International Research Journal of Management, IT & Social Sciences
Available online at https://sloap.org/journals/index.php/irjmis/
Vol. 8 No. 6, November 2021, pages: 569-578
ISSN: 2395-7492
https://doi.org/10.21744/irjmis.v8n6.1940

Factor Analysis on the Agricultural Technology Adoption and Arabica Coffee Productivity in Kintamani District, Bangli Regency

I Putu Hedi Sasrawan [a]
Ni Nyoman Yuliarmi [b]

Article history:

Submitted: 27 August 2021
Revised: 18 September 2021
Accepted: 09 October 2021

Keywords:

agricultural technology adoption;
factory of production;
farmer's characteristics;
productivity;

Abstract

The economy of Bali requires diversification through optimization of the agricultural sector. Arabica coffee is a potential commodity to diversify the agricultural sector and maximizing the potential of the highland at Kintamani District, Bangli Regency. Productivity must be improved considering that agricultural land in Bali is limited and many have been converted to residential or commercial use. According to evolutionary theory, agricultural productivity can be increased by technology. However, the technology application needs to be supported by adequate human resources and factors of production. The purpose of this study was to analyze the effect of farmer characteristics, production factors, and agricultural technology adoption on productivity, as well as to analyze the indirect effect of farmer characteristics and production factors on productivity through agricultural technology adoption. The area sampling method obtained a total sample of 98 farmers in 10 villages in the Kintamani District, Bangli Regency. Area sampling is carried out in two stages, first is determining regional samples and determining the respondents in each area by accident. The data collection methods are observation, structured interviews using questionnaires, and in-depth interviews. The data analysis technique used partial least square. The results show that the farmer's characteristics and factors of production had a significant positive effect on the adoption of Arabica coffee farming technology but did not directly affect the productivity of Arabica coffee. The agricultural technology adoption has a significant positive effect on Arabica coffee productivity. There is an indirect effect of farmers' characteristics and factors of production on Arabica coffee productivity through agricultural technology adoption.

Corresponding author:
I Putu Edi Sasrawan,
Faculty of Economics and Business, Udayana University, Denpasar, Indonesia.
Email address: hedisasrawan@gmail.com

[a] Faculty of Economics and Business, Udayana University, Denpasar, Indonesia
[b] Faculty of Economics and Business, Udayana University, Denpasar, Indonesia

1 Introduction

The agricultural sector is one of the pillars of the Indonesian economy that needs attention given that the workforce in Indonesia mostly works in the agricultural sector according to BPS data for August 2019. The government can pay attention to agricultural productivity. This is important considering that the majority of the poor live in rural areas, which mostly depend on low-productivity agriculture (Aji, 2015). Agricultural productivity can be increased through technology. Technology is born from various research and inventions. In Indonesia, agricultural technology is developing quite well. Research conducted by Rada & Fuglie (2012), shows that research in agriculture conducted by the Indonesian Agricultural Research and Development Agency has a positive and significant impact on increasing agricultural productivity in terms of total factor productivity. An increase in agricultural research of as much as 1 percent has an impact on an average increase in total factor productivity of 0.16 percent (Areal et al., 2020; Asfaw et al., 2012; Ashari, 2010; Özdemir, 2016).

The next challenge from using technology to increase agricultural productivity is how to make the technology used by farmers. Most farmers in Indonesia are small farmers who still use traditional or semi-modern equipment. Research conducted by Dewi & Sudarma (2020), on the types of technology used by vanilla farmers in the Gianyar Regency shows that most farmers are already using semi-modern technology. The technology is a drying machine that still requires human power in its operation. Many farmers complain about replacing it with modern machines because they are not ready and skilled in its operation (Vink, 2013; Weber, 2012; White et al., 2005; Wiratama et al., 2013).

As one of the provinces in Indonesia, Bali Province has different economic characteristics compared to other provinces in Indonesia. The GDRP contribution of the Province of Bali is more focused on sectors related to tourism and agriculture. Bali has neither big industry nor mining. Most of the Balinese people who live far from tourism centers generally work in the agricultural sector. This makes the Balinese economy urged not only to depend on the tourism sector. Because tourism is very vulnerable. Like the COVID-19 pandemic that began in 2020 which made Bali tourism die. Agriculture is an option to be developed because it is needed all the time and in all conditions (Takahashi et al., 2020; Tey & Brindal, 2012; Tomé, 2011; Nuryanti & Swastika, 2011).

