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Financial supply chain management on agricultural product trade: Simulation from Thailand to China

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A B S T R A C T

This study aims to explore the application of financial supply chain management on agricultural product trade, and an example simulation case that Thai durian exports to China. After collection of variables and relationships in previous literature, a model of durian trade supply chain with material flow and cash flow has been created. As a result of the simulation, we found that cash flows of downstream participants are strongly higher than the upstream, which is partly proving that the downstream participants have more opportunities to invest upstream for intervention. Besides, we suggest government agencies, business sector, and financial institutions should strengthen communication and cooperation to maintain stability of current Thai durian trade supply chain, meanwhile, remain on high alertness to postharvest, delivery delays and durian demand to prevent the impact of supply chain disruption on cash flow.

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1. Introduction

Agriculture industry is one of the most important basics of economics. Its products satisfy human activities such as food, biofuel, and raw materials. However, due to different geographical locations harvesting different agricultural products, people can only obtain locally suitable cultivation. With development of transportation and opening globalization, consumers have access to thousands of agricultural products from anywhere in the world as their needs. Meanwhile, agricultural products trade also aims to make up for the insufficient domestic demand. Due to the high dependence of human beings on agricultural products, the economy with a large population will be paid attention and studied by more scholars. China, which has the most population in the world, obviously accounts for the largest share of agricultural imports in the past decade from 2011 to 2020. At the same time, agriculture is crucial to countries in the Association of Southeast Asian Nations (ASEAN) and provides livelihoods for most of the population (Teng & McConville, 2016). Therefore, agricultural trade research on China and ASEAN countries can benefit most residents in the area. Thailand, which contributes the second most gross domestic product (GDP) in ASEAN, is an indispensable agricultural trading participant with China in the Indo-China Peninsula. Thailand and China have a long history of relationship in cultural and economic, especially in agricultural trade. Thailand is one of leading exporters of agricultural products in the world, and its agricultural products, such as rice and durian, have a high reputation in the world. And with the accession to the World Trade Organization (WTO) in 2001, the demand for Thai agricultural products in the consumer market of Chinese agricultural products is increasing steadily. In recent years, we noticed that Thai main agricultural products seem to be challenged, with a decline in Thai rice trade to China and a growing presence of Malaysian and Vietnamese durians in the Chinese market. Meanwhile, human development leads to environmental deterioration because of unstable change of global climate and postharvest of agricultural products becomes uncontrollable. Regretfully, the gusty disaster of COVID-19 and the intricacy of trade war have worsened the environment of the global trade supply chain. As an occurrence of the above situation, supply chain resilience has become a hot topic for scholars. In supply chain management (SCM), material flow and information flow attract academic and practical attention, but we believe cash flow is “the last straw

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that breaks the camel's back" for companies. Therefore, maintaining the steady growth of cash flow is one of the factors affecting whether enterprises can successfully resist risks. A steady and increasing cash flow not only helps companies to hedge against risks, but also allows them to have more capital to expand or invest in business activities. In this paper, for exploring how agricultural products trade between two agricultural trading economies, we will focus on examples of durian trading from Thailand to China and introduce the concept of financial supply chain management (FSCM) through observation of cash flows among three node companies in the chain.

This article aims to arrange the FSCM of agricultural product trade and present impact factors of supply chain in Thai main agricultural products from Thailand to China. To achieve the objectives, this study will proceed from the following contents: 1) reviewing literatures and collecting variables and relationships in the durian trade from Thailand to China; 2) drawing causal loop diagram and flow diagram on Vensim, which is used as simulation, and establishing the system dynamic flow model; 3) summarizing the simulated model results of durian trade supply chain from Thailand to China and giving suggestion.

