency and are early adopters of innovations that increase productivity (O'Donoghue and Heanue, 2018).

However, current constraints are affecting agricultural education such as the low enrollment rate, the negative image of an agricultural career, a shortage of teachers and graduates from agricultural education programs, and other constraints discussed later in this study. The present

research examines agricultural education, the constraints affecting this study field, resource usage, and the results derived from investment in this education.

This study is organized as follows. Chapters 1 and 2 state the research problem, knowledge gaps, and research objectives and questions. Chapter 3 presents the theoretical background and conceptual framework. Chapter 4 describes the data collection and analytical methods. Chapters 5 and 6 summarize the empirical results and compare them with similar studies. Finally, Chapter 7 concludes and states the implications for further studies.

1.1.The Research Problem

Regardless of its importance, agricultural education is neither a "priority in the development plans of countries" (van Crowder et al., 1998, p. 71) nor the first educational choice for many young people (Conroy, 2000). There is a negative perception of careers related to agriculture, which affects the recruitment of prospective students (Dyer and Breja, 2003). These careers are perceived as labor-intensive, attended by poor academic achievers (Dyer and Breja, 2003; Kidane and Worth, 2014), and limited to a few career paths. In addition, young agricultural entrepreneurs face limited access to land and loans (Badiru et al., 2019) and the probability of a low economic return after graduation. Previous work identifies the latter as a significant factor influencing the demand for education in general and a field of study in particular (Freeman, 1986).

The decreasing demand for agricultural education poses a risk to the future of the institutions providing this education (Mulder and Kupper, 2006; Thieman et al., 2016). These institutions experience economic hardship and are consequently faced with the necessity of cutting educational programs (Gillespie and Bampasidou, 2018). Budget constraints also affect the acquisition and maintenance of equipment, facilities, and other resources, as well as the attraction and retention of quality educators (van Crowder et al., 1998; Thieman et al., 2016).

There is a need to re-invent or adapt agricultural educational programs (Conroy, 2000; Rivera and Alex, 2008; Mulder and Pachuau, 2011). In developing countries, these programs are based on outdated curricula and fail to address the demands of the current labor market (Maguire, 2012). To date, the focus of the instruction has been on "a disciplinary and atomistic perspective with specialization in one component of the whole agrarian system" (Altieri, 1998, p. 233).

However, the complexity of the agri-food system requires new topics and approaches to understand this complexity better. They include system and interdisciplinary approaches and environmental and sustainable agricultural development (van Crowder et al., 1998; Altieri, 1998; Parr et al., 2007; LaCharite, 2016).

This complexity of the "modern food system" (FAO et al., 2017) requires agricultural education programs to extend the focus from production only to the processing, distribution, and consumption of agri-food products and services. It also requires programs that help learners understand the context of agriculture and its relationship with the society and the environment (LaCharite, 2016; David and Bell, 2018) as well as programs that develop the competencies required for available occupations beyond production (Conroy, 2000; Rivera and Alex, 2008). "Life sciences," "green education," or "food-system professions" are among the terms used to refer to these educational programs in the broad agricultural field of study (Acker, 1999; Mulder and Pachuau, 2011).

Based on the previously stated factors, there is a pressing need to re-examine agricultural education. This examination can be used "to support the diagnosis of problems and help clarify imbalances between capacity development requirements and priority audience needs" (Rivera and Alex, 2008, p. 380). It might also help decision-makers focus on the measures required to use the resources efficiently and achieve the objectives of agricultural education.

Agricultural education in Honduras is not exempt from the negative factors already outlined. However, there is an interest —shown both by the Honduran education authorities and the international development community supporting Honduras—in updating and articulating technical education programs (OEI-Gobierno de Honduras, 2018), such as those related to the agri-food sector. This situation makes the country an ideal study case in two ways. The insights gained regarding the situation of agricultural education in Honduras might provide insights for other Latin-American countries with a similar background. Secondly, the study will prove useful for the decision-making processes of the country´s educational authorities.

The following sections present a detailed description of the agri-food sector and agricultural education in Honduras.

1.2.Agri-food Sector in Honduras: Current Situation and Challenges

In Honduras, the agri-food sector accounts for 30.7% of its GDP. Agriculture is the primary source of income of 37.9% of the employed population, of whom 85.29% live in the rural area (INE, 2016a).

Approximately 65% of Honduras' population is 29 years old or younger. The agricultural sector employs 38.2% of the Honduran youth population (15–29 years old) (INE, 2019). However, the agricultural sector is among the sectors with the lowest productivity (Quijada and Sierra, 2014), and has the potential to become a modern and highly competitive sector (Foxley and Stallings, 2016).

The Honduran population, whose main occupation is within the economic activity of agriculture has, on average, attained 5.4 schooling years (INE, 2016b). However, the current level of education of agriculture labor in Honduras in part explains the low productivity of the agricultural sector. Prior studies using the dataset of multiple countries supports this statement. For example, Gollin et al. (2014) compute the average years of schooling by sector in 124 countries. They find that, in almost each of these countries, agriculture workers attained fewer schooling years than non-agriculture workers. Furthermore, when computing the human capital by sector, they find that non-agricultural workers, on average, have 1.3 to 1.5 times more human capital than agriculture workers. It means that non-agricultural workers receive more return for their skills and abilities compared to agriculture workers. Hence, according to these authors, this difference in schooling years, which influences the human capital, can partially explain the "differences in average labor productivity" between agriculture and other sectors, particularly in developing countries (ibid, p. 965).

Similarly, Reimers and Klasen (2013) show that the changes in the average schooling years of a country's population accounts for 20% of the increases in the agricultural productivity of a country. Nevertheless, this effect varies according to the educational level attained. The authors find that primary and secondary education has a positive effect on agricultural productivity, whereas tertiary education does not affect it. As for the particular case of Latin-American countries, Dias Avila A. et al. (2010) conclude that increases in the average years of schooling of the workforce positively affect increases in agricultural productivity.

In addition to the low productivity, other challenges affecting the agri-food sector in Honduras are the limited use of market information, slow technological change, limited access to technical assistance, and vulnerability to shock in the international markets and to the effects of climate change (Serna Hidalgo, 2007; Blanco and Samper, 2009; Andréu, 2012; Quijada and Sierra, 2014; World Bank, 2015).

Honduras is among the countries with high vulnerability to the effects of climate change and has been one of the most affected globally from 1995 to 2015 (Kreft et al., 2016). The current effects on agriculture for this country are prolonged drought, crop yield losses, and the reduction of soil productivity (Imbach et al., 2017). It is estimated that by 2030, economic losses will total approximately 9% of the country's GDP and will affect 250,000 Hondurans (ECLAC, 2015).

To cope with the aforementioned challenges, Honduras should diversify its agri-food production, improve the quality of the agricultural products and services, enhance land and worker productivity (Serna, 2007), and develop climate resilience.

Long term national policies seek to transform the situation of its undereducated youth. Twenty seven percent of the Honduran youth, who neither work nor study, cite the lack of access to quality education and the low return to schooling among the reasons for dropping out of school early (Cárdenas et al., 2015).

Likewise, formal enterprises in Honduras list insufficient educated personnel as one of the top-ten constraints on their operation (World Bank, 2017). Hence, the labor force (as well as other production factors) must improve its productivity and efficiency, including those involved in key agricultural value chains in Honduras. One pathway to achieve this aim is through formal agricultural education, as stated by the "Honduras Country Vision," a governmental policy that plans to achieve this vision by 2038 (Gobierno de Honduras, 2010).

1.3.Agricultural Education in Honduras

The Honduras Basic Education Act (2012) and the Higher Education Act (1989) dictate education in Honduras. The former defines the national educational system and provides the principles and guidelines of a Honduran education. The latter states the purpose of higher education and its organizational structure and accreditation.

The educational system comprises formal, informal, and non-formal education. This research focuses on formal education as a high share of public resources are devoted to this category. Formal education includes the following educational levels: pre-school, primary, secondary, and tertiary education. Of these, the secondary and tertiary educational levels serve agricultural education. The former level is controlled by The Ministry of Education, and the latter by The Council of Higher Education. The duration of the educational program ranges from two to five academic years and is served mostly by public educational institutions (Table 1).

The primary purpose of these programs is to prepare students to continue their education at the next educational level and at the highest levels and prepare them to immediately access the labor market by providing the competencies related to an occupation.

Table 1. Amount and type of institutions by education level, degree, and duration of the program

Educational level	ISCED* classification	Degree	Duration (years)	Amount and type of institutions	
				Public	Private
Secondary	Level 3	High school	3	123	11
Tertiary	Level 5	Higher technical education	2	1	1
Tertiary	Level 6	Bachelor or equivalent	4-5	2	3
			Total	126	15

Note: * 2011 International Standard Classification of Education

In 2015, approximately 17.63% (1,316 students) of university graduates completed a major in agricultural education (Central Bank, 2016). Of the 248,000 students enrolled in high school in 2010, 176,087 attended a vocational-technical high school. This constitutes 71% of the enrollment. Of the students enrolled in a vocational-technical academic program, 3% participated in an educational program related to agriculture.

The educational authorities overseeing secondary education recognized that technical education programs were diverse, the curricula were not up to date and did not include educational performance standards or competencies defined in the academic programs (Sierra and van Steenwyk, 2011).

An additional factor affecting the quality of technical education was the limited specialized equipment available in schools. Furthermore, the teachers did not fulfill the professional profile required for these academic programs and lacked appropriate supervision (Sierra and van Steenwyk, 2011).

During 2016, the Ministry of Education developed 15 technical academic programs to be served at the high school level. Although some of these educational programs focus on agroforestry, agriculture, and agroindustry, there is no evidence that the process of developing the aforementioned technical academic programs, included any analysis of the national agricultural policies or involved the Ministry of Agriculture (the institution responsible for planning and implementing the agricultural sector policy of Honduras) and therefore lack relevant contents.

The agricultural policy of Honduras includes agricultural education as a crosscutting activity which aims to support the agricultural transformation. This transformation entails furthering agricultural production and value chains, increasing competitiveness, and enhancing peasant agriculture considering gender inequalities (SAG, 2004).

Under this policy, the Ministry of Education and the Council of Higher Education are to make the academic programs adequate to the national and regional needs, as well as develop the professional profile required by the agricultural value chain actors and make the academic curricula adaptations necessary to supply this demand (ibid).

At the time of writing, information about the investment allocated to formal agricultural education in Honduras has not been publicly disclosed. In general terms, in 2013, the Government of Honduras invested 5.8% of its GDP in education for the same year as a percentage of the total government expenditure in education, dividing it 7.32% in pre-primary, 48.90% in primary, 25.29% in secondary, and 18.49% in tertiary education (UNESCO, 2019). It is estimated that the resources allocated to agricultural education are a share of the resources provided for secondary and tertiary education (i.e., it cannot be said clearly which amount was allocated for agricultural education).

As for the return on investment in education in Honduras, regardless of the educational level, one additional year of education increases an individual’s income by 12.4%. By educational level and regardless of the educational program attended, the return for completing secondary education is 10.7%, and it is 19.8% for completing the tertiary education level (Montenegro and Patrinos, 2014).

In Honduras, at the secondary educational level, Psacharopoulos and Chu Ng (1994) find differences in the rate of return due to the curricula. On average, the authors find that the earnings of graduates from a vocational/technical program are larger than those from a general academic program (3.98 percentage points of difference in the rate of return of graduates from a vocational/technical program and other graduates). No distinction was made regarding careers in agriculture.

To the best of the researcher's knowledge, no information about the return on investment in agricultural education in Honduras has been published previously to the present research.

2. Knowledge Gaps, Research Objectives and Questions

This section discusses two sources of knowledge gaps related to the research problem discussed in the previous section: the first, relates to the analysis used to examine agricultural education; the second, refers to the situation of Agricultural Education in Honduras. This section also shows the objectives and questions of the research, which aim to fill the knowledge gaps.

2.1.The Knowledge Gaps

Cost-benefit, quality, and efficiency analysis are essential tools for examining the performance of education's provision (Jimenez and Patrinos, 2008; UNESCO-IBE, 2012). Cost-benefit analysis, for instance, uses the outcomes of education in the form of the graduate earnings, to compute the return on investment in education; whereas quality analysis focuses on the output of the educational process, such as students` academic achievement and competencies; and efficiency analysis compares those outputs to the inputs such as expenditure per student and student/teacher ratio.

Return on investment in education is an indicator at two levels. At the policy level, it is used to evaluate educational programs, providing useful insights to allocate the available resources better. At the household or individual level, it helps to provide support to the choice of the educational level and field of study that an individual pursues. Individuals are likely to invest more in their education if they expect a higher return for their investment (Altonji, 1993; Psacharopoulos and Patrinos, 2004).

Studies analyzing the return to education such as Psacharopoulos and Chu Ng (1994), Psacharopoulos and Patrinos (2002), and Montenegro and Patrinos (2014) focus on the average return for each additional year or level of education. Empirical studies that analyze the return by field of study (e.g., education, business administration), and within the field by the level of education attained, are very few in number (Altonji et al., 2016). Moreover, studies that analyze agricultural education in developing countries are fewer still.

Among the reasons for the limited empirical evidence on the return by field of study is the lack of available data to estimate the real effect of it on earnings. This relationship is affected by selection bias, a bias that arises when individuals choose a field of study not randomly but by considering their preferences, the influence of their parents, or their perception of their own

abilities. Datasets that include information about the individual´s schooling years, earnings, career choice, ability, preferences, and parental influence, are rarely available. Therefore, the use of instrumental variables (IVs) and multinomial logit regressions are among the options to control this selection bias into the analysis (Altonji et al., 2012).

In the *analysis of quality of education,* outputs of the educational process are regarded as indicators of education quality. Examples of outputs of education are students´ academic achievement and competencies.

Several studies analyzing competencies across countries and industries have been conducted since the seminal work of McClelland (1973). These studies focus on general competencies (e.g., problem-solving, critical thinking, team working) and technical competencies (specific competencies to perform a job) in several fields (e.g., business, medicine). However, competencies development has been analyzed to a lesser extent in the agri-food sector, despite being a success factor for any size of agri-food entity (Mulder, 2001).

The dynamic nature and challenges faced by the agri-food sector (Fresco, 2009; Thompson and Scoones, 2009) suggest a continual update of the educational programs, considering the competencies required by the labor market as those needed to face the challenges affecting the agri-food sector (Easterly III et al., 2017). This continual update, rather, implies regular consultations with employers for future job statistics and requirements to adapt the agricultural educational programs (van Crowder et al., 1998).

Efficiency Analysis constitutes another gap: An efficient educational system achieves the expected outputs using the minimum of the resources available (Johnes et al., 2017). The efficient use of public resources is gaining greater importance in education (Witte and López-Torres, 2017), especially as publicly funded agricultural education in developing countries is under severe budget constraints (van Crowder et al., 1998).

In contexts in which resource scarcity prevails, making decisions on where to allocate the resources should be decided by efficiency and cost-benefit analyses (Izquierdo and Pessino, 2018). Nevertheless, little is found in the current literature regarding the efficiency of an agricultural education, more specifically, comparing the educational institutions which provide such an education or analyzing them by educational level.

In terms of the knowledge gaps particular to the situation in Honduras, little is known about how agricultural educational institutions prepare future graduates. Research on agricultural education in Honduras has focused on the descriptive analysis of the education system of which

agricultural education is a part of (see the work of Avila et al., 2002), the assessment of specific agricultural majors (e.g., agroindustry) (as the work of Vega, 2008), and the curriculum assessment of higher agricultural education (see the work of Fernandez, 1994).

Avila et al. (2002), for instance, describe the public and private entities offering agricultural education in Honduras, their academic programs, and student enrollment rate. They also provide an overview of the difficulties the education system faces in Honduras, including the institutions serving agricultural education. Among these difficulties, they mention education quality. Similarly, the work of Fernandez (1994) provides a detailed description of the agricultural educational programs at the tertiary educational level including the objectives, the content, and sequence, the instructional methods and resources, and the evaluation approaches. From the comparison of the curriculum, the author concludes that these programs emphasize theoretical rather than practical knowledge, thus limiting the students` opportunities to learn from the experience and to be exposed to real situations such as those they will face as professionals.

Finally, Vega (2008) assesses the pertinence of the academic curriculum "International business majoring in agroindustry" in the west region of Honduras. The author finds that almost half of the students interviewed in the study chose this career as their last option. Regarding the graduates interviewed, six out of ten faced hardships finding a job in the region; and nine out of ten considered that the graduate profile should be updated to better match the regional labor market demands.

Although previous research conducted in Honduras has shed light on important issues, little attention has been given to the analysis of agricultural education by educational level, graduates' competencies (i.e., quality), resource usage (i.e., efficiency), and effects derived from the investment on this education (i.e., return on investment). Therefore, this represents a knowledge gap which this research attempts to bridge.

In doing so, it is hoped that the results of this research will contribute to the definition of new educational policies and improvements in the efficiency and quality of this education. In the long run, this will enhance agricultural competitiveness, productivity, and technical efficiency helping the country's economic growth and development.

2.2.Research Objectives and Questions

In the context of the research problem and knowledge gaps, this research aims to analyze the determinants of the return on investment, quality, and efficiency of agricultural education. Circumscribed to the situation of agricultural education in Honduras, this research aims to determine whether the country´s agricultural education provision is using its resources efficiently and achieving its objectives in terms of the competencies developed and graduate earnings.

Specifically, this research seeks:

1) To determine the effect of agricultural educational attainment on graduate earnings.
2) To determine the discrepancy between the competencies provided by agricultural education and those required by the employers in the key agricultural value chains.
3) To estimate the efficiency of the agricultural education system at the secondary and tertiary level and identify the factors influencing the level of efficiency.

In more detail, the research questions answered in this study, are as follows.

Specific objective 1: Research question

- How does educational attainment in terms of agricultural education, years of experience, age, sex, geographical region of residence, and work sector affect graduate earnings?
    - Subsidiary research questions
        - Is there an earnings differential between agricultural and non-agricultural education at high school and university level?
        - Is there an earnings differential between agricultural graduates working in or out of the primary sector?

Specific objective 2: Research question

- What competencies do employers require in graduates from agricultural education programs?
    - Subsidiary research questions
        - How are the required competencies included in current agricultural education programs? At what educational level are they included?

        - Do the competencies required by employers differ from those required to face the challenges in the agricultural sector?

Specific objective 3: Research question

- What is the level of efficiency in public institutions delivering agricultural educational programs?
    - Subsidiary research questions
        - What inputs do the public institutions use in the educational process to deliver agricultural education?
        - To what extent do contextual factors affect the efficiency level of public institutions providing agricultural education?

3. Conceptual Framework and Theoretical Background

The following section presents the conceptual framework guiding this research. Furthermore, it reviews the theoretical foundation of the issues examined in this research, as stated in the past and current literature. These issues are agricultural education, return to investment in education, quality of education, graduates' competencies, and the efficiency of education.

3.1.Conceptual Framework

This sub-section aims to integrate the theoretical background underlying this research. The following paragraphs elaborate on the structure and components of the conceptual framework and how it guides this study. Figure 1 displays the conceptual framework.

Central to the framework is the system approach. Education, here, is understood as a system, whereby the educational process uses inputs and derives outputs and outcomes (Scheerens, 1990).

Borrowed from human capital theory (Schultz, 1960), this framework considers outcomes of education the earning differentials between those individuals who attained a higher level of education and their less-educated peers. By comparing the earning differential to the costs of getting an education, the return on investment of education is computed. A positive return on investment in education implies that more schooling leads to higher income. This consequently motivates individuals to continue their education. (Study 1).

Just as the quantity of schooling is essential for an individual, so is the quality of the education that this individual receives (Hanushek and Luque, 2003). Education quality is understood here as the fulfillment of the education`s purpose from the stakeholders' perspective (Harvey and Green, 1993; Cheong Cheng and Ming Tam, 1997). Of all the education stakeholders, this framework focuses on employers.

From the employer`s perspective, the purpose of education is to deliver a sufficient number of graduates with the required knowledge, skills, or competencies (Harvey and Green, 1993). Therefore, by acquiring the competencies required by employers, the individuals increase their employability. (Study 2).

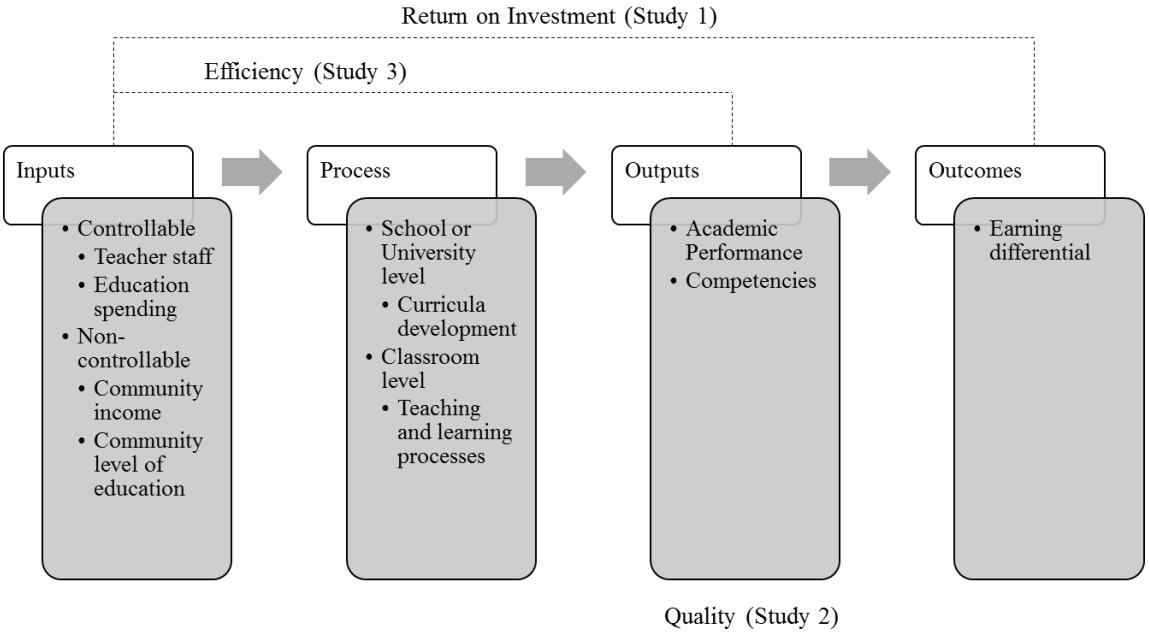

Figure 1. Conceptual Framework. Adapted from Scheerens, Luyten, & van Ravens (2011, p.40).

Competencies here refer to the individual's ability to cope with complex situations using knowledge, skills, values, and attitudes in different contexts (Rychen and Sagalnik, 2001; Halász and Michel, 2011). Competencies are the ultimate characteristics that employers seek in future or current employees (Rodriguez et al., 2002) and are used as an indicator of education quality (Harvey and Green, 1993).

Investments in the educational process produce outputs and outcomes. Like any other investment, the efficient use of these resources is of paramount importance. Resources in this framework encompass inputs, controllable and non-controllable, at the school or university level.

To estimate the level of efficiency, the outputs are compared to the inputs of the educational process. Here, "efficient use of resources occurs when the observed outputs from education are produced at the lowest level of the resource" (Johnes et al., 2017, p. 331; see Study 3).

All these aspects together encompass the current situation of agricultural education, and by analyzing them, useful insights can be gained to improve it. The framework outlines the issues under study, namely, the return on investment, quality, and efficiency of agricultural education.

For the sake of simplicity, henceforth these issues are referred to as studies one to three, respectively. Each of these studies encompasses the research objective and questions one to three, respectively.

The theories and concepts underlying the aspects included in the conceptual framework are reviewed in the next section, to gain a better understanding of these issues and to provide an appropriate framework for the selection of methods used in this research.

3.2.Theoretical Background

3.2.1. Agricultural Education

To understand the meaning of agricultural education, first, it is necessary to situate it within the broad definition of agriculture. Agriculture is understood as "*activities which foster biological processes involving growth and reproduction to provide resources of value. Typically, the resources provided are plants and animals to be used for food and fiber, although agricultural products are used for many other purposes also*" (Lehman et al., 1993, p. 127).

According to Harris and Fuller (2014), these activities take place in local landscapes shaped by the scale of cultivation (e.g., large, small). Therefore, agriculture is "the form of land use that represents a change in the landscape, as people regularly cultivate, raise, and focus more attention on domestic plants and animals" (Harris and Fuller, 2014, p. 110).

Casavant et al. (1999, p. 11) extend the definition of agriculture to understand it as a "complex system" that entails "the natural resources" and the sectors involved in providing "products of the land to consumers." These sectors are: (i) the farm sector or firms growing crops and livestock; (ii) the agro-business sector, including firms providing products and services to the farms, as well as firms processing and marketing agricultural products; and finally, (iii) the public sector, including institutions conducting and providing research, education, extension, and other services.

Turning to the definition of agricultural education Frick et al. (1991, pp. 52–54) define it as:

"*the understanding and knowledge necessary to synthesize, analyze, and communicate basic information about agriculture…this knowledge encompasses the production of plant and animal products, the economic impact of agriculture, its societal significance, agriculture's important relationship with natural resources and the environment, the marketing of*

agricultural products, the processing of agricultural products, public agricultural policies, the global significance of agriculture, and the distribution of agricultural products."

In addition to the extensional definition provided by Frick et al. (1991), Shinn et al. (2009, p. 83) expand the definition by positioning agricultural education in the branch of knowledge. They refer to agricultural education as "*a field of study in the social sciences, behavioral sciences, and natural and life sciences that is based on sound principles of teaching and learning and integrates the sciences relevant for the development of human capital and for the sustainability of agriculture, food, renewable natural resources, and the environment*." The development of human capital to which these authors refer are the graduates from this field of study as well as those individuals whom these graduates reach by practicing their profession. An example of the latter is the extension services provided by agricultural advisors (ibid, p.83).

3.2.2. Return on Investment in Education

The human capital theory proposed by Schultz (1960) and later developed by Becker (1962) states that skill and knowledge are a form of capital that individuals choose to invest in, aiming to enhance their productivity and future income.

Investment in human capital refers to all education expenses. The value of such investment is the return produced in the lifespan of an educated person, in comparison to a non-educated or less educated person (Psacharopoulos, 2006). In other words, the return on investment, specifically the return on education is the gain of investment in education compared to its costs.

The return on education can be private or social. The former considers the individual's costs to get an education (e.g., tuition and foregone earnings) and the benefits perceived after graduation (i.e., earnings) (Psacharopoulos, 2006). The latter considers the full cost of educating one person, including the private and public expenditures and the benefits that derive from it, such as the country's productivity and growth, crime reduction, and improvement on social cohesion (ibid).

An assumption in human capital theory is that the decision regarding how much education an individual attains is a rational decision resulting from comparing the cost of education and forgone income to the expected benefits. Therefore, an individual will attain a certain level of education when the expected benefits from this education at least equal the investment (Becker, 1962).

How much schooling an individual will attain is influenced by the expected return. However, the expected return is also influenced by uncertainties that individuals face and how they respond to these uncertainties (e.g., the individual's degree of risk aversion) (Becker, 1962). One example of these uncertainties is that individuals do not know when they will "collect this return" and the "environment when the return is to be received." Furthermore, the longer the period between investment and return, the less information is available (Becker, 1962, p. 41). In this regard, individuals make a decision using their best guess based on the information available. Once they collect more information, individuals also update their choices (Heckman et al., 2006).

Another source of uncertainty is their consciousness about their ability, especially when decisions about investment in education are made at a young age (Becker, 1962; Altonji et al., 2016). Individuals learn more about their ability by "experience" and "environment," for instance, than by attending school and taking exams (Altonji et al., 2012). An additional year of education reveals more information to the individual about the state of the labor market and the conditions of their abilities, consequently leading the individual to make better-informed decisions (Dickson and Harmon, 2011). Based on the awareness of their ability, individuals might choose to continue their schooling, dropping out of school or switching education programs.

The innate ability that an individual possesses, however, is not only related to education but to productivity and consequently also, earnings (Willis, 1986). For example, an individual who is more intelligent and diligent is likely to attain more education years. However, individuals with higher ability, in the long run, might be more productive, thus gaining more earnings even if they do not complete their careers (Ehrenberg and Smith, 2017).

Willis (1986) states that an issue arising in studies of the return on investment is that the individual's ability is not observed; what is observed is the decision made by the individual (e.g., the level of education and type of education chosen) and the consequences of this decision (e.g., earnings). In addition, none of the possible choices available for each individual are observed either, which is problematic as the set of choices differ from one individual to another. This situation, acknowledged in the literature of return on education as 'self-selection bias,' profoundly affects the causation of education on earnings.

