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Changing age structure and input substitutability in the Thai agricultural sector

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ABSTRACT

The rapidly aging society and agricultural abandonment by young people in Thailand have changed the age structure of Thai agricultural labor, and influenced the potential for agricultural production. Thus, it is important to study the feasibility of other inputs as a substitute for labor. This paper estimated the degree of elasticity substitution of inputs, particularly young labor, older labor, and physical capital. The elasticity of input substitution was estimated using a nested constant elasticity of substitution (CES) production function and nonlinear regression analysis. Research data were obtained from the annual secondary data of government sources from 1990 to 2013. The findings indicated that the input substitutability of young and older labor was low. However, capital and labor could substitute for each other. Moreover, capital better substituted for young labor than older labor. The results suggested that both the public and private sectors should encourage young people to engage in the agricultural sector, and support investment in farm machinery as a labor substitute.

Introduction

Agriculture plays a vital role in the Thai economy as the country is a major exporter of agricultural and food products which generate income for farming households and the labor force. However, the Thai agricultural sector is experiencing a change in its workforce age structure. Workers aged over 60 years increased from 4.79 percent in 1989 to 13.50 percent of the total agricultural labor force in 2013 (Table 1). The massive movement of young labor out of the agricultural sector has had a negative impact on agricultural production. However, the impact will depend on the degree of substitution between young and older labor, or on that between agricultural, physical capital and older labor. The impact will be less if young labor or physical capital can be easily substituted for older labor.

The different abilities or production skills between the young and older labor help to explain the degree of substitution. Stloukal (2004) examined previous studies regarding the relationship between aging and agricultural abilities in developing countries. He found that most of the older people had physical deficiencies and poor health. However, they continued working until they were very old, which might be a considerable obstacle to the expansion of agricultural yield or retaining existing production levels.

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Table 1
Age structure of the Thai agricultural labor force, 1989–2013 (%)

Age (years)	1989	1995	2001	2007	2013	Average
15–19	16.90	9.35	5.73	4.36	2.95	7.86
20–29	30.65	25.60	22.27	16.10	16.69	22.26
30–39	22.02	24.45	24.58	22.70	19.18	22.59
40–49	14.73	19.46	22.90	25.89	25.18	21.64
50–59	10.91	14.03	15.65	19.52	22.50	16.52
60 and over	4.79	7.11	8.87	11.42	13.50	9.14
Total	100	100	100	100	100	

Source: Calculated from the labor force survey (National Statistical Office, 2014)

Bryant and Gray (2005) assessed the differences in Thai farming operations between older and younger labor. They also identified the differences in utilization of land, type of production, orientation to the market, use of technology, use of credit market, and income from agriculture. Their results determined that older farmers differed from their younger counterparts in terms of farm mechanization, technological diffusion, crop choice, commercialization, and aggregate output. However, the differences were relatively low.

Previous empirical literature in Thailand focused on comparisons between capacity and the types of farming operation between the young and older labor. However, the estimated degree of input substitutability, particularly between young and older labor, and between physical capital and older labor has rarely been considered. Therefore, this paper attempted to develop an empirical model to estimate the elasticity of substitution of inputs.

Literature Review

Generally, the degree of substitutability between inputs can be measured by utilizing the elasticity of substitution, first presented by Hicks (1932). The elasticity of substitution is an economic tool commonly used to evaluate the substitutability between inputs. It is useful for decision-making on how the producer should increase or decrease the use of each input with existing production technology, when shortages of an input occur or the price changes.

The elasticity of substitution is applied to assess the input substitutability in the case where there are two inputs along an isoquant curve in the production process. An isoquant curve represents the relationship between two inputs of production at the same level of output. The degree of elasticity of substitution can be directly estimated from the production function. Alternatively, it can be measured indirectly from the cost function or the profit function based on duality theory. Nevertheless, this paper studied the aggregation or macro-level of Thai agricultural production, which has a limitation of input price regarding the price of aggregate capital which cannot be defined as a unit cost. Therefore, the estimation of elasticity of substitution from the production function was chosen because it did not require the availability of price data to estimate the function.

Four types of production functions can calculate the Hicks' elasticity of substitution: linear (additive), Leontief (fixed proportion), Cobb-Douglas, and CES (Griffin, Montgomery, & Rister, 1987, pp. 218–219). The degree of elasticity of substitution from estimating the linear function approaching infinity ($\sigma_{ij} \rightarrow +\infty$) implies perfect substitutability. For the fixed proportion (Leontief) function, the substitutability between input pairs is zero or impossible ($\sigma_{ij} \rightarrow 0$). The Cobb-Douglas function imposes that the elasticity of substitution between two inputs always equals one ($\sigma_{ij} = 1$). The CES function has less restrictive substitutability because it is used to allow more flexibility in estimating the elasticity of substitution which can be any value between zero and infinity ($0 \leq \sigma_{ij} \leq \infty$).

In addition to these functions, the translog production function developed by Christensen, Jorgenson, and Lau (1973) is also used to calculate Allen's partial elasticity of substitution (Allen, 1938). The translog production function allows flexibility in estimating the elasticity of substitution similarly to the CES function; moreover, it can include any inputs for which the estimation results for each pair of inputs may have a different elasticity of substitution. However, the estimation of Allen's elasticity is much more complex (Humphrey & Moroney, 1975, p. 70). Therefore, most empirical researchers have transformed this function into a translog cost function (Uzawa, 1962, p. 292), in which price data are needed as an estimating function.

According to the above advantages, the CES function has been extensively applied to examine the issue of substitutability of labor at different ages in macroeconomic modeling such as Guest (2007), Prskawetz and Fent (2007), and Prskawetz, Fent, and Guest (2008). In the case of Thai agriculture, Pisanwanich (2001) used the CES function to estimate the elasticity of substitutability of agricultural products in a computable general equilibrium (CGE) model. Nevertheless, the CES function was not applied to inspect the substitutability of labor at different ages in Thai agriculture.

The idea of the CES function originated with Solow (1956). Later, the general form of CES was extended by Arrow, Chenery, Minhas, and Solow (1961) as a popular instrument for research in the economics field; however it is limited as a constant return to scale. A parameter which allows the function to exist as an increasing or decreasing return to scale was added by Kmenta (1967).

The CES function of Arrow et al. (1961) has a restriction regarding the number of inputs allowing only two inputs or a pair. Thus, the n-input CES production functions with many inputs was proposed by Uzawa (1962) and McFadden (1963). However, the elasticity of substitution of all inputs in this function was equal, which is less useful for empirical research (Sato, 1967, p. 202). Hence, Sato (1967) suggested the two-level nested CES functions for three and four inputs, with different elasticity of substitution of each pair of inputs.

The nested CES function became a popular production function, found in studies by Kemfert (1998), Khan (1989), Koesler and Schymura (2012), Prywes (1986), Shen and Whalley (2013), Su, Zhou, Nakagami, Ren, and Mu (2012), and Wittmann and Yildiz (2013). Due to the reasons mentioned above, the nested CES production function was selected for use in this paper to assess the elasticity of substitution in the Thai agricultural sector.