2. Literature Review

2.1 Durian trade from Thailand to China with supply chain disruption

Economic activities between China and Thailand have a long history, and agricultural products are the main commodities in trading from Thailand to China. In 2021, half of Thai commodities traded to China were agricultural products, and this proportion was 43% in 2020. The most representative agricultural products are durian and tapioca which take the most share of value and volume in the trade, besides, Thai rice and rubber are also popular in the Chinese imported market. In this package of agricultural products, durian is one of the most representative agricultural products in Thailand. Over the past decade, durian plantation areas' total harvested durian area steadily expanded (Win, 2017), and Thai durian industry and the related industries have been developing continuously. With the expansion and development of Thai durian and the related industries, production and exports of durian have also increased. Through detailed research, the main process of exporting Thai durian to China has been established. The original durian trade supply chain (DTSC) process includes Thai durian orchardists, Thai middlemen (scalpers), Thai processors and exporters, Chinese importers and distributors, and Chinese end customers. As Thai durians became more popular in the Chinese market, Chinese entrepreneurs began to participate in the logistics, sorting and packaging of durian business between Thailand and China (Tantrakoonsab & Tantrakoonsab, 2021). With this vertical capital investment in the DTSC, the chain can be regarded as a three-stage supply chain which is divided by orchardists, trading manufacturers, and distributors. Durians have been harvested by orchardists, and precured and processed by trading manufacturers, then received and sold by distributors.

Research on financial supply chains can be reviewed from a decade or more, meanwhile, majority of scholars have paid more attention on inventory cost, transportation cost and cost related to material flow in the related supply chain research area, and lack of research on area crossed supply chain and finance (Khandelwal et al., 2021). Upstream intervention is a general way for purchasers to manage agricultural supply chains. When the credibility of the purchaser is higher than that of the supplier, upstream intervention can reduce the supply chain capital cost (Van Bergen et al., 2019). A similar case is Sam's Club which is run by Walmart. As a super-large retailer, Walmart invests its upstream suppliers to build its own brands in order to provide consumers with high-quality goods. This case is since Walmart has enough credibility to reinvest. Although the relationship between cash flow and investment is controversial, given the role of cash flow on credit frictions, it is reasonable to assume that cash flow is an important determinant of investment (Carpenter & Guariglia, 2008). With the breaking out of COVID19 pandemic, the virus is likely to coexist with humans for a long time. And we must think very carefully about the trade of fresh fruit under the threat of the virus for food safety. Over the past two years, we have learned that policy-influenced disruptions on the demand side have created financial pressures on the supply chain (Deconinck et al., 2020). Small-medium enterprises (SMEs) are more vulnerable to the devastating blow due to their shortage of cash flow. When supply chain disruption stops business, especially in agricultural trade, the SMEs hardly keep operating on daily expenses, such as labor wages, loan interest or rent for warehousing (Abu Hatab et al., 2021).

The proposed impact of system dynamics (SD) has aroused great response and provides decision-making tools for industries (Forrester, 1958). Although the SD has been proposed for many years, it still be used on solution to problems, such as discovering the impact of Chinese hog market with supply chain disruption within COVID19 (Wang et al., 2020), discussion of financial relationship among manufacturers and distributors (Sana et al., 2018). Briefly, building simulation models with system dynamics allows us to understand operation in supply chain and enables us to observe the influential variables and relationships more intuitively.

3. Methodology

3.1 Causal loop setting

Vensim allows drawing squares and arrows with marking relationships such as positive or negative. The overview of material flow and financial flow among the DTSC is shown as Fig. 1.

