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The Capital, Labour and Age Structure Substitution Effect in Malaysia Paddy Crop: A Study in MADA Kedah

Kamarudin Othman[1], Amir Hussin Baharuddin[2]

[1]Faculty of Business Management
Universiti Teknologi MARA (Kedah), 08400 Merbok, Kedah, Malaysia
[2]School of Economics
Universiti Utara Malaysia, 06010 UUM Sintok, Kedah, Malaysia

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ABSTRACT

High output is not necessarily in line with the level of efficiency, increased scale efforts, and the increase of the intensity of production factors. This situation may be attributed to the substitutability between the inputs used in a production process. The purpose of this study is to investigate the substitutability and return to scale between farmers' age structures and capital-labour substitutability in "Malaysia's Rice Bowl" area in Kedah. We employed a time series of data ranging from main and off seasons in 1996 to 2011 (1996H1 to 2011H1). The results showed that the substitution between capital-labour is inelastic. Meanwhile, the elasticity of substitution between farmers' age structure is unitary. This research has also found that the paddy production experienced increasing return to scale. For long-term development, the government should implement policies that encourage more young people to get involved in paddy farming.
KEYWORDS: Microeconomics, Production, Elasticity, Substitution, Agricultural Economic.

INTRODUCTION

Since the 1980s, Malaysian economy has transformed from agricultural-based economy to manufacturing and services oriented. This transformation is aimed to achieve fully developed nation by year 2020. However, these aims may not eliminate the agricultural role in national development. The Malaysian agricultural sector is still competitive and very important especially for the national food security and job opportunities. The economic transformation also has an impact to the entire agricultural sector, particularly paddy sub-sector. In Malaysia, paddy is a staple food crop that produces rice as a source of carbohydrate [1]. A modern agriculture sector involves the use of a comprehensive agricultural technology in farming activities. For example, the level of technology in paddy sub-sector has changed with the introduction of machinery in farming activities. Additionally, the development of this sector was also supported by research and development (R&D) activities through the introduction of hybrid seeds. An increase in the level of technology in the agricultural therefore requires educated, informative, and skilled workers to ensure the productivity of this sector is high.

Currently, there are at least 316,000 paddy farmers in Malaysia [2]. This sector is currently monopolised by the older people who are over than 60 years old [3, 4]. In addition, there are also young people who work in this sector yet the numbers of them are lesser than the elderly. This condition indirectly affects the total output of paddy production in Malaysia. Therefore, the government through the Ministry of Agriculture provides a numerous assistance to increase knowledge and information that related to paddy cultivation to the farmers. This may in turn help farmers to increase their production.

The national paddy target yield is between 5,000 to 10,000 kilograms per hectare every harvest season. However, the actual paddy yield in Malaysia is just around 3,000 kilograms per hectare in every harvest season. This shows that paddy production is lower than the national production target. Shortage in paddy production causes lacking of rice supply which technically could not support the domestic demand. Thus, to accommodate the shortage, the government had to import more rice from abroad. Approximately, Malaysia has imported from RM1.0 up to RM1.3 million of rice every year. Roughly, these amounts represent 30% of rice imported from 2010 to 2012.

To overcome the lack of local paddy production, the government has formulated a number of policies such as fertiliser subsidies, price guarantees, pesticides, hybrid seeds, etc. Although the various form of assistance provided by the government, the level of productivity is still below than 10% per annum. Basically, the productivity of paddy production is divided into two groups, namely granary and non-granary areas. Paddy productivity in the granary

Corresponding Author: Kamarudin Othman, Faculty of Business Management, Universiti Teknologi MARA (Kedah), 08400 Merbok, Kedah, Malaysia, E-mail: kbo176617@kedah.uitm.edu.my

areas has been reported to have increased from 3.8% in 2000, 4.5% in 2005 and 6.5% in 2010. Meanwhile, the productivity in non-granary recorded an increase from 2.2% in 2000 to 5% in 2010.