Regarding the choices available, investing in more education involves a decision about the type of education to pursue. Factors that may cause differences in earnings due to the field of study are the individual's preferences for a specific major, the occupation-specific talents that the

individual possesses, and the individual's selection of a major based on an occupation with a potential higher pay-off (Altonji et al., 2016).

The individual's decision about which major to pursue is affected by gender and stereotypes (Correll, 2001; Thieman et al., 2016), the individual's ability and preferences, and parental influences (Altonji et al., 2012; Thieman et al., 2016).

Wigfield and Eccles (2000) point out similar issues in their "expectancy-value model of achievement motivation." In the authors words, the individual's achievement related to choices is a consequence of the individual's expectation of success, subjective task value (e.g., utility value) self-schemata and goals, previous experiences, their interpretation of these experiences, socializers' beliefs and behaviors (e.g., parents, friends), and the cultural milieu (e.g., gender role and stereotypes). Of these factors at play while choosing an agricultural major, the individual's perceptions, socializers' beliefs and behaviors, previous experiences and their interpretation, and the individual's goals and schemata, have been empirically studied (Thieman et al., 2016).

Omitting the sources of differences in earnings produces bias estimates of the real effect on the return on education. Hence, in the present research, a careful selection of the methods was made, aiming to tackle these biases when computing the return on education. A description of the methods used is presented in Chapter 3.

3.2.3. Quality of Education

A consensus definition of 'quality of education' has yet to be made in the literature (Wittek and Kvernbekk, 2011), in part due to the perspective of the stakeholders involved in education, who shape the meaning of quality (Harvey and Green, 1993).

Consequently, different approaches, methods, and criteria to analyze and evaluate the quality of education have been developed and adopted by researchers and practitioners (Tam, 2001). The following paragraphs present the definitions of quality of education, as stated by researchers and practitioners. From the practitioners' perspective, this section discusses two cases, the definitions given by UNESCO and the Honduras education system respectively.

In the seminal work of Harvey and Green (1993), the authors relate the quality of education to five interrelated perspectives of quality. The first perspective defines quality in terms of achieving high standards or excellence, either by exceeding a set of high standards or by using the best resources and producing the best outcomes.

In the second perspective, quality is seen as compliant with a set of specifications. This ensures no defects or errors are produced by controlling the quality during the process.

In the third perspective, namely 'fitness for purpose,' quality is defined as the fulfillment of the product or service's purpose. This purpose can be set by the customer or by the provider of the product or service. From the customer's perspective, the purpose of education is to deliver a sufficient number of graduates with the knowledge and skills required. From the provider's perspective, the purpose of education is to achieve the institution's mission and goals and guarantee customer satisfaction.

The fourth perspective referred to as 'value for money' denotes quality as compliance with efficiency and the effectiveness of education. The need for accountability when using public funds in education drives this definition of quality, resulting in the development of performance indicators to monitor efficiency and effectiveness.

Finally, the fifth perspective, so-called 'transformative,' indicates the quality of education as the value added to the students as a result of the education process, such as knowledge, abilities, and skills, as well as the students` empowerment to make decisions that affect their transformation.

However, Cheong Cheng and Ming Tam (1997) identify seven conceptual models of quality education. Some of these conceptual models share similarities with the definitions found by Harvey and Green (1993). The similarities and differences between the definitions of quality proposed by these authors are given in Table 2.

Table 2. Similarities and differences in the definition of education quality

Definition of Quality	Perspective of quality by Harvey and Green (1993)	Model of quality by Cheong Cheng and Ming Tam (1997)
Achieving high standards or excellence, by using the best resources available, producing the best outcomes, and or attaining an outstanding reputation	'Quality as exceptional'	'Goal and specification'
		'Resource-input'
		'Legitimacy model'
Conducting a process that meets specifications and assures zero defects, errors or dysfunctions	'Quality as perfection or consistency'	'Absence of problems'
		'Process model'
Fulfillment of education's purpose from the stakeholders 'perspective	'Quality as fitness for purpose'	'Satisfaction model'

Definition of Quality	Perspective of quality by Harvey and Green (1993)	Model of quality by Cheong Cheng and Ming Tam (1997)
Compliance with efficiency and effectiveness of education	'Quality as value for money'	
Value-added and empowerment	'Quality as transformation'	
The capability of the organization for innovation, adapting, and routinely changing its processes and outcomes		'Organizational model'

In a recent account, Wittek and Kvernbekk (2011) focus on the commonalities among the definitions of quality of education. One of these commonalities refers to quality as a property. This property "describes the education process, programs, products, institutions, or systems" (ibid, p. 675). This property also implicitly carries a value judgment that assesses quality in terms of opposite poles (e.g., excellent or poor quality), quantity in terms of where is located in the spectrum (e.g., low or high quality) or as a continuum of values allowing graduality in the assessment. In the latter case, quality can increase, decrease, or improve

Global institutions promoting quality education, such as UNESCO, derive the definition of education quality from the observance of education as a system and the quality of such elements. UNESCO (2004, p. 37) states that quality of education is "seen as encompassing access, teaching and learning processes, and outcomes in ways that are influenced both by context and by the range and quality of inputs available."

The elements which intervene in education systems are: (i) the learners' characteristics, such as previous knowledge, previous school experience, and socioeconomic background; (ii) the context in which education takes place, for example, the socioeconomic conditions, educational policies, and public resources available; (iii) the available resources that support the teaching-learning process; (iv) the teaching and learning process at the classroom level; and finally, (v) the outcomes, based on the educational goals and objectives at the personal or social level (UNESCO, 2004).

In the case of Honduras, a permanent member of UNESCO, it takes elements from the UNESCO definition and extends them to include the fulfillment of the education's purposes. For instance, in the Fundamental Education Act (2012), quality of education is defined as the achievement of the learning outcomes and labor market's requirements, as set by the Honduras education system's objectives. In addition, quality of education is referred to as the result of

processes which aim to improve (i) the provision of education, (ii) the conditions and ways by which students learn, and (iii) the factors affecting education.

Similarly, Article 9 of the Evaluation, Accreditation, and Certification of the Quality and Equity of Education Act of Honduras (2014, p. 5) defines the quality of education as "a comprehensive, relevant and flexible education that provides people with knowledge, skills and attitudes, appropriate for their personal development, the full exercise of citizenship and lifelong learning."

In summary, this review reveals that, although much effort has been made to define the quality of education, a clear-cut definition does not as yet exist. As suggested by Harvey and Green (1993), there is no right or wrong definition of quality of education, as it depends on the perspectives of the education stakeholders. Hence, this study can be placed in the midstream of the definitions of Harvey and Green (1993) and Cheong Cheng and Ming Tam (1997) of quality of education as the fulfillment of the education`s purpose from the stakeholders' perspective. Of the education stakeholders, this research focuses on the employers' perspective, expressed as the labor market demands on competencies. The following subsection describes these competencies in more detail.

3.2.4. Competencies

Several interpretations of the concept of competencies exist, with varying emphasis on approaches, dimensions, and context, such as those found in the work of Hoffmann (1999), Stoof et al. (2002), Le Deist and Winterton (2005), and Mulder (2017).

Hoffmann (1999, p.276) states that competency is defined as (i) "an observable performance" in a specific job, (ii) "the standard or quality of the outcome's performance," or (iii) the attributes that an individual possesses, namely knowledge and skills.

In the work of Le Deist and Winterton (2005), Stoof et al. (2016), and Mulder (2017), competencies are seen as a multidimensional concept that varies according to its context, whether human resources management, education and labor market, or professional development (Mulder, 2001). Table 3, for instance, exemplifies some of the prevailing dimensions by which the definition of competencies might be categorized.

The multitude of understanding of competencies, as presented in Table 3, supports the statement that "the rationale for the use of competencies determine the definition given to the term…[hence, it requires] to clarify the purpose of the use of competency and to define the term

within the context of that purpose" (Hoffmann, 1999, 275—282). Competencies are used as a mechanism of (i) 'personnel development,' (ii) 'performance improvement,' and (iii) determiner of an individual's employability (Mulder, 2001, p 149).

Table 3. Definition of competencies according to their prevailing dimensions

Dimensions	Le Deist and Winterton (2005)	Stoof et al. (2016)	(Mulder (2017)
Cognitive dimension Inclusion of knowledge as an integral part of competencies	X		X
Individual performance dimension Competencies as characteristics that allow an individual to perform better than others	X	X	X
Applicability dimension Competencies as characteristics relevant for a specific job, context situation or profession vs. characteristics relevant to several jobs, context situations, and professions	X	X	X
Inherent dimension Competencies as characteristics that can be either or not be measured, defined, assessed, developed, or learned		X	X

In this study, as mentioned in the conceptual framework, competencies are defined as the individual's ability to cope with complex situations using knowledge, skills, values, and attitudes in different contexts (Rychen and Sagalnik, 2001; Halász and Michel, 2011). This definition relates to the cognitive, functional, and social dimensions, as well as the individual, performativity, and dynamic nature dimensions, as illustrated in Table 3. It is in line with the definition given by the Honduras education system and the European Qualifications Framework for Lifelong Learning.

The Honduras Ministry of Education defines competencies as a set of conceptual, procedural, and attitudinal characteristics. These characteristics allow efficient performances in real-life situations, such as work, study, and full exercise of citizenship.

Similarly, the European Qualifications Framework for Lifelong Learning defines competencies as "the proven ability to use knowledge, skills and personal, social and or methodological abilities, in work or study situations and professional and personal development" (European Commission, 2008, p.11).

This study uses the term competencies in the context of education and the labor market. In the labor market, competencies are considered as the ultimate characteristics that employers seek in their current or future employees (Rodriguez et al., 2002). In the education field, competencies are among the ultimate outcomes of the educational process (van Loo and Semeijn, 2004), thus they are used as a reference for education quality (Harvey et al., 1993; Mizikaci, 2006).

Competence-based education, in this regard, is expected to "better prepare learners to function more flexibly and adaptively in their future (professional) lives" (Koenen et al., 2015, p. 2). However, its implementation in practice is demanding (Galt et al., 2012), as it requires switching the traditional methods of teaching and learning toward a more multidisciplinary, self-regulated, work-oriented learning environment. In this learning environment, the competencies identified are assessed before, during, and after the educational process (Wesselink et al., 2010).

Knowing the competencies required is useful for developing a curriculum (Hoffmann, 1999; Halász and Michel, 2011), setting and evaluating learning goals, assessing student performance, and defining the learning process (Winterton et al., 2009). Competencies are required to set national or transnational standards and qualifications within and across sectors (Méhaut and Winch, 2012; European Centre for the Development of Vocational Training et al., 2017).

Competencies are also useful to evaluate job performance; select, promote, train, and retain personnel; and identify the requirements in terms of the organizational goals, the jobs, and the tasks to be carried out to achieve these goals (Campion et al., 2011; Stone et al., 2013).

This study focuses on the employers' assessment of competencies. The rationale for choosing this approach is twofold. First, this study follows Farber and Gibbons (1996) and Bailly (2008), who state that employers' assessment of the competencies influences the value of education and new recruitments. The prospective employee's education provides initial information to employers, who perceive this education as the worker's ability. This initial perception is modified when the employers observe the worker's performance on the job and assess this performance based on this observation. This performance influences the employer's perception

of the quality of education of the employee and influences the decisions that employers make when recruiting new personnel.

Secondly, Shavelson (2010) argues that the measurement of competencies relies on real-life situations, in which an individual response to a stimulus (e.g., a task in a specific job), is observed, and during this observation, an assessment of the level of performance in the target competency, can be conducted.

3.2.5. Efficiency of Education

The vast majority of research on the efficiency of education mostly relies on Farrell's definition of efficiency as "producing as large as possible output from a given set of inputs" (Farrell, 1957, p. 254).

Farrell (1957) describes two types of efficiency technical and allocative. Technical efficiency is related to the minimum use of input to produce the maximum possible output. Allocative efficiency refers to the allocation of inputs and output, considering their price. The product of both efficiencies is the overall efficiency of an entity. An illustration of these concepts is presented and described as follows.

In Figure 2, points P and Q represent two entities using two inputs to produce one output. The isoquant SS' represents "the various combination of the two factors that a perfectly efficient" entity uses to produce an output, assuming a constant return to scale (Farrell, 1957, p. 254). A constant return to scale means that an increase in inputs creates the same proportional increase in outputs.

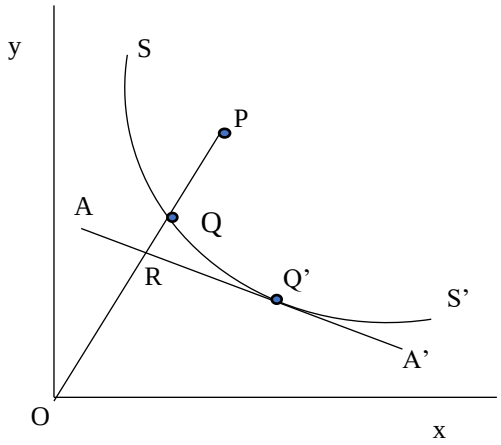

Figure 2. Technical Efficiency. Reprinted from Farrell (1957, p.254).

Both entities produce the same output, but Q uses a fraction (OQ/OP) of the same resources used by P. Conversely, Q produces "OP/OQ times as much output from the same inputs." Hence, the technical efficiency of P is the ratio of OQ/OP. This ratio takes the value of one unit for a perfectly efficient entity, and less than one as the number of input increases, meaning less technical efficiency (Farrell, 1957, p. 254).

Considering the prices within the analysis, AA' in Figure 2 illustrates the slope of the ratio of the inputs' prices, where Q' is the "optimal method of production." Q and Q' falls within the efficient production function, but Q' use a fraction OR/OQ of the costs of Q. This means that the allocative efficiency of Q is OR/OQ (ibid, p. 254).

An entity is considered efficient if it falls within the efficient part of the production function. Otherwise, it is inefficient. However, an overall efficient entity is when this entity is both technically and allocative efficient (ibid, p. 254).

In the education context, Lockheed and Hanushek (1994, p. 1779) define education efficiency as "a comparison of inputs and their related outputs." For example, an educational system is efficient when it produces more output using fewer inputs in comparison with other educational systems using similar resources.

Outputs of education are the immediate products from the educational process. They are the results of schooling based on the objectives of the educational level (Cordero-Ferrera et al., 2008). These outputs can be cognitive (e.g., students` cognitive skills) and non-cognitive (e.g., the student drop out rate) (Scheerens et al., 2011). Other examples of outputs are (i) graduation rates, (ii) the transition rate from high school to higher education, and (iii) student academic achievement (Chakraborty et al., 2001), usually measured by standardized achievement tests (Scheerens et al., 2011).

Although not exhaustively, Table 4 illustrates examples of the types of outputs used in empirical research. This shows that frequently used outputs, regardless the educational level analyzed, are students´ academic achievement and the number of graduates. At the tertiary educational level, in addition to the mentioned outputs, a further output is the number of published research articles. For a more thorough comparative analysis of empirical research on the efficiency of education and the outputs used, see the work of Witte and López-Torres (2017).

Inputs in the context of education are "*the material and immaterial pre-conditions for the core transformation process* [i.e. educational process] *…such as financial and material resources, human resources, and background conditions of the students"* (Scheerens et al, 2011, p.41). There are two types of inputs in education: controllable and non-controllable at the school level (contextual inputs). The controllable inputs are those used in the educational process and are under the management of the educational institutions. Examples of controllable inputs are (i) educational expenditure per student, (ii) classroom equipment (Scheerens et al., 2011), (iii) student—teacher ratio, and (iv) teachers' qualification (Chakraborty et al., 2001).

The non-controllable inputs are not under the control of the educational institutions. However, they influence how the institutions work and are frequently considered non-discretionary, as the educational institutions cannot choose whether to consider them in the educational process (Agasisti and Munda, 2017). Examples of non-controllable inputs are (i) ownership of the education center (private or public) (Cordero-Ferrera et al., 2008), (ii) location (rural or urban), and (iii) student's characteristics (i.e., socio-economic background) (Agasisti and Munda, 2017; Witte and Lopez-Torres, 2017).

Table 4 shows other examples of controllable (i.e., discretionary) and non-controllable (i.e., non-discretionary) inputs used in empirical studies of education efficiency. Of note in this table are examples of non-discretionary inputs related to the socioeconomic background of the students, such as parents` educational level, employment status, and income. These types of inputs, according to Witte and Lopez-Torres (2017) are the most frequently family-related, non-discretionary inputs used in education efficiency analysis, as there is some evidence that family socioeconomic background influences students` academic achievement.

Both types of inputs should be included in the analysis of efficiency in education. Failing to do so gives an incomplete picture of the factors influencing the level of efficiency as well as leading to inaccurate conclusions and recommendations to improve it (Agasisti and Munda, 2017).

Regarding the type of efficiencies, technical and allocative, provide valuable information about the functioning of educational systems. For example, technical efficiency informs about the optimal use of resources in the educational process to maximize its outputs, whereas the allocative efficiency measures how the resources acquired at the market prices are used to

produce outputs at the minimum cost. However, the analysis of allocative efficiency is used sparingly in the education context because education is a public service delivered by non-profit organizations (e.g., public schools and universities). Thus, input and output market prices are not available or are unknown (Chakraborty et al., 2001).

The next chapter provides details about the selection of the techniques used in the present research, considering the issues discussed here in this section.

Table 4. Type of inputs and outputs reported in empirical research

Level of education	Secondary education	Tertiary education	Secondary education	Tertiary education	Tertiary education	Primary education	Primary and Secondary education	Tertiary education
Output	Chakraborty, Biswas, and Lewis (2001)	Abbott & Doucouliagos (2003)	Cordero-Ferrera, Pedraja-Chaparro, and Salinas-Jimenez (2008)	Andersson, Antellius, Mansson, and Sund (2017)	Sagarra et al. (2017)	López-Torres and Prior (2016)	Ramzi, Afonso, and Ayadi, (2016)	M.A. Muñiz (2002)
Student standardized test results	X		X			X	X	X
Percentage of students who do not repeat 9th grade							X	
Number of students who passed standardized tests						X		X
Number of equivalent full-time students		X						
Number of post-graduates and undergraduates' degrees enrolled		X						
Number of postgraduate degrees conferred		X		X				
Number of undergraduates' degrees conferred.		X		X				
Number of completed credits on courses during one calendar year				X				
Bibliometric indicator (scientific publishing)				X				
Number of Scopus papers					X			
Number of graduates					X			

Level of education	Secondary education	Tertiary education	Secondary education	Tertiary education	Tertiary education	Primary education	Primary and secondary education	Tertiary education
Input	Chakraborty, Biswas, and Lewis (2001)	Abbott and Doucouliagos (2003)	Cordero-Ferrera, Pedraja-Chaparro, and Salinas-Jimenez (2008)	Andersson, Antellius, Mansson, and Sund (2017)	Sagarra, Mar-Molinero, and Agasisti (2017)	(Lopez-Torres and Prior (2016)	Ramzi, Afonso, and Ayadi, (2016)	M.A. Muniz (2002)
Student-teacher-ratio	X		X				X	X
Number of classes/100 students							X	
Percentage of teachers with an advanced degree	X							
Percentage of teachers with over 15 years' experience	X							
Percentage of students receiving subsidized lunch*	X							
Percentage of the population with a high school education	X							
Total number of academic staff		X						
Cost of the student excluding school personnel			X					X
Education spending per student							X	
Number of schools/million inhabitants							X	
Full-time equivalent graduate researchers and (or) teaching staff				X				
Full time equivalent other staff				X	X			
Number of teachers with a permanent contract						X		

Level of education	Secondary education	Tertiary education	Secondary education	Tertiary education	Tertiary education	Primary education	Primary and secondary education	Tertiary education
Input	Chakraborty, Biswas, and Lewis (2001)	Abbott and Doucouliagos (2003)	Cordero-Ferrera, Pedraja-Chaparro, and Salinas-Jimenez (2008)	Andersson, Antellius, Mansson, and Sund (2017)	Sagarra, Mar-Molinero, and Agasisti (2017)	(Lopez-Torres and Prior (2016)	Ramzi, Afonso, and Ayadi, (2016)	M.A. Muniz (2002)
Number of teachers with a temporary contract						X		
Number of undergraduate students adjusted by GPA achieved at university entrance.				X				
Number of graduate students				X	X			
Capital or tangible assets (e.g., land, machinery, buildings, etc.)				X				
Total enrollment					X			
Parents educational level						X		
Percentage of unemployed parents*						X		
Percentage of immigrant students*						X		
Percentage of students' absences during the academic year*						X		
Parents income*								X
Percentage of students who study at least 10 hours/week*								X
Percentage of students who believes that teachers and parents have higher expectancies upon the student*								X
Percentage of students who didn't change teaching center in the previous or current academic year*								X

Level of education	Secondary education	Tertiary education	Secondary education	Tertiary education	Tertiary education	Primary education	Primary and secondary education	Tertiary education
Input	Chakraborty, Biswas, and Lewis (2001)	Abbott and Doucouliagos (2003)	Cordero-Ferrera, Pedraja-Chaparro, and Salinas-Jimenez (2008)	Andersson, Antellius, Mansson, and Sund (2017)	Sagarra, Mar-Molinero, and Agasisti (2017)	(Lopez-Torres and Prior (2016)	Ramzi, Afonso, and Ayadi, (2016)	M.A. Muniz (2002)
Percentage of students who are only child*								X

Note: * Non-controllable inputs

4. Methodology

This section describes the methods employed to answer the research questions by considering the conceptual framework. Figure 3 illustrates in chronological order the process and methods employed in this research.

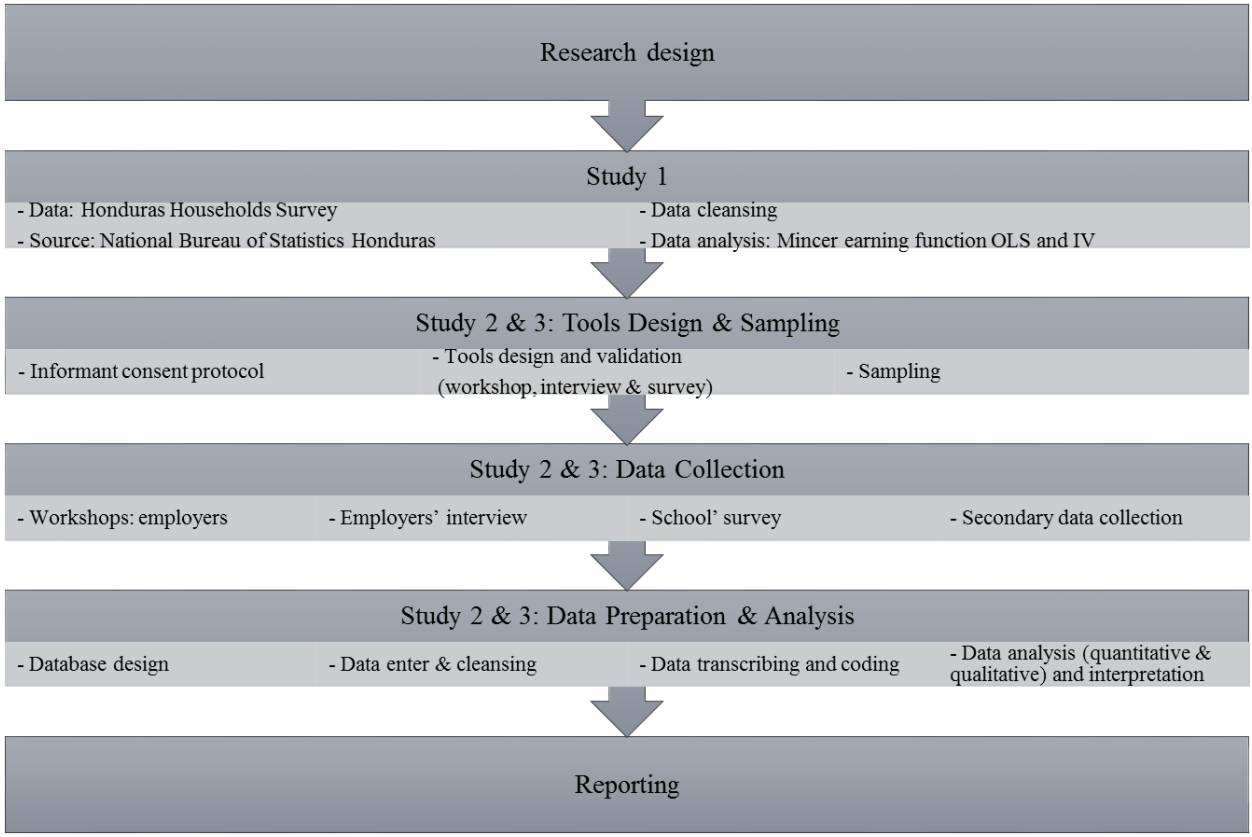

Figure 3. Research Process and Methods

The research was conducted from October 2016 to November 2019. The first phase of the research, namely, 'research design,' entailed the definition of the research problem, scope, objectives, questions, and literature review. The last phase, so-called 'reporting,' encompasses the writing of the present document.

To enhance comprehension, the following sections detail the methods employed, subdivided by study instead of presenting them in chronological order. Each section describes and justifies the methods chosen and illustrates the data sample used in this research.

4.1.Study 1: Return on Investment in Agricultural Education

4.1.1. Methods Used to Compute the Return on Investment

There are several approaches to estimate the return on investment in education, either private or social returns. Selecting one approach, however, depends on the type of data available. To estimate the social return on investment in education requires data that is not always available at the country level. Hence, this research estimates only the private return on education, which considers the individual`s earnings along with education.

Psacharopoulos and Ng (1994) describe the three approaches frequently used in empirical research as follows: (i) full discounting or elaborate, (ii) earning function, and (iii) short cut. The present research focuses on the second approach.

This approach, also known as the Mincer equation or Mincer earnings function, is the "current standard" approach (Montenegro and Patrinos, 2014). It specifies the human capital theory by regressing the logarithm of labor income (earnings) on years of schooling, potential experience, and potential experience squared. The investment in human capital here is schooling years and experience, and their coefficients are interpreted as the rate of return (Mincer, 1974). An advantage of this approach is that it does not include the cost of education in the computation of the return on investment (Boarini and Strauss, 2007), but the estimated coefficients are closely related to the marginal internal rate of return of education (Psacharopoulos and Ng, 1994).

One limitation of the Mincer earning function is that potentially omitted variables and endogenous variables can bias the estimates of return on education, as the model does not include all variables affecting the schooling decision (e.g., innate skills or ability). Two possible sources of bias, well documented in the literature on return on education, are (i) ability bias and (ii) selection bias (e.g., career choice).

If the earning function omits these sources of biases, it leads to an inaccurate estimation of the effect of education on earnings. To avoid this effect, the use of techniques such as IVs (Montenegro and Patrinos, 2014) and logit models are strongly recommended. The text below describes how these sources of biases were controlled for in the present research.

The Mincer earning function, basic and extended (Psacharopoulos and Chu Ng, 1994) with and without control variables, was used to estimate the return on investment in education.

It is given as follows:

$$lnY_i = \alpha + \beta_1 S_i + \beta_2 EX_i + \beta_3 EX_i^2 + \beta_x' X_i + \varepsilon_i \qquad (1)$$

Where Y_i is the monthly income of individual *i, S* is the number of years of schooling, *E and* E^2 express years of experience and its square, respectively. *X* is a vector of individual and labor market characteristics, such as type of employment, location of residence, sex, marital status, and educational program attended. The coefficient β_1 under strict conditions is interpreted as the rate of return on education, and ε_i is the residual.

In the extended Mincer earning function, the variable of education is decomposed into different educational levels, allowing the return on education by educational level to be computed:

$$lnY_i = \alpha + \beta_1 PRIM_i + \beta_2 SEC_i + \beta_3 UNIV_i + \beta_4 E_i + \beta_5 E_i^2 + \beta_x' X_i + \varepsilon_i \qquad (2)$$

Where PRIM, SEC, and UNIV are dummy variables that indicate if a person has completed the primary, secondary, or university level, respectively. The private return is estimated as:

$$r_{(PRIM)} = \frac{\beta_1}{S_{PRIM}} \qquad r_{(SEC)} = \frac{\beta_2 - \beta_1}{S_{SEC} - S_{PRIM}}$$

$$r_{(UNI)} = \frac{\beta_3 - \beta_2}{S_{UNI} - S_{SEC}} \qquad (3)$$

Where S_{PRIM} S_{SEC} and S_{UNIVE} denote the total number of schooling years at each level, primary education is six schooling years, 12 schooling years are assumed for secondary education, and 16 for tertiary education.