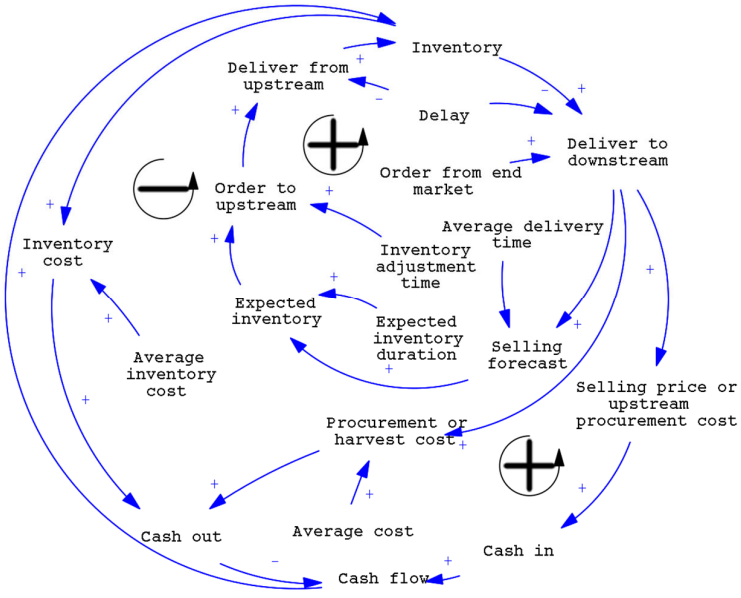

Fig. 1. casual loop of the DTSC

The DTSC is divided by two main flows with material flow and cash flow overall. In the viewing of material flow, order from the end market shows positive correlation to the volume delivered downstream. With change of the durian delivered downstream, the selling forecast among every participant in the chain will change positively, and it also should be considered by average delivery time. The expected inventory among every participant will be affected by selling forecast and expected inventory duration, and impact order to upstream with inventory adjustment time. Order to upstream will be the volume of delivery from upstream with considering the factor of delay. Equally, factor of delay can be viewed as an impact factor to deliver to downstream. In the viewing of cash flow, durians delivered downstream will be exchanged for equivalent cash, and the cash will be seen as "cash in" of cash flow. Some part of cash should be covered for the material procurement cost with average cost which is assumed in this model. Procurement cost is one of factors which affects "cash out" of cash flow, another is inventory cost. Inventory cost is impacted by expected inventory duration, average inventory cost and inventory (actual inventory). Cash flow is the difference between "cash in" and "cash out", which will be a considerable factor to inventory (Small, 2000). There are two casual loops in this durian trade supply chain, one exists in material flows and the other is in cash flows. Inventory, deliver to downstream (number of durians), selling forecast, expected inventory, order to upstream (number of durians), deliver from upstream (number of durians) form a positive feedback loop of material flow, which means changes of the above factors will affect the changes of other factors and the influence is positive. The feedback loops in the cash flows are divided by a positive loop and a negative loop. When durians deliver to downstream, the upstream will receive cash equivalents as selling price or which also be called the procurement cost of upstream. The selling price is the "cash in" to the upstream and is positive to the cash flow. Another feedback loop is the "cash out" which is negative to the cash flow. The "cash out" consists of procurement cost and inventory cost. Procurement cost, which is also harvest cost to the orchardists, is obtained with the selling quantity (Deliver to downstream) and average cost. Inventory cost is determined by inventory, average inventory cost, and expected inventory duration. Meanwhile, continuously increasing cash flow encourages participants to spend more payout, such as reinvestment on inventory (Van Doren, 2021). Therefore, cash flow is a positive factor for inventory.

3.2 Variables setting

Ten variables related to material flow which consists of inventory, flow in rate, flow out rate, order, selling forecast, expected inventory, delay, expected inventory duration, average delivery time, inventory adjustment time. To facilitate the understanding of the loop diagram of material flow, we renamed partial variables and arranged considerable variables in Table 1. The variable type of inventory is a state variable, and the mathematical expression is the integral of the difference between flow in rate and flow out rate. Flow in rate and flow out rate are flow variables and represent "deliver to downstream" and "deliver from upstream", and mathematical expression is DELAY (Order, Delay) which means orders are delivered (deliver to downstream) or arrived (deliver from upstream) after a delay. However, due to the upstream of orchardists and the downstream of distributors will not be considered in this model, flow in rate of orchardists is represented by post-harvest and flow out rate of distributors is selling rate. Selling rate is the end of material flow model, which has to be represented by selling price and durian demand. Selling price of durian will refer to selling data of Guangzhou Jiangnan fruit distribution market in from 2017 to 2018. Durian demand is set at 1,000,000, which means that the Chinese durian consumer market will

demand one million kilogram of durian daily. The variables of auxiliary variables include order, selling forecast, and expected inventory. Orders of trading manufacturers and distributors will vary based on their actual inventories, selling forecast, expected inventory and the inventory adjustment time. An order of orchardists can be viewed as the harvest willing of orchardists. In addition, the value of order should be represented by the MAX function due to it cannot generally be negative. Order, selling forecasts, and expected inventory are affected by other variables and shown as mathematical expressions with state variables, flow variables, and constants. There are four constant variables given literature reviewing or assumptions. The variables of delay are divided into harvest delay and transport delay. The harvest delay occurs before orchardists collect durian into the inventory, and represents an unit that inevitably is delayed in post-harvest. The variable of transport delay impacts the raw durian delivery rate at which orchardists transport durians to trading manufacturers. Once the durian is processed to avoid rapidly rotting and cleared by customs, likewise, variable of transport delay affects the processed durian delivery rate at which trading manufacturers ship durians to distributors. In this model, with information collected from widely unofficial interviews with trading business practitioners, we assumed that the harvest delay is two days and transport delay is three days, which means the durians have been harvested after two days and collected into the inventory of durian orchardist, and the periods of the durian orchardist to trading manufacturer and the trading manufacturer to the distributor separately spend three days on warehousing in the inventories of downstream participants. Since durian is a tropical fruit and decays extremely quickly after being off the tree, we assume expected inventory duration is one day due to participants expecting to trade the durians off the inventories as quickly as possible (Win, 2017). Literally, durians can only be kept for about seven days from leaving the trees to rot (Opara, 2003), therefore, we assume average delivery time is seven days because every participant will not deal rotten durians within this chain.