There are various factors affecting this situation. One of them is the farmers' age structure. On average, the age of Malaysian paddy farmers is around 60 years old and above. At this age, they may no longer be effective to execute physical works in paddy field. In addition, the age factor also affects the rate of absorption of the farming technology. Moreover, most of them are the traditional paddy farmers. These cause paddy yield to be relatively low and not competitive, consequently causing a circumstance whereby the income received by farmers is low. Subsequently, this causes farmers to remain in seemingly endless poverty.

To ensure the paddy production increase, the government then takes a proactive action in manpower planning. One of the components in manpower planning is the elasticity of substitution between workers and other inputs such as physical capital and age structure. The elasticity of substitution is important because it gives an overview on labour demand and the effectiveness of government policies. Factor price changes also depend on the value of elasticity of substitution. The elasticity of substitution knowledge is needed by policy-makers in formulating policies that can enhance the quality of labour. Therefore, this article aims to analyse the capital-labour elasticity of substitution and the elasticity of substitution between farmers' age groups in Malaysian staple food corps industry.

LITERATURE REVIEW

In economic theory, it is essential to examine the capital-labour elasticity of substitution and employees' age structure elasticity of substitution. The elasticity of substitution is the original work of Hicks in 1932 [5]. The elasticity of substitution is the basic tool to measure the substitution between capital-labour and farmers' age structure. Basically, the elasticity of substitution is used to estimate the amount of labour input to be replaced by capital input without increasing or decreasing the output [6]. When this value is large, it means that firms can easily substitute between capital and labour. Geometrically, it measures the curvature of the isoquant.

In early development, a few scholars attempt to show the importance of elasticity of substitution to the economic growth. Among them are Solow in 1957 and Sato in 1963. It showed that by allowing the elasticity of substitution to take any values, it may generate multiple growth paths. However, some of them are not balanced. Additionally, in other study done by [7, 8] is that using an overlapping generation growth model, it showed that the possibility of poverty traps depends on the value of the elasticity of substitution. This elasticity values is denoted by the σ, which has important features in several economic research. Generally, σ is an important element in determining the effectiveness of the policy and the resulting welfare changes. Despite this flexibility which has been adopted by a large number of empirical studies, there is debate about the proper value of the elasticity of substitution estimates. Some researchers believe that the elasticity value is around unity while others believe that the size is perhaps below 0.5.

There are a range of possible production functions which can be used to measure elasticity substitution such as Cobb-Douglas, Leontief function and Constant Elasticity Substitution (CES). The Cobb-Douglas framework assumes that the there is a constant return and unitary elasticity between capital and labour. However, the Leontief function presumes that the elasticity substitution is equal to zero, Meanwhile, Variable Elasticity Substitution (VES) frameworks presumes that the elasticity value interacts with the level of economic development. Nonetheless, according to CES production function, the elasticity turns out to be constant, which is convenient in many applications [9, 10].

Starting with a classical finding, the prominent scholars, Douglas and Solow have found that labour and capital are significant. This shows that both labour and capital are important in the production process. However, in the same empirical study, they found that capital stimulates less output compared to labour. A 1% increase in labour seems to increase the production of about three times compared to the increase of 1% in the capital. Therefore, this shows that labour is the most important factor that influences the production. Subsequently, after these empirical works, the literature on elasticity of substitution between capital and labour became vast. Numerous empirical estimation of elasticises of capital to labour substitution was revealed and a mixture of results was published.

The previous studies on elasticity of substitution have categorised labours into several types such as skill, unskilled, and educationally attained. These studies have also revealed that the elasticity of substitution between production workers and physical capital is higher compared to non-production workers with physical capital. This indicated that skill workers are difficult to be replaced by capital. Therefore, the industry with intensive capital may portray the higher level of technology. In tandem with this, the higher level of technology requires more skilled workers and both technology, hence, works become a complementary inputs. In the study of [11], by using data from US Current Population Survey (CPS) over the period 1963-1992, they found that the elasticity between skilled labour and capital is 0.67. Meanwhile, the elasticity of unskilled labour is 1.67. This evidently shows that the

substitution between capital, skill, and unskilled labours is easily substitutable. In the interim, in [12] who investigated the factors underlying the dispersion in the real unit labour cost growth rate across European countries indicated that the elasticity of substitution between capital and labour is 0.7. This situation is greatly influenced by the diversity of different empirical observation seating. According to [13], these differences are also attributed by the differences in quality of labours used.

