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Co–innovation for Agroindustry Development: A Case of Yantai Sweet Cherry Industry, China

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Based on the unique geographical advantage, Yantai Sweet Cherry Industry (YSCI) has been developed rapidly in past ten years. China became the top destination for worldwide cherry export, as well as Yantai has the strongest ability for domestic sweet cherry production. However, it still faces with challenges such as: labor outmigration, small–scale farmers show little interest in technology adoption, and production capital shortage. From the value chain perspective, this paper analyzes how YSCI rise influences on regional development, and how to deal with mentioned problems under dual action between technological embeddedness and organizational innovation. The results show that (1) relying on the pathway "exploit location advantage – embed key technologies – optimize value chain", YSCI becomes the local pillar agroindustry and offers regional development. (2) Coupling technological embeddedness and organizational innovation improves economic efficiency of new agricultural management subjects. (3) Adopting key technology copes with labor outmigration stress, furthermore, taking part in advanced organization actives small–scale farmers' interest on technology and supplies the capital gap. (4) Co–innovation of technology and organization not only reduces transaction cost, but also captures extra profit, and provides new motivation for emerging agroindustry development. During this new stage, agricultural development is supposed to pay more attention on integrated co–innovation of value chain.

Key words: Coupling technology and organization, co–innovation, sweet cherry industry, value chain

INTRODUCTION

Setting up agroindustry in rural areas is an important strategy to improve agriculture, prosper rural economy, and increase welfare for farmers. Exploring regional advantage is the original step to motivate development. The main idea of rural vitalization strategy is setting up agroindustry, and the development modes are supposed to enhance competitiveness based on the geographical resources[ii]. In fact, recovery of rural industry is the basic measurement to solve the agrarian problems in China (Fei, 1939). The Chinese government has actively created and optimized policies to support agroindustry to develop them with local advantages, a total of over 33.7 billion yuan has been invested by the central government[iii]. However, the weak industrial foundation in rural area still causes a series of deep–seated contradictions (Zhang, 2018), which means, development of agroindustry is facing with serious problems such as: labor outmigration, smallholders' low interest in adopting technology, and lack of production funds.

Recently, agroindustry in China lasts stable development due to agricultural modernization, standardization, and digital establishments. In 2021, the value added of the primary industry was 8308.6 million–yuan, accounting for 7.3% of GDP[iv]. Promoting rural vitalization strategy is supposed to focus on agroindustry upgrading and improving both quality and efficiency. During the new stage, the "Sannong" issue desires development of the whole value chain (Tang, 2022). In effect, the goals of agroindustry improvement are not only increase the economic added value, but also support to optimize regional industrial structure (Jiang and Lu, 2018); protect the ecological environment (Wen *et al.*, 2018); social security (Liu *et al.*, 2020); and urban–rural integration (Yan, 2021). Therefore, build rural agroindustry could make connection of national major strategies, which has played irreplaceable function among with rural vitalization, ecological construction, and promote common prosperity.

Technology is the foundation of agroindustry development and the fundamental source of extra profit. In August 2022, Ministry of Agriculture and Rural Affairs and Ministry of Finance of the People's Republic of China implemented <Special Administrative Measures for the Construction of Modern Agricultural Industrial Technology System>, which suggests to allocate technological strength in the value chain and aims to support agroindustry through technology progress[v]. Prior literatures had a series of exploration about the technological motivation during agroindustry development. In the production process, technology might prevent losses, increase productivity, variety and value of goods (Ronaghi and Ronaghi, 2021). As the world's supreme cotton planting area, Xinjiang cotton industry has developed because they combine policy guidance with technology innovation (Cheng, 2019). However, only technological improvement cannot perfectly solve the problem

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of increasing farmers' income. In Europe, adoption of new technology can provide important benefits, but the core agricultural transition is to support farmers in modernization of farms by management innovations (Fabiani *et al*., 2020).