The estimates were computed fourfold. First, the estimates used as a baseline were computed by ordinary least squares (OLS). In the second fold, the two-step Heckman procedure was used to correct for sample selection bias (Heckman, 1979). Third, multinomial logit regression was used to correct for selection bias (Dubin and McFadden, 1984). Finally, the estimates were computed using the instrumental variable method to correct for the endogeneity of education, as well as adding to the equation the sample and selection biases corrections. These estimates were compared to those computed by OLS.

Using the Honduras Households` Survey (HHS) of 2016 sample, the following regressions were conducted:

$$\ln Y_i^* = \propto + S_i\delta_1 + \sigma_{12}\lambda_i + \varphi_3 p_{ij} + \beta X_i' + \varepsilon_i \qquad (4)$$

Where $X_i^{'}$ is a vector of exogenous characteristics such as the location of residence, experience, sex, education, and type of employment. The logarithm of monthly income lnY_i^* is only observed if the individual works after completing schooling. To describe if the individual works or not requires a second equation:

$$w_i^* = X_{2i}^{'}\beta_2 + \varepsilon_{2i} \qquad (5)$$

$$lnY_i^* = lnY_i, \qquad w_i = 1 \qquad if w_i^* > 0$$

$$lnY_i \quad notobserved, \qquad w_i = 0 \qquad if w_i^* \leq 0$$

The conditional expected ln of income, given that the individual is working after completing school, is given by:

$$E(lnY_i | w_i = 1) = X_{1i}^{'}\beta_1 + \sigma_{12}\frac{\phi(X_{2i}^{'}\beta_2)}{\Phi(X_{2i}^{'}\beta_2)}. \qquad (6)$$

Where $\frac{\phi(X_{2i}'\beta_2)}{\Phi(X_{2i}'\beta_2)}$ denotes the inverse Mills ratio $\lambda(X_{2i}'\beta_2)$ computed for each observation in the first step as the likelihood of working after finishing schooling. In the second stage, the individual's income is estimated using the inverse Mills ratio as a predictor in the model if it is statistically different from 0. This way, it corrects for sample selection bias.

Adapted from the work of Berger (1988), Altonji et al. (2005) and Webber (2014), a multinomial logit was estimated to correct for selection bias introduced by choosing a major in agriculture. The multinomial logit estimates the contribution of observables to an academic major's choice, conditional on completing at least high school education. It computes the probability that the outcome for an individual i is alternative, conditional on the specific case regressors x_i', as follows:

$$p_{ij} = \Pr(y_i = j) = \frac{\exp(x_i'\beta_j)}{\sum_{l=1}^{m}\exp(x_i'\beta_j)} \qquad j = 1..., m \qquad (7)$$

Where x_i' is a vector of observables such as the individual's sex, the distance to the nearest educational center offering agricultural educational programs, and the percentage of the population whose main economic activity is agriculture. These variables affect the individual's preference for the field of study of agriculture but do not directly affect the individual's earnings. For instance, distance to the nearest educational center is a proxy variable of access to the field of study and access to information about careers in agriculture.

The former variable, distance to the education center, is particular to the situation in Honduras as access to secondary and tertiary agricultural educational programs is low, especially in rural areas. Esters and Bowen (2004) find the latter variable to be one that affects the individual's choice for a major in agriculture.

The percentage of the population whose main economic activity is agriculture is a proxy variable of environmental conditions or exposure to agriculture. The environment provides an individual with information about prospective employment or business opportunities, as well as prospective salaries in agriculture. These variables, exposure to agriculture and possessing previous information about career opportunities in agriculture, are found by Dyer and Breja (2003) and Torres and Wildman (2001) to be influencing factors when choosing an agriculture major.

Regarding the bias arising from unobservable variables such as the individual's ability, IVs were used in this study. Careful selection of the IVs is required because a weak correlation with the endogenous variables in the model leads to bias estimates (Bound et al., 1995; Card, 1999).

Hence, a valid instrument must fulfill the following conditions: (i) exogeneity, meaning that it is uncorrelated with the stochastic error of the model, and (ii) relevance, meaning that the partial correlation between the instrument and the dependent variable, is different from zero (Stock, 2001).

Examples of IVs in empirical research are (i) proximity to a college (Card, 1993), (ii) school infrastructure (Duflo, 2001), (iii) month of birth, and (iv) changes in compulsory schooling laws (Leigh and Ryan, 2008).

In the present research, two IVs from natural experiments were constructed using the information available in the dataset. These variables consider recent changes in Honduran educational policies and follow the approach used by Harmon and Walker (1995). The first of these changes occurred in 2011 in the form of the compulsory school attendance law in Honduras. This increased the ceiling of compulsory schooling from the 6^{th} to the 9^{th} grade. The second instrumental variable is related to a change in the high school education policy, which, since 2008, has allowed students 20 years old or above to complete upper high school in one year instead of three.

In this case, the model is given by a two-equation system

$$lnY_i = X_i'\beta_i + S_i\delta_2 + \varepsilon_i \quad (8)$$

$$S_i = \alpha Z_i + \gamma_i$$

where $X_i^{'}$ denotes a vector of exogenous characteristics such as the location of residence, experience, sex, and type of employment. S_i denotes years of schooling. If $Cov(S_{i'}, \varepsilon_i) \neq 0$, S_i is considered an endogenous variable. To address the endogeneity of schooling, a vector of exogenous variables Z_i (instrument) that influence S_i is required. A valid instrument must fulfill the following conditions:

$$Cov(Z_{i,}\varepsilon_i) = 0 \qquad Cov(Z_i, S_i) \neq 0 \quad (9)$$

In addition, the partial correlation between Z_i and S_i must be strong, otherwise the estimates computed from IV produce inconsistent estimates and are biased in a similar manner as the OLS estimates (Bound et al., 1995).

The rationale of using these IVs from a natural experiment is that the change in education policies creates "an environment" similar to a randomized experiment (Angrist and Krueger, 2001) in which an individual is affected or not by changes in the educational policies. In this study, these changes only affected the individual income by his/her years of schooling. This study assigned more schooling years to individuals in the dataset, based only on their age, but not on their expected income, family background, or any other characteristics affecting the individual's schooling decision.

Several tests were conducted to verify that the IV chosen fulfilled the conditions (9) mentioned above. For instance, to test that schooling years is an exogenous variable, this study used the Wu—Hausman and Durbin—Wu—Hausman tests. To test for the relevance of the instruments (H_o: instruments are weak) the Shea's Partial R squared statistic, the Stock-Yogo test, and the Cragg-Donald Wald test were used. Finally, to test for the validity of the instruments (H_o: all instruments are valid) Sargan's test, Hansen's test, and Basmann's test were used.

4.1.2. Description of the Data Sample

The dataset analyzed is the HHS of 2016, collected by the Honduras National Bureau of Statistics (INE). The HHS covers 16 of the18 departments of Honduras, and it has been collected since 1990. The HHS of the 2016 sample frame was 2,104,750 households registered

in the Honduras Pre-Census 2011 of the Census 2013. The HHS 2016 sample size was 7,200 households, and it is representative at the country level and for urban and rural areas (INE, 2017).

To ensure the quality of the HHS 2016 data, the National Bureau of Statistics (INE) conducted the following activities (i) training to enumerators, supervisors, data entry clerks, and data enter auditors. (ii) No-response follow-up and adjustment due to no-response. (iii) Implementing data enter quality controls such as the double data entering and data enter audit, and (iv) data validation during and after data collection (INE, 2017). A more detailed description of the sampling, data collection, and processing can be found in the Microdata Repository of the International Labor Organization (2017).

The original HHS dataset includes 27,297 individuals without any censoring. Descriptive statistics analysis detected outliers, resulting in the exclusion of 159 observations from the analysis.

Of the 27,138 observations, approximately 9,050 individuals reported being employed or self-employed, obtaining their income by working, education, occupation, and other demographic variables. The analysis excluded those not employed or self-employed or who do not report income by working. In addition, those who work and study currently were excluded, as one of the assumptions of the Mincer's model is that schooling precedes work.

The Heckman two-step procedure corrected the data for sample selection bias. The variables included in the wage equation for the 9,050 observations included in the analysis are shown in Table S1 in the supplementary appendix.

The monthly income reported is in the official Honduran currency (Lempiras or Lps). Years of schooling are computed from the grade, and the highest education program attended. Only graduates from secondary or tertiary educational levels reported the type of educational program attended. The reference group for the location of residence is 'rural area,' 'public sector employee' is the reference for the type of employee, and for 'occupation,' the reference is a worker in elementary occupations.

Based on the sample, an employee has, on average, 6.93 years of schooling and is 38 years old. Men constitute 63.24% of the respondents, who are younger on average than women (37 vs. 39 years old, respectively), and have fewer years of education (6.50 vs. 7.66 schooling years, respectively). The average income for men is higher compared with that of women (6,151 vs. 5,479 Lps.), and this difference is statistically significant at the 5% level.

Approximately 31.46% of the workers in the sample did not complete any educational level. In the economic activity of agriculture, this percentage increases to 57% of the workers. In both cases, those who did not complete any educational level earn the lowest income compared to their peers who attained at least one educational level (see table 5).

Table 5. Average income by educational level and economic activity

Educational level	Monthly Income (Lps)					
	All economic activities*			Economic activity: Agriculture*		
	n	Mean	Std. Dev	n	Mean	Std. Dev
No educational level	31.46%	3,459	3,878	56.88%	2,596	3,870
Primary	35.04%	4,764	5,252	34.81%	3,317	6,927
Lower high	8.84%	5,752	4,499	3.90%	2,881	3,601
Upper high	18.56%	7,983	5,981	3.99%	4,807	4,852
Tertiary	0.24%	18,966	15,096	0.41%	18,613	22,751

*The economic activities follow the International Standard Industrial Classification of all Economic Activities-ISIC, Revision 4, 2008.
Source: Own calculation

4.2.Study 2: Quality of Education from the Employer`s Perspective

4.2.1. Methods Used to Assess Competencies

To assess the competencies acquired, the individual needs to perform them in a specific context (e.g., the workplace). In addition, the assessment method should consider the interlinked combination of knowledge, skills, values, and attributes (Shavelson, 2010). Among the types of assessment are self-assessment and external assessment. The former is conducted by the individual who developed or acquired the competencies, whereas the latter is conducted by employers or teachers.

Among the methods used to identify the competencies required is “needs assessment.” Kaufman and English (1979) define needs assessment as a systematic process that identifies the gaps between the results achieved (e.g., competencies required) and the results expected (e.g., competencies acquired); organizing the gaps according to their priorities and choosing those which require immediate action.

The empirical work of Martensen and Grønholdt (2009) and the model of needs assessment for follow-up studies proposed by Borich (1980) constitute the basis for the assessment of the competencies in this study.

Borich (1980) bases his model of need assessment on a discrepancy analysis between "what" competencies the trainee or graduate possesses, and "what" competencies they should possess after a training process. The difference between these situations becomes an efficiency index of the training program, showing the elements to improve. The model is implemented in five steps as follows. First, the competencies of the training program are listed. Then, each of these competencies is self-assessed by its level of importance and performance, using a 5-point scale with no neutral point and a starting value of 1. Subsequently, the competencies are ranked based on the discrepancy index computed. Finally, the training program is compared and revised.

Like the Borich (1980) model, the approach of Martensen and Grønholdt (2009) is to list the competencies and subsequently survey the level of importance of the competencies listed with respect the tasks that should conduct and the level of performance of the competencies listed when conducting the tasks. A difference between these models is the computation of the discrepancy index. Martensen and Grønholdt (2009) do not compute this index but the average importance and average performance for each one of the competencies. They build a competencies matrix on a so-called strategic group map, where the origin is the interception between the average level of performance (y-axis) and importance (x-axis), as illustrated in Figure 4.

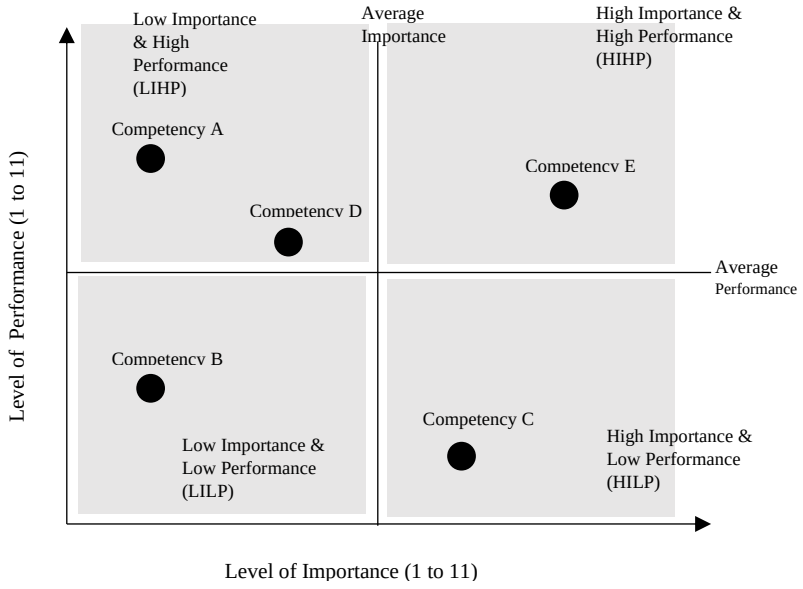

Figure 4. Matrix of Competencies. Adapted from Martensen & Grønholdt (2009).

Each competency is placed in this matrix based on its level of importance and performance. Those competencies above the average level of importance are considered highly important, and those above the average level of performance are considered with high performance. Conversely, those below the average level of importance or performance are considered low importance and low performance, respectively.

Finally, four groups of strategic competencies or groups emerge low importance and low performance (LILP), low importance and high performance (LIHP), high importance and high performance (HIHP), and high importance and low performance (HILP). The latter group is a priority group that requires immediate improvement.

According to Martensen and Grønholdt (2009), visualizing the results in this manner enable, as in this study, better management of the competencies that need improvement based on its strategic importance.

This study combined the methodologies used by Borich (1980) and Martensen and Grønholdt (2009), considering a mixed-methods research approach, conducted in three steps described as follows. First, the graduate competencies to be assessed were identified by analyzing the academic curriculum of agricultural educational programs at the secondary and tertiary educational levels, as provided by private and public educational institutions in Honduras. Other criteria were (i) that the educational program has at least one group of graduate students and (ii) that it is an officially approved program.

The Government of Honduras-Central Bank has published the list of universities, educational programs, and the number of graduates since 2000 (see Central Bank, 2018). The agricultural educational programs included in this study were chosen from the list published in 2016 (Central Bank, 2016). The Council of Higher Education later corroborated this preliminary list. This latter entity is the official entity responsible for tertiary education in Honduras. As for the education programs at the secondary educational level, a preliminary list was retrieved from the official web page of the Ministry of Education and later validated by the Directorate of High School Education at the Ministry of Education.

Of the 22 agricultural education programs offered by high schools and universities in Honduras in 2016, 20 complied with the criteria mentioned, but only 16 were accessible to the researcher, hence, they were included in this research. The four educational programs not accessible were programs at the university level. The list of educational programs is shown in Table S2 in the Appendices.

The method of analysis was summative content analysis (Hsieh and Shannon, 2005). Data from the academic curricula were coded in a two-cycle process using a deductive approach, computed assisted by NVivo® software. The methods chosen for coding were preliminary, structural, and descriptive coding in the first cycle and domain and taxonomic coding in the second cycle, as described by Saldaña (2015). During the second coding cycle, special attention was paid to the competency statement as written in the academic curricula because, as Gottipati and Shankararaman (2018, p.43) point out, these statements are "verbose in nature, and often multiple competencies are combined into a single statement."

In the absence of a written competency statement in the academic curriculum, a statement of competencies was reproduced during the second coding cycle. The procedure followed was based on Sanghi (2016) and considered the graduate's knowledge, skills, and attitudes which they are expected to obtain by the end of their qualification.

For instance, a typical statement of a technical competency found in these curricula takes the following form:

> "Select and process a product of animal or vegetable origin, complying with the quality and safety standards to meet consumer demands, maintaining a balance with the environment, and considering personal safety measures." (High School Program in Agricultural Development)

This statement was associated in this study to four competencies described as follows:

- Plan, organize, manage, control, and implement the processing of agricultural products
- Plan, organize, direct, control, evaluate, and implement processes for compliance with quality and safety standards
- Investigate and consider market needs in terms of supply and demand (local, national, and international)
- Evaluate and implement measures that reduce environmental impact

The second step was to develop a semi-structured questionnaire and a workshop plan, both to collect data. These instruments requested information about (i) the jobs and tasks carried out by graduates, and (ii) to identify and select only the competencies required to perform these tasks from the list of competencies, as stated in the academic curricula. Both instruments assessed the perceived level of importance of the competency, and the perceived level of the graduates' performance in each one of the competencies selected.

For the measurement of the perceived level of importance, this study used a scale from 1 to 11, where 1 depicts low importance and 11 high importance. A similar scale was used to measure the perceived level of performance, where 1 depicts low performance and 11 high performance. The aim of using an 11-point scale was to increase the variability of the respondent's response. This scale also considers the unidimensional and univocal measure of the competencies assessed (Hodge and Gillespie, 2007; Leung, 2011).

The unit of analysis was the employer (i.e., enterprise or organization) who hires the graduates and belongs to one of the following four agricultural value chains: cocoa, coffee, fruit & vegetables, and meat & dairy. Using the value chain approach (Porter, 1998; Kaplinsky, 2004) enables all stakeholders' type and the diversity of businesses operating in this sector to be covered. Therefore, employers represented in this study were: input suppliers, producers, local traders/retailers, and wholesalers, in addition to food processors, exporters, financial services, and providers of technical advisory services.

The Honduras Bureau of Statistics reports 149,345 commercial entities operating in 2015. Of them, 7,831 entities operate in the agri-food sector (INE, 2018). This list does not specify the agricultural value chain and the type of value chain' stakeholder. In addition, no contact information for these entities can be provided by the Honduras Bureau of Statistics because of the institution`s data protection policy.

The sampling frame of this study was (i) the public list of entities registered at the Ministry of Agriculture as a business or organizations operating or supporting the value chains chosen and (ii) the list of agri-business and organizations registered in AGROMERCADOS, which is the largest agri-food trade fair in Honduras, co-organized by the Ministry of Agriculture. These registers record the following information: description of the value chain, geographical ubication, and the contact information of the entities operating in these value chains.

The participants in this study were selected from this sampling frame. The sampling strategy used was purposeful sampling, maximum variation. This strategy allowed for the inclusion of all types of stakeholders operating in the value chains analyzed. It also ensured the study "get variation" on the competencies needed, "document diversity," and "identify important common patterns that are common across the diversity" of competencies, employers, jobs, and tasks carried out by agricultural graduates (Patton, 2015, p. 267).

The total number of employers consulted was 71, which meets the recommendation by Morse (2015) for this type of study. The data collection method was face-to-face interviews and workshops beginning with three workshops at three different geographical locations, namely, the central, north, and western regions of Honduras. The locations were chosen based on the number of employers of the agricultural value chains located in the region. A total of 79 employers were invited to the workshops. A printed and electronic invitation was sent 15 days prior to the workshop. It was followed by a telephone confirmation five days prior to it. This procedure is 'business as usual' in the Honduran context.

Of the 79 employers invited, only 22 attended the workshops, which was insufficient to reach the data saturation point as required for this study. Because of this, face-to-face interviews were conducted with employers who did not attend the workshops.

After the workshops, the employers who did not attend were once again reached by telephone. Among the reasons for not attending the workshops were: (i) the duration of the workshops was too long (approximately 6 hours), (ii) the date of the workshop conflicted with the employer schedule, and (iii) there was no interest in participating in the study. Those employers willing to participate were asked to be interviewed within six weeks after the workshop, additional 49 employers were visited at their location of convenience to conduct a face-to-face interview. This brought the total number of respondents to 71.

The respondents in the workshops and interviews were supervisors, human resource personnel, or managers of the agricultural education graduates. The data collection ceased when no new information was added in the next case (Guest et al., 2016)

During the third step, the interviews and workshops were transcribed verbatim and analyzed. The method of analysis was summative content analysis. The data were coded in three cycles using NVivo® software. The method used was preliminary and structural coding in the first cycle, evaluation in the second cycle, and pattern coding in the third cycle as described by Saldana (2015); helped by the discrepancy analysis by Borich (1980) and the strategic group mapping as described by Martensen and Grønholdt (2009).

4.2.2. Description of the Data Sample

This study analyzed 16 agricultural educational programs provided at the secondary and tertiary educational levels. The duration of the educational programs ranges from two to five academic years, provided mostly by public educational centers (Table 6).

Table 6. Academic curriculum by educational level, degree, duration, and type of institution

Educational level	ISCED* classification	Degree	Duration (years)	Type of institution	
				Public	Private
Secondary	Level 3	High school	3	3	0
Tertiary	Level 5	Higher technical education	2	4	0
Tertiary	Level 6	Bachelor or equivalent	4-5	7	2
			Total	14	2

Note: * 2011 International Standard Classification of Education - ISCED

Source: Own calculation

This study elicited a sample of 71 employers. The sectors of the employers' enterprises are private profit-oriented, private non-profit oriented (e.g., NGOs, associations), and public (e.g., agencies of the Ministry of Agriculture). Private profit-oriented enterprises are at each level of the value chain and most employ less than five agricultural graduates (Table 7).

Table 7. Employer by sector and number of graduates employed

Level of value chain	Employers by type of sector			Employers by number of graduates employed		
	Private-profit oriented	Private-no profit oriented	Public	Less than 5	Between 5 and 10	More than 10
Input supplier	8	0	0	5	2	1
Producers	13	0	0	9	2	2
Food processing	10	0	0	8	1	1
Retailer/wholesaler	6	0	0	3	2	1
Exporter	7	0	0	3	4	0
Financial services provider	4	0	1	2	2	1
Technical advisory services provider	4	10	8	4	9	9
Total	52	10	9	34	22	15

Source: Own calculation

Enterprises providing technical advisory services work in the private and public sectors, such as associations, foundations, or non-governmental organizations in the private sector, and governmental institutions in the public sector.

The 71 employers elicited assessed 197 job positions and tasks, performed by agricultural graduates employed in these job positions. The job positions were related to the following occupations: managers, professionals, technicians and associated professionals, and sales workers. Table 8 shows examples of the job positions assessed in this study.

Table 8. Jobs assessed by occupation

Occupations	Number of jobs positions assessed	Job positions examples
Managers	35	Production manager, Marketing manager, Program director.
Professionals	96	Soil scientist, Agricultural adviser, Production supervisor, Technical sales representative.
Technicians and associate professionals	56	Research assistance, Agricultural inspector, Agricultural value and loss assessors, Field crop technician, Food quality & safety inspector.
Sales workers	10	Salesperson or shopkeeper at pesticide or machinery retail shop, Farm to farm sales person.
TOTAL	197	

Source: Own calculation

4.3.Study 3: Efficiency of Agricultural Education

4.3.1. Methods Used to Compute Efficiency

The literature provides two-strands of methods to measure efficiency. Both estimate the production function (also called production frontier) and the level of efficiency (Witte and López-Torres, 2017). One strand is parametric, such as the stochastic frontier model proposed by Aigner et al. (1977). The second strand is non-parametric, such as the data envelopment analysis (DEA) proposed by Charnes et al. (1978).

In the context of education, the educational process produces multiple outputs. Hence, it is suggested that efficiency should be computed by using a non-parametric approach (Chakraborty et al., 2001), such as in the case of DEA. Additional advantages of using DEA are (i) the production function is estimated from the data analyzed, and (ii) there are no previous assumptions either about the functional form (Chakraborty et al., 2001) nor the distribution of the stochastic error (Abbott and Doucouliagos, 2003). Consequently, there are no restrictions that impose a careful interpretation of the results when the assumptions do not hold, such as the case of the parametric methods.

Consequently, the present study used Data Envelopment Analysis (DEA) to estimate the efficiency of agricultural education. DEA initially developed by Charnes et al. (1978, p. 429) is a nonlinear mathematics program model designed to evaluate the efficiency of public programs. These programs are a set of "decision-making units (DMU) using common inputs and outputs…" (Charnes et al., 1978, p.430). In this study, a high school education center is considered a DMU. The "measure of the efficiency of each DMU is obtained as the maximum of the ratio of weighted outputs to weighted inputs subject to the condition that the similar ratio for every DMU is less than or equal to unity" (ibid, p. 430).

Before performing a DEA analysis, it is necessary to consider four aspects to avoid possible drawbacks. First, the DMUs must be homogenous, in the sense that all DMU should use the same combinations of inputs and outputs and operate in similar environments. Second, to improve the level of discrimination between efficient and inefficient DMUs, the number of units to be analyzed should be at least twice the product of the number of inputs and outputs. Third, the scale of measurement of inputs and outputs should be of the same kind to reduce the misinterpretation of the efficiency estimates. Finally, the orientation of the model chosen should depend on the purpose of the analysis (Dyson et al., 2001; Cook et al., 2014).

Two orientations of the model exist, input-oriented or output-oriented. It is more reasonable to use an input-oriented model of DEA when the purpose of the analysis is to reduce input overuse. In contrast, when the analysis aims to increase outputs from specific amounts of input, an output-oriented model is preferred. In the case of education, when the aim is to improve student academic achievement, the output-oriented DEA model is more appropriate (Cook et al., 2014). Therefore, this latter model was used in this study.

This study performed an efficiency analysis only of public institutions because private agricultural education serving institutions were unwilling to participate in this study, and it is focused on the secondary educational level.

The rationale for this is manifold. First, DMUs at the secondary educational level are homogenous, in the sense that the inputs used, the outputs produced, and the context in which they operate are the same. At the tertiary educational level, only two public universities offer agricultural educational programs, namely, The Honduras National Autonomous University (UNAH) and The National University of Agriculture (UNA).

The UNAH has several campuses located in different geographical regions in Honduras. Despite its varied locations, they operate under a centralized DMU that supervises the operation and allocate the resources in a centralized manner.

Second, since 2016, the Honduras Council of Higher Education approved an external audit of the UNA. Consequently, several internal changes are in progress, affecting the organizational and the decision-making structures, the curriculum of the educational programs offered, and the resources allocation, among other changes.

Considering these circumstances, the DMUs operating at the tertiary educational level are hardly comparable. Consequently, only the secondary education level is included in this study.

Table 9 below shows the main inputs and outputs considered for the analysis of efficiency and their source of information. The number of inputs and outputs to compute the efficiency follows the recommendation of Cook et al. (2014) to achieve a higher degree of discrimination.

Table 9. Variables: Description and source of information

Type	Code	Description	Source of information
Input controllable	In_Tea	Full-time teacher equivalent of agricultural educational programs, from 2014 to 2016	Survey at school level
	In_PuEx	Public expenditure from 2014 to 2016	Ministry of Finance (Source: Annual report 2014 to 2016). Ministry of Education (Database: SACE enrollment)
	In_PrEx	Private expenditure from 2014 to 2016	Survey at school level

Type	Code	Description	Source of information
	In_Inf	Percentage of school infrastructure required to operate (e.g., access to water, sanitation, electricity, etc.)	Ministry of Education, Master plan of school infrastructure (Database: SIPLIE 2015)
Input non-controlable	In_NBI	Percentage of households with three or more unmet basic needs (access to water and sanitation, crowded condition, education, income, etc.), at the municipal level	National Bureau of Statistics (Database: Census 2013)
	In_HE	Percentage of the population with university education, at the municipality level	National Bureau of Statistics (Database: Census 2013)
	In_Ag	Percentage of the population whose main occupation is agriculture, at the municipality level	National Bureau of Statistics (Database: Census 2013)
Outputs	Ou_TS	Average pre-university standardized test score 2014 to 2016	Ministry of Education, Directorate of Curriculum and Evaluation (Database: Assessment of Secondary Education 2014-2016)
	Ou_Gr	Total number of graduate students from agricultural education programs, from 2014 to 2016	Survey at the school level

As illustrated in Table 9, primary and secondary information were collected. The provider of the information at the school level were school principals, administrative staff, and teacher coordinators. The data collection method was face to face interview.