Table 1
List of variables in the material flow

Variables	Variable belongs to	Variable type	Mathematical expression
Inventory	Material flow	State variable	$Inventory = INTEG(Flow\ in\ rate - Flow\ out\ rate, Initial\ value = 10000)$
Flow in rate	Material flow	Flow variable	$Flow\ in\ rate = DELAY(Order, Delay)$
Flow out rate	Material flow	Flow variable	$Flow\ out\ rate = DELAY(Order, Delay)$ $Selling\ rate = Durian\ demand * Selling\ price$
Order	Material flow	Auxiliary variable	$Order = MAX(0, Selling\ forecast + \frac{Expected\ inventory - Inventory}{Inventory\ adjustment\ time})$
Selling forecast	Material flow	Auxiliary variable	$Selling\ forecast = SMOOTH(Flow\ out\ rate, Average\ delivery\ time)$
Expected inventory	Material flow	Auxiliary variable	$Expected\ inventory = Expected\ inventory\ duration * Selling\ forecast$
Delay	Material flow	Constant	$Harvest\ delay = 2\ ;\ Transport\ delay = 3$
Expected inventory duration	Material flow	Constant	$Expected\ inventory\ duration = 1$
Average delivery time	Material flow	Constant	$Average\ delivery\ time = 7$
Inventory adjustment time	Material flow	Constant	$Invenotry\ adjustment\ time = 3$
Durian demand	Material flow	Constant	$Durian\ demand = 1{,}000{,}000$
Cash flow	Cash flow	State variable	$Cash\ flow = INTEG(Cash\ in\ rate - Cash\ out\ rate, Initial\ value = 10000)$
Cash out rate	Cash flow	Flow variable	$Cash\ out\ rate = Harvest\ or\ Procurement\ cost + Inventory\ cost$
Cash in rate	Cash flow	Flow variable	$Cash\ in\ rate = Precurement\ cost$
Procurement cost	Cash flow	Auxiliary variable	$Procurement\ cost = Order * Average\ procurement\ cost$
Inventory cost	Cash flow	Auxiliary variable	$Inventory\ cost = Inventory * Average\ inventory\ cost$
Average procurement cost	Cash flow	Auxiliary variable	$Average\ procurement\ cost = Average\ procurement\ cost\ of\ downstream * (1 - Average\ profit)$
Average inventory cost	Cash flow	Constant	$Average\ inventory\ cost = 1$
Selling price	Cash flow	Auxiliary variable	$Selling\ price = lookup(data\ of\ durian\ selling\ price)$
Average profit	Cash flow	Constant	$Average\ profit = 0.2$

Due to financial flow generally opposite to material flow, the forward side of Thai products exported to China will generate the backward side of Chinese payment to Thailand. Table 1 also presents variables in the financial flow of the APTSC from China to Thailand. In the same way as material flow, the variables of cash flow also include state variables, flow variables, auxiliary variables and constants. Cash flow, as a state variable, mathematically represents the integral of the difference between cash in rate and cash out rate. We assume the initial values of all participants are ten thousand. Every participant needs to pay for flow-in durians and receive payment from flow-out durians, and we refer them to cash out and cash in. Cash out rate, as flow variable, equals procurement cost (Harvest cost to orchardists) and inventory cost. Cash in rate of each participant comes from procurement cost of the downstream but distributors cash in rate gain in selling price. We assume two constants as average procurement cost and average inventory cost for intuitively expressing procurement cost and inventory cost. Procurement cost equals to order times average procurement cost, and inventory cost is that actual inventory times average inventory cost.