Therefore, researchers pay attention on the motivation mechanism and organization details of agroindustry development. Agricultural cooperatives in Japan producing brand products have effect on quality control and preservation of the local heritage are much more likely to achieve the two primary economic goals of income and employment generation (Ohe and Kurihara, 2013). Agricultural leading enterprise is an effective form of resource management, which drives the industrialization of Gansu geographical agricultural products by creating brand effect and market advantage (Liu and Zhou, 2017). Another Chinese agroindustry, Luochuan Apple geographical industry achieved economic increase rely on they comply with competition principle of market economy as well as compatible with competitive promotion incentives and political conventions (Liu and Zhou, 2020). Creative of organizational structure system could help enhance the profitability of agroforestry in European Union, such as the Protected Designation of Origin or the Protected Geographical Indication schemes (Escribano *et al*., 2020). However, the impacts of organizational innovation on changes in agroindustry are strongly debated in the literature. In India, while the brand management leads to increasing differentiation in retail markets, the brands might provide incomplete or misleading information for the consumer. Furthermore, there are little direct benefits to the farmers (Minten *et al*., 2013). Governance weaknesses may allow outside investors to capture more profit and further marginalize poor smallholders (Weng *et al*., 2013).

Agricultural technology progress has positive influence on productivity, but it is hard to directly improve profits. Commonly, higher production caused by technological innovation leads to new breakthrough of the scale and edge of marketing. Meanwhile, the relations of production are supposed to change by organizational structure. The existing literature shows the role technology and innovation have played in expanding access to benefits in agriculture, but also cautions that not everyone has been able to benefitted from such opportunities (Odame *et al*., 2020). Literature review showed that analysis the practice experience of agroindustry on whole stages based on value chain perspective is limited. Moreover, technology and organization need to be bridged for development. Actually, only several researches couple technology progress and organization structure to investigate the development of agroindustry, which lack of attention on the effect of such co–innovation. The aim of co–innovation on technology and organization is not only increase productivity, but also capture more value through different stages for every stakeholder. Organizational innovation combined with the technological capacity, favor organizational development (Pereira, 2021). To improve adoption of new technologies, human–organization–technology is supposed to fit as an overarching concept (Xu and Lu, 2022). Unfortunately, these studies did not go deep into operationalization and validation of this concept through specific cases.

Co–innovation of technology and organization reflects the cooperative change of productivity and productive relationship. Therefore, this paper attempts to comprehends the operation mode of agroindustry value chain and clarify how to couple technological embeddedness and organizational innovation for further contribution, using Yantai Sweet Cherry Industry (YSCI) in Shandong province, China for case study. Through analysis of the productivity and profit of Yantai City and compare development modes in three districts, the pathway of YSCI upscale process showed that co–innovation of technology and organization is effective for emerging agroindustry in general. Sweet cherry is known as the "first branch of spring fruit". More than 150 years ago, American missionaries planted the first sweet cherry tree in Bohai Bay, China. But it was not until 2007 that the agricultural department approved the implementation of geographical indication product protection for "Yantai Sweet Cherry", so that YSCI upscaled rapidly from 2010, becoming a well–known regional brand. This long dormant period is not only limited by technical barriers, but also due to lack of market construction, poor infrastructure and organizational structure.

Thus, from the value chain perspective, this paper analyzes how the YSCI rise influences on regional development and how to solve current problems under the dual action between technological embeddedness and organizational innovation. The results are expected to reveal the mechanism of couple technology and organization in the key stages of agroindustry development, so as to provide policy suggestions for the implementation of rural vitalization industrial formulation, and contribute positive experience for developing countries to enhance the competitiveness of agroindustry.

Compared with previous works, this paper contributes to provide further evidence on co–innovation in agroindustry of developing country, and to revel the coupling mechanism of technology and organization. This contribution lights on the importance of value–chain–based co–innovation in promoting local economic development.