The total schools surveyed was 20, corresponding to 16.26% of the total number of public high schools, providing agricultural education in Honduras, from 2014 to 2016. These 20 high schools were randomly chosen by the Ministry of Education to participate in the standardized pre-university student assessment in the period of 2014 to 2016. Of the remaining schools, the information regarding student academic achievement was computed using their assessment, therefore, producing non-comparable results.

The survey elicited information about budget and expenditures, graduate students, staff, and infrastructure. The expenditures elicited were private and public expenditures related to agricultural educational programs, provided by the school.

Private expenditures were activities funded by parents' economic contributions, donations, and other fundraising activities conducted at the school level. Public expenditures included school staff salaries. Information elicited about the graduate students and staff included the number of graduates by sex and educational program, the number and type of teachers, teachers' workload, and qualifications. The information gathered at the school level was compared to officially disclosed secondary information. The analysis included only information with supporting evidence.

The analysis excluded four of the 20 high schools because of the following reasons: One is a semi-private institution; two have only recently launched the agricultural educational program, thus, the student academic achievement reported corresponded to the other educational programs offered in these schools; and one school presented security and financial reasons that precluded a visit.

The analysis was conducted using the statistical package STATA version 15. Of the models available for the analysis, the two-stage model, output-oriented, and variable return to scale were chosen. The two-stage model is, by far, one of the most employed models in DEA analysis in education (Afonso and St. Aubyn, 2006) partly due to its simplicity in incorporating controllable and non-controllable inputs.

For example, in the first stage, the efficiency level was estimated using only controllable inputs. The efficiency level, considering an output-orientation, was estimated as follows (Cordero-Ferrera et al., 2008, p. 1325):

$$\max \quad \phi + \varepsilon \sum_{i=1}^{m} s_i^- + \sum_{r=1}^{s} s_r^+$$

$$\text{s. a.} \quad \sum_{j=1}^{n} x_{ij}\lambda_j + s_i^- = x_{i0} \qquad i = 1,2,\dots,m$$

$$\sum_{j=1}^{n} y_{rj}\lambda_j - s_r^+ = \phi y_{r0} \quad r = 1,2,\dots,s$$

$$\lambda_j \geq 0;\ s_r^+ \geq 0;\ s_i^- \geq 0 \ \ j = 1,2,\dots,n$$

Where ϕ is the efficiency score, ϵ is an infinitesimal non Archimedean, λi are the weightings and s_i^- s_r^+ are the inputs slacks and outputs slacks, respectively.

In the second stage, the efficiency level was adjusted by regressing the efficiency scores to non-controllable inputs (Cordero-Ferrera et al., 2008, p. 1327). The model is given as follows:

$$\phi_j = f(Z_j, \beta_j) + u_j$$

Where ϕ_j is the initial efficiency score, Z_j are the non-controllable inputs, β_j are the estimates of efficiency, and u_j are exogenous factors or error terms.

The two-stage DEA model provides more discriminatory power as the non-controllable inputs are included in the second stage. In this stage, the aim was to analyze the effect of the non-discretionary variable on the DEA efficiency coefficients. However, this effect only explains the differences between the coefficients; it does not correct them. (Cordero-Ferrera et al. 2008). In addition, it produced bias estimators, thus inadequate interpretations. This is because the estimates of efficiency are serially correlated, and the non-controllable inputs are correlated to the error term.

Additional disadvantages of the DEA are the absence of measures of fit that determine how the model fits the data (e.g., R^2 in the linear regression model) and the deterministic nature of this method (not affected by randomness). Therefore, it is not possible to make inferences from the sample data to the population (Andersson et al., 2017)

Extending the conventional DEA analysis is a method to overcome these disadvantages. For instance, the use of bootstrapping to determinate the sampling properties of DEA estimators, correcting for the bias affecting DEA, and setting confidence intervals (Simar and Wilson, 2000; Andersson et al., 2017).

In this study, the procedure followed in computing the estimate used DEA in two-stages and bootstrapping of the estimates, as suggested by Simar and Wilson (2007, p. 46). The bootstrapping was conducted in two loops. The first used 1500 bootstrap replications to compute the bias-corrected efficiency estimates ($L_1 = 1500$). The second one, 2000 bootstrap replications, was applied to the truncated regression model.

4.3.2. Description of the Data Sample

The dataset analyzed comprised 16 decision management units (DMU). Each DMU stands for a high school center serving agricultural education in the academic years 2014—2016. These 16 high schools represent 13% of the total public high school centers providing this program in Honduras.

From 2014—2016, senior students from these 16 schools took the pre-university standardized test. This test measures the student's readiness for university and allows the relative student academic performance to be compared among these educational centers. Four areas are evaluated in this test Math, Spanish (Language), Natural Sciences, and Social Sciences. The test scale is from 0 to 100, where a score of 69 or less, is a failure.

Table 10 summarizes the descriptive statistics of the outputs and inputs variables used to compute the efficiency scores. Two output variables are included in the analysis, namely, the number of graduates from agricultural education programs and the average pre-university test score. The results in Table 10 show that students´ academic performance is, on average, low. The school with the best performance in this dataset, achieved on average, a score (48 points out of 100), which is lower than the minimum expected to pass the test (70 points out of 100 in the pre-university test).

Table 10. Descriptive statistics of inputs and outputs variable

Variable	Obs	Mean	Std. Dev.	Min	Max
Full time equivalent teacher	16	28.59	33.13	7	144
Public expenditure	16	4,007,974	2,828,383	1,583,348	13,200,000
Private expenditure	16	532,650	916,230	87,000	3,768,894
School infraestructure	16	62.03	20.39	13.75	95
Households with three or more unsatisfied basic needs	16	18.10	6.65	9.29	29.41
Population with university education	16	2.15	1.06	0.36	4.3
Population whose main occupation is agriculture	16	51.20	15.45	31.07	78.18

Variable	Obs	Mean	Std. Dev.	Min	Max
Pre-university test score	16	37.69	5.47	29	48
Graduate students from agricultural education programs	16	92.94	75.67	27	336

Source: Own calculation

The inputs are full-time equivalent teachers, private and public expenditures, and school infrastructure. Public and private expenditures are in the official Honduran currency (Lempiras). On average, a school in this sample employs 28 full-time equivalent teachers and possesses approximately 62% of the necessary infrastructure to operate. Among the basic infrastructure are electricity, furniture and equipment, drinking water, and sewerage facilities.

The inputs, non-controllable at the school level, are the population's education and occupation, and households with three or more unmet basic needs. These households are deprived of basic needs such as housing conditions (overcrowding), housing characteristics (construction materials), sanitation, primary education, and level of economic dependency. Therefore, this is a proxy indicator of poverty at the household level. Households with three or more unmet needs are considered poor or extremely poor households.

Based on the results shown in Table 10, on average, a school in this sample is located in a municipality where a significant share of the households are deprived of basic needs (on average, 18% of the population compared to 3% at the national level). A low percentage of the population, at the municipal level, attained a university degree (2.15%). Furthermore, a significant share of its population works in the economic activity of agriculture (approx. 51%).

The non-controllable inputs are conditioning factors influencing the school's level of efficiency. To illustrate, it is expected that schools located in municipalities whose households meet their basic needs can invest more resources (e.g., income, time) in education. In addition, schools located in municipalities where the main population's occupation is agriculture, will motivate students to complete their educational program due to the awareness of the employment or entrepreneurial opportunities available in agriculture. The degree of influence of these aspects on the efficiency score is presented further in Chapter 5.

5. Results

Following the research questions of this research, this section is organized into three sub-sections. The first presents the results of the analysis of the return to investment in agricultural education, by educational level, program, and economic activity. The second sub-section focuses on the assessment of the graduates' competencies as a mechanism for assessing the quality of agricultural education programs. Finally, the third sub-section provides the level of efficiency and the contextual factors affecting the efficiency of agricultural educational centers. Each sub-section includes a summary that highlights the main findings.

5.1.Study 1: Return on Investment in Agricultural Education

This sub-section is subdivided into three parts. The first describes the agricultural graduates' characteristics as a frame of the analysis of the return on investment in education. The return on investment of education is presented in the second part. It is computed regardless of the educational programs used as a comparison of the return on agricultural education. The third part presents the results of the analysis of the return on investment in agricultural education. First, regardless of the educational level, and then differentiated by educational level.

5.1.1. Characteristics of Agricultural Graduates

As previously stated, agricultural education in Honduras is provided at the upper-secondary and tertiary educational levels. In the data analyzed, only 2.06% of the graduates from these educational levels completed an agricultural education program and are reported as having employment. However, these graduates work mostly in non- agricultural economic activities such as public administration, wholesale and retail trade, and manufacturing.

Only 13.04% of the agriculture graduates work in the economic activity of agriculture, forestry, and fishing. This economic activity entails jobs in the production of crops and animal products, fishing, post-harvest activities, support activities such as pest control and field preparation, and product preparation for primary markets. This economic activity excludes processing venues such as food and beverage manufacturing, and marketing venues such as those engaged in by buyers and sellers.

The main occupations of agricultural graduates are technicians, services and sales workers, and professionals. The occupations differ based on the educational level attained. For instance, individuals whose occupation is "professionals" conduct tasks requiring skills usually acquired at the tertiary educational level or by extensive training at the workplace. Table 11 summarizes the percentage of agricultural graduates by occupation and educational level.

Table 11. Occupation of agricultural graduates by educational level

Occupations		Educational level		Economic activity		Total
		Upper High School	University	Agriculture	Non-agriculture	
All occupations		47.83	52.17	13.04	86.96	100
*By occupation**						
Ocup1	Managers	0.00	20.83	16.67	10.00	10.87
Ocup2	Professionals	9.09	25.00	0.00	20.00	17.39
Ocup3	Technicians and associate professionals	22.73	33.33	16.67	30.00	28.26
Ocup4	Clerical support workers	0.00	0.00	0.00	0.00	0.00
Ocup5	Services and sales workers	31.82	8.33	0.00	22.50	19.56
Ocup6	Skilled agricultural, forestry and fishery workers	9.09	8.33	66.67	0.00	8.70
Ocup7	Craft and related trades workers	9.09	0.00	0.00	5.00	4.35
Ocup8	Plant and machine operators, and assemblers	18.18	0.00	0.00	10.00	8.70
Ocup9	Elementary occupation	0.00	4.17	0.00	2.50	2.17
Ocup10	Armed forces occupations	0.00	0.00	0.00	0.00	0.00
Ocup0	Unspecified occupation	0.00	0.00	0.00	0.00	0.00
Total by occupation		100.00	100.00	100.00	100.00	100.00

Note: *Occupations follow the International Standard Classification of Occupations ISCO-08 by ILO
Source: Own calculation

For income by occupation, Table 12 shows a significant difference between those who graduate from an agricultural education program and remain as farmers, compared to those who have the same occupation but do not graduate from this program. The difference suggests that might exist a positive return to the knowledge and skills that agricultural graduates possess.

In addition, in those occupations in which an individual earns the highest income (managers and professionals), there is no additional gain from graduating from an agricultural education program.

The occupation of "skilled agricultural, forestry and fishery workers" (Ocup6), entails market-oriented and subsistence farmers and fishers. Agricultural, fishery, and forestry laborers carrying out low skill and simple tasks belong to the category of "elementary occupation" (Ocup9). The level of education expected for occupations in Ocup6 and Ocup9 is high school and primary education, respectively.

As to agricultural graduates in Ocup9, it might indicate a misallocation of these graduates in the labor market. As noted in Table 11, agricultural graduates performing elementary tasks in Ocup9 are mainly graduates at the university level. However, the expected level of education for occupations in this group is primary education.

Table 12. Income by occupation: agriculture and non-agriculture graduates

Occupations		Monthly income (Lps.)				
		Graduate Agriculture Mean	Graduate Non-Agriculture Mean	U	Sample size	Pr > |z|
Ocup1	Managers	18,084	17,100	441.3	182	0.45
Ocup2	Professionals	27,175	18,240	1,268	329	0.51
Ocup3	Technicians and associate professionals	16,373	12,130	2,196.5	393	0.23
Ocup4	Clerical support workers	-	10,240	-	-	-
Ocup5	Services and sales workers	6,289	7,207	1,576.5	503	0.35
Ocup6	Skilled agricultural, forestry and fishery workers	26,007	5,019	70.5	63	0.03
Ocup7	Craft and related trade workers	1,870	6,685	-59.5	253	0.07
Ocup8	Plant and machine operators and assemblers	13,625	7,655	196.5	106	0.33
Ocup9	Elementary occupations	25,000	4,961	80.5	163	0.08
Ocup10	Armed forced occupations	-	17,833	-	-	-
Ocup0	Unspecified occupations	-	16,444	-	-	-

Note: Wilcoxon-Mann-Whitney test. Ho: an individual who graduates from a non-agri-food program will earn more than an individual who graduates from an agri-food program. Includes only upper high school and tertiary educational level. Source: Own calculation

5.1.2. Return on Investment in Education

The following paragraphs present the return on investment in education regardless of the educational level and program.

Table 13 compares the return on schooling based on the estimates computed using OLS, the two-step Heckman procedure for correcting sample selection bias, and IVs for correcting endogeneity of schooling.

All coefficients are similar in magnitude and significance, irrespective of the method used to compute these estimates. The sign of the coefficients is consistent with the current literature on return on schooling. The coefficient of the inverse Mills ratio (λ) suggests its inclusion is necessary to avoid sample selection bias. Its sign implies that the OLS produced downward bias estimates, as individuals who only work and earn income by working are more likely to earn a higher income. The results of the Wu—Hausman and Durbin—Wu—Hausman tests confirm that schooling is an endogenous variable, and the IVs chosen suffices the conditions for a valid IV, based on the tests conducted for the relevance and exogeneity of the instruments.

Table 13. Rate of return: OLS and IV estimates corrected for sample selection bias (robust error standard)

Explanatory variables	Log of monthly income	
	OLS	IV
Years of schooling	0.129*** (0.002)	0.137*** (0.007)
Experience	0.042*** (0.002)	0.038*** (0.003)
Experience squared	-0.000*** (0.000)	-0.000*** (0.000)
Λ		-0.269*** (0.043)
Constant	6. 691*** (0.039)	6.462*** (0.061)
R-squared	0.228	0.235
Number of observations	9,050	9,050
Test for endogeneity of schooling		
Wu—Hausman F test	-	11.57***

Explanatory variables	Log of monthly income	
	OLS	IV
Durbin—Wu—Hausman Chi squared test	-	11.56***
Test for relevance of the instrument		
Partial R—squared	-	0.182
F statistic joint significance of the instruments	-	1277.63***
Cragg—Donald Wald F statistic	-	1004.22
Stock —Yogo F statistic test critical values 10% maximal IV relative bias	-	19.93
Test for instrument exogeneity		
Hansen J statistic Chi squared test p-value	-	0.281
Sargan Chi squared test p-value	-	0.288
Basmann Chi squared test p-value	-	0.288

Note: Robust standard error in parentheses. *** = significant at 1% level.
Source: Own calculation

The magnitude of R-squared is consistent with the expected range indicated by Card (1999) when using the Mincer earning function. Card (1999) indicates that the variables included in this model explain between 20%—35% of the variation.

The straightforward interpretation of the schooling estimates from Table 13 shows that, on average, the private return on one additional year of education computed using OLS is 12.96%, with a 95% interval spanning 12.47%—13.45%. This rate of return is similar to the average return estimated by Montenegro and Harry Patrinos (2014) as 12.4% using OLS and 2011 Honduran HHS data.

Nevertheless, considering that the null hypothesis of no selectivity bias is rejected, and the inverse Mill ratio is negative, the OLS estimates are considered downwardly biased, thus resulting in a lower estimate of schooling using the Heckman two-step procedure. The IV estimates are corrected for sample selection bias and the endogeneity of schooling.

The tests conducted demonstrate that the instrumental variables were validly chosen. Consequently, the estimates computed using this method are expected to be consistent. By this latter method, the average private return on one additional year of education is estimated to be 13.64 %, with a 95% confidence interval spanning 12.33%—15.03%, regardless of the educational level attained.

5.1.3. Return on Investment in Education by Educational Level

Table 14 shows the estimates computed using the OLS or the Heckman two-step procedure. The results indicate an upward bias in the OLS estimates as the inverse Mills ratio is negative. Therefore, the return to education is computed using the Heckman estimates and the formula (3) proposed by Psacharopoulos and Chu Ng (1994)

An analysis of the fourth column in Table 14 reveals that an individual who completes primary education earns 6.09% more income than an individual who does not complete any educational level. The highest return is observed in those individuals who graduated from university. Those who complete the tertiary educational level earn 21.82% more income than those who complete the upper secondary educational level. Moreover, these latter graduates earn 8.37% more income than graduates who complete the lower secondary education level.

Table 14. Rate of return on investment by level of education: OLS and Heckman estimates (robust standard error)

Explanatory variables	Log of monthly income		Rate of return [a]
	OLS	Heckman	
Primary education	0.363*** (0.029)	0.365*** (0.028)	6.09
Lower secondary	0.739*** (0.043)	0.737*** (0.044)	12.40
Upper secondary	1.158*** (0.034)	0.999*** (0.039)	8.73
Tertiary education	2.046*** (0.039)	1.872*** (0.054)	21.82
Experience	0.043*** (0.002)	0.034*** (0.002)	
Experience squared	-0.000*** (0.000)	-0.000*** (0.000)	

Explanatory variables	Log of monthly income		Rate of return [a]
	OLS	Heckman	
λ		-0.329*** (0.035)	
Constant	7.089*** (0.039)	7.577*** (0.065)	
R-squared or Pseudo R-squared	0.232	0.197	
Number of observations	9,050	9,050	

Note: Robust standard error in parentheses. *** = significant at 1% level. [a]Considering only Heckman estimates, and compared to the previous educational level. Computations are based on formula (3) by Psacharopoulos and Chu Ng (1994)

Source: Own calculation

5.1.4. Return on Investment in Agricultural Education

The following section presents the return on investment in agricultural education regardless of the educational level attained and controlled by individual and labor market characteristics.

The estimates of the return on investment are shown in Table 15. They were computed using OLS and IVs. For the latter, the constructed inverse Mills ratio (λ) and the selection into an academic major variable (φ) were inserted in the earning equation to correct for sample selection and selection into an agricultural major. The variables (λ) and (φ) were estimated using the Heckman procedure and the multinomial logit model, respectively.

The reference category of locality is 'rural area,' the type of employee is public employee, and the type of occupation is elementary occupation (Ocup9).

When it was controlled for individual and market characteristics, the coefficient of the inverse Mills ratio (λ) suggests that its inclusion is not necessary to avoid sample selection bias. Contrary to sample selection bias, the coefficient of selection into an academic major (φ) provides evidence of positive selection since its coefficient is statistically different from zero at a 5% significance level. The negative sign of the coefficient suggests that individuals choosing an agricultural major are more likely to earn more income than a random individual with the same characteristics.

The Wu—Hausman and Durbin—Wu—Hausman tests for the endogeneity of years of schooling suggest that schooling is an endogenous variable at the 10% significance level; thus, an IV is needed. Considering these results, the interpretations of the estimates rely on IV

corrected for the endogeneity of schooling, sample selection, and selection into an agriculture major bias.

Table 15. Rates of return controlled by type of education, individual and labor market characteristics. Coefficient estimates are reported with robust standard error in parentheses

Explanatory variables		Log of monthly income	
		OLS	IV
Education attainment			
Years of schooling		0.059***	0.077***
		(0.003)	(0.015)
Agricultural education		0.201	0.152
		(0.159)	(0.159)
Individual's characteristics			
Sex		0.321***	0.402***
		(0.022)	(0.024)
Family head		0.213***	0.213***
		(0.023)	(0.095)
Labor market's characteristics			
Experience		0.034***	0.037***
		(0.002)	(0.003)
Experience squared		-0.000***	-0.000***
		(0.000)	(0.000)
Private sector's employee		-0.165***	-0.148***
		(0.031)	(0.034)
Self-employee		-0.702***	-0.687***
		(0.036)	(0.038)
Ocup1	Managers	1.107***	0.976***
		(0.059)	(0.082)
Ocup2	Professionals	1.025***	0.848***
		(0.057)	(0.095)
Ocup3	Technicians and associate professionals	0.823***	0.714***
		(0.041)	(0.053)
Ocup4	Clerical support workers	0.832***	0.721***
		(0.041)	(0.051)
Ocup5	Services and sales workers	0.618***	0.568***
		(0.029)	(0.033)
Ocup6	Skilled agricultural, forestry, and fishery workers	-0.019	0.002
		(0.043)	(0.043)

Explanatory variables		Log of monthly income	
		OLS	IV
Ocup7	Craft and related trade workers	0.422*** (0.033)	0.371*** (0.034)
Ocup8	Plant and machine operators and assemblers	0.727*** (0.038)	0.661*** (0.042)
Ocup10	Elementary occupations	1.172*** (0.263)	1.068*** (0.298)
Ocup0	Armed forces occupation	0.771** (0.338)	0.746*** (0.301)
Location of residence			
Locality 1		0.329*** (0.027)	0.263*** (0.041)
Locality 2		0.407*** (0.030)	0.351*** (0.036)
Locality 3		0.139*** (0.027)	0.110*** (0.030)
λ			0.009 (0.145)
φ			-2.893*** (0.484)
Constant		6.823*** (0.056)	6.731*** (0.324)
Number of observations		9,050	9,050
R-squared		0.399	0.400
Test for endogeneity of schooling			
Wu—Hausman F test p-value		-	0.079
Durbin-Wu-Hausman Chi squared test p-value		-	0.079
Test for relevance of the instrument			
Partial R-squared		-	0.059
F statistic and p-value		-	353.347***
Cragg—Donald Wald F statistic		-	280.512
Stock -Yogo F test critical values 10% maximal IV relative bias		-	19.93
Test for instrument exogeneity			

Explanatory variables	Log of monthly income	
	OLS	IV
Hansen J statistic Chi squared test p-value	-	0.182
Sargan Chi squared test p-value	-	0.194
Basmann Chi squared test p-value	-	0.194

Note: Robust standard error in parentheses. ***=significant at 1% level, **=significant at 5% level, *=significant at 10% level.
Source: Own calculation

Based on the estimates shown in Table 15, the interpretation of the return on education is as follows: on average, regardless of the educational level, and controlled by other factors, one additional year of education increases an individual's income by 7.7% with a 95% interval spanning 4.65% — 10.71%.

Concerning the estimates of agricultural education in Table 15, after controlling for individual and labor market characteristics, no difference in earnings by the educational program was found at the 5% significance level. This implies that the income of those who graduate from an agricultural education program and those who graduate from other educational programs do not differ significantly from each other.

Irrespective of the computation method, the results fail to reject the null hypothesis at a 1% significance level that there is no difference between the individual's sex and location of residence. The size, sign, and significance of these coefficients imply that men earn more income than women, and those who live in urban or semi-urban localities earn more income than those living in a rural locality.

A self-employed person or a paid worker from the private sector earn less income than a public employee. In addition, individuals whose occupation is managers (Ocup1), professional (Ocup2), or member of the armed force (Ocup10) earn the highest income in comparison to those who work at elementary occupations (Ocup9). For the first two occupations mentioned, at least a tertiary educational level is expected to perform the tasks related to these occupations.

Regarding the coefficient of "skilled agricultural, forestry, and fishery workers" (Ocup6), the results fail to reject the null hypothesis implying that there is no earning differential between those working in this occupation and those working at elementary occupations. A plausible explanation for this result is that both groups include individuals with low skills. For instance,

60.82% of the individuals whose occupation is "skilled agricultural, forestry and fishery workers," and 40.02% of the individuals in "elementary occupation," have not completed any educational level. However, the expected level of education in the former occupation is lower or upper secondary, and in the latter occupation is primary educational level.

5.1.5. Return on Investment in Agricultural Education by Educational Level

Table 16 reports the OLS and OLS corrected estimates, by educational level attained and controlled by individual and labor market characteristics. The OLS corrected estimates were corrected for sample selection and selection into an agriculture major by the prior computing of the estimates of a reduced form multinomial logit and Heckman selection models. These estimates were then inserted into the earning function.

The extended Mincer earning function was decomposed into educational pathways. Upper-high secondary and tertiary education levels are divided into two pathways: those who graduate from agricultural education, and those who graduate from other educational programs. In addition, Table 16 shows the estimates of the full sample regardless of the economic activity related to their occupation and those whose occupation is related or not to the economic activity of agriculture.

As illustrated in Table 16, the majority of the estimated coefficients of education are positive and statistically significant, except for the corrected estimate for lower secondary education in the economic activity of agriculture and upper-secondary outside the economic activity of agriculture. The positive signs of the coefficients imply that the rate of return increases with each educational level attained.

Table 16. Mincer extended earning function controlled by type of education, individual and labor market characteristics. Coefficient estimates with robust standard error in parentheses

Explanatory variables	Log of monthly income								
	All economic activities			Agriculture			No Agriculture		
	OLS	OLS corrected	Rate of return[a]	OLS	OLS corrected	Rate of return[a]	OLS	OLS corrected	Rate of return[a]
Primary education	0.179*** (0.028)	0.162*** (0.027)	2.71	0.136** (0.052)	0.119** (0.052)	1.99	0.160*** (0.033)	0.153*** (0.032)	2.55

Explanatory variables	Log of monthly income								
	All economic activities			Agriculture			No Agriculture		
	OLS	OLS corrected	Rate of return[a]	OLS	OLS corrected	Rate of return[a]	OLS	OLS corrected	Rate of return[a]
Lower secondary	0.326*** (0.039)	0.294*** (0.040)	4.37	0.182 (0.119)	0.154 (0.118)	1.16	0.295*** (0.043)	0.277*** (0.043)	4.12
Non- agricultural education program									
Upper secondary	0.546*** (0.036)	0.457*** (0.060)	5.44	0.633*** (0.130)	0.637*** (0.132)	16.08	0.492*** (0.039)	0.387*** (0.055)	3.67
Tertiary education	1.073*** (0.055)	0.970*** (0.078)	12.83	2.080*** (0.432)	2.035*** (0.445)	34.97	1.018*** (0.057)	0.895*** (0.073)	12.69
Agricultural educational program									
Upper secondary	0.602** (0.231)	0.587** (0.233)	9.78	1.871*** (0.092)	1.944*** (0.084)	59.65	0.419* (0.238)	0.379 (0.239)	3.39
Tertiary education	1.255*** (0.212)	1.14*** (0.217)	13.89	1.811** (0.547)	1.766** (0.534)	-4.43	1.104*** (0.218)	0.973*** (0.225)	14.85
Other characteristics									
Individual	Yes	Yes		Yes	Yes		Yes	Yes	
Labor market	Yes	Yes		Yes	Yes		Yes	Yes	
λ	-	-0.110 (0.103)		-	-2.741 (1.818)		-	-0.454** (0.228)	
φ (Upper-secondary)	-	-1.285*** (0.328)		-	-1.145** (0.442)			-1.147** (0.466)	
φ (Tertiary)	-	-1.827*** (0.432)		-	-1.232 (0.780)			-1.508** (0.528)	
Constant	6.978*** (0.054)	7.272*** (0.161)		5.792*** (0.135)	7.978*** (1.379)		7.229*** (0.059)	7.713*** (0.210)	

Explanatory variables	Log of monthly income								
	All economic activities			Agriculture			No Agriculture		
	OLS	OLS corrected	Rate of return[a]	OLS	OLS corrected	Rate of return[a]	OLS	OLS corrected	Rate of return[a]
R-squared or Pseudo-R squared	0.402	0.405		0.133	0.137		0.387	0.389	
Number of observations	9,050	9,050		2,433	2,433		6,617	6,617	

Note: Robust standard error in parentheses. *** = significant at 1% level, ** = significant at 5% level, * = significant at 10%. [a]Considering only Heckman estimates, and compared to the previous educational level. Computations are based on formula (3) by Psacharopoulos & Chu Ng (1994).

Source: Own calculation

Considering all the economic activities, the estimates of tertiary education are larger than the estimates of upper-secondary education, implying that, on average, the rate of return is higher at the tertiary educational level. Graduates from an agricultural educational program at upper-secondary education on average earn 9.78% more income than those who attained lower secondary education, and graduates from a tertiary agricultural education program earn 13.89% more income than graduates from upper secondary education.

Comparing the economic activities, the rate of return for an additional educational level attained is higher in the economic activity of agriculture than outside of it, except for the return of graduates from an agricultural program at the university level.

Within those who graduate from an agricultural education program and remain in the economic activity of agriculture, the highest return on education is achieved by graduates from upper-secondary education. They earn 59.6% more income than graduates from lower secondary education.

