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Cost Structure and Comparative Advantage of Export Supply Chain of Chu-Mango in the Mekong Delta, Vietnam

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ABSTRACT

This study aims at identifying the production cost structure of the main actors in the Chu-mango supply chain at the market price, and the comparative advantage of the export supply chain at the social price. The comparative advantage of the Chu-mango trade system is measured by the domestic resource cost per shadow exchange rate (DRC/SER ratio) based on a systematic supply chain management approach. It is based on 603 observations among main actors in the Mekong Delta, Vietnam. The results indicate that the export supply chain of Chu-mango in the Mekong Delta has three main channels. The total production cost of export channel 1 triples that of export channels 2 and 3. The main reason for this disparity is Chu-mango grade 1 and high test and transport costs (airplane), whereas channel 2 is mango grades 3 and 4 (shipping line), and channel 3 is mango grade 2 (roadway). The result was three export channels of the Chu-mango trade system to obtain EE with a DRC/SER ratio of less than one. In export channel 1, the DRC/SER ratios are 0.52, 0.53, and 0.49 for seasons 1, 2, and 3, respectively. In export channel 2, these numbers were 0.66, 0.67, and 0.62 for seasons 1, 2, and 3, respectively. In export channel 3, the DRC/SER ratios are 0.49, 0.53, and 0.42 for seasons 1, 2, and 3, respectively. Policymakers and governments need export business incentives based on better exploitation of the comparative advantage to contribute to the sustainable development and economic growth of Chu-mango. The findings of this study contribute to the literature on comparative advantage analysis of export supply chains for other tropical fruits and vegetables, and confirm that the right value of the Ricardian model in international trade is valid and applicable to the real world.

Keywords: *Chu-mango; export channel; domestic resource cost; marketing cost.*

1 Introduction

The total fruit production area of the Mekong Delta (MD) was 1.1 million hectares in 2019. It is the largest fruit producing region in Vietnam (approximately 34.5%) (Anh et al., 2020). Mango is a popular tropical fruit worldwide, particularly in Asia. Vietnam was ranked 11th and 7th in terms of mango volume in the world and Asia, respectively. In Southeast Asia, Vietnam ranked 3rd in terms of mango volume, after Thailand and Indonesia (FAOSAT, 2019). Mango has grown in all provinces of the country with a mango production volume of approximately 815,200 tons and a mango production area of approximately 104,000 ha in 2019 (GSO, 2020). Although the export value of fruits and vegetables declined in 2019 and 2020 compared with 2018 due to the covid-19 pandemic, the export value of Vietnamese mangoes rose from USD 68 million in 2016 to USD 279 million in 2020 (Khoi, 2021). According to GSO, 2020, MD has the largest share of mango production in Vietnam. It was the largest mango production region in the country, with 48,200 ha (46.3% of the national total). The total mango volume in Vietnam was 815,200 tons. The MD region of Vietnam is a mango cultivation center, occupying approximately 62.8% of the Vietnamese mango volume (511,945 tons). A study by the mango project MST (2020) showed that the structure of mango volume in MD was Tuong-mango (45.5%), Chu-mango (22.6%), HoaLoc-mango (9.4%), and others (22.5%). Although Chu-mango ranks second in terms of volume, it is a mango variety that stands out not only in terms of the diversity of consumption markets but also in term of the variety of products derived from it (fresh fruit, several processed products). Tuong-mango focuses on the Chinese market with raw fresh fruit, whereas HoaLoc-mango is focused on the domestic market with ripe fresh fruit. At the regional level, the total Chu-mango volume in MD was 115,700 tons in 2020. In Vietnam, Chu-mango is planted mainly in MD with about 80% of Vietnam's production). However, Chu-mango cultivation is primarily a smallholder activity, with an average growing area of 0.5-1.0 ha.

Predominantly, smallholder production results in difficulties in applying new technology and relatively complex and fragmented links between farmers and markets. It is difficult for receiving market signals related to demand, variety, quality, and food safety and to translate them into changes at the farm level (Peter, 2020; William, 2014). This results in reduced competitiveness in international markets. Porter (2001) contended that competitiveness is not a simple concept. It may be represented by a country's share in the world market and without considering product differentiation, depend on a country's cost advantages in relation to competing countries. However, a pre-requisite for competitiveness is to assure a quality product in line with the requirements of the final recipient of the product. This requires a quality focused intreraction among partners in the value chain. It is reached by establishing business partnership patterns and institutions. It requires strict coordination among stakeholders along the chain from production to consumption in a systemic approach and based on proper policies towards sustainable development of the whole chain. The analysis of comparative advantage through an evaluation of stakeholders' cost efficiency considering trade related and costs of non-tradable inputs could reflects these collaborations. This study applies cost analysis to Chu-mango export activities. It focuses on two key objectives: the production cost of the main actors of Chu-mango export channels at market prices and domestic cost of non-tradable resources of Chu-mango export channels at social prices. This helps policymakers identifying the comparative advantage of the Chu-mango trade system and propose policies for commercial progression.

2 Methodology

2.1 Sampling technique

The data were collected in multiple stages. First, the Mekong Delta (MD) region was purposively selected because of its comparative advantage in mango production systems, accounting for 62.8% of the production volume and 48.2% of the production area in Vietnam. Second, Dong Thap, An Giang, Tien Giang, and Vinh Long provinces were chosen because four provinces accounted for approximately 71% of the volume and made up 60% of the area in the MD (GSO, 2020). Finally, a simple random technique was used to select 603 sampling observations for the Chu-mango supply chain (526 farmers, five cooperatives, 30 collectors, five wholesalers, seven export enterprises, and five processing firms).

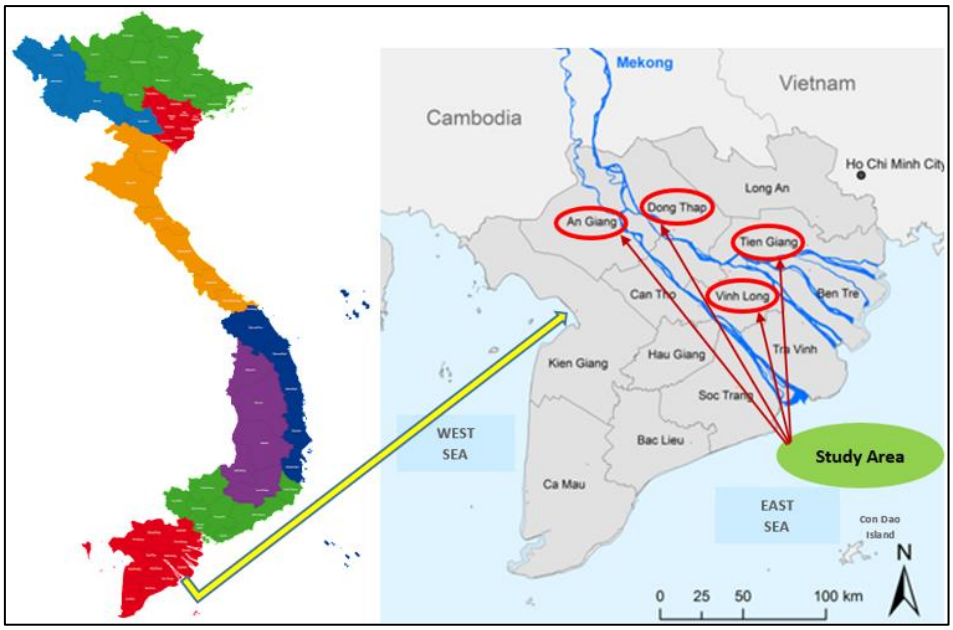

Figure 1. Study area in the Mekong Delta, Vietnam (Source: Design by author, 2021).