[ii] Source: Ministry of Agriculture and Rural Affairs of the People's Republic of China, http://www.moa.gov.cn/govpublic/XZQYJ/202007/t20200716_6348795.htm

[iii] Data source: Ministry of Agriculture and Rural Affairs of the People's Republic of China, http://www.moa.gov.cn/govpublic/XZQYJ/202107/t20210707_6371192.htm

[iv] Data source: The State Council of the People's Republic of China, http://www.gov.cn/xinwen/2022–02/28/content_5676015.htm

[v] Source: Ministry of Agriculture and Rural Affairs of the People's Republic of China, http://www.moa.gov.cn/govpublic/KJJYS/202208/t20220803_6406153.htm

THEORETICAL FRAMEWORK

In 1871, the first cherry tree in China was planted by an American missionary. It is located in Yantai City. Through three technology revolutions which are grafting technique in 1990s, hand–pollinate technique in 2000, and close planting technique in 2010, Yantai sweet cherry became one of the most popular Chinese Famous Fruits. It has higher benefit than other fruits, and sweet cherry planting is the world–renowned golden farming industry. Especially in 2014, the growing demand for fresh sweet cherry makes China as the largest consumption market. Based on the rich production and excellent quality, YSCI has nearly 70% of the Chinese market share, worthy of being the local pillar industry.

The motivation of technology breakthrough in YSCI is reasonable distribution of labors. In China, labor outmigration is confirmed as one of the basic reasons that restrain agricultural production and rural sustainable development (Su *et al*., 2020). High speed of urbanization in China not only brought numerous benefits, but also cause intensified crisis, such as rural decline, which has led to a general fallen of the development capacity of villages (Li *et al*., 2014; Liu *et al*., 2018). In such situation, adoption of new technology is required to raise efficiency. Farm managers prefer new technologies, and vocational training provide them more information so that they are capable of integrated technology adopters (Ammann *et al*., 2022). For example, Chinese new agricultural management subjects employ seasonal farmers in busy hours and introduces advanced equipment to support YSCI development, replacing part of labor input with capital and technical elements. However, most of small–scale farmers are not interested in advanced technology, expensive equipment input costs are daunting: although they obtained information of new planting and marketing technologies, small–scale farmers lack of abilities to adopt them. Faced with high machinery acquisition cost, delayed information collection time, complex technical operation specifications and possible commodity return risk, small–scale farmers prefer traditional planting mode (Tamirat *et al*., 2018). Fortunately, indirect interventions between government and agricultural enterprise, such as informational support to counteract industry bias, and demonstration to prove the viability of economic return may be effective at agroindustry development (Barnes *et al*., 2019). Under the process of limited resources reorganization, technological embeddedness is supposed to bring potential extra profits, however, reasonable organization is necessary for such extension of new technology.

Our theoretical framework is shown in Fig. 1. The coupling mechanism of co–innovation between technology and organization is guaranteed the interaction of productivity and productive relationship in sweet cherry value chain. Technological embeddedness could improve the productivity among all industrial stages, and organizational innovation is effective for coordination of productive relationship. Co–innovation theoretical framework suggests technology as "flesh" which is the source of extra profit, and organization as "skeleton" to enhance the ability of capture extra profit. When coupling technology and organization, the innovative management through value chain will achieve improvement of YSCI.

YSCI became the local pillar industry in recent ten years, and it owe to co–innovation of coupling technology and organization. Both steps through value chain reflected these progresses. In production stage, hand–pollinate and protect–shack technologies are basic and necessary. Mandatory policy guidance and support achieve such widespread. To be specific, local government of Yantai City starts "One Village, One Mu[vi], One Demonstration" project. Under this project, village collective has duty on land consolidation, and farmers are required to experience the application of sweet cherry production technologies. In transportation and processing stage, there is a strong connection between low temperature cooling, cold–chain transportation, and intelligent fruit selection technologies. No small–scale farmer