However, graduates from tertiary education earn 4.43% less income than graduates from upper secondary education. This indicates that the type or the level of skills acquired in an agricultural educational program at the university level, are not fully appraised in this economic activity.

As mentioned earlier, agriculture as an economic activity in this dataset entails only the primary production of agricultural products. Therefore, the skills, knowledge, and competencies

acquired in an agricultural education program at the secondary educational level, could better match the requirements of the jobs available in this economic activity.

In other words, the interpretation of the size of these returns is that the knowledge and skills acquired in an agricultural education program, at the university level, may be more valuable for performing tasks in jobs in non-agriculture economic activities. For example, "public administration," "education," "wholesale and retail trade," "manufacturing," and "professional, scientific and technical activities" as university graduates from agricultural education earn 14.85% more income than graduates from upper secondary educational level. This return is the highest achieved within the no-agriculture economic activities; it is also higher than the return of university graduates from non-agricultural educational programs.

In summary, the results show that regardless of the educational program, "the spending on human capital is a good investment" (Psacharopoulos and Patrinos, 2018, p. 455). This remark is based on the sign and size of the return on investment, found in this study. Overall, regardless of the economic activity in which the individuals work, graduates from agricultural educational programs perceive positive returns to their investment in education. This is because no statistical difference was found between those who chose this major and those choosing other academic majors. Graduates from agricultural educational programs, at the high school level perform better within the economic activity of agriculture than, graduates from agricultural educational programs at the university level, whose competencies are better rewarded in economic activities outside of agriculture.

5.2.Study 2: Quality of Education from the Employers Perspective

To answer the research questions regarding the graduates' competencies, the first part of this sub-section presents the details about the data used in the empirical analysis, and the second part presents the demand and assessment of the graduates' competencies. This is followed by reporting the results of the strategic and discrepancy analyses of the competencies in the third and fourth parts of this sub-section, respectively.

5.2.1. Competencies Included in the Academic Curricula

Overall, 20 competencies were identified in the analysis of 16 curricula. The list of competencies and their respective short-codes is shown in Table S3 in the Supplementary Appendix. All the curricula analyzed included a list of knowledge, skills, attitudes, and values, described in the graduate profile, as the salient graduate characteristics. In five of the 16 curricula, a clear description of the technical competencies, aligned to the learning goals and outcomes and the instructional activities, were found.

However, in only very few curricula (three of 16) were the technical competencies linked to a technical norm. This norm should define the performance standards and the mechanism to assess these competencies. In the remaining curricula, the competencies were derived from the analysis of the knowledge, skills, and attitudes stated in the academic curricula.

The 20 technical competencies found in the analysis of the educational programs are shown in Table 17. The emphasis of these competencies differs by educational level. For example, at the secondary educational level, the five top competencies most frequently mentioned are the production of agricultural products (C17), the community/regional development process (C23), the addressing of market needs (C13), the processing of agricultural products (C22), and the application of technical and legal standards and procedures according to national and international regulations (C4).

At the tertiary educational level, the main characteristics of the graduates from short programs (two-year program) are a compliance with quality and safety standards (C15), the processing of agricultural goods (C22), and the application of technical and legal standards and procedures according to national and international regulations (C4), as well as, the competencies of business development (C5) and the production of agricultural products (C17).

Finally, the competencies most frequently mentioned in the education programs at the tertiary level 4-year program are business development (C5); the production of agricultural products (C17); the understanding and adhering to policies and institutions influencing the agri-food sector (C2); the competencies, design, organization, and implementation of research processes (C6); and the use of technologies that increase efficiency productivity or competitiveness (C11).

Regardless of the educational program and the educational level, the main competencies mentioned in the academic curriculum are business development (C5) and the production of

agricultural products (C17), suggesting that commercial agriculture is the primary focus of the agricultural education programs analyzed.

Table 17. Competencies by number of references and educational level

Code	Technical competencies (short name)	Number of references	Educational level		
			Secondary	Tertiary[a]	Tertiary[b]
C1	Agricultural value chain	3	1	1	1
C2	Policies and institutions	30	3	2	25
C3	Sustainability	14	4	4	6
C4	National and international regulations	27	7	12	8
C5	Agri-Business development	72	7	11	54
C6	Research	30	3	8	19
C7	Technology design	12	0	0	12
C8	Environmental impact	20	2	3	15
C9	Climate change	2	1	0	1
C10	Partnership and collaboration	14	1	7	6
C11	Use of technology	24	0	5	19
C12	Food security	2	1	0	1
C13	Market needs	22	9	5	8
C15	Quality and safety standards	33	3	27	3
C16	Marketing of agricultural products	9	7	0	2
C17	Production of agricultural products	69	23	11	35
C20	Management and conservation of natural resources	17	5	2	10
C21	Technical and technological services	23	5	4	14
C22	Processing agricultural products	38	8	16	14
C23	Local/ regional development	24	10	3	11

Note: [a]Tertiary short (2 years), [b]Tertiary long (4 years)

Source: Own calculation

Regardless of the educational level to which the educational programs belong, the five competencies least mentioned in the academic curricula are food security, climate change, agricultural value chains, the marketing of agricultural products, and technology design.

5.2.2. Competencies Required by Employers

The five competencies required to perform tasks appropriately in the respective job positions assessed, which were most frequently mentioned by employers are:

- Plan, organize, manage, control, and implement agricultural production and harvesting processes (C17)
- Define, manage, control, and implement strategies and (or) financial, administrative, commercial, and organizational processes in agri-business development (C5)
- Plan, organize, manage, control, implement and (or) evaluate community, regional and (or) national development processes (C23)
- Investigate and consider market needs in terms of supply and demand (local, national, and international) (C13)
- Plan, organize, manage, control, and implement the processing processes of agricultural products (C22)

Sixty of the 71 employers elicited these competencies. The employers stand for all types and sizes of value chains' stakeholders, from input suppliers to services providers, and from small to large-size employers.

These five competencies were also those which are most frequently mentioned in academic curricula, suggesting a match between the competencies demanded and offered. However, according to the interview partners, these competencies differ by the level of importance and performance, as described below.

5.2.2.1.Perceived Level of Importance

On a scale of 1 to 11, the average importance of the competencies listed is 9.39. This score implies the level of relevance of the competencies, targeted in the academic curricula, for the jobs and tasks performed by agricultural graduates. The competencies with the highest average level of importance are environmental impact (C8), local/regional development (C23), food security (C12), climate change (C9), and quality and safety standards (C15) (see Table 18).

The competencies in the top-five list mentioned above were chosen by at least 52 of 71 employers and were found among the five most important competencies mentioned by stakeholders' type along the value chains elicited in this study (See Table S4 in the Appendices).

Table 18 below shows the average importance by competency and the top-three value chain stakeholders who regard the highest, average-group importance, by competency.

Table 18. Perceived level of importance by competency

Technical competencies		Average Importance	Stakeholder who, on average, regard highest importance*
Code	Short name		
C1	Agricultural value chain	8.42	(b), (e), (f)
C2	Policies and institutions	9.42	(c), (d), (e)
C3	Sustainability	9.50	(c), (d), (e)
C4	National and international regulations	9.53	(c), (d), (e)
C5	Agri-Business development	9.46	(b), (d), (e)
C6	Research	9.23	(b), (c), (g)
C7	Technology design	8.76	(c), (d), (e)
C8	Environmental impact	9.71	(b), (d), (e)
C9	Climate change	9.55	(c), (e), (f)
C10	Partnership and collaboration	9.54	(b), (c), (e)
C11	Use of technology	9.38	(c), (e), (g)
C12	Food security	9.60	(b), (c), (e)
C13	Market needs	9.21	(c), (d), (e)
C15	Quality and safety standards	9.56	(c), (d), (e)
C16	Marketing of agricultural products	9.51	(b), (d), (e)
C17	Production of agricultural products	9.43	(c), (d), (e)
C20	Management and conservation of natural resources	9.40	(b), (d), (e)
C21	Technical and technological services	9.53	(b), (c), (e)
C22	Processing agricultural products	9.47	(c), (d), (e)
C23	Local/ regional development	9.67	(c), (d), (e)

Note: *
a) Input supplier
b) Producer
c) Food processing
d) Retail/wholesaler
e) Exporter
f) Financial services provider
g) Technical services provider

Source: Own calculation

This latter information, shown in the last column of Table 18, indicates that the level of importance that employers attribute to these competencies is not the same for each type of stakeholder. Rather, it depends on the nature of the tasks carried out in these jobs. For example, the competency of agri-business development, although it is a competency ranked, on average

with a score of 9.46— thus considered important— it is particularly critical for the tasks carried out by producers, retailers, and exporters.

Employers perceive an increasing consumer demand for agri-food products that meet higher environmental, food safety, and quality standards, whether in local or international markets. This trend influences the production, processing, and marketing of food, as well as the competencies required in agricultural graduates. For instance, there is currently more demand for knowledge and skills about quality, free trade, or organic certifications in coffee and cacao value chains as well as fruit—vegetables and dairy—meat value chains, mainly focusing on good agricultural and good handling practices. An example of this perception is expressed by one of the interviewees:

> *"Graduates must manage good agricultural and handling practices since they do not only apply at international but also at national levels, now local supermarkets focus on the safety and traceability of products as well..."* (Interview 6).

Employers also attached high importance to the competency related to 'plan, organize, manage, control, implement and (or) evaluate local, regional and (or) national development processes' (C23). For them, the graduate's role is also to facilitate the social, economic, and environmental process, oriented to improving the living conditions of the community in which they participate. Among these processes are transferring technology and providing advice and support to local stakeholders in developing business opportunities or any other development projects oriented to this aim. The following quote illustrates this perception:

> *"Graduates should use facilitation tools and understand that the customer is the farmer and should meet his/her needs in terms of production. The aim is the human being and not the crop since human being determines if the production system is efficient or not. Farmers barely attain 5th grade of formal education; thus, the graduate must be prepared to facilitate complex systems processes in these conditions…"* (Interview 37)

Employers perceive climate change as a risk affecting their operations in the agri-food systems; thus, they rate this competency as very important. For instance, recently, in Honduras, privately or publicly granted loans for specialty crops, have begun requiring insurance when a threshold in the loan size is met. Agricultural graduates working in this sector should create regional or individual indexes based on climatological data or crop yield, assessing the risk associated with the farmer´s location and climate variability, and assessing the loss and damage caused by

climate variability. By mastering this competency, employers indicate that graduates will have the technical expertise to identify and assess the risks accurately.

5.2.2.2. Perceived Level of Performance

The overall average graduate performance in the competencies assessed is 7.33. On a scale from 1 to 11, this score suggests an intermediate performance between the lowest and the highest performance expected. Graduate performance in public and private jobs is similar. The employers regarded graduate performance, on average, as 7.19 and 8.07 in private and public jobs, respectively. Nevertheless, it is worth noting that public employers were only found in two types of value chain stakeholders, namely, financial services providers and advisory services providers (See Table S5 in the Appendices).

The results of the performance assessment in each of the competencies are shown in Table 19, as well as the top-three value chain's stakeholders who regard the lowest, average-group performance, by competency. The five-bottom competencies, which employers regard as demonstrating the lowest graduate performance, are shown below and are among the five-bottom competencies by type of value chain's stakeholders (see Table S6 in the Appendices). These competencies are:

- Analyze, manage, implement, and assess processes based on the value chain approach (C1)
- Design, organize, and implement research processes (C6)
- Define, manage, control, and implement strategies and (or) financial, administrative, commercial, and organizational processes in agri-business development (C5)
- Identify, evaluate, select, promote, and use technology that increases efficiency, productivity, or competitiveness (C11)
- Identify, assess, and implement actions to mitigate the effects of climate change (C9)

Table 19. Perceived level of performance by competency

Technical competencies		Average Performance	Stakeholder who, on average, regard lowest performance*
Code	Short name		
C1	Agricultural value chain	6.32	(a), (b), (g)
C2	Policies and institutions	7.45	(c), (d), (f)
C3	Sustainability	7.54	(a), (d), (f)
C4	National and international regulations	7.57	(a), (d), (f)
C5	Agri-Business development	6.86	(a), (c), (d)
C6	Research	6.51	(a), (c), (f)
C7	Technology design	7.55	(a), (d), (g)
C8	Environmental impact	8.19	(a), (d), (f)
C9	Climate change	7.00	(c), (d), (g)
C10	Partnership and collaboration	7.01	(a), (d), (f)
C11	Use of technology	6.90	(a), (c), (d)
C12	Food security	7.64	(a), (c), (d)
C13	Market needs	7.19	(a), (b), (f)
C15	Quality and safety standards	7.85	(a), (d), (f)
C16	Marketing of agricultural products	7.41	(a), (d), (f)
C17	Production of agricultural products	7.67	(a), (d), (f)
C20	Management and conservation of natural resources	7.50	(c), (d), (f)
C21	Technical and technological services	7.14	(a), (d), (f)
C22	Processing agricultural products	7.88	(a), (f), (g)
C23	Local/ regional development	7.18	(d), (f), (g)

Note: *
a) Input supplier
b) Producer
c) Food processing
d) Retail/wholesaler
e) Exporter
h) Financial services provider
i) Technical services provider

Source: Own calculation

The employers frequently appraise the graduates' performance in the competency of climate change (C9) as below or on the average, on a scale of 1 to 11. They ascribe the low graduate performance to the limited inclusion of this competency in the educational programs offered, and the fact that more tenured graduates are not up to date on this topic. Employers require that graduates are able to assess the impact of climate change on agricultural production, using decision-support tools to assess or choose among prevention or mitigation measures, and implementing measures to mitigate climate change effects.

Similarly, in the competency of value chains (C1), employers describe graduates as frequently lacking the knowledge and skills of how to analyze value chains, how to describe and implement the value chain approach on real-life situations, or how to recognize the importance of value chains in their work. Employers explain the level of performance as an effect of the graduates' former education, as illustrated in the following group discussion excerpt:

> *"All agri-food graduates should be instructed [in] using the value chain approach, emphasizing each chain. Currently, the graduates are competent in how to produce. However, the emphasis is also needed in the last levels of the value chains as well [e.g., processing and marketing]"* (Workshop 1, group 5).

Regarding the competency of use of technology (C11), employers consider that first-time employees frequently have little experience in using computers beyond the basics, or using software that supports analysis, such as market analysis, budget, or planning.

According to the employers, areas with room for improvement in the graduates' performance are the use of biotechnology to optimize the efficiency of plant and animal production; and the use of cutting-edge technologies that improve quality and cost-effectiveness. In addition, they request an improvement in the application of appropriate technologies in the management of agroecosystems, the use of equipment and mapping software (e.g., GPS) to optimize and adapt the technology available, and, finally, the ability to provide recommendations about the suitable technology.

5.2.3. Strategic Group of Competencies

Figure 5 depicts the four groups of competencies which result from matching the individual perceived level of performance and importance. The competencies in the upper-left quadrant (high importance and performance) are the competencies perceived as the graduates' strengths. In this quadrant are the competencies related to adhering to policies and institutions (C2); sustainability (C3); the use of technical and legal standards and procedures according to national and international regulations (C4); environmental impact (C8); food security (C12); compliance with quality and safety standards (C15); the marketing, production, and processing of agricultural products (C16, C17, and C22, respectively); and the management and conservation of natural resources (C20).

However, the competencies in the bottom-left quadrant (high importance and low performance) are perceived as very critical competencies to competently carry out the job's tasks but requiring immediate action to improve the level of performance in future graduates. In this quadrant are the following competencies:

- Plan, organize, manage, control, implement and evaluate community, regional, and national development processes (C23)
- Identify, assess, and implement actions to mitigate the effects of climate change (C9)
- Identify, develop partnerships, and collaborate with public and private actors (C10)
- Define, manage, control, and implement strategies and (or) financial, administrative, commercial, and organizational processes in agri-business development (C5)
- Plan, organize, manage, control and implement agricultural technical and technological services (C21)

These competencies are also interrelated, being phrased differently when mentioned in the interview; for example, for the competency C23, the interviewee frequently also mentioned another competency, competency C10. The competencies frequently mentioned jointly in the interviews are C23 and C10, or C9 and C23.

A plausible explanation for this is that problems faced in development interventions are frequently complex ones (e.g., poverty, environmental degradation, and climate change effects). A typical feature of this type of problem is the interaction of different stakeholders who are acting and pursuing their interests. Consequently, to solve these problems, the collaboration and partnership of different actors is required. The following interview excerpt illustrates this situation:

> *"The graduates should know how to organize producers, and guide them in the protection of the environment, for example. They must know who the actors are, what each actor does, and how each actor can contribute to the solution of problems. They must set up alliances with the government and train the producers."* (Interview 46)

The second-order competencies that require attention are those placed in the bottom-right quadrant of Figure 5. Graduates perform below the average in these competencies, and although these competencies are scored below the average level of importance, their potential to become

more critical soon is highly likely. In this quadrant are the following competencies: agricultural value chains (C1), research (C6), use of technology (C11), and market needs (C13).

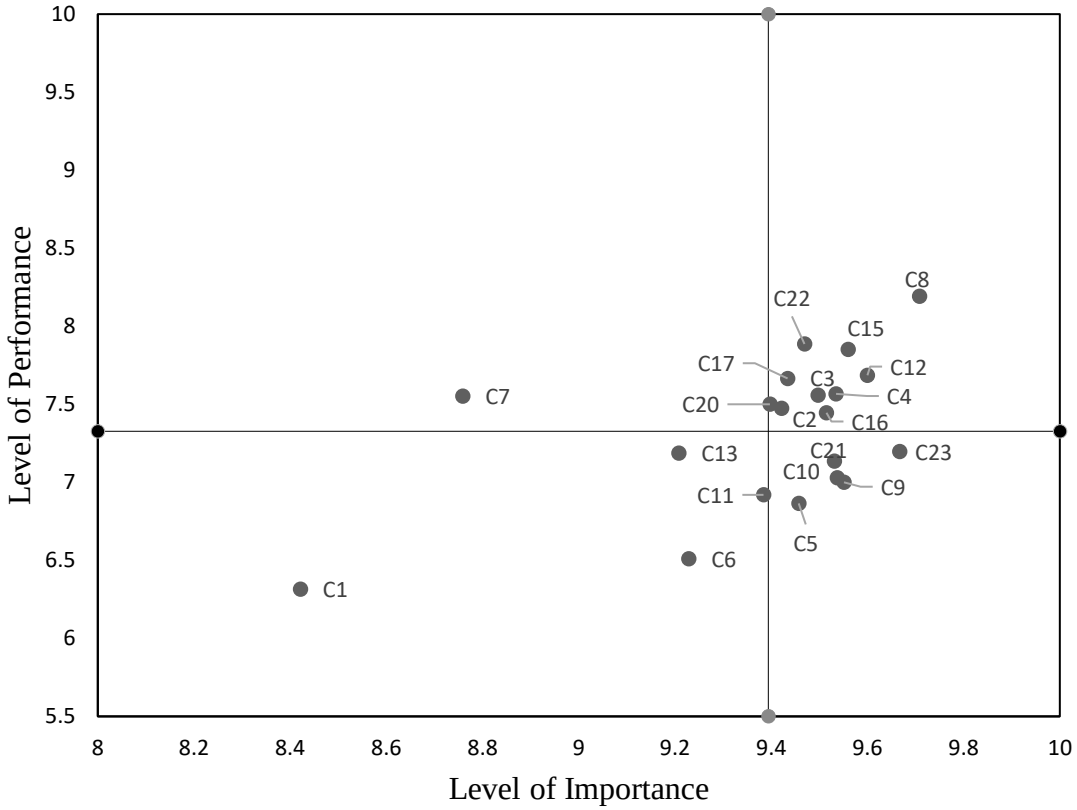

Figure 5. Strategic Groups of Competencies

This potential change in the level of importance will occur based on upcoming trends affecting agriculture worldwide; for instance, the changes in consumer behavior as previously described, or technological changes to improve efficiency, as explained by one of the employers in the following quote:

> *"Recently, we made a trip to Costa Rica to visit other banana producers, and we observed that they are using drones and other technologies that allow them to save money. In our case, for example, we would like to use drones to identify in which sites we must water. At this moment, we are watering the same amount throughout the field, so we are wasting resources that we could save if we had better technology that tells us where and when to do it. We want graduates who can understand these technologies and can offer us a recommendation."* (Workshop 3, group 3)

This quote also illustrates that some competencies are interrelated, for instance, the competencies of the use of technology (C11) and providing technical advisory and technological services (C21), as well as the use of technology (C11), providing technical advice (C21), and research (C6), and the competencies related to business development and analysis and consideration of the market's needs (C5 and C13). This suggests the importance of considering the competencies' interrelation while deciding on measures to enhance these competencies in future graduates.

5.2.4. Discrepancy Analysis

As explained earlier, the discrepancy analysis identifies the competencies with the highest difference between the level of importance and level of performance. The competencies with the highest score are those whose level of importance is high but the level of performance is low, or competencies scored as less important but also highly performed. Hence, the rank is a guide for scrutinizing the academic curriculum and educational processes which aim to develop the competencies.

Table 20 shows the competencies ranked according to their discrepancy score in descending order. The five top competencies, ranked with the value one to five, are those whose discrepancy score is the highest among the competencies.

Table 20. Ranked discrepancy score of competencies

Code	Competency	Score	References	Rank
C6	Research	25.08	92	1
C5	Business development	24.51	385	2
C9	Climate change	24.37	78	3
C10	Partnership and collaboration	23.91	134	4
C23	Local/regional development	23.88	249	5
C11	Use of technology	23.12	112	6
C21	Technical and technological services	22.83	177	7
C16	Marketing of agricultural products	19.69	101	8
C4	National and international regulations	18.76	187	9
C13	Market needs	18.61	241	10
C3	Sustainability	18.40	177	11
C12	Food security	18.38	70	12

Code	Competency	Score	References	Rank
C2	Policies and institutions	18.35	114	13
C20	Management and conservation of natural resources	17.83	146	14
C1	Agricultural value chain	17.73	19	15
C17	Production of agricultural products	16.75	521	16
C15	Quality and safety standards	16.33	175	17
C22	Processing agricultural products	14.99	211	18
C8	Environmental impact	14.24	120	19
C7	Technology design	10.57	29	20

Source: Own calculation

A feature of these five top competencies, as shown in Table 20, is that four of them are regarded as having a high importance for employers but demonstrating low performance by graduates; and for the remaining competencies, although employers rank them as less important, they might turn out to be very influential in the near future (C6).

The competency, 'design, organize and implement research process' (C6), heads the list of competencies for which the gap between the level of importance and performance, is the largest. Of the 71 employers, 34 requested this competency, and they stand for all types and sizes of value chains' stakeholders.

Employers are interested in graduates being able to plan, conduct, and evaluate agricultural research, whether it be disciplinary, interdisciplinary, and transdisciplinary research. In addition, employers stress the use of social research 'methodologies for identification of factors in poverty reduction or agriculture and agri-industry development, as well as the use of research findings to tackle problems faced by the company or organization, or for technological development and innovation. One interviewee illustrated these points as follows:

> '*Graduates should research about agricultural issues in the country and outside it since based on these results; decisions are made. The topics of the student's thesis should be relevant for our country, for example, about cocoa, we now know that Honduras has good quality cocoa, but others discover it first then us. Graduates should be acquainted with the best practices implemented in other countries in order to implement them in Honduras.*' (Interview 48)

Business development (C5) is the competency with the second largest gap. Although this competency is one of the most frequently mentioned competencies in the academic curriculum and the most required competency to carry out the tasks in the jobs analyzed, it is the competency with the third lowest performance. In the following excerpts, for instance, employers express what they perceive to be the current emphasis of agricultural education concerning the competency of business development.

> *"The current graduates are good in* [agricultural] *production but not in administration, project management, and marketing. They have very few leadership skills and initiative. They are often waiting to be told what to do. The university prepares the graduates to become an employee but no an entrepreneur."* (Interview 47)

> *"The university must develop administrative skills in students, how to calculate costs, and how to set prices. Agronomy now* [in Honduras] *focuses only on how to produce, but not efficiently. It does not consider the costs to set up a price that generates profits. They* [educational centers] *should also focus on financial analysis and development of business plans."* (Interview 41)

Furthermore, employers used the metaphor of "boots and a cowboy hat" to express the necessity for change in the agricultural sector. This transformation leaving behind traditional agriculture for a more advanced and complex kind, must involve the competency of business development.

> *"Agriculture is no longer boots and a cowboy hat; that has changed. The current* [academic] *training focuses only on production, but not on the use of technology; the challenge is how to understand the market, how external markets and import processes work, as well the national regulations. Emphasis should be placed on measuring efficiency, logistics, leadership skills, negotiation, establishing relationships with third parties, adding value to products, …"* (Interview 49)

Regarding the competency related to technical and technological services (C21), employers suggested updating this content as in terms of the approaches used to provide agricultural advisory services. This is illustrated in the excerpt from the interview 37 presented above, and in the following quote in which the interviewee focuses on the client approach while providing advisory services.

> "*Students, when they graduate, think they know everything and give a recommendation as a recipe to follow. The graduate should be a professional capable of facilitating knowledge and processes and providing advice focusing on the client. Not giving*

> *prescribed recommendations but presenting solutions to the client. Graduates must consider that farmers have experience and knowledge from practice, so the advisor should focus on the clients acknowledging their knowledge*." (Interview 30)

As previously mentioned, it is important to consider the interconnection among the competencies to create an educational process and content that fosters it. For example, the interconnection between the local and regional development process (C23) and partnership and collaboration (C10); and between climate change (C9) and the local and regional development process (C23).

Ultimately, as expressed in the following quote, the professional required should have not one but several competencies to increase their employability:

> *"…the worker profile in our company requires an individual trained on a bit of everything such as agricultural production, the climatic zones in the country, how the climate affects crops, the use of technological tools such as GPS to map the crop that will be insurance… and business plan."* (Interview 43)

In summary, this study found that employers' perception of graduates' performance is at an intermediate level. The employers focus their assessment on the competencies required to carry out the tasks in the jobs available. This result therefore suggests the need to improve the quality of the educational programs by updating the academic curriculum and the educational process.

The strategic and discrepancy analysis converge in the type of competencies that immediately require action; namely, the competencies C5, C9, C10 and C23. These competencies are not only crucial to carry out the tasks in the jobs available, but are also essential for facing the challenges currently affecting the agricultural sector in Honduras.

5.3.Study 3: Efficiency of Agricultural Education

This sub-section presents two sets of findings related to the efficiency of agricultural education at the secondary education level. The first set relates to the efficiency level attained by each educational center, whereas the second set relates to the factors influencing the level of efficiency of these centers.

5.3.1. Efficiency Scores by Education Center

The output technical efficiency scores computed for each DMU (i.e., education center) are shown in Table 21. These scores were computed considering the output-oriented approach and the variable return to scale.

Table 21. DMU efficiency score and rank: Bias and bias-corrected

DMU	DEA 2-stage		Simar & Wilson	
	Score	Rank	Bias-corrected score	Rank
1	0.866	10	1.179	9
2	0.694	16	1.504	16
3	1	1	1.222	12
4	0.719	15	1.425	15
5	0.984	7	1.039	5
6	0.854	12	1.202	11
7	1	1	1.011	1
8	0.990	6	1.019	3
9	1	1	1.016	2
10	1	1	1.020	4
11	0.808	13	1.284	13
12	0.960	8	1.053	7
13	0.777	14	1.317	14
14	0.859	11	1.193	10
15	1	1	1.045	6
16	0.955	9	1.081	8

Source: Own calculation

The first three columns in Table 20 show the DMUs, the baseline efficiency scores computed only with controllable inputs, and the score's position in the efficiency ranking.

The average efficiency of the total DMUs is 0.904 (or 90.4). A DMU with a value equal to 1 is an efficient DMU. A total of five full efficient DMUs are shown in Table 21, implying that these public high schools are maximizing the academic performance and the number of graduates of agricultural programs, given the controllable inputs at the school level (i.e., financial and teaching resources).

The last two columns in Table 21, show the efficiency scores bias-corrected and the score's position in the efficiency ranking. The efficiency scores were computed using the Simar and Wilson (2007) procedure, thus they are corrected for poorly defined data mechanism and correlation among the efficiency scores.

The computation also includes the non-controllable inputs (environmental variables) that might affect the ability of each DMU to efficiently use the financial and teaching resources available at the school level.