2.2 Conceptual framework

The theory of comparative advantage was mentioned in Ricardian's 1817 model by David Ricardo. Comparative advantage theory suggests that a country should specialize in products that are produced at the lowest opportunity costs and trade with others to procure goods and services that are relatively cheaper in other countries, generating mutual advantages. This way a country can successfully compete with goods in the international market. Comparative advantage is a measure of economic efficiency through the efficient use of land, labor, and capital inputs for benefitting from trade (Monke and Pearson, 1989). In addition, a comparative advantage is a good way to determine potential competitiveness. Domestic resource cost (DRC) is an indicator used to measure comparative advantage. It relates to a measure of real opportunity cost in terms of the total domestic resources of producing (or saving) a net marginal unit of foreign exchange (Bruno, 1972). The DRC is widely used in policy analysis and advice. It identifies efficient and inefficient production and business systems and suggests that policies should be targeted to improve production costs (Gorton et al., 2000). Therefore, the DRC index is associated with the theory of comparative advantage in international trade. Many previous studies have applied DRC to analyze the comparative advantages of fruit and vegetable exports. According to Soetriono et al. (2019), the farming of snake fruit in Pronojiwo village has comparative advantages, with a DRC (0.20) of less than one. Another fruit product, Siamese orange in Kanagarian Koto Tingg, Indonesia, has a comparative advantage (DRC 0.11) with diverse domestic resources and favorable agro-climate. In addition, the DRC analysis for sugarcane production by Khan et al. (2006) pointed out that Pakistan should not encourage export objectives (DRC 1.31 more than one), but its production should be produced for self-sufficiency as an import substitution policy (DRC 0.59 less than one). Olayinka et al. (2014) showed that pineapple production in Nigeria is economically efficient using both the sucker and crown techniques, in which the sucker technique (DRC 0.22) is more efficient than the crown technique (DCR 0.27).

2.3 Empirical model

Domestic resource cost analysis (DRC) is a measure of real opportunity cost in terms of total domestic resources for producing (or saving) a net marginal unit of foreign exchange (Bruno, 1972). In the agricultural sector, DRC has been used as an effective tool for evaluating comparative advantages and policymaking (Monke and Pearson, 1989). It identifies efficient and inefficient production and suggests areas policies should target and improve (Gorton et al., 2000). Example studies have focused on e.g. the comparative regional advantage of grain production in China (Funing and Xu, 2002) or the domestic resource cost of tea production in Nelap (Bishnu, 1983).

The DRC calculation can be expressed as

$$DRC_i = \frac{\sum_{j=k+1}^{n} a_{ij} \; V_j}{p_i^r - \sum_{j=1}^{k} b_{ij} \; p_j^r}$$

where a_{ij}, j= k+1 to n is the technical coefficient for domestic resources and non-tradable inputs and V_j is the shadow price of domestic resources and non-tradable inputs necessary to estimate the opportunity costs of domestic production. p^r_i is the border/reference price of traded output (FOB), b_{ij}, j=1 to k, is the technical coefficient for traded inputs and p^r_j is the border/reference price of traded inputs (CIF) (Gorton et al., 2000).

When the DRC is smaller than 1, domestic production is efficient and internationally competitive because the opportunity cost of spent domestic resources is smaller than the net foreign exchange it gains in exports or saves by substituting for imports.

The opposite is true when DRC is larger than 1. The balanced situation is represented by a DRC equal to 1 where the economy neither gains nor saves foreign exchange through domestic production.

The shadow exchange rate can be estimated through the following formula:

SER = OER * (1+ FX premium)

where:

- SER: Shadow Exchange Rate
- OER: The official Exchange Rate (OER), 2018-2019 (published by the Ministry of Finance, 2019) is 22,622 VND/USD.
- FX premium represents a risk premium; the World Bank recommends an FX premium of 20% (0.2) for developing countries (Minh et al., 2016).

Opportunity cost: The opportunity cost of labor in the production phase is measured in real prices paid by households, assuming that the labor market is relatively perfect. The opportunity cost of land is determined by the household land rent price for mango farmers. All land costs were calculated as internal resource costs. The opportunity cost of agricultural instruments and machines is determined by assuming constant efficiency for years and loss of value per year (Lorenzo, 2013). In this study, opportunity cost are land rent, machine depreciation and family labour.

CIF price: “Cost insurance and freight”, a term used to describe pricing or valuation of imported goods, includes all the transfer costs of delivering the goods to the point of consumption. Tradable input of agrochemicals (material import price) in this study is calculated based on CIF price.

FOB price: “Free On Board” a price calculation where the transfer costs are excluded. It refers to exports. In this research, the calculation of revenue is based on FOB prices for the exports of trade enterprises, processing firms and wholesalers.

Tradable commodities are commodities that have border prices. If the prices can be expressed in three levels: farm gate price, cost of transport price, marketing price, and so forth, they can be transferred into shadow prices through transfer factors. The transfer factor is the ratio of the revenue of the opportunity product with border prices to the actual product revenue expressed in market prices.

Non-tradable commodities such as production inputs (e.g., land and labor) have unknown border prices and pricing is expressed in social prices. In this case, the economy neither gains nor saves foreign exchange through domestic production.

2.4 Estimation of tradable and domestic percentage of input materials

To identify the proportion of tradable and domestic input materials, the study used the results of the national mango project in the 2017-2020 period from the Ministry of Vietnamese Science and Technology (MST) with the code KHCN-TNB. ĐT/14-19/C14. A report by Phuong in 2020 stated that fertilizer production in Vietnam met 70% of the domestic demand. This finding is similar to the mango project of MST (2020) which calculated fertilizer from domestic production to 72.8% and from imports to 27.2%.

Table 1.
Imported percentage of input materials (unit: %).

No.	Products	F	Vietnam	Other country
1	Fertiliser	5,903	72.8	27.2
2	Agrochemical	14,555	19.7	80.3
3.1	Fuel	5,094	60.0	40.0
3.2	Electricity	9,461	100.0	0.0
4	Machine depreciation	5,020	30.0	70.0
5	Wrapping bag	6,450	20.0	80.0

Source: MST, 2020

For pesticide production, Vietnam depends on raw materials from foreign markets (77%) with a 0% import tariff (52% from China, 7% Singapore, 5% Germany and Thailand 4%) (Ngoc, 2020), while the results of the mango project MST (2020) indicate that 85.7% of the pesticides used in mango cultivation are from Vietnam and 14.3% from imports. However, most Vietnamese agro-input companies import raw materials from other countries. Thus, the tradable percentage of agrochemicals was 14.3% + (85.7% *0.77) = 80.3%, and the domestic percentage was 19.7%.

Mango farming uses two primary power sources, fuel and electricity. Research on mango projects shows that mango growers consume 35% of fuel and 65% of electricity. According to the Ministry of Industry and Trade in 2019, Vietnam imports approximately 40% of its fuel to supply domestic demand, while Vietnam may provide 100% of its national electricity demand. Hence, the tradable percentage of energy is 35%*0.4 = 14%, and the domestic percentage is 65% + 35%*0.6 = 86%. In addition, Sang and Xe (2016) mentioned that 30% of agricultural machines are domestic and 70% are imported. The MST mango project in 2020 showed that most farmers use imported fruit bags from Taiwan and South Korea to wrap (about 80%), while about 20% of bags are from domestic production.