3.3 Simulation model setting

We put the variables mentioned above into Vensim with Fig. 1 of causal flow of the DTSC, then set the mathematical expressions and constants according to Table 1. We assume a model that shows a daily change of the material flow and cash flow of Thai durians exported to China over a period of 720 days. Fig. 2 presents a model flow diagram of the DTSC from Thailand to China. The model starts from the selling rate where it takes orders from Chinese durian demand. According to data from the Bank of Thailand, Thailand exported about 55 thousand tons of durian from 2017 to 2022. In detail, the minimum was 1432 tons, the maximum was 274 tons, the median was 24975, the standard deviation was 62285. Therefore, with public reports of the media, on average, 43% of exported Thai durian has been sold to China, which is approximately 23 thousand tons. By parity of reasoning, we assume the minimum volume that Thailand exported durians to China was 0 per day, the maximum was 4000, the mediant was 350, the standard deviation was 900, the initial value was average value, which was 800, and collect a random variable of durian demand into the model. Distributors selling forecasts receive the selling rate after passing the average delivery time and affect their expected inventory with expected inventory duration. Distributors order must be measured by selling forecast, expected inventory, actual inventory, and inventory adjustment time, then the order determines processed durian delivery rate, and the same situation is transmitted to trading manufacturers and orchardists. As the durians flowed, so did in the cash flows. Selling price is multiplied by the selling rate to obtain distributors cash in, and the cash flow is obtained by subtracting the cash out incurred by procurement cost and inventory cost. And procurement cost of distributors, in turn, is the cash in of trading manufacturers, so did orchardists. Procurement cost and inventory cost can be obtained by extracting data from the material flow and multiplying by the assumed average procurement cost and average inventory cost.

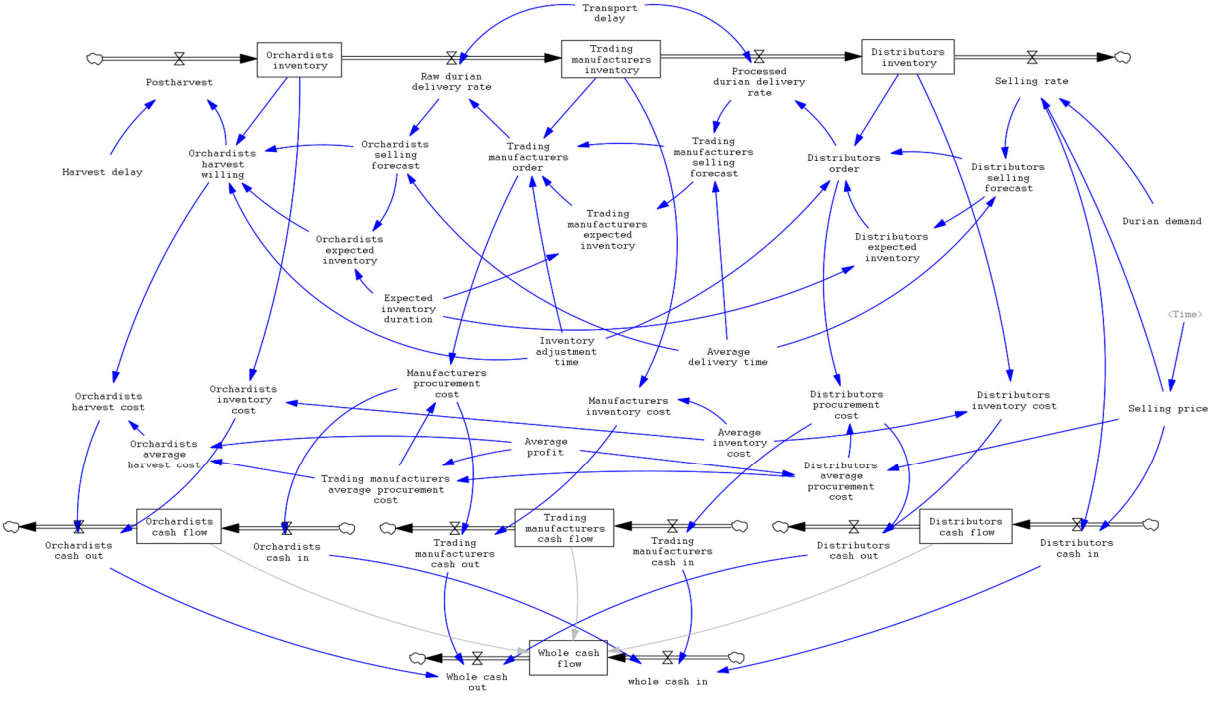

Fig. 2. Flow diagram of material flow and cash flow in the DTSC

4. Results

We assume day is unit for time and time step is 1 in this model, which means each change in the model takes 1 day and data for each day is recorded according to the model. The day starts at 0 and ends at 720. The integration technique is Euler. After running the setup model which follows the above information, we output the results for the cash flows of orchardists, trading manufacturers, and distributors and draw into Fig. 3. The cash flows of three participants increased during the period. The cash flow of distributors grew the fastest and far more than the other participants. The cash flow of durian orchardists increased slowest, which trading manufacturers had a better rise than.