Another proxy that is often used to represent labours is the age groups. According to [14], there are numerous studies that ignored all the issues of substitution between age groups of labour. All these studies presumed the degree of substitution of all age groups to be same and treated as homogeneous inputs. However, in [15] believed the point of view that the different age groups are homogenous as unrealistic. Additionally, it believed that the more similar the skill of two groups ages of labour is, the greater the degree of substitution between them. This indicated that the difference age groups are substitutable inputs in production system. If the elasticity of substitution between age groups, with respect to homogeneous skill, is less than infinite (not perfectly elastic), then the impact of the age groups on the production rate may differ across the various age groups of workers [16].

In [14] has again highlighted the issues of the elasticity of substitution between difference age groups of farmers. It then stressed that the different age groups of farmers are substitutable input. However, it indicated that there is a substantially imperfect substitution between different age groups of farmers. There are also other scholars such as by [17] who discovered that the elasticity of substitution between different age groups in the U.S. and the U.K is imperfect. However, the value of elasticity of substitution is about 4-5 range for different age groups.

However, in practice, a variety of circumstances should be taken into consideration in measuring the elasticity of substitution between age groups of farmers such as the level of education, experience, and skills. If these factors are ignored, then the results produced may be inaccurate. Therefore, in [18] has conducted a research and incorporated all the elements above in his empirical study. It discovered that when the above elements are added, the elasticity of substitution becomes inelastic. The study also supported the findings of other researchers who noted that the different age groups of farmers are not perfect substitutes.

In the meantime, in [19] exploited plant-level panel data containing 1,860 manufacturing and non-manufacturing firms in the U.S. It found that the elasticity of substitution between capital and labour is approximately 0.4. There are also a number of other researches using panel data such as by [20]. It employed the panel-level data from the U.K firms. Using this data, they provided the estimation of the long-run elasticity of substitution between capital and other factors of production. From the empirical analysis, it found that the elasticity of substitution is approximately 0.4. This is consistent with the result generated by [19] for manufacturing and non-manufacturing study in the U.S. In further analysis, in [20] discovered that the estimated returns to scale exceeds unity.

The literature about the elasticity of substitution in agricultural sectors is comparatively inadequate as most of the scholars who conducted empirical analyses put their focal point on the manufacturing sectors. Similar to Malaysia, the empirical study on the elasticity of substitution between capital and labour mainly focused on the manufacturing sector [21]. As early as 1969, in [22] has measured the elasticity of substitution between capital and labour by using 1,968 census data. Using the CES method, it discovered that capital-labour substitution is significant. The elasticity values range between 0.45 and 1.18. Other researches such as by [23, 24] also found that the capital-labour elasticity of substitution for Malaysian manufacturing sector is higher. All the above studies demonstrated that the consumption-oriented industries tend to have a relatively higher elasticity than investment-oriented industries. These imply that capital and labour are easily substitutable in consumption-oriented industries.

Likewise, researchers such as by [25] also found that the elasticity of substitution between capital and labour in the agricultural sector is substitutable. However, it discovered that the value of elasticity of substitution is inelastic. This indicated that agricultural sector employs the low level of technology or labour intensive. In a study done by [26], it found that capital and labour are substitutable in Tunisian agricultural sector, which means that capital can be used to replace labour. This also reflects that capital can easily replace labour in agricultural production process. Meanwhile, in [27] found that the agricultural elasticity of substitution between capital and labour are complementary. This means that the right combination of capital and labour is important in influencing the production output. The diversity of these results shows that capital and labour in agricultural sector are dynamic and the directions of effects may differ from one to another place.

Frequently the effects of changes in population structure have attracted many agricultural economics scholars. Changes in the age structure of farmers may have an impact on the effectiveness, the level of productivity, and the profitability of farming activities [28]. Normally, the scholars grouped the age groups into main general categories such as young and old farmers. However, in [29] has categorised labours into more specific groups such as young adults (18-35) middle-aged adults (35-54) young old (55-66) and older adults (65 and above). Basically, young adults groups are more energetic compared to old groups. Regardless, either developed or developing countries, young people prefer to migrate to urban areas while elderly stay in countryside.