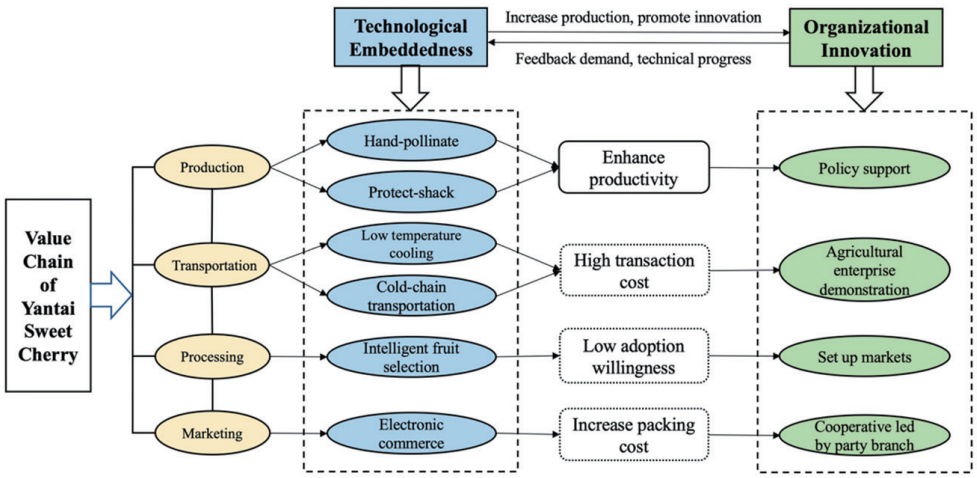

Fig. 1. Theoretical framework.

[vi] 1 mu = 1/15 hectare

can build cold storage system by itself because of high cost. So that local government combines with agricultural enterprises to demonstrate and set up market are effect on meet small–scale farmers' desire of transportation and processing. In marketing stage, we can regard electronic commerce as a main technology for expanding market. But digital divide leads small–scale farmers keep distance with e–commerce, furthermore, complex package and post–sales service increase marketing cost. In Yantai, "Cooperative Led by Party Branch" mode focuses on adoption rate of e–commerce technology. The cooperative invites small–scale farmers to join and scales up sweet cherry supply, which means they combine into a strong organization to face with the demand market. These organizational arrangements response the requirement of technology extension, show dual action between technological embeddedness and organizational innovation. As we can see, coupling technology and organization achieves more motivation for YSCI development.

New technologies are source of extra profit, while organization guarantees to capture extra profit. Co–innovation of technology and organization makes this goal available. Under the traditional planting mode in Yantai, low production and fragile pericarp of sweet cherry limits the market range, farmers cannot get more benefit. Embed new technologies enhance production and increase quality of sweet cherry, at this time, innovate organization through value chain, and then, the ability of capture extra profit will be improved. Therefore, develop agroindustry needs technological embeddedness, and organizational innovation is also necessary. Co–innovation of technology and organization is fundamental security for agroindustry development.

CASE SELECTION

This study follows the typical qualitative method (Patton, 1987) and chooses YSCI as a case study object, which is a high–profile and representative in the implementation of rural vitalization strategy. To obtain as complete as a picture as possible of YSCI situation, the survey was addressed to local government, managers of new agricultural management subjects, cooperatives, small–scale farmers. From August 7 th to 13 th in 2022, our research group finished field survey in Yantai City including Laishan, Qixia, Fushan districts. Combine in–depth interview and random interview, we interviewed 26 key informants and 182 respondents. Research group invite professors, research assistant and postgraduate students as component.

Basic information

Yantai City is surrounded by sea in three sides, and located on 37~38 degrees north latitude (Fig. 2). This region is one of the best places to grow high–quality sweet cherry because of temperature varies widely from day to night, plenty of water, and soil is rich in limestone. Based on these geographical advantages, Yantai sweet cherry planting area was more than 23,000 hectares in 2020, annual output reached 210 thousand tons; so YSCI was definitely the local pillar agroindustry in China.

Sweet cherry is originated from the Black Sea coast of Europe and western Asia, suitable for cool climate conditions. As one of the world's popular fruits, sweet cherry is rich in nutrition and with high economic value, is the world's important trade fruit products (Webster and Looney, 1996; Chockchaisawasdee *et al*., 2016). The quantity of global cherry exports increased from 145 thousand tons in 2000 to 376 thousand tons in 2011, with the USA, Turkey, Chile, and Spain as the main exporters (FAOSTAT, 2015). Although circum–Bohai sea region in China (including Yantai) has a long history of sweet cherry planting and more than 100,000 hectares under cultivation, sweet cherry still under "demand outstripping supply" context (Cui *et al*., 2017). Data from the United States Department of Agriculture showed that China became the top destination for Chile's cherry exports (Perez, 2017). China is becoming the world's largest market of sweet cherry[vii].