Table 2.
Percentage of tradable and domestic inputs (units: %).

No.	Products	Tradable percentage	Domestic percentage
1	Fertiliser	27.2	72.8
2	Agrochemical	80.3	19.7
3	Energy	14.0	86.0
4	Machine depreciation	70.0	30.0
5	Wrapping bag	80.0	20.0

Source: Calculation of author, 2020

3 Results and Discussions

3.1 The export supply chain of Chu-mango in the Mekong Delta, Vietnam

The Chu-mango supply chain trade system includes the following three main export channels:

Channel 1 Farmer → Cooperative → Export Enterprise

Channel 2 Farmer → Cooperative → Wholesaler → Processing Firm

Channel 3 Farmer → Collector → Wholesaler (Chinese market)

Marketing Channel 1: Developed nations including Europe, the U.S., Australia, Japan, Korea, and Canada are the key importers of Chu-mango in Channel 1. Sanitary and phytosanitary regulations for this high-end market segment are stringent. It must be Chu-mango of grade 1 and be traveled by aircraft. The majority of Chu-mangoes grade 1 stem from cooperatives that strictly monitor agrochemicals use, have safety certificates (VietGAP, GlobalGAP), agricultural diary books, and traceability codes. It must be ensured that extrinsic attribute requirements of the Chu-mango grade 1 such as appealing attractive packaging and labelling, weight over 280 g, wrapping bag, blemish-free, wrinkle-free, yellow and

bright skin colour without abscission layers are in place. Chu-mango grade 1 accounts for approximately 23% of the total mango harvest. However, just 3.4% of the supply chains deal with Chu-mango grade 1 in Channel 1. The channel's actors regularly engage with one another and coordinate closely together (Fernandez-Stark et al,2011). The export value chain is very competitive, and to meet importers' demands at each stage of the chain, it necessitates both high-quality products and collaborating actors. Information on export firms is provided in appendix 2.

Marketing Channel 2: Chu-mangoes marketed in Channel 2 involve processed products (juice, dried mango, frozen mango, jam, jellies, etc.). Most of these products are transported to importing markets (Korea, Japan, Australia, the US, China, Europe, etc.) via Shipping lines. Chu-mango grades 3 and 4 are available in weights of 200 g or 250 g and have lower-quality skin. The percentages of Chu-mango grades 3 and 4 at orchards in MD were roughly 35% and 7%, respectively. Vietnamese mangoes with the greatest share of processed products is the Chu-mango, which accounts for 22.1 percent of the supply chain's export volume. Information on processing firms is provided in appendix 3.

Marketing Channel 3: Channel 3's primary market is the Chinese market. Chu-mango is mainly shipped by large trucks through the trade gates at the Vietnam–China border with Chu-mango grade 3 (indicators: traceability code, weight 250-280 g, wrapping bag, partly blemish, wrinkle-free and bright color). The percentage of Chu-mango grade 2 is about 35%. Chu-mango volume exported to the Chinese market is approximately 7.9%. Wholesalers are important actors as the foundation of the Chu-mango supply chain. At the regional and national levels, they play an important role as both input and output partners of actors in the value chain. Additionally, the wholesaler exports fresh mangoes to the Chinese market. Mangoes are primarily transported by trucks to China (60–72 hours from MD to the Chinese market). Heavy vehicles involve a cooling system with an electronic chip to manage the temperature during the journey. Transactions in Channel 3 take place either in Chinese or Vietnamese territory. If transactions take place in China, the cost of customs will be between USD 260 and USD 350 per container (25-30 tons).

3.2 The structure of production costs of main actors in the supply chain at market prices

The production cost structure of the main actors in the three export channels was calculated at market prices. It was used to compute social prices before entering the comparative advantage analysis of the Chu-mango supply chain. It helps to identify the important components of the production cost of each actor in every export channel.

Table 3 compares the production cost structure of Chu-mango growers across the three seasons. The opportunity cost (machine depreciation, family labor, and land) was also used to calculate the total cost. The total production cost is a combination of the input and marketing costs, accounting for 46% of the input costs and 56% of the marketing costs. The most important component of the input cost is the fungicide cost, which accounts for slightly more than a quarter of the total cost. The factors that play an essential role in marketing costs are family labour costs, which account for over 20% of the total cost. In particular, the production cost of season 2 is the highest at 632 USD/ton, followed by season 1 (604.4 USD/ton), and season 2 is 500.9 USD/ton. Meanwhile, the production cost of mango growers per year is classified based on mango quality comprising: 1,012.7 USD/ton in channel 1 with mango grade 1, 346 USD/ton in channel 2 with mango grades 3 and 4, and 717.5 USD/ton in channel 3 with mango grade 2.

A large difference can be found in the production costs of cooperatives between channels 1 and 2, which can be well illustrated by the fact that the input costs in channel 1 are 2.5 times the costs in channel 2 (Table 4). This disparity is derived from the selling price of mangoes. The input costs of the cooperative is the selling price of farmers. Chu-mango in Channel 1 with mango grade 1 receives a sales price which is three times that of mango grade 3 in Channel 2.

Table 3.
The production cost of Chu-mango farmer (units: USD/ton).

No.	Items	Season 1	Season 2	Season 3	Sig.
1	**Input cost**	**277.2±195.9^{b}**	**291.0±234.0^{b}**	**231.3±201.7^{a}**	**
1.1	Root fertilizer	52.4±45.4	58.9±61.7	50.6±53.0	ns
1.2	Leaf fertilizer	16.6±19.8	19.4±23.5	15.0±22.7	ns
1.3	Paclobutrazol	14.8±21.4^{c}	7.6±18.2^{b}	3.1±12.3^{a}	***
1.4	Herbicide	0.7±1.9^{b}	0.7±3.1^{b}	0.2±0.7^{a}	**
1.5	Insecticide	36.4±55.5	43.6±60.9	31.9±43.8	ns
1.6	Fungicide	156.4±151.0	160.8±153.3	130.4±158.6	ns
2	**Marketing cost**	**327.2±195.3^{b}**	**341.3±232.7^{b}**	**269.6±172.8^{a}**	**
2.1	Energy	5.1±6.0	6.7±10.0	5.1±6.9	ns
2.2	Wrapping bag	42.3±59.9	48.4±86.8	37.2±48.6	ns
2.3	Machine depreciation	7.1±8.0	10.4±26.2	8.2±15.9	ns
2.4	Transport	0.9±2.7	1.8±6.9	1.4±3.3	ns
2.5	Hired labour	64.0±81.8^{b}	69.8±101.2^{b}	41.2±69.0^{a}	***
2.6	Family labour	142.5±118.4^{b}	125.4±113.1^{ab}	108.3±103.0^{a}	**
2.7	Land rent	65.3±44.1^{b}	78.8±69.6^{a}	68.3±49.5^{ab}	**
3	**Total**	**604.4±326.8^{b}**	**632.3±409.7^{b}**	**500.9±312.3^{a}**	***

Source: Field Survey Data, 2018

*Note: The numbers in the same row followed by different letters are significant at the 5% level via the statistical Duncan test. * Significant at 10% level, ** significant at 5% level, *** significant at 1% level, and ns is non-significant.*

Table 4.
The production cost of cooperative in the marketing channels 1 and 2 (units: USD/ton).