So far, the government has paid more attention to rice farming. Control not all land in Bali is suitable for rice fields. As in Kintamani District, Bangli Regency, which has a tropical climate, cold temperatures, and relatively high rainfall (Wiratama et al., 2013). These climatic conditions coupled with the soil conditions which are in a high area make this area suitable as a place for plantation activities such as Arabica coffee (Nuriasih et al., 2018; Kath et al., 2020). This makes Bangli Regency the district with the highest amount of Arabica coffee production compared to other districts/cities in Bali Province. Based on data from the BPS in 2019, Bangli Regency produced 2,247 tons of Arabica coffee. The second rank is in Buleleng Regency with a production of 1,278 tons and the third rank is in Badung Regency with a production of 534 tons (Ahmad et al., 2020; Barrow, 2009; Black, 2000; Bold et al., 2017).

Arabica coffee from Kintamani District is well known and is often marketed under the branding "Kintamani coffee". Kintamani coffee is unique because it is grown using an institution called Subak Abian and by following the Tri Hita Karana principle (Saravanadurai & Manimehalai, 2016; Challa & Tilahun, 2014; Debertin, 2012). The main taste of Kintamani coffee is the acidity and aroma similar to citrus fruits. Kintamani coffee is also not too bitter and not pungent and there are no significant taste defects (MPIG Kintamani Arabica Coffee Bali, 2007).

However, even though it has become the center of Arabica coffee production in Bali, Arabica coffee production in Bangli Regency tends to experience a decline. This is due to the phenomenon of land conversion from Arabica coffee plantations to citrus plantations. According to one coffee farmer interviewed by Permana & Sukana (2019), this phenomenon began with the purchase of land to plant oranges, which later became known to local farmers that the income earned from citrus plantations was very high compared to coffee.

The phenomenon of the conversion of coffee plantations into citrus plantations cannot be separated from the lower productivity of coffee plantations. Research conducted by HERYANA et al. (2016), showed that on an area of 0.5 ha, citrus farming income was higher at Rp. 114,945,000 compared to coffee farming which was only Rp. 63,530,000. The low quality of human resources is also considered as a trigger for many farmers who immediately decide to switch to crops that are felt to be rising in price without taking into account the costs involved. Coffee is an agricultural commodity that can still be increased its productivity. The productivity of smallholder coffee plantations in Indonesia in 2018 was 798 kg/ha/year. Meanwhile, the productivity of large state and private coffee plantations is not much different at 849 kg/ha/year and 810 kg/ha/year, respectively (Perkebunan, 2018). This figure is still far below its potential production of 2 tons/ha/year (Listyati et al., 2013).

Technology is considered as a solution to increase agricultural productivity. Technology is everything that humans do to make their lives easier. Technology has been used to increase production in many sectors. Since the Industrial

Revolution 1.0 to 4.0, human productivity has increased rapidly (Bro et al., 2019; Carvalho et al., 2020; Witt, 2016; Udayana, 2017). Technology in agriculture can be in the form of means of production, agricultural techniques, solutions to control pests and diseases and make the agricultural industry a sustainable industry. According to research conducted by Thamrin (2014), the adoption of technology in the form of land preparation and planting techniques has a positive impact on arabica coffee productivity.

Although technology is considered as a solution to increase agricultural productivity. The most important thing is how the technology is implemented properly by the farming actors. Although agricultural technology has developed, in the agricultural sector, especially in developing countries, there are not many farmers who are able and willing to adopt new technology because there are obstacles caused by various social, economic, institutional, and environmental factors (Mariano et al., 2012). According to Andriaty & Setyorini (2012), the application of agricultural technology is determined by several factors. Starting from the potential or individual capabilities in this case the farmers themselves, then the availability of information, the dissemination process, and the characteristics of innovation.

One of the factors that influence the level of adoption of agricultural technology is the characteristics of farmers. Farmer characteristics are related to the level of education and experience of farmers (Mariano et al., 2012). This is inseparable from the mastery of technology which is largely determined by the quality of the human resources of its users. The quality of human resources can be improved through education. The higher the level of education, the farmers will more easily understand and be able to apply the technology. In addition to formal education, training can also increase the rate of adoption of agricultural technology. Research conducted by Kuntariningsih & Mariyono (2013), shows that training for farmers has a positive impact on farm performance as indicated by an increase in farm production and profits. Increased production and profits occur due to the more effective and efficient use of production inputs. This study also shows that formal education and experience in farming also greatly affect the productivity and profitability of farming (Šūmane et al., 2018; Susilowati & Maulana, 2012; Syed & Miyazako, 2013).