Similar to many other countries, Malaysia is also facing dramatic changes in population structure, especially in the agricultural sector. Many youths migrate to the urban areas because of lucrative jobs earnings. In addition, the education attainment also becomes one of the key factors that attract them to migrate to cities. Therefore, the traditional sector such as paddy sub-sector is being abandoned and therefore undertaken by the elderly. Despite that, there are also young and middle-aged farmers but the percentage is not balanced. According to [30], the Malaysia proportion of elderly workers has been increased from 2.8% to 4.7% from 1957 to 2010. This occurrence also reflects on farmers' age structure in the granary areas. For instance, there are approximately more than 60% of them are the active elderly farmers in Muda Agricultural Development Authority (MADA) granary areas and their age ranges from 50 to 75 and above [31].

METHODOLOGY

This section describes about the model specifications used to get the value of the elasticity of substitution. The model was based on the assumption of homogeny labour input for each study area. For the purposes of analysis, this study was based on the production function CES as follows:

$$Y_t = \theta\left[\delta {K_t}^{-p} + (1-\delta){L_t}^{-\beta}\right]^{-\mu/p} \quad (1)$$

$$Y_t = \theta\left[\delta {L40_t}^{-p} + (1-\delta){L41_t}^{-\beta}\right]^{-\mu/p} \quad (2)$$

where $(\theta > 0, 1 > (1-\delta) > 0, \mu > 0, p \geq -1)$. Equation 1 was used to measure the capital-labour elasticity of substitution. Meanwhile, Equation 2 was used to measure the elasticity of substitution between young and old farmers. Variables of Y, K, L, L40 and L41 are respectively the value-added, capital, labours, young farmers, and old farmers. In the meantime, μ is the scale parameter, δ is the distribution parameter, p is the parameter substitution and θ is the efficiency parameter. The age for young farmers represented by L40 is below than 55 years old while the age of old farmers represented by L41is 55 years old and above.

In logaritma (ln) form, both Equations 1 and 2 can be expressed as follows:

$$\ln Y_t = \ln\theta - \mu/p \ln[\delta K^{-p} + (1-\delta)L^{-p}] + \varepsilon_t \quad (3)$$

$$\ln Y_t = \ln\theta - \mu/p \ln[\delta L40^{-p} + (1-\delta)L41^{-p}] + \varepsilon_t \quad (4)$$

Equations 3 and 4 are based on [32]. The estimation of the elasticity of substitution between capital and labour model is as follows:

$$\ln Y = \ln\beta_1 + \beta_2 \ln K + \beta_3 \ln L + \beta_4 (\ln K - \ln L)^2 + \varepsilon_t \quad (5)$$

The estimation of the elasticity of substitution between age structure models is as follows:

$$\ln Y = \ln\beta_1 + \beta_2 \ln L40 + \beta_3 \ln L41 + \beta_4 (\ln 40 - \ln L41)^2 + \varepsilon_t \quad (6)$$

From the coefficient, it then compute the μ as the scale parameter, δ as the distribution parameter, p as the parameter substitution and θ as the efficiency parameter:

$$\theta = \text{antilog}\,\beta_1 \quad (7)$$

$$\mu = \beta_2 + \beta_3 v \quad (8)$$

$$\delta = \frac{\beta_2}{\beta_2 + \beta_3} \quad (9)$$

$$p = \frac{-2\beta_4(\beta_2+\beta_3)}{\beta_2\beta_3} \quad (10)$$

According to [32], this function exhibits the property of possessing CES as given by:

$$\sigma = 1/(1+\beta) \quad (11)$$

Equations 6 and 7 were used to analyse the elasticity of substitution between capital-labour and age structure in MADA regions. The data used were secondary data obtained from MADA for the main session 1996 (1996H) to main session 2011 (2011H1). Equations 6 and 7 were estimated by using the Ordinary Leas Squares (OLS) method. To determine the significance level of independent variable with respect to the dependent variable, the research has then employed the p value (t-test) or F-test.