No.	Items	Cooperative Channel 1		Cooperative Channel 2	
		Mean	Percentage (%)	Mean	Percentage (%)
1	**Input cost**	1,416.3	88.4	494.2	77.0
2	**Marketing cost**	185.2	11.6	147.4	23.0
2.1	Packaging	37.4	2.3	23.0	3.6
2.2	Hired labor	61.0	3.8	50.8	7.9
2.3	Transport	55.7	3.5	47.7	7.5
2.4	Others	31.1	1.8	25.9	4.0
	Total	**1,601.5**	**100.0**	**641.6**	**100.0**

Source: Field Survey Data, 2019

Table 5 lists the costs of collectors in Channel 3 and of wholesalers in Channels 2 and 3. For collectors, the share of input costs amount to 92.3%, while the share of marketing costs amount only to 7.7% (83.2 USD/ton) of the total costs. The marketing costs are usually low because collectors do not store or label mangoes.They purchase and sell mangoes on the same day. The situation with wholesalers is different. Differences are due to differences in input and marketing costs in different marketing channels. Costs of quality certification and higher prices for higher quality mangoes lead to higher input costs. As an example, input costs of mango grade 1 in channel 3 are 2.4 times higher than of mango grade 3 and 4 in channel 2. Furthermore, marketing costs in channel 3 are 1.3 times higher than in channel 2 due to higher costs for packaging and transport. In Channel 3, wholesalers assume the role of an exporting company exportiung fresh mangoes directly to Chinese partners at border gates.

Table 6 shows the structure of costs of export and processing firms. It is a combination of input and marketing costs where marketing costs include e.g. the costs of packing, hired labor, transport, treatment, and testing. There is a large difference in costs between export and processing firms where costs of an export enterprise are five times higher that of the processing firm. The main reason for the disparity is due to market segmentation. Marketing channel 1 deals with Chu-mango grade 1 for fresh fruit exports and marketing channel 2 with Chu-mango grades 3 and 4 for exports of processed products. As a result, the input costs of the export enterprise are 2.6 times higher than of the processing firm.

Table 5.
The production cost of collector and wholesaler (units: USD/ton).

No.	Item	Collector Channel 3		Wholesaler Channel 2		Wholesaler Channel 3	
		Mean	Percentage (%)	Mean	Percentage (%)	Mean	Percentage (%)
1	**Input cost**	1,003.8	92.3	480.9	76.0	1,156.8	84.7
2	**Marketing cost**	83.2	7.7	151.6	24.0	209.8	15.3
2.1	Packaging	8.8	0.8	34.9	5.5	56.1	4.1
2.2	Hired labor	40.1	3.7	32.3	5.1	37.6	2.7
2.3	Transport	20.6	1.9	51.3	8.1	73.4	5.4
2.5	Others	13.7	1.3	33.2	5.2	42.7	3.1
	Total	**1,087.0**	**100.0**	**632.6**	**100.0**	**1,366.6**	**100.0**

Source: Field Survey Data, 2019

Table 6.
The production cost of export enterprise and processing firm (units: USD/ton)

No.	Item	Export Enterprise		Processing Firm	
		Mean	Percentage (%)	Mean	Percentage (%)
1	**Input cost**	1,863.2	27.1	705.1	55.6
2	**Marketing cost**	5,011.9	72.9	563.2	44.4
2.1	Packaging	146.8	2.1	127.3	10.0
2.2	Hired labor	41.1	0.6	54.8	4.3
2.3	Domestic transport	57.2	0.8	54.7	4.3
2.4	Foreign transport	2,958.9	43.0	25.8	2.0
2.5	Test for export	884.1	12.9	42.0	3.3
2.6	Others	923.9	13.4	258.6	20.4
	Total	6,875.2	100.0	1,268.2	100.0

Source: Field Survey Data, 2019

Marketing costs in export enterprises are nine times higher than for the processing firm. Packaging requirements in both, export and processing firms, are similarly high resulting in costs higher than for other actors specified in table 4. The main reason for differences in marketing costs is due to differences in costs for transport and testing. The test costs of mango grades 3 and 4 in the processing firm are 42 USD/ton, whereas the test costs of mango grade 1 for either irradiance or vapor heat treatment are 884.1 USD/ton. Noticeably, the costs of shipping lines (used for processed products) are much cheaper (by a factor of about 115) than the costs of airfreight (fresh mango fruit).

Table 7 presents the production costs of every marketing item and reflects the impact of transport and test costs on operation costs. The main reason for the disparity in costs among marketing channels results from differences in the mango quality of market segments (grade 1 for export channel 1, grades 3 and 4 for export channel 2, grade 2 for export channel 3, grade 2 for domestic channel 4, and non-classified mango for domestic channel 5.

Export channel 1 has the highest operation costs in the Chu-mango trade system (9,489.4 USD/ton). It triples the costs in export channels 2 and 3. The difference not only due to differences in the sales price, but also due to differences in export transportation and test costs. To ensure fresh export quality, Chu-mango in Channel 1 is usually exported by airplanes and has to adhere to sanitary and phytosanitary regulations. The transport and test costs were 3,958.2 USD/ton, accounting for 41.7% of the operation costs in Channel 1. This leads to a significant cost increase which reduces the competitiveness of Chu-mango in the international market.

In export channel 2, transportation and test costs constitute only 7.7% of the operation costs. However, the local transportation costs (roadway) are six times higher than the export transportation cost (shipping line). This reflects the high logistics cost inside Vietnam. Downstream actors have to pay higher transport costs than upstream actors in all marketing channels (Table 7).

Table 7.
Percentage of test and transport costs in total production cost in export supply chain (units: USD/ton).

Actors	Farmer	Coop.	Collect	Whole	Export Enterp	Proce. Firm	Total	Percent (%)
Channel 1								
Production	1,012.7	1,601.5			6,875.2		9,489.4	
Local transport	2.3	55.7			57.2		115.2	1.2
Export transport					2,958.9		2,958.9	31.2
Test for export					884.1		884.1	9.3
Channel 2								
Production	346.0	641.6		632.6		1,268.2	2,888.4	
Local transport	0.8	47.7		51.3		54.7	154.5	5.3
Export transport						25.8	25.8	0.9
Test for export						42.0	42.0	1.5
Channel 3								
Production	717.5		1,087.0	1,366.6			3,171.1	
Transport	1.6		20.6	73.4			95.4	3.0

Source: Field survey data in 2018 for farmer, in 2019 for other actors

3.3 Comparative advantage of Chu-mango export supply chain at social price

According to Monke and Pearson (1989), the valuation of social profit based on social prices is a measure of comparative advantage. The comparative advantage of this study is the DRC/SER ratio, which serves as an indicator of relative degrees of efficiency. Minimizing the DRC is a way to maximize social profits. The Chu-mango supply chain is divided into five primary marketing channels with three directed to exports and dealing with mangoes of different gradings.

Tables 8, 9, and 10 show that the revenue values in the export channels are greater than the total tradable and domestic costs for channels 1, 2, and 3 in all three seasons. This means that social profitability is positive, implying that the three cropping seasons in channels 1, 2, and 3 use scarce resources efficiently at social prices. This implies that the Chu mango trade system can generate foreign exchange earnings through channels 1, 2, and 3 during the three seasons. In general, the Chu-mango trade system is profitable at social prices.