Of the methods employed to compute the efficiency scores, the latter method produces better discrepancy among the DMU's analyzed. Here, only one DMU is considered the most efficient, and 15 DMU's are found to be inefficient. None of the DMUs analyzed were found to be fully efficient. A score of 1.01, for example, means that to attain a higher level of efficiency, outputs should be expanded by 1% without changing current inputs. Conversely, a score of 1.50 implies that this DMU should expand 50% of its outputs to attain optimal performance. This latter score corresponds in Table 20 to the less efficient high school serving agricultural education.

Regardless of the method used to compute the efficiency scores, the results in Table 21 show that both methods converge in the DMUs regarded as the most efficient and inefficient high schools (DMUs seven and two, respectively). Compared to the most efficient high school in this data sample, the least efficient high school produces approximately twice the number of graduates but achieved half the average in the student academic test results. It also possesses half the infrastructure, spent on average twice the financial resources and used half the teaching resources than the most efficient high school in this data sample (See Table S7 in the Supplementary Appendix).

5.3.2. Determinants of Agriculture Education Efficiency

Regarding the next step of the efficiency analysis, the non-controllable inputs were used to explain inefficiency in producing the current outputs. The non-controllable inputs are the percentage of households with three or more unmet basic needs, the percentage of the population who attained a university degree, and the percentage of the population whose main occupation is related to the economic activity of agriculture.

It was necessary to ensure the absence of multicollinearity, so the interpretation of the regression analysis could be safely performed. Table 22 shows the pairwise correlations across the efficiency scores (dependent variable) and the non-controllable inputs (explanatory variables). The correlation and the variance inflation factor (VIF) among these variables indicate that no collinearity problem exists that might bias the regression results.

Nearly all the pairwise correlation coefficients were below the threshold of 0.8 (see Table 22). In addition, the average VIF computed was 3.14, which is lower than the tolerance value of 10.

Table 22. Correlation between variables used in the second stage

	Efficiency score	Households with three or more unsatisfied basic needs	Population with university education	Population whose main occupation is agriculture
Efficiency score	1.000			
Households with three or more unmet basic needs	-0.584	1.000		
Population with university education	0.447	-0.572	1.000	
Population whose main occupation is agriculture	-0.698	0.804	-0.746	1.000

Source: Own calculation

The results from the truncated regression of the second stage of the analysis are summarized in Table 23. The coefficients of the explanatory variables in Table 23 have the expected sign and are statistically significant, except for the percentage of the population with university education.

Table 23. Determinants of public agricultural education at secondary education level

Explanatory variables	Output technical efficiency	95% boot confidence interval	
		Low	High
Households with three or more unsatisfied basic needs	0.019**	0.003	0.038
	(0.009)		
Population with university education	0.013	-0.079	0.090
	(0.041)		
Population whose main occupation is agriculture	-0.028***	-0.043	-0.015
	(0.007)		
Constant	0.092***	1.624	2.556
	(0.235)		
Observations	16		

Note: Bootstrapped standard error in parentheses. *** = significant at 1% level, ** = significant at 5% level, * = significant at 10%.
Source: Own calculation

The statistical significance of these estimates implies that changes in the efficiency scores are associated with changes in the local socio-economic characteristics surrounding these schools. In particular, the percentage of households deprived of basic needs and the percentage of the population whose main occupation is related to the economic activity of agriculture.

The negative sign of the estimate of the percentage of the population whose main occupation is related to the economic activity of agriculture implies that an increase in the percentage of the population working in the economic sector of agriculture reduces the school's level of inefficiency. In other words, if the school is located in a dominant agriculture based-community the school efficiency increases. This might imply that students are more motived to complete their education program in agriculture due to the job or business opportunities available in the region.

In contrast, when the percentage of households deprived of basic needs increases, the level of the school's inefficiency also increases. A possible explanation for this phenomenon is that students who come from poor households might have fewer opportunities to learn, as their parents might have insufficient income to buy school supplies or might be lacking the sanitary conditions at home, thus affecting the students health and class attendance.

Summarizing the main findings of this sub-section, by considering only the unbiased scores of efficiencies, none of the high schools (DMUs) analyzed are fully efficient units. Even maintaining the current level of investment, there is room for improvement in the school's performance, by expanding the outcomes in a range of 1% to 50%.

Of the two outcomes analyzed, the student academic achievement raises greater concerns due as the best performing school attained a score, on average, far lower than the minimum expected. The level of efficiency proved to be affected by the poverty level of the school's location and the share of the population working in the agricultural sector.

6. Discussion

This section aims to interpret the main findings of the three studies presented in this document. This interpretation revisits the conceptual framework of this research as well as previous empirical studies that support or contradict the stated position. The insights gained are restricted to the situation in Honduras.

The conceptual framework in Chapter 3 outlines the three issues that examine the provision of agricultural education. Firstly, the economic return that graduates receive from their investment in agricultural education or the profitability of said education. Secondly, the quality of agricultural education as expressed by the graduates' competencies from the perspective of their employers. Finally, the efficiency of resources invested in the educational process to achieve the best possible agricultural educational outputs.

Given these three issues, the following paragraphs discuss, first, how profitable the agricultural educational programs are and where the graduates from these programs are better rewarded. Second, what the labor market demands —in terms of competencies— from the agricultural educational programs; to what extent these demands have been met; and what changes are suggested in the academic curricula to prepare future graduates. Finally, how efficiently the resources have been used to produce the agricultural graduates; and what factors influence this level of efficiency.

The underlying assumption behind the examination described above is that formal agricultural education is expected to enhance the performance of the agri-food sector while benefiting those who attained a formal education certification in this field of study. The positive benefits from this research might encourage prospective students, educational planners, and employers either to pursue this career, to allocate resources to it, or to hire graduates from these educational programs.

6.1.Profitability of Agricultural Education

The findings of study 1 provide compelling evidence that, on average, one additional year of education, regardless of the level and the program attended, increased the individual's income by 13.7% when no control variables were included and 7.7% when they were.

Considering a threshold rate of return of 7% for education projects (Borjas 2010), the rate of return found in this study justifies the investment in education.

As for agricultural education, regardless of the level, no statistical difference in earnings was found between graduates from agriculture and graduates from other fields of study. This finding is consistent with the result of Koshy et al. (2016) but differs from the findings reported by Altonji et al. (2016), Groot (1994), and Artz et al. (2013). The size of the difference reported depends on the particularities of the study, for example, the comparison group.

For instance, Altonji et al. (2016) found that agricultural graduates earn 0.125 log points more than graduates from education; but earn less than graduates whose major is in physical and computer sciences, nursing, economics, marketing, and business. In contrast, Groot (1994) found that agricultural education graduates earn 23% less income than graduates majoring in general education. Finally, Artz et al. (2013) reports that agricultural graduates earn 24% compared to a 32% salary premium of non-agricultural graduates in agricultural jobs located in urban areas.

The three works mentioned document the return on investment by field of study at the university level. These studies use similar methods to that used in this research, for instance, the multinomial logit to tackle for selection bias. However, the contribution of the first study in the current research is the computation of the return by educational levels, thus providing evidence about the difference between those graduating from secondary and tertiary levels.

The lack of difference found in study 1, could represent a positive observation for educational planners and prospective students in Honduras because, despite the empirical evidence discussed above, graduates from agriculture, on average, perceive relatively similar earnings than graduates from any other field of study in Honduras.

Moreover, the study found differences in the return on investment due to the educational level attained and the type of educational program. Graduates from the tertiary educational level have better economic prospects than graduates from secondary educational levels, regardless of the educational program attended. This finding is in line with the outcomes of several other studies, which computed the rate of return by educational level of Honduras and other low-middle income countries (Psacharopoulos and Chu Ng, 1994; Psacharopoulos and Patrinos, 2004, 2018).

Most notably, in study 1, regardless of the economic activity in which the individuals work, graduates from agricultural education programs earn more income than graduates from other programs, when comparing these graduates to the previous educational level attained. This

confirms that agricultural education is providing a good return on investment by education level, so the field of study is still a lucrative one.

When comparing the educational level attained, and the economic sector in which the individual works, the difference in graduates' earnings is higher. This comparison is of interest in Honduras, as graduates from agricultural educational programs work mostly in economic activities outside agriculture (only 13.04% work in agriculture). This is similar to the result reported by Artz, Kimle, and Orazem (2013), who find that 21% of the agricultural graduates in their sample and 13% in the USA, work in agriculture.

Agricultural graduates from high school who remain in the economic activity of agriculture, achieve a larger positive return than graduates from other programs at secondary education level as well as agricultural university graduates. This latter outcome supports the finding of Heanue and O'Donoghue (2014), who report that farmers with an upper secondary level of agricultural education have higher farm incomes than their peers who have lower education levels. Nevertheless, farmers with a university degree, although they achieve a positive return, it is less than that achieved by graduates from upper secondary agricultural education.

In the case of Honduras, a plausible explanation for this finding is the current level of technology and innovation in the economic activity of agriculture (understood mainly as the primary production of agricultural goods). This level might match the level of specialized knowledge and skills acquired at the high school level. The rationale on this issue follows Schultz (1964) and Huffman (2001), who argue that a higher return on education in agriculture is expected in modernized agriculture compared to traditional agriculture, because in the former kind, new information and technologies are available, and complex decision-making processes are required to improve efficiency (Schultz, 1964; Makki et al., 1999; Huffman, 2001).

Findings from study 1 also show that agricultural university graduates are better rewarded in economic activities outside agriculture. This result is consistent with the findings of Barkley and Biere (2001) but differs from the outcome of Artz, Kimle, and Orazem (2013). The latter authors find differences in earnings in or outside agriculture due to the location of the job (i.e., rural vs. urban).

Artz at al. (2013) observe that graduates from agricultural education earn a 24% salary premium in agricultural jobs if these jobs are in an urban area. Conversely, they find no difference between jobs, in or outside agriculture, in rural areas. As for Honduras, approximately 83% of the university agricultural graduates work in non-agricultural jobs. Eighty-five percent of these

graduates work in jobs located in urban areas. Hence, the location, along with the economic activity, might explain the difference in the graduates' earnings.

Artz at al. (2013) do find differences in earnings in jobs outside agriculture, depending on the agriculture major attained. Their results indicate that in comparison to a non-agricultural university graduate in a non-agricultural job, graduates from food science, agribusiness, and plant science earn a salary premium of 10.8%, 6.7%, and 8%, respectively, working in a non-agricultural job. In contrast, graduates majoring in natural resources, animal science, agricultural studies, and agricultural engineering earn more income in jobs in agriculture. A study of the return on investment by an agriculture major would provide evidence of whether the heterogeneity of graduates' earnings differ in the Honduran labor market by major.

As shown by the findings of study 1, for instance, agricultural graduates earn a greater income in the economic activities of public administration, manufacturing, and wholesale and retail trade, as examples of non-agriculture economic activities. For example, 30% of agriculture university graduates work in public administration. Panizza and Qiang (2005) and Gindling and Terrell (2009) offer an explanation for higher earning in public administration. Panizza and Qiang (2005) find that wages in the public sector in Honduras are higher compared to the private sector, ranging from a 1%— 37% premium depending on the estimation method. In Gindling and Terrell (2009), the results show that only 6% of public sector employees earn less than 90% of the minimum wage compared to self-employees and private sector employees (43.2% and 30.6%, respectively).

Following the previous findings, this suggests that in Honduras, a highly educated individual will choose a job in an economic activity that provides a higher payoff. No exception is expected for agriculture graduates who earn a university degree.

6.2. Performance and Demand of Competencies

Study 2 examined the employers' perception of the performance of agricultural graduates in technical competencies. These competencies are crucial for competently carrying out the tasks in the jobs available at each level of the agricultural value chains included in this research.

The findings of this study suggest that overall, the average graduate's performance in the competencies assessed is at an intermediate level. Hence, there is room for improvement to better prepare the graduates in order to meet the employers' requirements and to cope with the challenges affecting the agricultural sector in Honduras.

Based on the level of importance and performance among the 20 competencies analyzed in this study, it is urgent that educational authorities act upon six of them. Among these competencies are business development, technical and technological services, partnership and collaboration, and climate change.

The findings show that agricultural production (C17) and business development (C5), are among the competencies most frequently required to perform the tasks in the jobs assessed. In terms of importance, employers gave more importance to the competency of business development than agricultural production. The results indicate that, on average, graduates perform far better in the latter than the former competency. This outcome extends to the findings of Poole and Lynch (2003), who point out that farmers in develop and developing countries have extensive expertise in the production of agricultural goods but to a less so in agribusiness.

Nevertheless, the demand for more competitive, efficient, and sustainable agri-food systems requires a change in the focus from solely production, to include the processing, transporting, and marketing of goods and services (Fresco, 2009). This transformation requires the use of business and entrepreneurial competencies by which farmers seize opportunities and choose the best business strategy to succeed in this sector (McElwee, 2006; Díaz-Pichardo et al., 2012).

The role of education in the acquisition of the competency of business development is crucial, as shown by Kilpatrick (2000) and Pouratashi (2015). Kilpatrick (2000) demonstrates that agricultural businesses managed by graduates from formal agricultural education are more likely to improve farm management and its profitability in comparison to businesses managed by less-educated peers. In addition, Pouratashi (2015) find that attending entrepreneurship courses is one of the factors which increases the likelihood of agricultural students becoming entrepreneurs. Therefore, the evidence suggests including these courses and other learning opportunities in the academic curriculum of agricultural education programs.

Changes in production, manufacturing, and marketing practices at the workplace is also a consequence of changes in the advancement of technology and has become one of the critical business factors determining the type of competencies required in prospective employees in the agri-food sector (Jack et al., 2014). In such a context, employers need competent workers able to use these technologies to make technological changes happen, as found in the present research.

Comparable to this study, Umar et al. (2017) and Suvedi et al. (2018) also find a wider discrepancy score in the competency of 'use of technology' in agricultural graduates, particularly in those providing extension services. The authors argue that the use of technology (i.e., ICT technologies) nowadays is commonplace when providing information and advice to farmers and requires constant training to catch-up to the advancements in technology.

In the case of Honduras, the poor performance in the use of technology might undermine the potential to overcome the current stagnation of this economic sector. As stated by Meller and Gana (2016), technological innovation in emerging economies, such as the Latin-American countries, is positively related to economic growth, competitiveness, and convergence with developed economies. However, this depends on the level of investment in research and development and the human capital available, who should be able to use it and understanding how the technology works and how to improve or adapt it (ibid).

Furthermore, considering the expansion of the agri-food sector, the competency of the use of technology needs to address not only productivity growth but also agri-food sector environmental impact reduction (Tilman et al., 2001). Spiertz (2010) argues that the use of modern technologies (e.g., machinery, biotechnology, precision agriculture) and 'knowledge-intensive decision support systems' allows for the efficient use of resources while reducing environmental externalities.

The role in the adoption and diffusion of technologies and practices is crucial for the development and transformation of the agri-food sector. This role, performed by agriculture graduates, requires the competency of 'providing technical and technological services.' Graduates in study 2 were found to perform poorly in this competency. Employers suggest changing the approaches taught at the educational centers.

This result is consistent with the findings of Rodríguez-Solera and Silva-Laya (2017, p. 289). In this study, employers of agricultural graduates, in Central-American countries, regarded recently graduated agronomists as individuals who see themselves as "the ones who have control over knowledge" and disregard farmers' knowledge.

Therefore, as requested by employers in this study, graduates should be able to facilitate problem-solving and decision-making processes to reach client-based solutions. This also extends to the findings of Charatsari and Lioutas (2019), who conclude that using the 'one-size-fits-all' approach when providing advisory services does not provide solutions to the demands of the stakeholders in the agri-food sector.

In conclusion, if the approaches taught in the academic curricula are changed, then an improvement in the performance of prospective graduates in the competency of 'technical and technological services' can be expected.

Similarly, 'Partnership and collaboration with public and private actors' is among the competencies highly important for employers and poorly performed by graduates. Other studies also support the relevance of this competency. For instance, Demssie et al. (2019) consider it as the competency of "stakeholder and policy coordination" and value as it one of the key competencies in professionals facilitating activities to achieve sustainable development. Likewise, Charatsari and Lioutas (2018) conclude that 'networking competencies,' are highly required by farmers, in agronomists to provide support in the transition to sustainable agriculture production systems.

Finally, climate change is also a competency with a wider discrepancy upon its relative importance and performance. The performance in this competency, for instance, might impair agricultural graduates from facing the challenges and risks from climate variability. This is particularly important in a country currently one of the worst affected by climate change worldwide (Kreft et al., 2016).

Burandt and Barth (2010, p. 659) suggest that this competency, along with other competencies are "of particular importance for the target group of potential future decision-makers who is addressed in higher education." Therefore, specific "learning settings are needed in higher education that are suitable for that goal" (ibid, p. 659). According to the authors, these learnings settings entails the analysis of complex systems, development of scenarios, and assessment of alternatives of solution.

The low performance in the competency of 'climate change' might be in part because of the low inclusion of this competency in the academic curricula. Therefore, the graduates had limited exposure to educational activities to develop it. Study 2 shows that only two of the 16 academic curricula include this competency.

This result extends to those of Abegaz and Wims (2015), who also report low inclusion of climate change in the curriculum of agricultural technical and vocational education programs. The authors recommend reconsidering this matter in pre-service education programs of agriculture extensionists, as these professionals have the potential to change the farmer's behaviors, as well as to promote climate change adaptation and mitigation measures in agriculture.

In regard to the changes suggested in the academic curriculum and the educational process, study 2 found that the competencies required to cope with the challenges faced by the agricultural sector in Honduras are among the 20 competencies found in the academic curricula. For example, the competencies related to climate change (C9), use of technology (C11), technology design (C7), technical and technological services (C21), sustainability (C3), local and regional development process (C23), agricultural value chains (C1), among others. This therefore confirms the relevance of these competencies.

However, these competencies are not addressed adequately in the academic curricula at each educational level. For example, the competency related to climate change (C9), as earlier mentioned, and the competencies related to agricultural value chains (C1), use of technology (C11), and technology design (C7). These competencies are in three, twelve, and three of the 16 academic curricula analyzed, respectively. Furthermore, these competencies are among the lowest performed competencies; as is the case for value chains (C1), climate change (C9), and use of technology (C7).

The integration of these competencies in the curriculum should be made in conjunction or interrelation with other competencies, as the findings of this study indicate. For instance, globalization in agri-food value chains is a driven force which switches the focus of local production for a local market to production for a global market where the competition is not only based on cost-efficiency, but also in compliance with food quality and safety standards (Henson and Humphrey, 2010; Lee et al., 2012), and the reliability and timely supply of goods (Swinnen and Maertens, 2007). Therefore, the competency of agricultural value chains (C1) shows a relationship with other competencies as well, such as the competencies of national and international regulations (C4), compliance with quality and safety standards (C15), and agri-business development (C5).

As mentioned earlier in this study, only five of the 16 academic curricula analyzed, clearly stated the technical competencies, and three of the 16 curricula have a competencies profile and the assessment mechanism to value the competency acquisition.

Consequently, there is no assurance that students are leaving high school or the university with relevant competencies. That, in part, explains the low performance in the competencies required by employers.

The lack of curriculum alignment seen in the curricula analyzed also could cause the graduates' low performance in the required competencies. In competencies-based education, alignment is required between the educational goals (what is expected to be achieved), assessment mechanisms (what and how is evaluated), and the instructional process (what and how is taught) to increase its effectiveness (Koenen et al., 2015). This effectiveness is represented here as the graduates' competencies acquired, as a result of the educational program attended.

Future work should, therefore, include a review of the educational process in practice. This would provide insights about experiential learning and the relationship between theory and practice used to enhance these competencies. As mentioned earlier, employers, claim that graduates present difficulties transferring what they have learned into current practice, which could be solved if graduates during their studies acquire practical experiences that allow them to reflect upon these experiences. A similar finding is reported by Jack et al. (2014) who find that employers in the agri-food sector value in new recruitments supervision posts and previous workplace competencies acquired through 'work-based learning' or 'learning by doing' approaches, and avoid hiring a recent graduate for supervisory and management job positions if they lack previous professional experience.

Employers in Honduras are aware of the limited access that public universities and high school centers have to technological resources or workplace environments. Hence, they suggest the education authorities should make partnerships with the private sector through which students could acquire workplace experience and get acquainted with new technological products available in the market. As the findings of Jack et al. (2014) indicate, employers in Honduras should consider all relevant stakeholders (i.e., employers, education providers, and government) when deciding upon the design and delivery of educational programs, in order to meet the demands of the agri-food sector.

6.3. Efficiency in Resources Usage in Agricultural Education

Study 3 analyzes the level of efficiency of educational centers serving agriculture education at the secondary education level. Each education center is considered a DMU. The study analyzed 16 out of 120 DMUs. Only public DMUs whose senior students participated in the national pre-university standardized test, from 2014 to 2016, were included in the analysis. The method of analysis used was DEA two-stage, following the procedure suggested by Simar and Wilson (2007).

Three types of resources were analyzed, namely, full-time equivalent teachers, public and private expenditures, and school infrastructure. As for the outputs, total graduates and academic performance were used.

This study provides evidence that none of the agriculture education centers are considered a full efficient DMU, so this should be interpreted as having poor performance. However, there is potential to improve the usage of the current resources. The findings suggest expanding the outcomes in a range of 1%— 50% without changing the current resources. However, the sample size is a limitation worth noting, which requires a careful interpretation of the research findings.

In general, the low level of efficiency of the public education system in Honduras is reported by Yitzack Pavon (2008), Vos et al. (2010), Afonso et al. (2013), and World Bank (2013). According to Yitzack Pavon (2008), Vos et al. (2010) and World Bank (2013), a high share of public expenditure is devoted to education. They argue that teachers' salaries and fringe benefits are among the highest share of this investment. However, this does not necessarily translate to higher accountability, better teacher performance, and improvement in educational outcomes.

In the study of Afonso et al. (2013), a DEA analysis concludes that the efficiency level of Honduras' public spending is ranked 17^{th} and 18^{th} of 23 Latin-American countries in terms of achieving literacy rate and the quality of math and science, respectively. The countries were ranked from most to least efficient in terms of achieving these educational outcomes. The authors find Honduras to be among the least effective and efficient countries. They also conclude that on average, the countries included in the analysis "can achieve the same level of outcome using 40 percent less spending or can increase their performance by 19 percent with the same level of inputs" (ibid, p.19).

Empirical research regarding technical—vocational agricultural education at the secondary education level, in Honduras, was not available to compare with the findings of study 3. Nevertheless, studies conducted in other developing countries show mixed outcomes regarding the efficiency of agriculture vocational education. For instance, Ulimwengu and Badiane (2010), using the stochastic frontier method to compute efficiency, demonstrate that female graduates from agricultural vocational training programs are more efficient in producing agricultural outputs than female graduates who attained primary-secondary education, or no education at all. However, no difference at all was found when both genders were included in the analysis.

Regardless of the academic major, there are also mixed results in the literature regarding the performance of technical-vocational high schools compared to general academic high schools. For example, in the study of Demir and Depren (2010), vocational-technical high schools have a higher average efficiency than general high schools in producing high performer students in the PISA' s test (Programme for International Student Assessment).

As mentioned earlier in study 3, externals factors, such as the level of poverty and the share of the population working in agriculture, influence the level of efficiency of these educational centers. As for the level of poverty, several studies also confirm this finding (Chakraborty et al., 2001; Deutsch et al., 2013; Ramzi et al., 2016). The overall evidence shows that the education centers whose students are from advantaged socioeconomic backgrounds achieve a higher level of efficiency. Furthermore, Witte and López-Torres (2017, p. 17) in their revision of empirical studies on the efficiency of education, state that "there is a global consensus about the impact of these variables [family variables, socioeconomic status and educational level of parents] as deemed predictive of educational achievement."

Although the level of poverty is an external factor not controlled by the education centers, governmental policies fostering education which target economic support for students or their families could positively affect the education's efficiency, as suggested by Deutsch et al. (2013).

Of the outputs analyzed, the low student academic achievement of the agricultural graduates is a double concern. First, the students failed to achieve an acceptable academic performance, and second, it reduces the probability of being accepted at the university. Furthermore, it also exacerbates the stigma regarding vocational—technical and agricultural education students, who are perceived as low ability students that sort themselves in less challenging academic programs (Dyer and Breja, 2003; Kidane and Worth, 2014; Fieger et al., 2017). This situation, in turn, is among the factors that might affect, in the long run, the recruitment of new students (Dyer and Breja, 2003).

Among the factors, under control of the education centers, that have significant positive effects on educational achievement are teaching quality (Hanushek et al., 1998; Leithwood et al., 2019), and school principal's leadership (Leithwood et al., 2019). Further research investigating the effect of these factors will be beneficial to identify practical measures that could improve the quality of agricultural education.

7. Conclusions

This final section seeks to draw conclusions about agricultural education applicable to the situation of Honduras. These conclusions could be extended, with caution, to other Latin-American countries which share similar realities and context as Honduras. This section also lays out the limitations of the three studies conducted and provides suggestions for future work.

7.1.Main Conclusions

The purpose of this research was to analyze the determinants for the return on investment, quality, and efficiency of agricultural education. The research consisted of three studies, which sought to answer questions about how agriculture education affects graduates' earnings, what competencies employers request in agriculture graduates, and what the level of efficiency is of the resources used in agriculture education. Qualitative and quantitative methods were used, purposely chosen to overcome the well-documented caveats in the analysis of the issues at hand.

Regarding the research question about how agriculture education affects graduates' earnings, the findings of this dissertation provide compelling evidence that each additional level of agricultural education in Honduras is worth the investment. They also suggest that informing prospective students that graduating from agricultural education will provide a positive return on their investment might convince them to pursue this field of study.

The findings of study one demonstrate that secondary agriculture education appears to be effective for those who remain in the economic activity of agriculture, whereas those graduating from university are better rewarded in economic activities outside agriculture, such as public administration, education, manufacturing, and wholesale and retail trade. This suggests that additional analysis and re-orientation of the knowledge, skills, and competencies of the agricultural educational curriculum, should be based on the needs particular to these economic activities and where the graduates are being employed and may be employed in the future.

As for the second research question on what competencies employers request in agriculture graduates, study two provides evidence that the competencies included in the academic curricula are relevant in coping with the challenges faced by the agri-food sector in Honduras. However, the agricultural graduates' performance in these competencies is far from outstanding. Thus, there is room for improvement in order to prepare the graduates better to meet the employers' requirements and to cope with these challenges. Among the 20

competencies analyzed in this study, the current situation in six of them suggests an urgency to act.

In relation to the third research question concerning the level of efficiency of the resources used in agriculture education, the analysis of the efficiency of secondary education clearly shows that none of the agriculture education centers were found to be fully efficient. These findings demonstrate that, under the assumed framework conditions, it is possible to increase the students' academic achievement and the number of graduates without increasing the current resources.

The evidence across the three studies supports the premise laid out by several scholars that agricultural education is in need of re-invention or adaptation to meet the demands of the agri-food sector and its prospective students. The findings indicate that graduates from both levels of agriculture education are necessary to support Honduras' economy. Nevertheless, improvements should be made in terms of the quality and resources used.

Hence, based on the research findings, the following recommendations are made. First, the academic curriculum should be revised using the discrepancy analysis' results as an entry point. Second, the implementation of the educational processes should be analyzed to enhance the competencies requested and to identify better management of the resources available. Third, a formal collaboration should be established between the education centers' authorities and the private sector, through which employers have a say in the updating process of the agricultural educational programs. In addition, the students should acquire work-place experience and get acquainted with new technological products available in the market as part of their education.

7.2.Limitations of the Studies and Future Research

This section discusses several limitations of the studies presented which should be addressed in future work. These limitations are related to the dataset and sample sizes employed and the topics not addressed in the research.

In study one, to compute better estimates of return on investment in agriculture education, a variety of information that is seldom available is required, particularly in developing countries, as is the case of Honduras. Most of the information used in study 1 was from a nationwide HHS. There were still gaps in the information required, that information had to be produced from other sources. It would be beneficial in further research if this gap could efficiently be filled by including additional questions in this survey, such as the level of education and occupation of

the parents of the households' heads. This additional information can be used as IVs in the analysis of the return on investment in education to produce better estimates.

Study two investigated the performance of agricultural graduates in technical competencies, the demand of these competencies, and the level of inclusion of these competencies in the academic curricula. To further refine this research, it would be beneficial to include a comprehensive analysis of the curriculum and how it is implemented. Future research can also extend this research by increasing the sample size and randomly selecting the employers to statistically make inferences about the entire population of agricultural graduates in Honduras.