RESULTS AND DISCUSSION

We began by assuming that the aggregate production in all MADA regions could be represented by a constant return to scale production function characterised by a constant elasticity of substitution between the two factors. In [33] showed that the assumption of a constant elasticity of substitution implied the following functional form for the production function as shown in Equations 5 and 6. The advantage of this function is that it has one less restrictive assumption by allowing the elasticity to take values other than zero or one. In addition, this function also allows the assumption of constant returns to scale.

Capital-Labour Elasticity of Substitution

The estimation of the elasticity of substitution is presented in Table 1. The OLS estimation technique was employed to the data covering the time period from 1996H1 to 2011H1. As in most time-series analysis, this study also checked the time series properties. From the unit roots test, it found that all data employed are stationary at first difference or I(1). This study also checked the problem of serially correlated residuals in the model. The presence of serial correlation implied that the regression coefficients using the least squares estimation method are not efficient and the estimated variances are biased. Based on the OLS regression output, it discovered that Durbin-Watson value and LM Test indicated that OLS estimation for MADA Regions 1, 2 and 4 are free from first and second-order serial correlation. However, Durbin-Watson value on OLS estimation showed that MADA Region 3 is suffering a negative first-order serial correlation. A further investigated on the second-order serial correlation by employing the LM test. It found that the OLS estimation is free from second-order serial correlation. Therefore, to nurse the problems of first-order serial correlation in MADA Region 3, the Cochrane-Orcutt iteration method is employed.

The estimation of the capital-labour elasticity of substitution is presented in Table 1. Equation 5 above was used to estimate the capital-labour elasticity of substitution for all MADA regions. All the results reported were free from first- and second-order of serial correlations. The result revealed that the elasticity of substitution between capital and labour in all MADA production regions ranges from 0.555 to 0.845.This shows that the elasticity of substitution between capital and labour is inelastic because the values are less than one, this finding is accordance with [12, 19]. Furthermore, empirical estimation also indicated that the elasticity of substitution value is positive for all respective areas. In this case, changing relative proportions of each input does not change a lot in the face of changing relative input prices. A 1% change in relative factor prices resulted less than 1% change in the capital-labour ratio.

Table 1: The estimation results for elasticity of substitution between capital and labour

Variables	MADA Regions			
	1	2	3	4
LnK	-3.308823 (-1.661092)	-3.022251 (-1.484280)	0.679363 (0.563740)	7.161634 (3.655625)**
LnL	6.403609 (-2.99492)**	5.990105 (2.571181)**	2.898467 (2.052318)**	-3.584724 (-2.07407)**
LnKL	-0.623497 (-1.7247)***	-0.472589 (-1.432021)	0.122589 (0.532381)	-0.662840 (-2.14430)**
Constant	-24.35287 (2.829443)**	-25.30520 (-3.12739)**	-35.15785 (-4.34534)**	-29.37702 (-4.18866)**
R^2	0.660714	0.686311	0.809851	0.762142
F-statistic	17.52633**	19.69085**	36.91159*	28.83774*
D.W	1.590227	2.042243	2.010954	2.021512
σ_{KL}	0.817864	0.84505	0.554517	0.815295
v	3.09	2.97	3.57	3.58
N	31	31	31	31

Notes: All the values are computed by the researcher
where σ_{KL} is capital-labour elasticity of substitution, v is return to scale parameter, with t-values in parentheses, ** and *** donate 5% and 10% significant level.

The elasticity of substitution in MADA Region 1 is 0.82, which means that 1% change in relative factor prices results in 0.82% change in capital-labour ratio. Meanwhile, in MADA Region 2, the elasticity of substitution is 0.85. It denotes that any changes in 1% in factor prices may increase capital-labour ratio by 0.85%. The responded capital-labour ratio to the change in factor price of MADA Region 3 is 0.55. These showed that increasing 1% in factor prices may lead capital-labour to increase by 0.55%. Furthermore, a change of 1% in factor price may cause capital-labour ration in MADA Region 4 to change by about 0.82%. The value of the elasticity of substitution is less than one, which means that the substitution between capital and labour in the MADA paddy production regions is relatively difficult. The study also found that the CES regression result shows that the return to scale parameters for MADA Regions 1, 2, 3 and 4 are 3.09, 2.97, 3.57 and 3.58 respectively. On average, the return to scale parameter for the entire MADA regions is 3.15 and this shows that overall MADA also experiences increasing return to scale.