The results of the analysis (see Table 8 in the Appendix) show the coefficients of DRC and DRC/SER in export channel 1. The DRC/SER values are 0.59, 0.60, and 0.58 (less than 1) for seasons 1, 2, and 3, respectively, thereby indicating that the export business of channel 1 will earn a foreign currency value of 1 USD by using domestic factor costs of 0.59, 0.60, and 0.58 in all the three seasons. Chu-mango production and exports are economically efficient at utilizing domestic resources.

In export channel 2 (Table 9 in the Appendix), the DRC/SER values were found to be less than one (0.66, 0.67, and 0.62 for seasons 1, 2, and 3, respectively). This reflects an efficient use of domestic resources to generate social profitability. However, The DRC/SER values are higher than those of channel 1 indicating a comparative advantage of channel 1.

Information from Table 10 in the Appendix provides the results of the analysis for marketing channel 3. The findings indicate that the DRC/SER values of the three cropping seasons of Chu-mango were smaller than one, including 0.49, 0.53, and 0.42 for seasons 1, 2, and 3, respectively. This reflects that channel 3 can save one USD of foreign exchange by using domestic resources of 0.49, 0.53, and 0.42 USD for seasons 1, 2, and 3, respectively proving the efficient allocation of scarce domestic resources to these crops.

Although all three export channels have a comparative advantage, there are significant differences in the DRC/SER ratio among the export channels and the cropping seasons of each channel. Channel 2 has a lower comparative advantage than channels 1 and 3. Cropping season 3 had a higher comparative advantage than seasons 1 and 2. This fundamental outcome emphasizes the international competitive advantage and economic efficiency of the Chu-mango production system for exports. Therefore, policymakers and governments should adopt incentive policies to improve product quality, eliminate border and non-tariff barriers, and better exploit the comparative advantage based on favorable climatic, soil, and water conditions, which are important factors contributing to sustainable development and economic progression.

4 Conclusion

The Chu-mango trade system includes three export channels (export channels 1, 2, and 3). Actors in channel 1 involve farmers, cooperatives and expert enterprises with operation costs in export channel 1 of 1,012.7 USD/ton, 1,601.5 USD/ton, and 6,875.2 USD/ton. Actors in channel 2 involve farmer, cooperatives, wholesalers, and processing firms with opertaion costs of 346 USD/ton, 641.6 USD/ton), 632.6 USD/ton, and 1,268.2 USD/ton. Actors in channel 3 involve farmers, collectors, and wholesalers delivering to the Chinese market with operating costs of 717.5 USD/ton, USD 1,087/ton, and USD 1,366.6/ton.

The economic efficiency of the Chu–mango trade operation is reflected by the comparative advantage of the export channels measured by the DRC/SER ratio. All trading operations of the three exporting channels are economically efficient with a DRC/SER ratio less than one. Export channel 3 has the best comparative advantage, followed by export channel 1. Furthermore, mango produced in season 3 has the best comparative advantage, followed by productions in season 1, and season 2.

The results of this study contribute to the basic principle of the Ricardian model in analyzing the comparative advantage of export supply chains, especially in tropical fruit fields. Today, when the world is moving towards greater liberalization and globalization, each country specializes in the production of goods and services on the basis of comparative advantage and enters international trade. Each country attempts to lower the cost of producing internationally traded goods to gain an advantage in the global market. This research provides useful tools in support of the Ricardian model as well as evidence that the Ricardian model's insight into international trade is valid and applicable to the real world.

Authors' contributions

The authors confirm the contribution to the paper as follows: study conception and design: Kiet Hong Vo Tuan Truong and Shaufique Fahmi Sidique; data collection and data sheet entry: Kiet Hong Vo Tuan Truong; analysis and interpretation of results: Kiet Hong Vo Tuan Truong; draft manuscript preparation: Kiet Hong Vo Tuan Truong, Shaufique Fahmi Sidique, Mad Nasir Shamsudin, Ahmad Hanis Izani Abdul Hadi. All authors reviewed the results and approved the final version of the manuscript.

Availability of data and materials

The data that support the findings of this study are available from the "Technology and science program for sustainable development in the Mekong Delta region", but restrictions apply to the availability of these data, which were used under license for the current study and are not publicly available. However, data are available from the authors upon reasonable request and with the permission of the Technology and Science Program for Sustainable Development in the Mekong Delta region.

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Conflict of interest

No potential conflict of interest was reported by the authors.

References

Anh, S.T., Hung, L. M, Lam, T.L., Oang, T.T.K., Pho, L.D., Hanh, P.N., Phuc, N.V., Nam, N.H., Peter, J. (2020). *Activity 1.5: Value chain study – Mango processing,* Improving smallholder farmer incomes through strategic market development in mango supply chains in southern Vietnam project. The *Australian Centre for International Agricultural Research* (*ACIAR*), Australia, available at: https://apmangonet.org/wp-content/uploads/2020/05/AGB2012061-A1.5-VC-Processed.pdf.

Bishnu, B.B. (1983). *Domestic resource cost of tea prroduction in Nelap*. HMG. U.S. AID-A/D/C Project. Strengthening Institutional Capacity in the Food and Agricultural Sector in Nepal, available at: https://pdf.usaid.gov/pdf_docs/PNAAN944.pdf.

Bozarth, C.C., Handfield, R.B. (2006). *Introduction to Operations and Supply Chain Management,* Pearson Education, Upper Sadle River, New Jersey.

Brian, B., An, D., Minh, P., Truc, D., Nhi, N., Tuan, T., Trinh, D. (2021). *Agriculture report*. Hanoi: Business Centre British Chamber of Commerce Vietnam, available at: https://britchamvn.com/wp-content/uploads/2021/04/Vietnam-2021%E2%80%93AGRICULTURE-Sector-Briefing.pdf.

Bruno, M. (1972). Domestic resource costs and effective protection: Clarification and Synthesis. *Journal of Political Economy*, **80** (1): 16-33, available at: https://www.jstor.org/stable/1830128.

FAO (2021). *Major Tropical Fruits: Preliminary results 2020*. Food and agriculture organization of the United Nations, Rome, available at: http://www.fao.org/3/cb6196en/cb6196en.pdf.

FAOSAT (2019). Retrieved June 12, 2021 from http://www.fao.org/faostat/en/#rankings/countries_by_commodity.

Fernandez-Stark, K., Bamber, P., Gereffi, G. (2011). *The fruit and vegetables global value chain: economic upgrading and workforce development*, Center on Globalization, Governance and Competitiveness, Duke University, Durham, NC, USA, available at: https://gvcc.duke.edu/wp-content/uploads/2011-11-10_CGGC_Fruit-and-Vegetables-Global-Value-Chain.pdf.

Funing, Z., Zhigang, X. (2002). Regional comparative advantage in grain production in China's main grain crops. Asia Pacific Press, available at: https://core.ac.uk/download/pdf/156616306.pdf.

Gorton, M., Davidova, S., Ratinger, T. (2000). The competitiveness of agriculture in Bulgaria and the Czech Republic Vis-à-vis the European Union (CEEC and EU Agricultural Competitiveness). *Competitive Economics Studies*, **42**(1): 59-86, doi: 10.1057/ces.2000.2.

GSO (2020). *Statistical YearBook 2019.* The general statistic office of Vietnam (GSO). Statistical Publishing House, Hanoi City.