Under the double boost of regional condition and market demand, fruit industry has made great contributions to improving the economic benefits of Yantai City (Fig. 3). Before 1990, agricultural technology information was blocked, fruit planting area and output were low. Co–innovation of technological embeddedness and organizational innovation provides motivation for

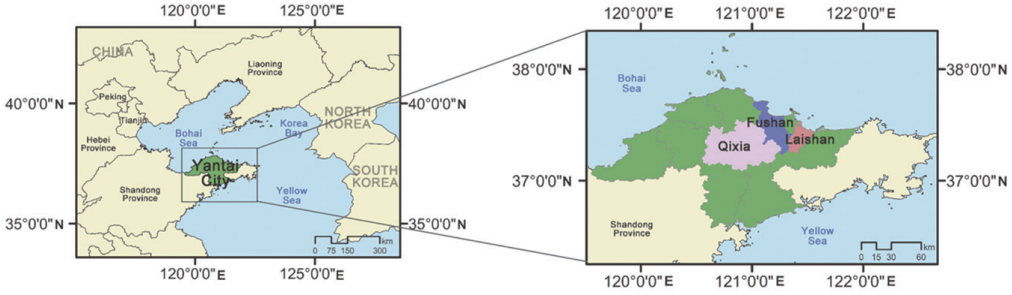

Fig. 2. The study area.

[vii] Source: U. S. Department of Agriculture, Economic Research Service: https://www.ers.usda.gov/topics/crops/fruit–tree–nuts/commodity–highlights/

upscale fruit industry in Yantai. Especially a rapid growth after 2000. It is worth mentioning that fruit planting area is not expand infinitely, its growth rate is far lower than fruit production. Under limitation of objective conditions, the fundamental reason for promoting fruit industry is improving efficiency of per unit yield through technological and organizational innovation.

Review of YSCI

In October 2022, Yantai sweet cherry was selected into the list of agricultural brand quality cultivation program of the Ministry of Agriculture and Rural Affairs of China, and raised its brand competitiveness. Following "exploit location advantage – embed key technologies – optimize value chain structure" pathway, YSCI has become a pillar agroindustry in Yantai City.

Exploit location advantage

Global agricultural practitioners have widely recognized that sweet cherries are difficult to grow. Fortunately, the oceanic climate and rolling hilly landform in the Bohai region of China form a unique mild microclimate. Under the encouragement of Yantai local government, sweet cherry farmers exploit location advantage actively. Yantai sweet cherries are known for their excellent quality due to their unique growth condition.

In addition, surface of sweet cherry is fragile, thin and low toughness skin makes it perishable. Sweet cherry often sale as fresh fruit in local market because of its short store time. Key point for YSCI development is cultivating high–quality varieties which are easier to store and transport. There are more than 600 varieties of sweet cherry in the world, and more than 100 varieties are grown in China. However, foreign varieties are not well adapted to the ecological climate in China, and their planting performance is not satisfactory (Li *et al.*, 2019). Since the 1960s, China has carried out sweet cherry breeding and cultivated over 10 new varieties of economic cultivation which planted gradually in Yantai. Combining geographical condition and cultivated seed, YSCI has exploited unique location advantages due to multi–response led by local government.

Embed key technologies

YSCI has experienced three major technological revolutions. International fruit tree grafting technology has been spread in 1990s, and Chinese farmers have applied it to cultivate sweet cherry. Best quality sweet cherry varieties originate from Russia, the United States and Canada are gradually introduced into China. And fruit tree grafting technology improves survival rate and nutrient supply capacity of these varieties. Since 2000, sweet cherry production grown rapidly by the popularity of artificial pollination technology. Natural sweet cherry trees rely on wind and animals as intermediaries to complete the pollination process, which is of low quality and high risk. Artificial pollination technology intervenes pollinate directly, so that improves fruit setting rate. Greenhouse planting mode introduces a root limiter for above–ground planting, breaks the constraints of region, temperature, soil, and labor; meanwhile, combines with digital standardization system to adjust fresh fruit supply timing and expand planting range.