Age Structure Elasticity of Substitution

By using Equation 6, the OLS result indicated that MADA Regions 2 and 4 are free from the first- and second-order serial correlations. However, for MADA Regions 1 and 3, it found that there is a presence of the first- and second-order serial correlations. Therefore, to nurse the problems of first-order and second-order serial correlations in MADA Regions 1 and 3, the researcher employed the Cochrane-Orcutt iteration method.

The result in Table 2 shows the elasticity of substitution between young and old farmers in all MADA regions. Specifically, the empirical results show that the elasticity of substitution for MADA Regions 1, 2 and 4 is approximately 0.99 and near to Cobb-Douglas. Meanwhile, for MADA Region 3, the elasticity of substitution is equal to 1. Generally, this shows that the elasticity of substitution between young and old farmers is approximately unitary elastic which also shows that young and old farmers are perfectly substitutable. However, this finding is contradictory to the previous empirical finding that showed that the elasticity of substitution from difference age groups is not perfectly substitutable. Either labours are homogeneous or not, the value of the elasticity is lower than infinity values. This finding is consistent with [34]. The perfect substitution between young and old farmers is due to the homogeneity of production technology employed by both farmers. This indicates that the different age groups respond equally to the paddy production in MADA regions.

Table 2: The estimation results for elasticity of substitution between young and old farmers

Variables	MADA Regions			
	1 (PB)	2	3 (PB)	4
LnL40	-110.7830 (-1.661092)	268.6128 -1.432021	69.12767 1.529117	-87.14597 -1.153148
LnL41	114.6936 (2.829443)**	-265.5150 2.571181**	-65.41276 -1.440173	91.70288 1.209787
LnYO	-22.16904 (-1.724657)***	-39.61918 -1.484280	4.806084 1.535907	-6.822310
Constant	-117.2462 (-2.994921)**	398.3228 1.144088	167.9102 1.135956	-197.0588 -1.219994
R^2	0.436800	0.697186	0.825656	0.696920
F-statistic	6.721582**	20.72118*	41.04343*	20.69515*
D.W	2.218477	2.339124	2.232011	1.670008
σ_{YO}	0.986354	0.996558	1.007897	0.99222
N	31	31	31	31

Notes: All the values are computed by the researcher
where σ_{YO} is young-old farmers' elasticity of substitution, with t-values in parentheses, ** and *** donate 5% and 10% significant level.

CONCLUSION

This research revealed that the elasticity of substitution between capital and labour in MADA production region is less than 1. This illustrated that the elasticity of substitution between capital and labour is inelastic. In this case, the substitution between capital and labour in the MADA paddy production regions is relatively difficult. As an additional finding, the average parameter of return to scale for entire MADA regions is 3.15 and this showed that all MADA regions also experienced increasing return to scale. The empirical findings also revealed that the elasticity of substitution between young and old farmers for all MADA regions is approximately 1. Generally, this showed that the elasticity of substitution between young and old farmers is approximately unitary elastic. This also showed that young and old farmers could be perfectly substitutable.

In the meantime, the study found that there are two different situations. The first one is the rate of substitution between capital and labour, which is difficult to replace. This means that the paddy sub-sector in Malaysia is labour-intensive industry. The second situation is that the elasticity of substitution between young and old farmers is 1. It indicated that the response of different age structure to the production systems is equal. In this situation, to increase the output production, the government should encourage more young people to get involved in the paddy sub-sector. Reliance on old farmers may result in declining in production productivity because old farmers have reached more than 50 years old and their healthy conditions are gradually falling. For long-term development, the government should implement policies that encourage more young people to become paddy farmers by attracting them to through the use of modern technology, research and development, and agricultural education and training system. Furthermore, the government should ensure that the income from this sector is more attractive than that of private companies. Therefore, further researchers should expand the study by investigating the income benchmark to ensure young people staying in this sector.

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