Khan, A., Farooq, A., Saddozai, K.N. (2006). Comparative advantage of sugarcane production in Pakistan. *The Bangladesh Journal of Agricultural Economics*, **29**(1-2): 69-79.

Khoi, C. (2021, April 12). Giving Vietnamese mango to the world, export growth 16.5% of the first quarter 2021. Retrieved April 26, 2021, from https://vneconomy.vn/xoai-viet-ra-the-gioi-xuat-khau-tang-truong-165-trong-quy-1-20210409144035179.htm.

Lorenzo, G.B. (2013). *Value chain analysis for policy making: Methodological guidelines and country cases for a quantitative approach*. Food and agriculture organization of the United Nations (FAO), Rome, available at: http://www.fao.org/3/at511e/at511e.pdf.

Mentzer, J.T. (2004). *Fundamentals of supply chain management: Twelve drivers of competitive advantage*. Sage, California.

Ministry of Finance (MF) (2019). Monthly exchange rate. Retrieved October 8, 2019 from https://www.mof.gov.vn/webcenter/portal/mof/r/o/tght?_afrLoop=4475622333496555#%40%3F_afrLoop%3D4475622333496555%26centerWidth%3D670px%26leftWidth%3D286px%26rightWidth%3D0%26showFooter%3Dfalse%26showHeader%3Dfalse%26_adf.ctrl-state%3D10fqxcqtka_261.

Ministry of industry and trade (MIT) (2019). *Vietnam import-export report 2018*. Industry and Trade, Ha Noi, Vietnam, available at: https://wtocenter.vn/file/17146/Bao%20cao%20Xuat%20nhap%20khau%20Viet%20Nam%-202018.pdf.

Ministry of Science and Technology (MST) (2020). *Value chain development of Vietnamese mango fulfilling requirement for domestic and international markets in 2017-2020. Code: KHCN-TNB.ĐT/14-19/C14*. The Technology and science program for sustainable development in the Mekong Delta. Ministry of Science and Technology (MST), Vietnam.

Minh, H.T., Trang, D.T.N., Chen, J.C. (2016). Applying the DRC (Domestic resource cost) index to evaluate the competitive advantage of Dak Lak Coffee. *Open Access Library Journal*, **3**(6): 1-8, available at: doi: 10.4236/oalib.1102727.

Monke, E.A., Pearson, S.R. (1989). *The policy analysis matrix for agricultural development*. Cornell University Press, New York, available at: https://www.cepal.org/sites/default/files/courses/files/03_3_pambook.pdf.

Ngoc, B.D. (2020). *Initial valuation report: Agricultural Industry*. (Unpublished report). FPT Securities, Vietnam, available at: http://www.fpts.com.vn/FileStore2/File/2020/05/28/EN_LTGValuation_RptMay2020_deaa8c8b.pdf.

OECD/FAO (2020). *OECD-FAO Agricultural Outlook 2020-2029*. Food and agriculture organization of the United Nations, Rome, available at: http://www.fao.org/3/ca8861en/CA8861EN.pdf.

Olayinka, A., Omobowale, O., Iyabo, A. (2014). Competitiveness of pineapple production in Osun state, Nigeria. *Journal of Economics and Sustainable Development*, **5**(2): 205-214.

Peter, J. (2020). *Activity 1.5: Value chain study – fresh.* Improving smallholder farmer incomes through strategic market development in mango supply chains in southern Vietnam project. The *Australian Centre for International Agricultural Research* (*ACIAR*), Australia, available at: https://apmangonet.org/wp-content/uploads/-2020/05/AGB2012061-A1.5-VC-Fresh.pdf.

Porter, M.E. (2001). *Competitive Advantage–Creating a Sustaining Superior Performance*. The Free Press, New York.

Phuong, T.B. (2020). *Fertilizer industry update report: Positive prospects from agriculture, fertilizer companies continued to wait for VAT policy.* (Unpublished the report). FPT Securities, Vietnam, available at: http://www.fpts.com.vn/FileStore2/File/2021/02/04/FPTSFertilizer_Industry_Update_ReportDec2020Eng_a7427bd1.pdf.

Ricardo, D. (1817). *The works and correspondence of David Ricardo Vol. 1: On the principles of political economy and taxation*. Cambridge University Press, New York, available at: http://ricardo.ecn.wfu.edu/-~cottrell/ecn265/Principles.pdf.

Sang, V.M., Xe, D.V. (2016). Comparative advantage in rice production and export of Vietnam. *Scientific journal of Open University of Ho Chi Minh City,* **50**(5): 1-14.

Soetriono, D.S., Ariq, D.M., Dimas, B.Z. (2020). Proceeding from EDP Sciences: *The competitiveness of Pronojiwo snake fruit*. E3S Web of Conferences 142, 05007. Doi.org/10.1051/e3sconf/202014205007.

Thang, C.T. (2018). *Impact of free trade agreements (AEC, CPTPP, EVFTA) on horticulture in Vietnam*. (Unpublished report). Institute of policy and strategy for agriculture and rural development, Vietnam.

Waters, D. (2003). *Logistics: An introduction to supply chain management*. New York: Palgrave Macmillan, the U.S., available at: https://juancarlosvergaras.files.wordpress.com/2013/06/waters_d-_logisticsc_an_introduction_-to_supply_chain_management_2003en354s.pdf.

William, S. (2014). *Business engagement in smallholder agriculture: Developing the mango sector in Dong Thap province*. (Unpublished ODI Report), Overseas Development Institute, England, available at: https://cdn.odi.org/media/documents/9137.pdf.

Appendix 1

Table 8.
Comparative advantage of Chu-mango in the export channel 1 (units: USD/ton).

No.	Indicator costs	Season 1 (n=212)	Season 2 (n=173)	Season 3 (n=141)	Sig.
	Official exchange rate in 2018-2019 (USD 1 = VND 22,622)				
1	Tradable inputs	**435.66^{b}**	**461.88^{b}**	**361.38^{a}**	**
1.1	Root fertiliser	27.51	30.93	26.59	*Ns*
1.2	Leaf fertiliser	8.71	10.22	7.88	*Ns*
1.3	Paclobutrazol	22.98^{c}	11.86^{b}	4.83^{a}	***
1.4	Herbicide	1.07^{b}	1.15^{b}	0.32^{a}	**
1.5	Pesticide	56.42	67.58	49.52	*Ns*
1.6	Fungicide	242.67	249.41	202.32	*Ns*
1.7	Fuel	1.37	1.81	1.39	*Ns*
1.8	Wrapping bag	65.31	74.80	57.46	*Ns*
1.9	Machine depreciation	9.62	14.11	11.05	*Ns*
2	Domestic factors	**676.89^{b}**	**698.95^{b}**	**562.15^{a}**	**
2.1	Root fertiliser	61.36	68.98	59.32	*Ns*
2.2	Leaf fertiliser	19.43	22.79	17.58	*Ns*
2.3	Paclobutrazol	4.70^{c}	2.42^{b}	0.99^{a}	***
2.4	Herbicide	0.22^{b}	0.24^{b}	0.07^{a}	**
2.5	Pesticide	11.53	13.82	10.12	*Ns*
2.6	Fungicide	49.61	50.99	41.36	*Ns*
2.7	Fuel	7.02	9.26	7.12	*Ns*
2.8	Wrapping bag	13.61	15.58	11.97	*Ns*
2.9	Machine depreciation	3.44	5.04	3.95	*Ns*
2.10	Transport	1.49	2.92	2.20	*Ns*
2.11	Hired labour	103.04^{b}	112.36^{b}	66.27^{a}	**
2.12	Family labour	275.25^{b}	242.25^{ab}	209.24^{b}	**
2.13	Land rent	126.21^{a}	152.28^{b}	131.97^{ab}	**
3	Marketing cost of traders	**5,184.96^{b}**	**5,163.44^{a}**	**5,231.57^{c}**	***
3.1	Cooperative	184.74^{b}	183.97^{a}	186.40^{c}	***
3.2	Export enterprise	5,000.22^{b}	4,979.47^{a}	5,045.17^{c}	***
4	Total Domestic = (2) +(3)	**5,861.85^{a}**	**5,862.39^{a}**	**5,793.72^{b}**	**
5	Revenue	**8,701.92^{b}**	**8,665.80^{a}**	**8,780.14^{c}**	***
6	Domestic resource cost	**0.71^{b}**	**0.72^{b}**	**0.69^{a}**	**
7	**Comparative advantage**	**0.59^{b}**	**0.60^{b}**	**0.58^{a}**	**