In addition to the characteristics of farmers, the level of adoption of agricultural technology can also be influenced by production factors. Factors of production are resources used in the production process, in this case, related to the area of land owned and capital. Some studies state a positive relationship between land area and technology adoption (Mignouna et al., 2011). The larger the land area, the more likely it is for farmers to use new technologies that are more expensive but still maintain profitability. Some studies state a negative relationship. The narrower the land, the farmers will maximize the productivity of their land by utilizing technology. Narrow land will trigger innovation to produce higher production (Yaron et al., 1992). The conflicting results of these studies require further research on the impact between land area and the adoption of agricultural technology. Meanwhile, research conducted by Hendayana (2013), shows that the ratio of own capital ownership has a positive influence on the level of agricultural adoption. The greater the ratio of own capital ownership in farming, the higher the adoption of agricultural technology. Farmers who control their land have three times the opportunity to adopt agricultural technology compared to farmers who do not own their land (Bravo-Monroy et al., 2016; Brecher et al., 2017; Habib, 2015).

Farmer characteristics and production factors can directly affect productivity, but this is not enough. This relationship is based on neoclassical theory which states that only land, labor, and capital affect production (Todaro & Smith, 2015). Neoclassical production theory cannot explain the relationship between traditional factors of production and modern production. Therefore, it is more appropriate to use an evolutionary theory approach (Mekonnen et al., 2015). Evolutionary theory holds that productivity can be developed through technology. Technology is considered an evolutionary agent because it is unpredictable in its emergence and its impact cannot be predicted before it is implemented (Hodgson & Huang, 2012). While the neoclassical theory views the economy as going hand in hand with changes in factors that can be anticipated. However, investing in technology without effective adoption results in low returns. Successful innovation requires access to physical and human resources. Adequate physical and human resources will be able to take advantage of innovation so that productivity will increase (Nelson, 2008). Technology is needed to maximize the potential of human resources (in this case the characteristics of farmers) and their production factors to bring agricultural products to a higher level. So there is an indirect relationship between the characteristics of farmers and factors of production on productivity through technology as an evolutionary agent.

According to Fereres & Villalobos (2016), productivity in agriculture is defined by the output per unit of resource used. Productivity growth arising from an increase in output without an increase in input is the best type of productivity growth because inputs in agriculture are often not easy to increase. This type of productivity growth can be achieved by using technology and increasing efficiency through the application of certain techniques (Fan & Brzeska, 2010). Agricultural productivity in several countries in East Asia and Southeast Asia began to increase after the development and adoption of agricultural technology in the form of superior seeds (Estudillo & Otsuka, 2010). Similar results were also obtained in the agricultural sector in South Asia (Hazell, 2010), Latin America, and the Caribbean (Avila et al., 2010). According to evolutionary theory, successful technology or innovation requires access to physical resources and human resources (Nelson, 2016). Physical resources can be in the form of production factors owned. Meanwhile, human resources cover the quality of farmers' resources, from education to farming experience (Dewi & Yuliarmi, 2017; Adhitya et al., 2013; Feder et al., 1985).

2 Materials and Methods

This research is associative quantitative research. The sampling method used stratified random sampling with a total sample of 98 Arabica coffee farmers (Reimers & Klasen, 2013; Rogers, 2003; Samuelson & Nordhaus, 2009). First, strata based on the village are carried out. For this reason, 10 villages were selected in Kintamani District, Bangli Regency, namely Satra Village, Bentang Village, Dausa Village, Sukawana Village, Belantih Village, Selulung Village, Catur Village, Bayung Gede Village, Mengani Village, and Pursuit Village. Then individual samples were collected by accident in each stratum. Methods of data collection using observation, structured interviews using questionnaires, and in-depth interviews (Foster & Rosenzweig, 2010; Fuglie, 2018; Fuglie et al., 2012). The data analysis technique used partial least square.