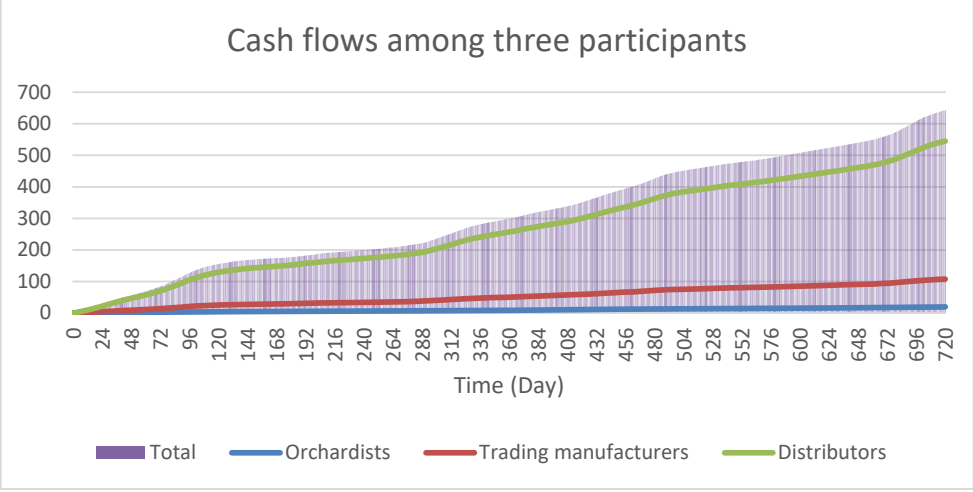

Fig. 3. Cash flows of participants and total within setup model

We assume harvest delay and transport delay improve to 20 and 30 as a result of simulation that processes of production and trade are disrupted, and output Fig. 4. With holding other variables, the cash flow of orchardists showed a relatively large vibration. While there has been some impact on the pace of cash flow growth for trading manufacturers and distributors, both are still growing with total cash flow. In addition, we also found that change of durian demand does not significantly affect the cash flows of three participants in the setup model. However, when both variables of delay are raised, the growth of durian demand will aggravatedly deteriorate the cash flows and show a downward trend; And selling prices significantly show negative in the cash flow of distributors.