Source: Field survey data in 2018 for farmer, in 2019 for other actors

*Note: The tradable input is the CIF price, and the tradable output is the FOB price. The numbers in the same row followed by different letters are significant at the 5% level via the statistical Duncan test. * Significant at 10% level, ** significant at 5% level, *** significant at 1% level, and ns is non-significant.*

Table 9.
Comparative advantage of Chu-mango in the export channel 2 (units: USD/ton).

No.	Indicator costs	Season 1 (n=212)	Season 2 (n=173)	Season 3 (n=141)	Sig.
	Official exchange rate in 2018-2019 (USD 1= VND 22,622)				
1	Tradable inputs	**148.83^{b}**	**157.78^{b}**	**123.45^{a}**	**
1.1	Root fertiliser	9.40	10.57	9.09	*ns*
1.2	Leaf fertiliser	2.98	3.49	2.69	*ns*
1.3	Paclobutrazol	7.85^{c}	4.05^{b}	1.65^{a}	***
1.4	Herbicide	0.37^{b}	0.39^{b}	0.11^{a}	**
1.5	Pesticide	19.27	23.09	16.92	*ns*
1.6	Fungicide	82.90	85.20	69.12	*ns*
1.7	Fuel	0.47	0.62	0.47	*ns*
1.8	Wrapping bag	22.31	25.55	19.63	*ns*
1.9	Machine depreciation	3.29	4.82	3.77	*ns*
2	Domestic factors	**231.24^{b}**	**238.77^{b}**	**192.04^{a}**	**
2.1	Root fertiliser	20.96	23.57	20.26	*ns*
2.2	Leaf fertiliser	6.64	7.79	6.01	*ns*
2.3	Paclobutrazol	1.60^{c}	0.83^{b}	0.34^{a}	***
2.4	Herbicide	0.07^{b}	0.08^{b}	0.02^{a}	**
2.5	Pesticide	3.94	4.72	3.46	*ns*
2.6	Fungicide	16.95	17.42	14.13	*ns*
2.7	Fuel	2.40	3.16	2.43	*ns*
2.8	Wrapping bag	4.65	5.32	4.09	*ns*
2.9	Machine depreciation	1.17	1.72	1.35	*ns*
2.10	Transport	0.51	1.00	0.75	*ns*
2.11	Hired labour	35.20^{b}	38.38^{b}	22.64^{a}	**
2.12	Family labour	94.03^{b}	82.76^{ab}	71.48^{b}	**
2.13	Land rent	43.11^{a}	52.02^{b}	45.08^{ab}	**
3	Marketing cost of traders	**860.20^{b}**	**856.63^{a}**	**867.93^{c}**	***
3.1	Cooperative	147.08^{b}	146.47^{a}	148.40^{c}	***
3.2	Wholesaler	151.27^{b}	150.64^{a}	152.63^{c}	***
3.3	Processing firm	536.14^{b}	533.92^{a}	540.96^{c}	***
4	Total Domestic = (2) +(3)	**1,091.43^{b}**	**1,095.40^{b}**	**1,059.97^{a}**	**
5	Revenue	**1,551.14^{b}**	**1,544.70^{a}**	**1,565.08^{c}**	***
6	Domestic resource cost	**0.79^{b}**	**0.80^{b}**	**0.74^{a}**	**
7	**Comparative advantage**	**0.66^{b}**	**0.67^{b}**	**0.62^{a}**	**

Source: Field survey data in 2018 for farmer, in 2019 for other actors

*Note: The tradable input is the CIF price, and the tradable output is the FOB price. The numbers in the same row followed by different letters are significant at the 5% level via the statistical Duncan test. * Significant at 10% level, ** significant at 5% level, *** significant at 1% level, and ns is non-significant.*

Table 10.
Comparative advantage of Chu-mango in the export channel 3 (units: USD/ton).

No.	Indicator costs	Season 1 (n=212)	Season 2 (n=173)	Season 3 (n=141)	Sig.
	Official exchange rate in 2018-2019 (1 USD= 22,622 VND)				
1	Tradable inputs	**308.48^{b}**	**327.04^{b}**	**255.88^{a}**	**
1.1	Root fertiliser	19.48	21.90	18.83	*Ns*
1.2	Leaf fertiliser	6.17	7.24	5.58	*Ns*
1.3	Paclobutrazol	16.27^{c}	8.40^{b}	3.42^{a}	***
1.4	Herbicide	0.76^{b}	0.82^{b}	0.23^{a}	**
1.5	Pesticide	39.95	47.85	35.06	*Ns*
1.6	Fungicide	171.83	176.60	143.26	*Ns*
1.7	Fuel	0.97	1.28	0.98	*Ns*
1.8	Wrapping bag	46.25	52.97	40.69	*Ns*
1.9	Machine depreciation	6.81	9.99	7.82	*Ns*
2	Domestic factors	**479.29^{b}**	**494.91^{b}**	**398.05^{a}**	**
2.1	Root fertiliser	43.45	48.84	42.00	*Ns*
2.2	Leaf fertiliser	13.76	16.14	12.45	*Ns*
2.3	Paclobutrazol	3.33^{c}	1.72^{b}	0.70^{a}	***
2.4	Herbicide	0.16^{b}	0.17^{b}	0.05^{a}	**
2.5	Pesticide	8.17	9.78	7.17	*Ns*
2.6	Fungicide	35.13	36.10	29.29	*Ns*
2.7	Fuel	4.97	6.56	5.04	*Ns*
2.8	Wrapping bag	9.63	11.03	8.48	*Ns*
2.9	Machine depreciation	2.43	3.57	2.79	*ns*
2.10	Transport	1.05	2.07	1.56	*ns*
2.11	Hired labour	72.96^{b}	79.56^{b}	46.92^{a}	**
2.12	Family labour	194.90^{b}	171.53^{ab}	148.16^{a}	**
2.13	Land rent	89.36^{a}	107.83^{b}	93.44^{ab}	**
3	Marketing cost of traders	**292.30^{b}**	**291.09^{a}**	**294.93^{c}**	***
3.1	Collector	83.04^{b}	82.70^{a}	83.79^{c}	***
3.2	Wholesaler (China)	209.26^{b}	208.39^{a}	211.14^{c}	***
4	Total Domestic = (2) +(3)	**771.59^{b}**	**786.00^{b}**	**692.98^{a}**	**
5	Revenue	**1,704.61^{b}**	**1,697.53^{a}**	**1,719.93^{c}**	***
6	Domestic resource cost	**0.59^{b}**	**0.64^{b}**	**0.51^{a}**	**
7	**Comparative advantage**	**0.49^{b}**	**0.53^{b}**	**0.42^{a}**	**