With above–mentioned key technologies, yield and quality of Yantai sweet cherries have been improved. Sweet cherry varieties are constantly updated, from Hongdeng, Meizao, Samit to Brooks, Russia 8, etc., gradually optimizing average single fruit weight and skin toughness. Up to now, YSCI new technology has achieved all–round breakthroughs in supply growth, fruit diversification, and improved storage and transportation

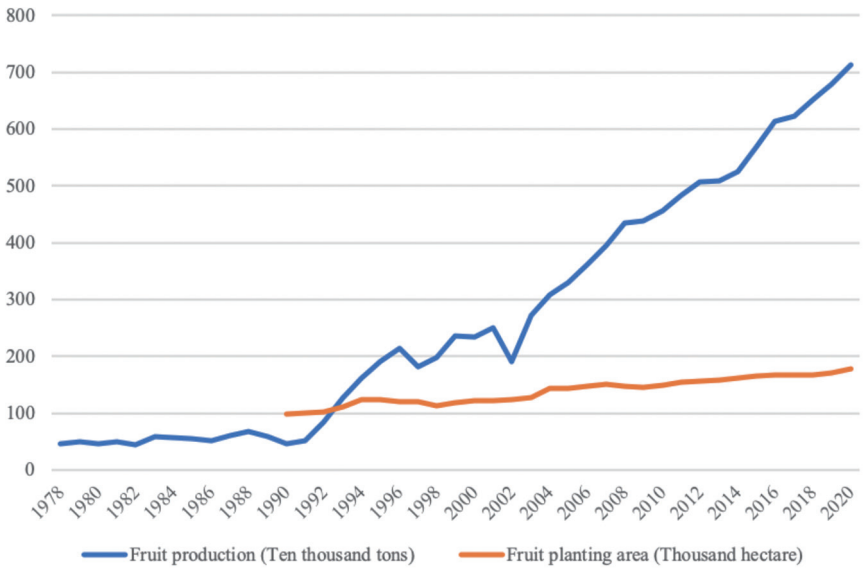

Fig. 3. Trend of fruit industry in Yantai City (1978~2020)[viii].

[viii] Data materials come from the Statistical Yearbooks, Government Work Reports of Yantai City, and field survey and interview with local farmers by authors.

resistance. Organization of marketing and distribution needs to make some matching response in order to truly capture these possible extra profits.

Optimize value chain

In order to improve efficiency of sweet cherry industry and capture extra profits, it is necessary to optimize structure of the value chain. Despite location advantage and key technologies application, the characteristics of fresh sweet cherry still pose challenges to its distribution. When harvesting sweet cherry, under high temperature environment is important. But the fruits might soften and rot soon after harvest. Every year, over 40% sweet cherry production loss occurs in Yantai, and larger sale market means higher loss (Yang and Feng, 2016). "Production – transportation – processing – marketing" process is complex and risky, which means it is not suitable for small–scale farmers with weak foundations to intervene in value chain alone.

Organizational innovation of YSCI suggests multi–response led by local government, which support small–scale farmers integrate into value chain. From practical experience, farmers have less limitation during production stage, but may suffer loss due to wrong selection of sweet cherry varieties; farmers never pay for over–expensive equipment during transportation and processing stages; and farmers are unavailable to take risk of return so they are hard to expand market during marketing stage. So, local government cooperates agricultural enterprise to guide sweet cherry varieties for small–scale farmers and set up equipment and market of value chain. Both of small–scale farmers, local government and agricultural enterprise can obtain more profits under this "multi–response" process.

Through the pathway of "exploit location advantage – embed key technologies – optimize value chain structure", YSCI coupled technology and organization to overcome the labor outmigration, technology low adoption and capital shortage issues. Such pathway offers YSCI captures extra profit and becomes pillar agroindustry.

CASE ANALYSIS

Co–innovation of technology and organization reflects interaction of productivity and productive relationship. In Yantai City, 23,000 hectares of sweet cherry plantation is divided into outdoor and greenhouse, Laishan, Qixia, and Fushan districts are performed differently (Table 1). Most of plantation in Laishan is outdoor by small–scale farmers, total yield is the lowest. Qixia has the highest yield per unit, with more than 350 hectares greenhouse, and is the most concentrated equipped plantation. Although Fushan has the lowest yield per unit, it has the largest planting area (7200 hectares outdoor and 170 hectares greenhouse), yield and total output in Fushan are far higher than others. We are supposed to conclude different cases reflect different modes: traditional practice with technological embeddedness, modernization development with organizational innovation, market–leading by government and cooperative.