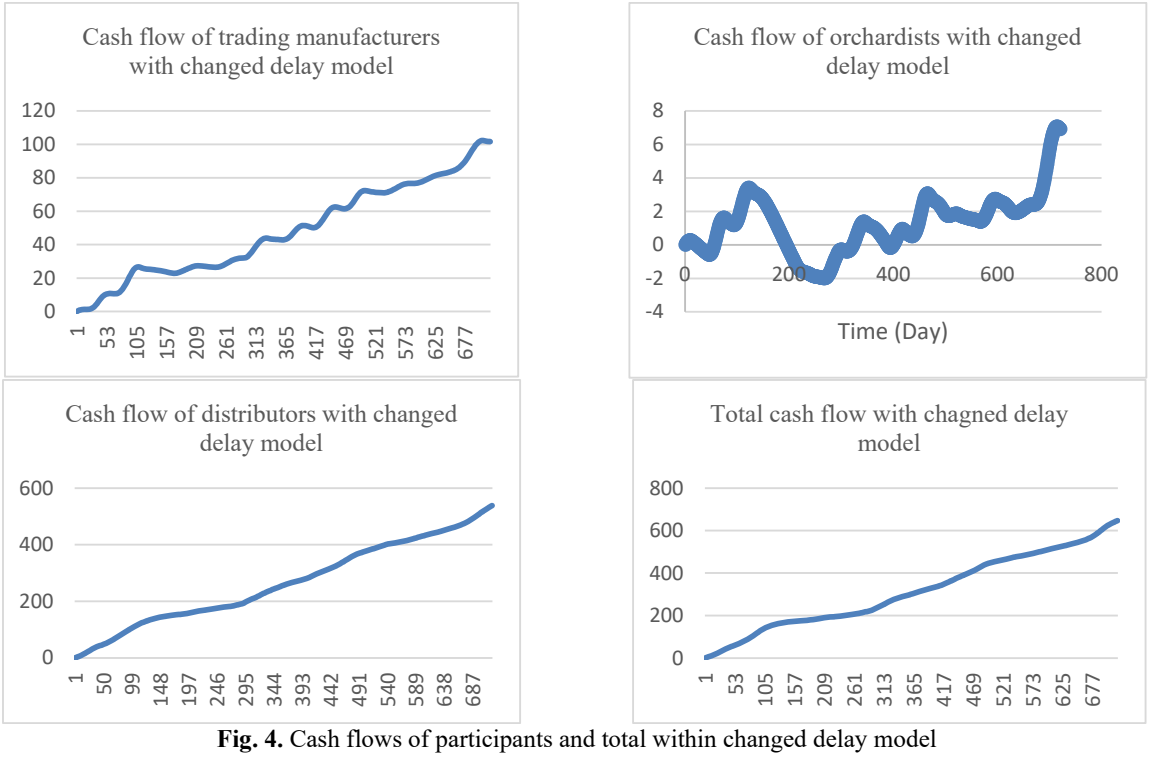

Fig. 4. Cash flows of participants and total within changed delay model

5. Conclusion and discussion

This study has reviewed the situation that Thai durian exports to China and simulated the material flow and cash flow of each participant. The results have shown that the cash flows in the DTSC would be affected differently under the bullwhip effect. With the assumption of this model, the cash flow of each participant in the DTSC is different. Due to the bullwhip effect in the supply chain, excessive selling forecasts lead to orders being magnified. Expanding inventory and production increase inventory costs and procurement costs, then makes difference of cash flow improvement under fixed profit. The cash flows of the upstream participants will grow more slowly than the downstream ones. More cash flow generally represents more potential protection against risk and more options in reinvestment. The comparison of cash flow in the result can partly provide evidence as to why Chinese investment is gobbling up the source of durian trade in the DTSC between Thailand and China.

In addition, we have simulated a situation in which harvested and transported delays increase, how do the response of cash flows of three participants increase? The results show that an increase in delay causes the growth of cash flows to become erratic, and orchardists descend to be the biggest victim. Therefore, the DTSC needs to avoid long harvest and transportation times, even if durian can be stored for a long time, it will have a negative impact on the cash flow of orchardists. Moreover, we found that the increasing expected inventory duration, inventory adjustment time, and average delivery time will reduce the rate of cash flow growth, though it is insignificant, but the effect will be multiplied with durian demand increases. Consequently, when durian demand continues to rise, it is more important that participants make quick and correct decisions in material flow to avoid magnified mistakes.

Overall, cooperation among every participant in the DTSC between Thailand and China. Since we noticed that the cash flow of durian orchardists, trading manufacturers and distributors showed different growth trends even at the same profit margin, it was necessary to improve the overall credibility of the supply chain through close cooperation (Ma et al., 2020). Due to this study, the DTSC is affected by the bullwhip effect, through closer cooperation, the bullwhip effect can be effectively prevented to reduce pressure of inventory on cash flow. As a result, unless the Thai government expands another durian consumer market which is bigger than Chinese, it is an unwise choice to completely deny Chinese investment access to durian business in the current situation. However, allowing Chinese investment to interfere with Thai durian farming can be an inappropriate choice which should not be the only one. The more downstream participants obtain higher cash flow; therefore, we believe that Thai businessmen and the government could attempt to invest in Chinese durian distribution for securing participation in durian business. In the DTSC, the closer to demand, the closer to correct inventory, and thus the more ideal cash flow will be obtained. Meanwhile, government and durian merchants need to jointly avoid increased harvest and transport delays. When there are disruptions in the DTSC, distributors are the best participants who can solve cash flow problems. Although distributors benefited from most of the increase in cash flow, selling price has the most significant impact to the cash flow of distributors. Hence, we suggest that the other two participants also need to aid distributors when the selling prices are unstable.

Finally, we believe that this simulation case can be applied to most fruit trading financial supply chains, even in agricultural products with similar price elasticity of demand. In the future, we will also keep improving this model with the characteristics of different agricultural products until the model can cover the majority.

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