Moreover, although employers included in study 2 are diverse and offer an array of different jobs, therefore, requiring many competencies, it is important to remember that these results only represent the employers' views regarding the agricultural graduates' performance. Further studies are required to establish the perspective of graduates and education providers and to identify the training areas that adequately prepare the students for their future jobs, as well as the areas that are lacking.

Finally, study three has only considered efficiency in a small sample of secondary education centers providing agricultural education. It would be particularly interesting to explore a bigger sample of these centers, as well as analyze whether there are differences between private and public agriculture high schools, or between educational levels (e.g., secondary and tertiary education levels), regarding their level of efficiency and the factors influencing them. Increasing the sample size would allow the techniques used in this study to be expanded further, for instance the stochastic frontier method would enable these estimates to be compared better.

Lastly, future work on agricultural education required to explore how the education process is conducted in practice, particularly the assessment of the academic curriculum and aspects that positively affect student academic performance, such as teaching quality and the role of school leadership.

8. Bibliography

Abbott, M.; Doucouliagos, C. (2003): The efficiency of Australian universities: a data envelopment analysis. In *Economics of Education Review* 22 (1), pp. 89–97. DOI: 10.1016/S0272-7757(01)00068-1.

Abegaz, Dagmawi M.; Wims, Padraig (2015): Extension Agents' Awareness of Climate Change in Ethiopia. In *The Journal of Agricultural Education and Extension* 21 (5), pp. 479–495. DOI: 10.1080/1389224X.2014.946936.

Acker, David G. (1999): Improving the quality of higher education in agriculture globally in the 21st century: Constraints and opportunities. In *Journal of International Agricultural and Extension Education* 6 (2), pp. 47–53.

Afonso, Antonio; Romero-Barrutieta, Alma; Monsalve, Emma (2013): Public Sector Efficiency: Evidence for Latin America. In *SSRN Journal*. DOI: 10.2139/ssrn.2365007.

Afonso, António; St. Aubyn, Miguel (2006): Cross-country efficiency of secondary education provision: A semi-parametric analysis with non-discretionary inputs. In *Economic Modelling* 23 (3), pp. 476–491. DOI: 10.1016/j.econmod.2006.02.003.

Agasisti, Tommaso; Munda, Giuseppe (2017): Efficiency of investment in compulsory education: An Overview of Methodological Approaches. Joint Research Centre (Seville site).

Aigner, Dennis; Lovell, C. KnoxA; Schmidt, Peter (1977): Formulation and estimation of stochastic frontier production function models. In *Journal of econometrics* 6 (1), pp. 21–37.

Altieri, Miguel A. (1998): An agroecological perspective to guide graduate educational programs in agricultural economics and rural development in Latin America of the XXI century. In *Ecological Economics* 27 (3), pp. 227–236.

Altonji, Joseph G. (1993): The Demand for and Return to Education When Education Outcomes are Uncertain. In *Journal of Labor Economics* 11 (1), pp. 48–83. Available online at http://www.jstor.org/stable/2535184.

Altonji, Joseph G.; Arcidiacono, Peter; Maurel, Arnaud (2016): The analysis of field choice in college and graduate school: Determinants and wage effects. In : Handbook of the Economics of Education, vol. 5: Elsevier, pp. 305–396.

Altonji, Joseph G.; Blom, Erica; Meghir, Costas (2012): Heterogeneity in human capital investments: High school curriculum, college major, and careers. In *Annu. Rev. Econ.* 4 (1), pp. 185–223.

Altonji, Joseph G.; Elder, Todd E.; Taber, Christopher R. (2005): Selection on Observed and Unobserved Variables: Assessing the Effectiveness of Catholic Schools. In *Journal of political economy* 113 (1), pp. 151–184. DOI: 10.1086/426036.

Andersson, C.; Antelius, J.; Månsson, Jonas; Sund, Krister (2017): Technical efficiency and productivity for higher education institutions in Sweden. In *Scandinavian Journal of Educational Research* 61 (2), pp. 205–223.

Andréu, Carlos (2012): Rural poverty in Honduras: despite progress, an ongoing challenge. In *Global Majority E-Journal* 3 (2), pp. 100–109.

Angrist, Joshua D.; Krueger, Alan B. (2001): Instrumental Variables and the Search for Identification. From Supply and Demand to Natural Experiments. In *Journal of Economic Perspectives* 15 (4), pp. 69–85. DOI: 10.1257/jep.15.4.69.

Antle, John M. (1983): Infrastructure and Aggregate Agricultural Productivity: International Evidence. In *Economic Development and Cultural Change* 31 (3), pp. 609–619. DOI: 10.1086/451344.

Artz, Georgeanne M.; Kimle, Kevin L.; Orazem, Peter F. (2013): Does the Jack of all trades hold the winning hand? Comparing the role of specialized versus general skills in the returns to an agricultural degree. In *American Journal of Agricultural Economics* 96 (1), pp. 193–212.

Avila, Juan; Duarte, Lazaro; Bonilla, Idalia; Romero, Gustavo; Berrios, Reulo (2002): Situacion de la Educacion Agricola en Honduras. In *La Ceiba* 43 (1), pp. 21–25.

Badiru, Idris Olabode; Aluko, Bolanle; Adejumo, Adewale Adisa (2019): Teachers' Perception of the Effects of the New Education Curriculum on the Choice of Agriculture as a Career Among Secondary School Students in Oyo State. In *Journal of Agricultural & Food Information* 20 (1), pp. 86–95. DOI: 10.1080/10496505.2018.1531008.

Bailly, Franck (2008): The role of employers' beliefs in the evaluation of educational output. In *The Journal of Socio-Economics* 37 (3), pp. 959–968. DOI: 10.1016/j.socec.2006.12.083.

Barkley, Andrew P.; Biere, Arlo (2001): Does undergraduate major matter? Differences in salaries and satisfaction levels of Agribusiness and Agricultural Economics majors at Kansas State University. In *The International Food and Agribusiness Management Review* 4 (2), pp. 167–187.

Becker, Gary S. (1962): Investment in human capital: A theoretical analysis. In *Journal of political economy* 70 (5, Part 2), pp. 9–49.

Berger, Mark C. (1988): Predicted Future Earnings and Choice of College Major. In *Industrial and Labor Relations Review* 41 (3), p. 418. DOI: 10.2307/2523907.

Blanco, M.; Samper, M. (2009): Información general sobre la agroindustria rural en Honduras. IICA, Tegucigalpa (Honduras).

Boarini, Romina; Strauss, Hubert (2007): The Private Internal Rates of Return to Tertiary Education: New Estimates for 21 OECD Countries (591). DOI: 10.1787/031008650733.

Borich, Gary D. (1980): A Needs Assessment Model for Conducting Follow-Up Studies. In *Journal of Teacher Education* 31 (3), pp. 39–42. DOI: 10.1177/002248718003100310.

Borjas, George J. (2010): Labor economics. 5. ed., internat. student ed. Boston, Mass: McGraw-Hill/Irwin (McGraw-Hill higher education).

Bound, John; Jaeger, David A.; Baker, Regina M. (1995): Problems with Instrumental Variables Estimation when the Correlation between the Instruments and the Endogenous Explanatory Variable is Weak. In *Journal of the American Statistical Association* 90 (430), pp. 443–450. DOI: 10.1080/01621459.1995.10476536.

Burandt, Simon; Barth, Matthias (2010): Learning settings to face climate change. In *Journal of Cleaner Production* 18 (7), pp. 659–665. DOI: 10.1016/j.jclepro.2009.09.010.

Campion, Michael A.; Fink, Alexis A.; Ruggeberg, Brian J.; Carr, Linda; Phillips, Geneva M.; Odman, Ronald B. (2011): Doing Competencies Well. Best Practices in Competency Modeling. In *Personnel Psychology* 64 (1), pp. 225–262. DOI: 10.1111/j.1744-6570.2010.01207.x.

Card, David (1993): Using geographic variation in college proximity to estimate the return to schooling. National Bureau of Economic Research.

Card, David (1999): The causal effect of education on earnings. In : Handbook of labor economics, vol. 3: Elsevier, pp. 1801–1863.

Cárdenas, Mauricio; Hoyos, Rafael de; Székely, Miguel (2015): Out-of-School and Out-of-Work Youth in Latin America: A Persistent Problem in a Decade of Prosperity. In *Economía* 16 (1), pp. 1–40. Available online at http://www.jstor.org/stable/24570864.

Casavant, Ken; Infanger, Craig L.; Bridges, Deborah E. (1999): Agricultural economics and management: Prentice Hall.

Central Bank (2016): Honduras en cifras. Periodo 2013 a 2015. Goverment of Honduras. Available online at http://www.bch.hn/honduras_en_cifras.php, checked on 10/31/2016.

Central Bank (2018): Honduras en Cifras. Goverment of Honduras. Tegucigalpa, Honduras. Available online at https://www.bch.hn/honduras_en_cifras.php, checked on 1/13/2018.

Chakraborty, Kalyan; Biswas, Basudeb; Lewis, W. Cris (2001): Measurement of Technical Efficiency in Public Education: A Stochastic and Nonstochastic Production Function Approach. In *Southern Economic Journal* 67 (4), p. 889. DOI: 10.2307/1061576.

Charatsari, C.; Lioutas, E. D. (2019): Is current agronomy ready to promote sustainable agriculture? Identifying key skills and competencies needed. In *International Journal of Sustainable Development & World Ecology* 26 (3), pp. 232–241.

Charnes, Abraham; Cooper, William W.; Rhodes, Edwardo (1978): Measuring the efficiency of decision making units. In *European journal of operational research* 2 (6), pp. 429–444.

Cheong Cheng, Yin; Ming Tam, Wai (1997): Multi-models of quality in education. In *Quality assurance in Education* 5 (1), pp. 22–31.

Conroy, Carol A. (2000): Reinventing Career Education and Recruitment in Agricultural Education for the 21st Century. In *Journal of Agricultural Education* 41 (4), pp. 73–84.

Cook, Wade D.; Tone, Kaoru; Zhu, Joe (2014): Data envelopment analysis: Prior to choosing a model. In *Omega* 44, pp. 1–4.

Cordero-Ferrera, Jose Manuel; Pedraja-Chaparro, Francisco; Salinas-Jiménez, Javier (2008): Measuring efficiency in education: an analysis of different approaches for incorporating non-discretionary inputs. In *Applied Economics* 40 (10), pp. 1323–1339.

Correll, Shelley J. (2001): Gender and the career choice process: The role of biased self-assessments. In *American journal of Sociology* 106 (6), pp. 1691–1730.

David, Christophe; Bell, Michael M. (2018): New challenges for education in agroecology. In *Agroecology and Sustainable Food Systems* 42 (6), pp. 612–619. DOI: 10.1080/21683565.2018.1426670.

Demir, İbrahim; Depren, Özer (2010): Assessing Turkey's secondary schools performance by different region in 2006. In *Procedia - Social and Behavioral Sciences* 2 (2), pp. 2305–2309. DOI: 10.1016/j.sbspro.2010.03.326.

Demssie, Yared Nigussie; Wesselink, Renate; Biemans, Harm J. A.; Mulder, Martin (2019): Think outside the European box: Identifying sustainability competencies for a base of the pyramid context. In *Journal of Cleaner Production* 221, pp. 828–838.

Deutsch, Joseph; Dumas, Audrey; Silber, Jacques (2013): Estimating an educational production function for five countries of Latin America on the basis of the PISA data. In *Economics of Education Review* 36, pp. 245–262. DOI: 10.1016/j.econedurev.2013.07.005.

Dias Avila, Antonio Flavio; Romano, Luis; Garagorry, Fernando (2010): Chapter 71 Agricultural Productivity in Latin America and the Caribbean and Sources of Growth. In : Handbook of Agricultural Economics, vol. 4: Elsevier, pp. 3713–3768. Available online at http://www.sciencedirect.com/science/article/pii/S1574007209040717.

Díaz-Pichardo, René; Cantú-González, Cecilia; López-Hernández, Patricia; McElwee, Gerard (2012): From Farmers to Entrepreneurs:The Importance of Collaborative Behaviour. In *The Journal of Entrepreneurship* 21 (1), pp. 91–116. DOI: 10.1177/097135571102100104.

Dickson, M.; Harmon, C. (2011): Economic returns to education: What We Know, What We Don't Know, and Where We Are Going—Some brief pointers. In *Economics of Education Review* 30 (6), pp. 1118–1122. DOI: 10.1016/j.econedurev.2011.08.003.

Dubin, Jeffrey A.; McFadden, Daniel L. (1984): An Econometric Analysis of Residential Electric Appliance Holdings and Consumption. In *Econometrica* 52 (2), p. 345. DOI: 10.2307/1911493.

Duflo, Esther (2001): Schooling and labor market consequences of school construction in Indonesia: Evidence from an unusual policy experiment. In *American economic review* 91 (4), pp. 795–813.

Dyer, James E.; Breja, Lisa M. (2003): Problems In Recruiting Students Into Agricultural Education Programs: A Delphi Study Of Agriculture Teacher Perceptions. In *Journal of Agricultural Education* 44 (2), pp. 75–85. DOI: 10.5032/jae.2003.02075.

Dyson, Robert G.; Allen, Rachel; Camanho, Ana S.; Podinovski, Victor V.; Sarrico, Claudia S.; Shale, Estelle A. (2001): Pitfalls and protocols in DEA. In *European journal of operational research* 132 (2), pp. 245–259. DOI: 10.1016/S0377-2217(00)00149-1.

Easterly III, R. G.; Warner, Anna J.; Myers, Brian E.; Lamm, Alexa J.; Telg, Ricky W. (2017): Skills Students Need in the Real World: Competencies Desired by Agricultural and Natural Resources Industry Leaders. In *Journal of Agricultural Education* 58 (4), pp. 225–239.

ECLAC (2015): Climate Change in Central America. Potential Impacts and Public Policy Options. Edited by ECLAC. United Nations. Mexico D.F, Mexico. Available online at https://repositorio.cepal.org//handle/11362/39150, checked on 8/22/2019.

Ehrenberg, Ronald G.; Smith, Robert S. (2017): Modern Labor Economics. Thirteenth Edition. | New York : Routledge, 2017. | Revised edition of the authors' Modern labor economics, [2015]: Routledge.

Esters, Levon T.; Bowen, Blannie E. (2004): Factors Influencing Enrollment in an Urban Agricultural Education Program. In *Journal of career and technical education* 21 (1), pp. 25–37.

European Centre for the Development of Vocational Training; UNESCO; European Training Foundation (2017): Global inventory of regional and national qualifications frameworks 2017. With assistance of Jens Bjørnåvol, Slava Pevec Grm, Ernesto Villalba. Luxembourg: Publilcation Office of the European Union.

European Commission (2008): The European Qualifications Framework for Lifelong Learning. (EQF). European Commission -Education and Culture. Luxemburg.

FAO; ECLAC; IICA (2017): The Outlook for Agriculture and Rural Development in the Americas. A Perspective on Latin America and the Caribbean 2017-2018. FAO; ECLAC; IICA. San Jose, Costa Rica (252).

Farber, H. S.; Gibbons, R. (1996): Learning and Wage Dynamics. In *The Quarterly Journal of Economics* 111 (4), pp. 1007–1047. DOI: 10.2307/2946706.

Farrell, M. J. (1957): The Measurement of Productive Efficiency. In *Journal of the Royal Statistical Society. Series A (General)* 120 (3), p. 253. DOI: 10.2307/2343100.

Fernandez, Roberto (1994): Evaluacion Curricular de las Instituciones de Educacion Superior Agricola en Honduras. Thesis. Escuela Agricola Panamericana El Zamorano, El Zamorano, Honduras.

Fieger, Peter; Villano, Renato Andrin; Rice, John; Cooksey, Ray (2017): Two dimensional efficiency measurements in vocational education: evidence from Australia. In *International Journal of Productivity and Performance Management* 66 (2), pp. 196–215.

Foxley, Alejandro; Stallings, Barbara (2016): Innovation and inclusion in Latin America: strategies to avoid the middle income trap: Springer.

Freeman, Richard B. (1986): Demand for education. In *Handbook of labor economics* 1, pp. 357–386.

Fresco, Louise O. (2009): Challenges for food system adaptation today and tomorrow. In *Environmental science & policy* 12 (4), pp. 378–385.

Frick, Martin J.; Kahler, Alan A.; Miller, W. Wade (1991): A definition and the concepts of agricultural literacy. In *Journal of Agricultural Education* 32 (2), pp. 49–57.

Galt, Ryan E.; Parr, Damian; Jagannath, Janaki (2012): Facilitating competency development in sustainable agriculture and food systems education. A self-assessment approach. In *International Journal of Agricultural Sustainability* 11 (1), pp. 69–88. DOI: 10.1080/14735903.2012.683569.

Gillespie, Jeffrey M.; Bampasidou, Maria (2018): Designing Agricultural Economics and Agribusiness Undergraduate Programs. In *J. Agric. Appl. Econ.* 50 (3), pp. 319–348. DOI: 10.1017/aae.2017.36.

Gindling, Tim H; Terrell, Katherine. (2009): Minimum wages, wages and employment in various sectors in Honduras. In *Labour Economics* 16 (3), pp. 291–303. DOI: 10.1016/j.labeco.2008.10.001.

Gobierno de Honduras (2010): Vision de Pais 2010-2038 y Plan de Nacion 2010-2022. 2010. Tegucigalpa, Honduras.

Gollin, Douglas; Lagakos, David; Waugh, Michael E. (2014): The Agricultural Productivity Gap. In *The Quarterly Journal of Economics* 129 (2), pp. 939–993. DOI: 10.1093/qje/qjt056.

Gottipati, Swapna; Shankararaman, Venky (2018): Competency analytics tool. Analyzing curriculum using course competencies. In *Education and Information Technologies* 23 (1), pp. 41–60. DOI: 10.1007/s10639-017-9584-3.

Groot, Wim (1994): Differences in Rates of Return by Type of Education. In *Education Economics* 2 (2), pp. 209–214. DOI: 10.1080/09645299400000017.

Guest, Greg; Bunce, Arwen; Johnson, Laura (2016): How Many Interviews Are Enough? In *Field Methods* 18 (1), pp. 59–82. DOI: 10.1177/1525822X05279903.

Halász, Gábor; Michel, Alain (2011): Key Competences in Europe. Interpretation, policy formulation and implementation. In *European Journal of Education* 46 (3), pp. 289–306. DOI: 10.1111/j.1465-3435.2011.01491.x.

Hanushek, Eric; Kain, John; Rivkin, Steven (1998): Teachers, Schools, and Academic Achievement. Cambridge, MA.

Hanushek, Eric A.; Luque, Javier A. (2003): Efficiency and equity in schools around the world. In *Economics of Education Review* 22 (5), pp. 481–502.

Harmon, Colm; Walker, Ian (1995): Estimates of the Economic Return to Schooling for the United Kingdom. In *The American Economic Review* 85 (5), pp. 1278–1286.

Harris, David R.; Fuller, Dorian Q. (2014): Agriculture: definition and overview. In *Encyclopedia of global archaeology*, pp. 104–113.

Harvey, Lee; Green, Diana (1993): Defining quality. In *Assessment & evaluation in higher education* 18 (1), pp. 9–34.

Harvey, Lee; Green, Diana; Burrows, Alison (1993): Assessing Quality in Higher Education. A transbinary research project. In *Assessment & evaluation in higher education* 18 (2), pp. 143–148. DOI: 10.1080/0260293930180206.

Heanue, Kevin; O'Donoghue, Cathal (2014): The economic returns to formal agricultural education. *Teagasc: Oak Park Carlow, 2*.

Heckman, James J. (1979): Sample Selection Bias as a Specification Error. In *Econometrica* 47 (1), p. 153. DOI: 10.2307/1912352.

Heckman, James J.; Lochner, Lance J.; Todd, Petra E. (2006): Earnings functions, rates of return and treatment effects: The Mincer equation and beyond. In *Handbook of the Economics of Education* 1, pp. 307–458.

Henson, Spencer; Humphrey, John (2010): Understanding the complexities of private standards in global agri-food chains as they impact developing countries. In *The journal of development studies* 46 (9), pp. 1628–1646.

Hodge, David R.; Gillespie, David F. (2007): Phrase Completion Scales. In *Journal of Social Service Research* 33 (4), pp. 1–12. DOI: 10.1300/J079v33n04_01.

Hoffmann, Terrence (1999): The meanings of competency. In *Jnl Euro Industrial Training* 23 (6), pp. 275–286. DOI: 10.1108/03090599910284650.

Hsieh, Hsiu-Fang; Shannon, Sarah E. (2005): Three approaches to qualitative content analysis. In *Qualitative health research* 15 (9), pp. 1277–1288.

Huffman, Wallace E. (2001): Human capital: Education and agriculture. In *Handbook of agricultural economics* 1, pp. 333–381.

ILO (2017): Honduras - Encuesta Permanente de Hogares y Propósitos Múltiples, Jun 2016. ILO. Available online at https://www.ilo.org/surveydata/index.php/catalog/1616/study-description#page=data_collection&tab=study-desc, checked on 11/8/2019.

Imbach, Pablo; Beardsley, Megan; Bouroncle, Claudia; Medellin, Claudia; Läderach, Peter; Hidalgo, Hugo et al. (2017): Climate change, ecosystems and smallholder agriculture in Central America: an introduction to the special issue. In *Climatic Change* 141 (1), pp. 1–12. DOI: 10.1007/s10584-017-1920-5.

INE (2016[a]): Censo de XVII Poblacion y VI Vivienda 2013. uadros de Mercado Laboral - Población de 10 años y más, por categoría ocupacional, según departamento, área, sexo y rama de actividad. Goverment of Honduras. Tegucigalpa, Honduras. Available online at http://www.ine.gob.hn/index.php/component/content/article?id=81, checked on 10/15/2016.

INE (2016[b]): Encuesta Permanente de Hogares EPHPM 2016. Cuadros de Mercado Laboral. Cuadro No. 2. Tasa de Desempleo Abierto (TDA), Población en Edad de Trabajar (PET) y Población Económicamente Activa (PEA),según dominio, nivel educativo, rango de edad, sexo, rama de actividad. Tegucigalpa, Honduras. Available online at http://170.238.108.227/binhnd/RpWebEngine.exe/Portal?BASE=EPH2016&lang=ESP, checked on 12/11/2019.

INE (2017): Metodologia de la LIV Encuesta Permanente de Hogares de Propositos Multiples (EPHPM) Junio 2016. Goverment of Honduras. Tegucigalpa, Honduras. Available online at https://www.ilo.org/surveydata/index.php/catalog/1616, checked on 11/8/2019.

INE (2018): Directorio de Establecimientos Economicos. Base de datos. Gobierno de Honduras. Tegucigalpa, Honduras. Available online at http://170.238.108.227/binhnd/RpWebEngine.exe/Portal?BASE=DEE1&lang=ESP, checked on 1/18/2018.

INE (2019): Tomos del Censo de Poblacion y Vivienda 2013. Caracteristicas Generales de la Poblacion. Mercado Laboral. Gobierno de Honduras. Tegucigalpa, Honduras. Available online at https://www.ine.gob.hn/index.php/component/content/article?id=81, checked on 5/28/2019.

Izquierdo, Alejandro; Pessino, Carola (2018): Better spending for better lives. How Latin American and the Caribbean can do more with less. Edited by Alejandro Izquierdo, Carola Pessino. Washington, D.C.: Inter-American Development Bank.

Jack, Claire; Anderson, Duncan; Connolly, Niamh (2014): Innovation and skills: implications for the agri-food sector. In *Education+ Training* 56 (4), pp. 271–286.

Jimenez, Emmanuel; Patrinos, Harry Anthony (2008): Can Cost-Benefit Analysis Guide Education Policy In Developing Countries?: The World Bank.

Johnes, Jill; Portela, Maria; Thanassoulis, Emmanuel (2017): Efficiency in education: Taylor & Francis.

Kaplinsky, Raphael. (2004): Spreading the Gains from Globalization. What Can Be Learned from Value-Chain Analysis? In *Problems of Economic Transition* 47 (2), pp. 74–115. DOI: 10.1080/10611991.2004.11049908.

Kaufman, Roger A.; English, Fenwick W. (1979): Needs assessment. Concept and application: Educational Technology.

Kidane, T. T.; Worth, S. H. (2014): Student Perceptions of Agricultural Education Programme Processes at Selected High Schools in KwaZulu-Natal Province, South Africa. In *The Journal of Agricultural Education and Extension* 20 (4), pp. 381–396. DOI: 10.1080/1389224X.2013.872046.

Kilpatrick, Sue (2000): Education and training: impacts on farm management practice. In *The Journal of Agricultural Education and Extension* 7 (2), pp. 105–116.

Koenen, Anne-Katrien; Dochy, Filip; Berghmans, Inneke (2015): A phenomenographic analysis of the implementation of competence-based education in higher education. In *Teaching and Teacher Education* 50, pp. 1–12. DOI: 10.1016/j.tate.2015.04.001.

Koshy, Paul; Seymour, Richard; Dockery, Mike (2016): Are there institutional differences in the earnings of Australian higher education graduates? In *Economic Analysis and Policy* 51, pp. 1–11. DOI: 10.1016/j.eap.2016.05.004.

Kreft, Sönke; Eckstein, David; Melchor, Inga (2016): Global Climate Risk Index 2017. Who Suffers Most From Extreme Weather Events? Weather-related Loss Events in 2015 and 1996 to 2015. Edited by Joanne Chapman-Rose, Daniela Baurm. Germawatch. Bonn, Germany. Available online at https://www.germanwatch.org/en/cri, checked on 8/22/2019.

LaCharite, Kerri (2016): Re-visioning agriculture in higher education: the role of campus agriculture initiatives in sustainability education. In *Agriculture and Human Values* 33 (3), pp. 521–535. DOI: 10.1007/s10460-015-9619-6.

Le Deist, Françoise Delamare; Winterton, Jonathan (2005): What Is Competence? In *Human Resource Development International* 8 (1), pp. 27–46. DOI: 10.1080/1367886042000338227.

Lee, Joonkoo; Gereffi, Gary; Beauvais, Janet (2012): Global value chains and agrifood standards: Challenges and possibilities for smallholders in developing countries. In *Proceedings of the National Academy of Sciences* 109 (31), pp. 12326–12331.

Lehman, Hugh; Clark, E. Ann; Weise, Stephan F. (1993): Clarifying the definition ofSustainable agriculture. In *Journal of Agricultural and Environmental Ethics* 6 (2), pp. 127–143.

Leigh, Andrew; Ryan, Chris (2008): Estimating returns to education using different natural experiment techniques. In *Economics of Education Review* 27 (2), pp. 149–160.

Leithwood, Kenneth; Harris, Alma; Hopkins, David (2019): Seven strong claims about successful school leadership revisited. In *School Leadership & Management* 3 (4), pp. 1–18. DOI: 10.1080/13632434.2019.1596077.

Leung, Shing-On (2011): A Comparison of Psychometric Properties and Normality in 4-, 5-, 6-, and 11-Point Likert Scales. In *Journal of Social Service Research* 37 (4), pp. 412–421. DOI: 10.1080/01488376.2011.580697.

Lockheed, Marlaine E.; Hanushek, Eric Alan (1994): Concepts of educational efficiency and effectiveness: World Bank Washington, DC.

Lockheed, Marlaine E.; Jamison, T.; Lau, Lawrence J. (1980): Farmer Education and Farm Efficiency: A Survey. In *Economic Development and Cultural Change* 29 (1), pp. 37–76. DOI: 10.1086/451231.

López-Torres, Laura; Prior, Diego (2016): Centralized allocation of human resources. An application to public schools. In *Computers & Operations Research* 73, pp. 104–114. DOI: 10.1016/j.cor.2016.04.001.

M.A. Muñiz (2002): Separating managerial inefficiency and external conditions in data envelopment analysis. In *European journal of operational research* 143 (3), pp. 625–643. DOI: 10.1016/S0377-2217(01)00344-7.

Maguire, Charles J. (2012): Agricultural Education and Training to Support Agricultural Innovation Systems. In : Agricultural innovation systems. An investment sourcebook. Washington, D.C: The World Bank (Agriculture and rural development), pp. 107–177.

Makki, Shiva S.; Tweeten, Luther G.; Thraen, Cameron S. (1999): Investing in research and education versus commodity programs: implications for agricultural productivity. In *Journal of Productivity Analysis* 12 (1), pp. 77–94.

Martensen, Anne; Grønholdt, Lars. (2009): Quality in higher education. Linking graduates' competencies and employers' needs. In *Int J Qual & Service Sciences* 1 (1), pp. 67–77. DOI: 10.1108/17566690910945877.