Source: Field survey data in 2018 for farmer, in 2019 for other actors

*Note: The tradable input is the CIF price, and the tradable output is the FOB price. The numbers in the same row followed by different letters are significant at the 5% level via the statistical Duncan test. * Significant at 10% level, ** significant at 5% level, *** significant at 1% level, and ns is non-significant.*

Appendix 2. Information on exporting enterprises

Feature Exporting Enterprises of Fresh Fruits
Cattuong Agricultural Processing and Production Company Limited o Established 2015 o Address: No 212, Highway 50, Hamlet 3B, Dao Thanh Commune, My Tho City, Tien Giang, Vietnam. o Number of employees: 500 o Products: Fresh fruit (Dragon fruit, mango, star apple, grapefruit, jack fruit, pineapple, rambutan, longan, durian) and processing fruit. o A modern cool storing system with a capacity of 2,000 tons. o A vapor heat treatment factory of fresh fruits. o A standard packing factory has been tested by U.S experts o Annual average export: 15,000 tons o Annual demand of Chu-mangoes: 100 – 150 tons. o Annual turnover from Chu-mango: USD 450 – 880 thousand o Exporting markets: USA, Japan, Korea, Australia, New Zealand, Taiwan, China, etc.
Goodlife Co., Ltd o Established 2009 o Address: 7A/31 Thanh Thai Street, Ward 14, District 10, HCM City o Number of employees: 160 o Products: Fresh fruits (Dragon fruit, mango, coconut, pineapple, durian, banana), and processing fruits o A modern cool storing system ($0^oC – 10^oC$) o A vapor heat treatment factory of fresh fruits (Japanese technology) o A standard packing factory in Long An o Annual average export: 2,000 - 3,000 tons o Annual demand of Chu-mangoes: 80 – 150 tons. o Annual turnover from Chu-mango: USD 560 – 1,000 thousand o Exporting markets: Japan, South Korea, Taiwan, other potential markets
Yasaka Fruits Processing Co., Ltd o Established 2008 o Address: Room 34, 4th Floor, Centec Building, 72-74 Nguyen Thi Minh Khai, Ward 6, District 3, Ho Chi Minh City, Vietnam o Factory: Binh Giao, Thuan Giao, Thuan An, Binh Duong o Number of employees: 200 o Products: Fresh fruits (Dragon fruit, mango, coconut, rambutan, avocado) o A modern cool storing system o A vapor heat treatment factory of fresh fruits (Japanese technology) o A standard packing factory o Annual average export: 4,000 - 6,000 tons o Annual demand of Chu-mangoes: 100 – 180 tons. o Annual turnover from Chu-mango: USD 710 – 1,900 thousand o Exporting markets: Japan, South Korea, Taiwan, China, Hong Kong, New Zealand
Hoang Phat Fruits Co., Ltd o Established 2007 o Address: Building LIM2, 15th floor, Cach Mang Thang 8 Street, Ward 6, District 3, HCM City, Vietnam o Factory: Phu Thanh Halmet, Tam Vu, Chau Thanh, Long An, Vietnam o Number of employees: 200 o Products: Fresh fruits (Dragon fruit, mango) o A modern cool storing system. A vapor heat treatment factory of fresh fruits o A standard packing factory o Annual average export: 4,000 -5,000 tons o Annual demand of Chu-mangoes: 50 – 120 tons. o Annual turnover from Chu-mango: USD 360 – 700 thousand o Exporting markets: Japan, South Korea, Taiwan, Australia, etc.

Source: Field Survey Data, 2019

Appendix 3. Information on processing firms

Feature Processing Firms
Thuan Phong Agricultural Products Processing Co., Ltd o Established 2015 o Address: 334, Long Hoa Halmet, Chau Thanh District, Ben Tre, Vietnam o Office and Factory area: 10 hectares o Number of employees: more than 1,200 o Annual average production capacity: 50,000 tons of finished-product o Annual demand of raw material fruits and vegetables: 100,000 – 120,000 tons o Annual demand of raw Chu-mango: 4,000 – 5,500 tons o Annual turnover form Chu-mango: USD 2.3 – 2.8 million o Processing products: fruits and vegetables (frozen, dried, canned, juice) o Exporting markets: USA, Japan, Korea, Australia, China, and Europe.
Phu Thinh Food Processing & Export Joint Stock Company o Established 2008 o Address: Tan Phu Thanh Industrial Zone, Chau Thanh A District, Hau Giang, Vietnam o Office and Factory area: 40,000 m2 o Number of employees: 600 o Two cold storages (-23^{0}C) have capacity: 2,000 tons o One cool storage (-5^{0}C) has capacity: 1,000 tons o Annual average production capacity: 14,000-18,000 tons of finished-product o Annual demand of raw material fruits and vegetables: 30,000 – 35,000 tons o Annual demand of raw Chu-mango: 3,000 – 3,500 tons o Annual turnover form Chu-mango: USD 2.3 – 2.8 million o Processing products: Fruits and vegetables with frozen and canned o Exporting markets: North America, Europe, Australia, China, Japan, Korea
Long Uyen Co., Ltd o Established 2009 o Office: B2-12 Nam Thien 1, Tan Phong Ward, District 7, Ho Chi Minh City, Vietnam. o Factory: 9999, Kim Son Village, Chau Thanh District, Tien Giang, Vietnam. o Number of employees: 500 o Annual average production capacity: 12,000-15,000 tons of finished-product o Annual demand of raw material fruits and vegetables: 25,000 – 30,000 tons o Annual demand of raw Chu-mango: 5,000 – 6,000 tons o Annual turnover form Chu-mango: USD 3.8 – 4.8 million o Processing products: Fruits and vegetables (frozen and popsicles) o Exporting markets: The U.S, Canada, Australia, Malaysia, Singapore, Hong Kong, China, Japan, Korea, the Netherland, Germany, Russia, Italy, and Sweden.
Hung Phat Fruits Producing Co., Ltd o Joined in Andors group 2016. Andros is the European leading fruit processing Group in France, with more than 30 factories worldwide. o The Asian Andros has three factories: two in Vietnam (Hung Phat Co., Ltd), one in China, distribution network in 15 Asian countries. o Address: 47-49-51 My Tho Industrial Zone, My Tho city, Tien Giang, Vietnam o Number of employees: 450 o Four cold storages (-18 ^{o}C, - 20^{o}C) have capacity: 14,000 tons o Annual average production capacity: 12,000 – 18,000 tons of finished-product o Annual demand of raw material fruits: 20,000 – 28,000 tons o Annual demand of raw Chu-mango: 1,500 – 2,000 tons o Annual turnover form Chu-mango: USD 1.0 – 2.0 million o Processing products: Fruits (frozen, puree, blend, chunky, jams, syrups, snacks) Exporting markets: The U.S, Europe, Australia, China, Japan, Korea, Singapore, Malaysia

Source: Field Survey Data, 2019