3 Results and Discussions

Based on age, the majority of respondents are in the productive age, namely 15-64 years. There is 14 percent of respondents aged above or equal to 65 years. Farmers belonging to the age group above the productive age generally have more experience so that it is easier to understand the latest agricultural techniques and be able to adapt them to the conditions of their agricultural land. 73 percent of respondents are between 35-64 years old and generally learn from more senior farming and training actors. Meanwhile, there is 12 percent of respondents aged under 35 years are characterized as just starting (Hermawan & Andrianyta, 2012; Hodgson & Lamberg, 2018; Huch & Franz, 2015). This age group mostly only learns from their predecessors and still lacks experience and has not attended much training so they have not fully mastered agricultural technology. Based on the latest education, the majority of respondents received education up to elementary school as many as 34 people or by 35 percent. Then followed by respondents with high school/vocational education level as many as 28 people or 29 percent and junior high school education level as many as 22 people or 22 percent. Based on the length of farming experience, the Arabica coffee farmers who were the respondents had the longest farming experience of 51 years (Marinoudi et al., 2019; Mayrowani, 2013; Pornel & Saldaña, 2013; Rasmussen, 2012). While the latest is 1 year with an average of 24.8 years. Based on the number of training, Arabica coffee farmers in Kintamani District did the most training 13 times. While at least 2 times with an average of 7 times. Based on the land area, the land area owned by the respondents is 2.1 hectares. With the narrowest land area of 0.1 hectares and an average area of 0.9173 hectares. Based on the labor used, the coffee farmers who use the most labor are 115 OH. While the minimum is 4 OH with an average of 35 OH. Based on the capital used, arabica coffee farmers in Kintamani District have the highest capital of Rp. 24,375,000 and the lowest capital of Rp. 2,990,000 with an average of Rp. 13,153,316 (Ghazali, 2008; Gollin, 2010; Gollin et al., 2014; Gurtner, 2007).

Table 1
Convergent loading factor validity test results

Variable Correlation	Original Sample	Standard Deviation	T Statistics	P Values
X1.1 <- X1	0.988	0.002	624.005	0.000
X1.2 <- X1	0.994	0.001	1230.848	0.000
X1.3 <- X1	0.984	0.002	445.696	0.000
X2.1 <- X2	0.916	0.042	22.078	0.000
X2.2 <- X2	0.966	0.008	121.189	0.000
X2.3 <- X2	0.979	0.004	268.135	0.000
Y1.1 <- Y1	0.990	0.003	307.917	0.000
Y1.2 <- Y1	0.981	0.004	238.431	0.000

Y1.3 <- Y1	0.993	0.001	727.120	0.000
Y1.4 <- Y1	0.990	0.003	319.012	0.000
Y1.5 <- Y1	0.957	0.008	116.500	0.000
Y1.6 <- Y1	0.985	0.003	307.221	0.000
Y2.1 <- Y2	0.548	0.101	5.424	0.000
Y2.2 <- Y2	0.484	0.126	3.826	0.000
Y2.3 <- Y2	0.935	0.015	63.999	0.000

Based on Table 1, it can be seen that all construct indicators of farmer characteristics (X1), factors of production (X2), adoption of agricultural technology (X3), and productivity (X4) are statistically significant with an at-count value greater than 1.96 and a p-value less than 0. .05 and 0.01. Similarly, the loading values are all above 0.5. Thus it can be stated that the data in the study is valid (Kassie et al., 2011; Kebede, 2001; Keith, 2019; Klerkx et al., 2012).

Table 2
Cronbach's alpha, composite reliability, and average variance extracted constructs of farmer characteristics, factors of production, adoption of agricultural technology, and productivity

Konstruk	Cronbach's Alpha	Composite Reliability	Average Variance Extracted (AVE)
Farmer Characteristics (X1)	0.989	0.993	0.978
Factors of Production (X2)	0.950	0.968	0.910
Agricultural Technology Adoption (Y1)	0.993	0994	0.966
Productivity (Y2)	0.496	0.709	0.470

Table 2 above can be seen that the value of Cronbach's alpha, composite reliability, and AVE on the construct of farmer characteristics, production factors, and adoption of agricultural technology is greater than 0.7. While the AVE value of the productivity construct can still be maintained because it is between 0.4 and 0.7 as long as removing one of the indicators does not increase the results (Hair et al., 2021). Meanwhile, constructs with results below 0.4 in research with factor analysis should be removed (Hulland, 1999). Thus, the data in the study can be said to be reliable.