Comparative analysis shows it is difficult to increase profit by new technologies only. Co–innovation of technology and organization can mobilize potential production and finally promote YSCI to be regional pillar agroindustry. Three cases show that value–chain–based co–innovation has positive influences on local economic development.

Laishan: traditional practice with technological embeddedness

Traditional practice by small–scale farmer shows YSCI is limited to capture extra profit in Laishan. Laishan is located in urban area of Yantai, sweet cherry planting is being popular, but fragmented topography and landform limited farming area. Artificial equipment is one common measurement to replace part of labors, but not suit fragile fruits. We realized that small–scale farmers show low level ability of capture extra profit due to lack of organizational innovation support by local government or enterprise.

Laishan mode (Fig. 4) has following characteristics. First, both outdoor and greenhouse embedded key technologies. Hand–pollinate and protect–shack technologies in production stage are widely adopted, but low temperature cooling and cold–chain transportation technologies in transportation stage and intelligent fruit selection technology in processing stage are only for greenhouse farmers. Second, small–scale farmers generally have low willingness to adopt e–commerce technology in marketing stage. Most of farmers in Laishan prefer traditional market rather than new social media tools. During field survey, farmers said frankly, "I don't want to sell sweet cherry online. Packaging cost is too high that I can't bear the risk when return." Obviously, it is difficult for small–scale farmers to reduce transaction cost by themselves, so as capture extra profit. Third, organizational structure has shortcoming that only part of extra profit is achieved. Local government of Laishan always insist on developing agriculture and tourism at

Table 1. Basic information of three cases (2021)[ix]

Case	Area (ha)	Yield (ton)	Yield per unit (ton/ha)	YSCI output (million yuan)	GDPPC (thousand yuan)
Laishan	780	12,880	16.51	200	107.69
Qixia	3300	60,000	18.18	800	62.84
Fushan	7370	80,000	10.85	1100	87.52

[ix] Data source: The Statistical Yearbooks of Yantai City, and field survey with government official, local farmers by authors

the same time, but strength from local government is limited. We found it is hard to expand sweet cherry distribution from Laishan due to lack of government–enterprise cooperation. Failure to flow into larger market means that extra profit is unavailable.

Therefore, traditional practice by small–scale farmers in Laishan shows that technological embeddedness is source of extra profit, but incomplete organizational innovation makes capture extra profit as hard mode.

Qixia: modernization development with organizational innovation

Modernization development led by cooperative in Qixia brings a new idea for organizational innovation of YSCI. Qixia is one of the most famous apples producing area in China, until now, sweet cherry planting area is no more than one–tenth of apple planting area. Different from traditional practice in Laishan, Qixia raised modernization development with organizational innovation, has the most concentrated greenhouse application (over 350 hectares). Based on case analysis, organizational innovation provides stable environment, and helps to increase productivity and improve productive relationship (Fig. 5).

YSCI High–quality Development Office in Qixia is organized by local government, agricultural enterprise and cooperative. Local government support small–scale farmers through policy, and distribution center which set up by cooperative helps fruit transportation. Agricultural enterprise manages industrial park, town service center and village service station to cover all kinds of YSCI stakeholders. From value chain perspective, different stages have different requirements for technology and organization during "production – transportation – processing – marketing". It is unable to provide sufficient motivation for capturing extra profit is fragmented innovation ignores value chain.

Taking "One Village, One Mu, One Demonstration" project as example, village collective has duty on land consolidation, and farmers are required to experience the application of sweet cherry production technologies. However, this project only plays a role on technology adoption (production stage) instead of capturing extra profit (whole value chain). Modernization development with organizational innovation regards local government as core direction, cooperative which participated by small–scale farmers to achieve high market share. In production stage, small–scale farmers are available to adopt new technologies, but they are not positive in transportation, processing, and marketing stages. Without organizational innovation through whole value chain, the potential extra profits cannot be captured.