McClelland, David C. (1973): Testing for competence rather than for "intelligence". In *American psychologist* 28 (1), p. 1.

McElwee, Gerard (2006): Farmers as entrepreneurs: developing competitive skills. In *Journal of developmental entrepreneurship* 11 (03), pp. 187–206.

Méhaut, Philippe; Winch, Christopher (2012): The European Qualification Framework. Skills, Competences or Knowledge? In *European Educational Research Journal* 11 (3), pp. 369–381. DOI: 10.2304/eerj.2012.11.3.369.

Meller, Patricio; Gana, Joaquín (2016): Perspectives on Latin American technological innovation. In : Innovation and Inclusion in Latin America: Springer, pp. 89–114.

Mincer, Jacob (1974): Schooling, Experience, and Earnings. Human Behavior & Social Institutions No. 2. New York: National Bureau of Economic Research, Inc.

Mizikaci, Fatma (2006): A systems approach to program evaluation model for quality in higher education. In *Quality assurance in Education* 14 (1), pp. 37–53. DOI: 10.1108/09684880610643601.

Montenegro, Claudio E.; Patrinos, Harry Anthony (2014): Comparable estimates of returns to schooling around the world: The World Bank.

Morse, Janice M. (2015): Analytic Strategies and Sample Size. In *Qualitative health research* 25 (10), pp. 1317–1318. DOI: 10.1177/1049732315602867.

Mulder, Martin (2001): Competence development-some background thoughts. In *The Journal of Agricultural Education and Extension* 7 (4), pp. 147–158.

Mulder, Martin (2017): Competence Theory and Research. A Synthesis. In Martin Mulder (Ed.): Competence-based vocational and professional education. Bridging the worlds of work and education / Martin Mulder, editor. Switzerland: Springer Verlag (Technical and vocational education and training: issues, concerns and prospects, volume 23), pp. 1071–1106.

Mulder, Martin; Kupper, Hendrik (2006): The Future of Agricultural Education: The Case of the Netherlands. The Journal of Agricultural Education and Extension. In *The Journal of Agricultural Education and Extension* 12 (2), pp. 127–139. DOI: 10.1080/13892240600861658.

Mulder, Martin; Pachuau, Angela (2011): How agricultural is agricultural education and extension? In *The Journal of Agricultural Education and Extension* 17 (3), pp. 219–222. DOI: 10.1080/1389224X.2011.559056.

Mundlak, Yair; Larson, Donald; Butzer, Ritz (1997): The Determinants of Agricultural Production: A Cross-Country Analysis. US: The World Bank (The Determinants of Agricultural Production: A Cross-Country Analysis).

O'Donoghue, Cathal; Heanue, Kevin (2018): The impact of formal agricultural education on farm level innovation and management practices. In *The Journal of Technology Transfer* 43 (4), pp. 844–863. DOI: 10.1007/s10961-016-9529-9.

OEI-Gobierno de Honduras (2018): Marco Nacional de Cualificaciones para la Educación y Formación Técnica Profesional de Honduras. Organización de Estados Iberoamericanos. Tegucigalpa, Honduras.

Panizza, Ugo; Qiang, Christine Zhen-Wei (2005): Public–private wage differential and gender gap in Latin America: Spoiled bureaucrats and exploited women? In *The Journal of Socio-Economics* 34 (6), pp. 810–833. DOI: 10.1016/j.socec.2005.07.022.

Parr, Damian M.; Trexler, Cary J.; Khanna, Navina R.; Battisti, Bryce T. (2007): Designing sustainable agriculture education: Academics' suggestions for an undergraduate curriculum at a land grant university. In *Agriculture and Human Values* 24 (4), pp. 523–533. DOI: 10.1007/s10460-007-9084-y.

Patton, Michael Quinn (2015): Qualitative research & evaluation methods. Integrating theory and practice. Fourth edition. Los Angeles, London, New Delhi, Singapore, Washington DC: Sage.

Poole, Nigel D.; Lynch, Kenny (2003): Agricultural market knowledge: Systems for delivery of a private and public good. In *The Journal of Agricultural Education and Extension* 9 (3), pp. 117–126. DOI: 10.1080/13892240385300181.

Porter, Michael E. (1998): Competitive advantage. Creating and sustaining superior performance : with a new introduction / Michael E. Porter. New York, London: Free Press.

Pouratashi, Mahtab (2015): Entrepreneurial intentions of agricultural students: Levels and determinants. In *The Journal of Agricultural Education and Extension* 21 (5), pp. 467–477.

Psacharopoulos, George (2006): The value of investment in education: Theory, evidence, and policy. In *Journal of Education Finance*, pp. 113–136.

Psacharopoulos, George; Chu Ng, Ying (1994): Earnings and Education in Latin America. In *Education Economics* 2 (2), pp. 187–207. DOI: 10.1080/09645299400000016.

Psacharopoulos, George; Patrinos, Harry (2002): Returns to investment in education. A further update. In *The Policy Research Working Paper Series* 2881, pp. 1–28.

Psacharopoulos, George; Patrinos, Harry Anthony (2004): Returns to investment in education: a further update. In *Education Economics* 12 (2), pp. 111–134. DOI: 10.1080/0964529042000239140.

Psacharopoulos, George; Patrinos, Harry Anthony (2018): Returns to investment in education: a decennial review of the global literature. In *Education Economics* 26 (5), pp. 445–458. DOI: 10.1080/09645292.2018.1484426.

Quijada, José Alejandro; Sierra, José David (2014): Productividad total de los factores en Honduras: Diagnóstico y posibles determinantes.

Ramzi, Sourour; Afonso, António; Ayadi, Mohamed (2016): Assessment of efficiency in basic and secondary education in Tunisia: A regional analysis. In *International Journal of Educational Development* 51, pp. 62–76. DOI: 10.1016/j.ijedudev.2016.08.003.

Reimers, Malte; Klasen, Stephan (2013): Revisiting the role of education for agricultural productivity. In *American Journal of Agricultural Economics* 95 (1), pp. 131–152.

Rivera, William M.; Alex, Gary E. (2008): Human Resource Development for Modernizing the Agricultural Workforce. In *Human Resource Development Review* 7 (4), pp. 374–386. DOI: 10.1177/1534484308324633.

Rivera, William M.; Qamar, M. Kalim; Mwandemere, Henry K. (2005): Enhancing coordination among AKIS/RD actors: An analytical and comparative review of country studies on agricultural knowledge and information systems for rural development (AKIS/RD).

Rodriguez, Donna, et al. (2002): Developing competency models to promote integrated human resource practices. In *Human Resource Management: Published in Cooperation with the School of Business Administration, The University of Michigan and in alliance with the Society of Human Resources Management* 41 (3), pp. 309–324.

Rodríguez-Solera, Carlos Rafael; Silva-Laya, Marisol (2017): Higher education for sustainable development at EARTH University. In *International Journal of Sustainability in Higher Education* 18 (3), pp. 278–293.

Rychen, Dominique Simone; Sagalnik, Laura H. (2001): Defining and selecting key competencies. Kirkland, WA: Hogrefe & Huber.

SAG (2004): Politica de Estado para el Sector Agroalimentario y el Medio Rural de Honduras. 2004-2021. SAG-Gobierno de Honduras. Tegucigalpa, Honduras.

Sagarra, Marti; Mar-Molinero, Cecilio; Agasisti, Tommaso (2017): Exploring the efficiency of Mexican universities: Integrating data envelopment analysis and multidimensional scaling. In *Omega* 67, pp. 123–133.

Saldaña, Johnny (2015): The coding manual for qualitative researchers: Sage.

Sanghi, Seema (2016): The handbook of competency mapping. Understanding, designing and implementing competency models in organizations. Third edition. Los Angeles: Sage.

Scheerens, Jaap (1990): School Effectiveness Research and the Development of Process Indicators of School Functioning. In *School Effectiveness and School Improvement* 1 (1), pp. 61–80. DOI: 10.1080/0924345900010106.

Scheerens, Jaap; Luyten, Hans; van Ravens, Jan (2011): Measuring educational quality by means of indicators. In : Perspectives on educational quality: Springer, pp. 35–50.

Schultz, Theodore W. (1960): The formation of human capital by education. In *Journal of political economy* 68 (6), pp. 571–583.

Schultz, Theodore W. (1964): Transforming traditional agriculture. In *Transforming traditional agriculture*.

Serna Hidalgo, Braulio (2007): Honduras: tendencias, desafíos y temas estratégicos del desarrollo agropecuario: CEPAL.

Shavelson, Richard J. (2010): On the measurement of competency. In *Empirical research in vocational education and training* 2 (1), pp. 41–63.

Shinn, Glen C.; Wingenbach, Gary J.; Lindner, James R.; Bries, G. E.; Baker, Matt (2009): Redefining agricultural and extension education as a field of study: Consensus of fifteen engaged international scholars. In *Journal of International Agricultural and Extension Education* 16 (1), pp. 73–88.

Sierra, Rolando.; van Steenwyk, Ned. (2011): La oferta y demanda de educacion tecnica y la formacion profesional en Honduras. GIZ. Tegucigalpa, Honduras.

Simar, Léopold; Wilson, Paul W. (2000): A general methodology for bootstrapping in non-parametric frontier models. In *Journal of applied statistics* 27 (6), pp. 779–802.

Simar, Léopold; Wilson, Paul W. (2007): Estimation and inference in two-stage, semi-parametric models of production processes. In *Journal of econometrics* 136 (1), pp. 31–64. DOI: 10.1016/j.jeconom.2005.07.009.

Spiertz, Huub (2010): Food production, crops and sustainability: restoring confidence in science and technology. In *Current Opinion in Environmental Sustainability* 2 (5-6), pp. 439–443.

Stock, James. H. (2001): Instrumental Variables in Statistics and Econometrics. In David L. Sills (Ed.): International encyclopedia of the social and behavioral sciences /edited by Neil J. Smelser and Paul B. Baltes. New York: Elsevier Science, pp. 7577–7582. Available online at http://www.sciencedirect.com/science/article/pii/B0080430767004484.

Stone, Thomas; Webster, Brian; Schoonover, Stephen (2013): What Do We Know About Competency Modeling? In *International Journal of Selection and Assessment* 21 (3), pp. 334–338.

Stoof, Angela; Martens, Rob L.; van Merriënboer, Jeroen J. G.; Bastiaens, Theo J. (2002): The Boundary Approach of Competence: A Constructivist Aid for Understanding and Using the Concept of Competence. In *Human Resource Development Review* 1 (3), pp. 345–365. DOI: 10.1177/1534484302013005.

Suvedi, Murari; Ghimire, Ramjee; Channa, Ty (2018): Examination of core competencies of agricultural development professionals in Cambodia. In *Evaluation and program planning* 67, pp. 89–96.

Swan, Benjamin G.; Lay, Ann M. de (2014): Agricultural experiences and factors of undergraduates who enroll in a college of agriculture. In *NACTA Journal* 58 (4), pp. 330–334.

Swinnen, Johan F. M.; Maertens, Miet (2007): Globalization, privatization, and vertical coordination in food value chains in developing and transition countries. In *Agricultural economics* 37, pp. 89–102.

Tam, Maureen (2001): Measuring quality and performance in higher education. In *Quality in higher Education* 7 (1), pp. 47–54.

Thieman, Erica; Rosch, David; Suarez, Cecilia (2016): Consideration of Agricultural Education as a Career: A Statewide Examination by High School Class Year of Predicting Factors. In *Journal of Agricultural Education* 57 (4), pp. 29–43. DOI: 10.5032/jae.2016.04029.

Thompson, John; Scoones, Ian (2009): Addressing the dynamics of agri-food systems: an emerging agenda for social science research. In *Environmental science & policy* 12 (4), pp. 386–397.

Tilman, David; Fargione, Joseph; Wolff, Brian; D'antonio, Carla; Dobson, Andrew; Howarth, Robert et al. (2001): Forecasting agriculturally driven global environmental change. In *Science (New York, N.Y.)* 292 (5515), pp. 281–284.

Torres, Robert M.; Wildman, M. (2001): Factors identified when selecting a major in agriculture. In *Journal of Agricultural Education* 42 (2), pp. 46–55.

Ulimwengu, John; Badiane, Ousmane (2010): Vocational Training and Agricultural Productivity: Evidence from Rice Production in Vietnam. In *The Journal of Agricultural Education and Extension* 16 (4), pp. 399–411. DOI: 10.1080/1389224X.2010.515062.

Umar, Sulaiman; Man, Norsida; Nawi, Nolila Mohd; Latif, Ismail Abd; Samah, Bahaman Abu (2017): Core competency requirements among extension workers in peninsular Malaysia: Use of Borich's needs assessment model. In *Evaluation and program planning* 62, pp. 9–14.

UNESCO (2004): The quality imperative. 2nd printing. Paris, France: UNESCO Publishing (EFA global monitoring report, 2005).

UNESCO (2019): Education Honduras. Government expenditure on education. UNESCO. Available online at http://data.uis.unesco.org/, checked on 10/6/2016.

UNESCO-IBE (2012): General Education Quality Analysis. Diagnosis Framework (GEQAF). UNESCO. Geneva, Switzerland. Available online at http://www.ibe.unesco.org/en/activity/general-education-quality-analysis-framework-geqaf-initiative, checked on 10/1/2019.

van Crowder, L.; Lindley, W. I.; Bruening, Th.H.; Doron, N. (1998): Agricultural education for sustainable rural development: Challenges for developing countries in the 21st century. In *The Journal of Agricultural Education and Extension* 5 (2), pp. 71–84. DOI: 10.1080/13892249885300201.

van Loo, Jasper; Semeijn, Judith (2004): Defining and Measuring Competences. An Application to Graduate Surveys. In *Quality & Quantity* 38, pp. 331–349.

Vega, Reyna (2008): Evaluacion de la Pertinencia de la Carrera Comercio Internacional con Orientacion a la Agroindustria en la Zona Occidental de Honduras. Master's dissertation. UNAH, Santa Rosa de Copan, Honduras. CUROC.

Vos, Rob; Ganuza, E.; Lofgren, H.; Díaz-Bonilla, C.; Sánchez, Marco (2010): Public Policies for Human Development. Achieving the Millennium Development Goals in Latin America. London: Palgrave Macmillan UK. Available online at http://gbv.eblib.com/patron/FullRecord.aspx?p=4719851.

Webber, Douglas A. (2014): The lifetime earnings premia of different majors: Correcting for selection based on cognitive, noncognitive, and unobserved factors. In *Labour Economics* 28, pp. 14–23. DOI: 10.1016/j.labeco.2014.03.009.

Welch, Finis (1970): Education in production. In *Journal of political economy* 78 (1), pp. 35–59.

Wesselink, Renate; Dekker-Groen, Agaath M.; Biemans, Harm J. A.; Mulder, Martin (2010): Using an instrument to analyse competence-based study programmes. Experiences of teachers in Dutch vocational education and training. In *Journal of Curriculum Studies* 42 (6), pp. 813–829. DOI: 10.1080/00220271003759249.

Wigfield, Allan; Eccles, Jacquelynne S. (2000): Expectancy–Value Theory of Achievement Motivation. In *Contemporary Educational Psychology* 25 (1), pp. 68–81. DOI: 10.1006/ceps.1999.1015.

Willis, Robert J. (1986): Chapter 10 Wage determinants: A survey and reinterpretation of human capital earnings functions. In : Handbook of Labor Economics, vol. 1: Elsevier, pp. 525–602. Available online at http://www.sciencedirect.com/science/article/pii/S1573446386010131.

Winterton, Johathan; Mulder, Martin; Gulikers, Judith; Biemans, Harm; Wesselink, Renate (2009): The new competence concept in higher education. Error or enrichment? In *Journal of European Industrial Training* 33 (8/9), pp. 755–770. DOI: 10.1108/03090590910993616.

Witte, Kristof De; López-Torres, Laura (2017): Efficiency in education: a review of literature and a way forward. In *Journal of the Operational Research Society* 68 (4), pp. 339–363. DOI: 10.1057/jors.2015.92.

Wittek, Line; Kvernbekk, Tone (2011): On the Problems of Asking for a Definition of Quality in Education. In *Scandinavian Journal of Educational Research* 55 (6), pp. 671–684.

World Bank (2013): Honduras Public Expenditure Review: Towards Restoring Fiscal Consolidation. World Bank Other Operational Studies. The World Bank (17364). Available online at https://EconPapers.repec.org/RePEc:wbk:wboper:17364.

World Bank (2015): Honduras economic DNA: Maintaining commitment–With a special focus section on poverty and shared prosperity: World Bank Group Washington, DC.

World Bank (2017): Enterprise Survey: Honduras 2016 Country Profile. The World Bank Group. Available online at https://www.enterprisesurveys.org/data/exploreeconomies/2016/honduras, checked on 8/8/2019.

Yitzack Pavon, Fernando (2008): Improving Educational Quality in Honduras: Building a Demand-Driven Education Market. In *Journal of Public & International Affairs* 19.

9. Appendices

Table S1. Descriptive statistics of the HHS 2016 dataset

Variable name	Variable description	Mean	Std. Dev.
lnIncome	Natural logarithm of monthly income	8.1255	1.1838
Exper	Potential years of experience (Age-schooling years-6)	25.4046	16.6034
Expersq	Potential years of experience squared	921.0391	1071.078
Schooling	Years of schooling	6.9305	4.4500
Nolevel	No educational level attained (Yes=1, No=0)	Yes = 2,847 (31.46%)	
Primary	Primary education attained (Yes=1, No=0)	Yes = 3,171 (35.04%)	
Lowerhigh	Lower secondary attained (Yes=1, No=0)	Yes = 800 (8.84%)	
Upperhigh	Upper secondary attained (Yes=1, No=0)	Yes = 1,680 (18.56%)	
Upperhighag	Upper secondary in agri-food educational program attained (Yes=1, No=0)	Yes = 22 (0.24%)	
Upperhighnonag	Upper secondary in a non-agri-food educational program attained (Yes=1, No=0)	Yes = 1,658 (18.32%)	
Tertiary	Tertiary education attained (Yes=1, No=0)	Yes = 552 (6.10%)	
Tertiaryag	Tertiary education in agri-food educational program attained (Yes=1, No=0)	Yes = 24 (0.27%)	
Tertiarynonag	Tertiary education in a non-agri-food educational program attained (Yes=1, No=0)	Yes = 528 (5.83%)	
EduAgri	Respondent graduates from an agricultural education program (Yes=1, No=0)	Yes = 46 (0.51%)	
Sex	Respondent's sex (Male=1, Female=0)	Male = 5,723 (63.24%)	

Variable name	Variable description	Mean Std. Dev.
Family head	Respondent is the head of the family (Yes=1, No=0)	Yes = 4,431 (48.96%)
Locality1	Location of residence: Tegucigalpa (Yes=1, No=0)	Yes = 1,602 (17.70%)
Locality2	Location of residence: San Pedro Sula (Yes=1, No=0)	Yes = 983 (10.86%)
Locality3	Location of residence: Other urban areas (Yes=1, No=0)	Yes = 2,245 (24.81%)
Locality4	Location of residence: Rural areas (Yes=1, No=0)	Yes = 4,220 (46.63%)
Publicempl	Respondent is a public-sector employee (Yes=1, No=0)	Yes = 592 (6.54%)
Privatempl	Respondent is a private-sector employee (Yes=1, No=0)	Yes = 4,476 (49.46%)
Selfempl	Respondent is a self-employee (Yes=1, No=0)	Yes = 3,982 (44%)
Ocup1	Respondent's main occupation: Managers (Yes=1, No=0)	Yes = 245 (2.71%)
Ocup2	Respondent's main occupation: Professionals (Yes=1, No=0)	Yes = 341 (3.77%)
Ocup3	Respondent's main occupation: Technicians and associate professionals (Yes=1, No=0)	Yes = 602 (6.65%)
Ocup4	Respondent's main occupation: Clerical support workers (Yes=1, No=0)	Yes = 279 (3.08%)
Ocup5	Respondent's main occupation: Services and sales workers (Yes=1, No=0)	Yes = 2,080 (22.98%)
Ocup6	Respondent's main occupation: Skilled agricultural, forestry and fishery workers (Yes=1, No=0)	Yes = 1,391 (15.37%)
Ocup7	Respondent's main occupation: Craft and related trades workers (Yes=1, No=0)	Yes = 1,478 (16.33%)
Ocup8	Respondent's main occupation: Plant and machine operators, and assemblers (Yes=1, No=0)	Yes = 524 (5.79%)

Variable name	Variable description	Mean	Std. Dev.
Ocup9	Respondent's main occupation: elementary occupation (Yes=1, No=0)	Yes = 2,099 (23.19%)	
Ocup10	Respondent's main occupation: armed forces occupations	Yes = 4 (0.04%)	
Ocup0	Respondent's main occupation: no specified occupation or 1st time job seeker (Yes=1, No=0)	Yes = 7 (0.08%)	
Law1	Individual is affected by changes in the educational policy of 2011 (Yes=1, No=0)	Yes = 5,720 (63.20%)	
Law2	Individual is affected by changes in the educational policy of 2008 (Yes=1, No=0)	Yes = 4,169 (46.07%)	

Table S2. Educational programs by educational institution in 2016

Educational Programs*	Amount of Academic Institutions	Educational Level	ISCED** classification	Amount of Programs complying the criteria***
B.Sc. Agriculture	5	Tertiary	Level 6	5
B.Sc. Agroindustry	1	Tertiary	Level 6	1
B.Sc. Food Tecnology	2	Tertiary	Level 6	2
B.Sc. Agricultural Economics	1	Tertiary	Level 6	1
B.Sc. Agribussines	2	Tertiary	Level 6	2
B.Sc. Natural Resources Management	2	Tertiary	Level 6	2
B.Sc. International Trade oriented to Agribussiness	1	Tertiary	Level 6	1
Coffee Quality	1	Tertiary	Level 5	1
Agricultural Production	1	Tertiary	Level 5	1
Poultry Production	1	Tertiary	Level 5	0
Food Technology	1	Tertiary	Level 5	1
Agriculture	1	Secondary	Level 3	1
Agroforestry	1	Secondary	Level 3	1
Agriculture and Livestock	1	Secondary	Level 3	1
Agroinsdustry	1	Secondary	Level 3	0
Total Educational Programs	22			20

Note: * Source: Ministry of Education and (2017) and Central Bank (2017)
** 2011 International Standard Classification of Education
*** Criteria: i) the program has at least one group of graduate students and ii) officially approved program.

Table S3. List of competencies, short codes and description

Code	Short name	Description The graduate can...
C1	Agricultural value chain	Analyze, manage, implement, and assess processes based on the value chains approach
C2	Policies and institutions	Understands, adhere, adapts and influences reality, policies, and institutions of the agricultural, agroforestry and environmental sectors
C3	Sustainability	Considers the sustainability of natural resources
C4	National and international regulations	Considers and applies technical and legal standards and procedures according to national and international regulations
C5	Agri-Business development	Define, manage, control and implement strategies, financial, administrative, commercial and organizational processes in agri-business development
C6	Research	Design, organize and implement research processes
C7	Technology design	Design, plan, evaluate, control equipment, machinery or physical structures aimed at the production, processing or marketing of agricultural products
C8	Environmental impact	Evaluate and take measures that reduce environmental impact
C9	Climate change	Identify, assess, and implement actions to mitigate the effects of climate change
C10	Partnership and collaboration	Identify, develop partnerships and collaborate with public and private actors
C11	Use of technology	Identify, evaluate, select, promote and use technology that increases efficiency, productivity or competitiveness
C12	Food security	Increase productivity for food security and income generation
C13	Market needs	Investigates and consider market needs in terms of supply and demand (local, national and international)
C15	Quality and safety standards	Plan, organize, direct, control, evaluate and implement processes for compliance with quality and safety standards
C16	Marketing of agricultural products	Plan, organize, control, and implement marketing processes of agricultural (agroforestry) products and services
C17	Production of agricultural products	Plan, organize, manage, control and implement agricultural (agroforestry) production and harvesting processes
C20	Management and conservation of natural resources	Plan, organize, direct, control and implement processes for the management and conservation of Natural Resources and Environment
C21	Technical and technological services	Plan, organize, manage, control and implement agricultural technical and technological services

Code	Short name	Description The graduate can...
C22	Processing agricultural products	Plan, organize, manage, control and implement processing processes of agricultural (agroforestry) products
C23	Development	Plan, organize, manage, controls, implement and evaluate processes of community, regional or national development

Table S4. Five-top important competencies by type of value chain' stakeholder

Rank	Input supplier	Producers	Food processing	Retailer/ wholesaler	Exporter	Financial services provider	Technical advisory services provider
1	C12	C16	C22	C16	C12	C1	C15
2	C2	C1	C4	C17	C23	C9	C11
3	C9	C12	C9	C8	C16	C7	C8
4	C23	C10	C3	C13	C10	C12	C6
5	C11	C8	C10	C5	C2	C10	C21

Note: Based on the average importance of the competency by stakeholder type
Source: own calculation

Table S5. Graduate competencies' performance in private and public jobs

Code	Short name	Type of Employer	
		Public	Private
C1	Agricultural value chain	8.75	5.67
C2	Policies and institutions	7.77	7.44
C3	Sustainability	7.13	7.60
C4	National and international regulations	8.50	7.37
C5	Agri-Business development	8.00	6.68
C6	Research	8.45	6.25
C7	Technology design	8.50	7.19
C8	Environmental impact	8.60	8.13
C9	Climate change	7.50	6.96
C10	Partnership and collaboration	7.38	6.98
C11	Use of technology	8.36	6.71

Code	Short name	Type of Employer	
		Public	Private
C12	Food security	7.50	7.72
C13	Market needs	8.37	7.04
C15	Quality and safety standards	8.74	7.72
C16	Marketing of agricultural products	7.92	7.51
C17	Production of agricultural products	8.32	7.60
C20	Management and conservation of natural resources	7.44	7.51
C21	Technical and technological services	8.29	6.86
C22	Processing agricultural products	8.24	7.83
C23	Development	7.71	7.09
	Average Performance	8.07	7.19

Source: Own calculation

Table S6. Five-bottom performed competencies by type of value chain' stakeholder

Rank	Input supplier	Producers	Food processing	Retailer/ wholesaler	Exporter	Financial services provider	Technical advisory services provider
1	C1	C1	C9	C9	C11	C16	C9
2	C6	C13	C20	C20	C6	C15	C1
3	C4	C21	C11	C23	C1	C3	C6
4	C5	C11	C5	C2	C7	C4	C5
5	C11	C23	C6	C12	C5	C13	C10

Note: Based on the average performance of the competency by stakeholder type
Source: own calculation

Table S7. Descriptive information of the education centers

	Output		Input Controllable at the School Level				Input Non-Controllable at the School Level		
DMU	Average pre-university standardized test score	Total graduates	Number of Full time equivalent teachers	Private Expenditure (Lps)	Public Expenditure (Lps)	Percentage of the school infrastructure required to operate	Percentage of the households with three or more unmet basic needs, at the municipal level	Percentage of the population with university education, at the municipality level	Percentage of the population whose main occupation is agriculture, at the municipality level
1	36	95	13.5	780,000	5,554,831	61.74	13.02	4.3	42.51
2	30.5	68	27	1,043,974	4,071,538	57.49	9.29	2.19	31.07
3	37	336	144	3,768,894	13,241,688	73.77	26.72	2.07	48.39
4	32.5	46	27	140,000	2,310,089	59.46	15.44	3.21	39.51
5	39	122	24	121,638	4,928,836	62.09	22.59	2.41	49.50
6	36	84	10.5	689,000	4,162,202	68.60	21.97	2.03	51.61
7	48	38	55.5	194,086	2,011,976	78.65	24.57	0.36	78.18
8	44	70	19	127,363	2,744,819	78.65	24.57	0.36	78.18
9	36	171	9	124,000	2,282,278	33.25	29.41	1.05	75.61
10	35	28	7	87,000	1,583,348	21.62	24.09	1.54	66.88
11	36	56	21	225,200	3,097,103	47.40	9.29	2.19	31.07
12	38	124	23	129,300	6,539,557	71.58	11.17	1.54	48.42
13	29	43	8	99,300	2,655,892	64.99	15.44	3.21	39.51
14	36	88	34	145,500	3,616,314	45.08	16.52	1.96	46.21
15	48	27	10	119,000	1,853,640	52.79	14.06	3.09	50.36
16	42	91	25	728,150	3,473,466	69.75	11.46	2.83	42.24