In assessing the structural model with PLS structural, it can be seen from the value of R-squares. the value of R-squares for the variable of adoption of agricultural technology (Y1) is 0.943 which indicates it has a strong influence. While the value of R-squares for the productivity variable (Y2) is 0.892 which indicates that it has a strong influence. This shows that the variation in the productivity variable (Y2) can be explained by 99.4 percent by farmer characteristics (X1), production factors (X2), and adoption of agricultural technology (Y1), while the remaining 0.6 percent is explained by other variables outside the model (Jain et al., 2009; Jara-Rojas, et al., 2012; Jena, 2019; Jimenez, 2019).

Table 3
Hypothesis test results

Variable	Original Sample	Standard Deviation	T Statistics	P Values
Agricultural Technology Adoption (Y1) =>Productivity (Y2)	0.777	0.128	6.047	0.000
Factors of Production (X2) => Adoption of Agricultural Technology (Y1)	0.603	0.057	10.547	0.000
Factor of Production (X2) =>Productivity (Y2)	0.160	0.124	1,.92	0.197
Farmer Characteristics (X1) => Agricultural Technology Adoption (Y1)	0.388	0.057	6.793	0.000
Farmer Characteristics (X1) => Productivity (Y2)	0.015	0.103	0.142	0.887
Factors of Production (X2) => Adoption of Agricultural Technology (Y1) => Productivity (Y2)	0.468	0.087	5.367	0.000

Farmer Characteristics (X1) => Agricultural Technology Adoption (Y1) => Productivity (Y2)	0.301	0.069	4.387	0.000

The beta value is 0.777 and the t-statistics value is 6.047 with P-values of 0.000 <0.05, it can be concluded that the adoption of agricultural technology (Y1) has a positive and significant effect on productivity (Y2). The beta value is 0.603 and the t-statistics value is 10.547 with P-values of 0.000 <0.05, it can be concluded that the production factor (X2) has a positive and significant effect on the adoption of agricultural technology (Y1) (Ainembabazi & Mugisha, 2014; Alexander & Alexander, 1982; Antle & Capalbo, 1988). The beta value is 0.160 and the t-statistics value is 1.292 with P-values 0.197 > 0.05, it can be concluded that the production factor (X2) has no direct effect on productivity (Y2). Beta value of 0.388 and t-statistics value of 6.793 with P-values of 0.000 <0.05, it can be concluded that the characteristics of farmers (X1) have a positive and significant effect on the adoption of agricultural technology (Y1). Beta value of 0.015 and t-statistics value of 0.142 with P-values of 0.887 > 0.05, it can be concluded that farmer characteristics (X1) do not directly affect productivity (Y2) (Maheswari et al., 2008; Mankiw, 2006; Marginson, 2019; Maridelana et al., 2014).

Meanwhile, for the indirect effect, it can be seen that the P values for the two indirect effects are 0.000. It can be said that the indirect effect of the independent variable on the dependent variable in the model involves significant mediating variables. These results can be interpreted that the support of better production factors and farmer characteristics can lead to an increase in the level of adoption of agricultural technology which in turn leads to an increase in the productivity of Arabica coffee farming in Kintamani District, Bangli Regency (Kline, 2015; Kondo et al., 2020; Koundouri et al., 2006; Asih Kuswardinah, 2012).

4 Conclusion

Farmer characteristics and production factors have a significant positive effect on the adoption of agricultural technology. Farmer characteristics and production factors have a significant positive effect on productivity through the adoption of agricultural technology. Characteristics of farmers and production factors do not directly affect the productivity of Arabica coffee so that the adoption of agricultural technology acts as a mediation. The suggestions given to the Regency Government and the Department of Agriculture, Food Security, and Fisheries of Bangli Regency are expected to be more intensive in providing counseling and training related to procedures for Arabica coffee farming so that the coffee produced is according to standards. Especially on the variable indicator of agricultural technology adoption which has the lowest value, namely land management. The training provided should also be adapted to the conditions of the farmers' land.

Conflict of interest statement
The authors declared that’s they have no competing interests.

Statement of authorship
The authors have a responsibility for the conception and design of the study. The authors have approved the final article.

Acknowledgments
We are grateful to two anonymous reviewers for their valuable comments on the earlier version of this paper.

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