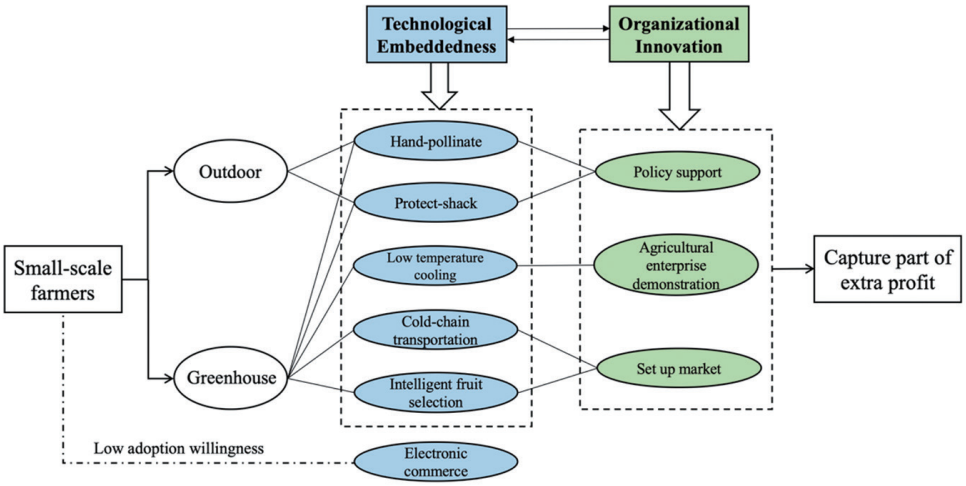

Fig. 4. Traditional practice in Laishan.

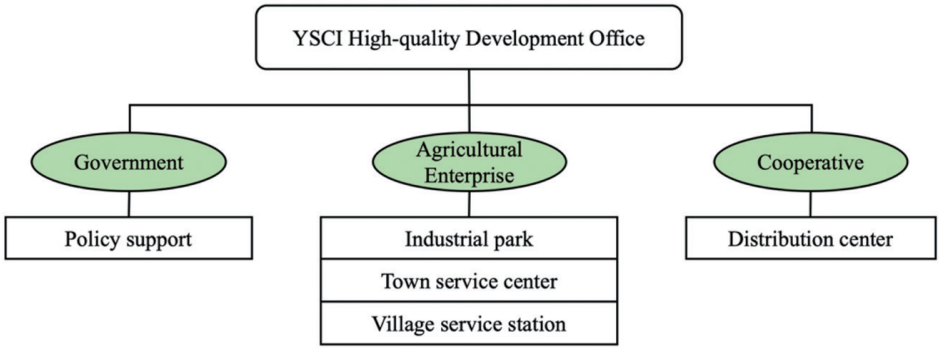

Fig. 5. Organizational innovation of YSCI (Qixia).

Technological embeddedness increases productivity, organizational innovation improves productive relationship of agroindustry. It is worth noting that only co–innovation covering all stages of value chain can achieve the goal of expanding market, increasing price, and finally capturing extra profit.

Fushan: market–leading by government and cooperative

Based on market–leading by government and cooperative mode, Fushan sweet cherry shows a new scheme of "technology + organization" co–innovation. Co–innovation mode focuses on labor immigration issue, low level technology adoption and production capital shortage, aims to capture extra profit. Total investment of the modern agricultural industrial park project is 180 million yuan which covers Menlou Street, Gaotuan Town, Huili Town and Zhanggezhuang Town. Fushan raises leading enterprise and sets up a series of large–scale plantation which covers "production – transportation – processing – marketing" value chain. For example, demonstration base for new varieties of outdoor sweet cherry; efficient water–saving irrigation and precision fertilization integrated system; comprehensive service center and big data platform; agricultural waste comprehensive treatment center; sweet cherry processing and marketing channel. This section analyses technological embeddedness and organizational innovation in Fushan mode, finds out how the co–innovation motivate YSCI to deal with current problems and capture extra profit through value chain perspective.

Technology breakthrough: from single to integrated

Emerging agroindustry development is inseparable from key technology, moreover, integrated innovation is necessary. Fushan is known as the hometown of sweet cherry in China, and location advantage is also unique. In 2022, plantation is more than 7,000 hectares, and the output value exceeds 1 billion yuan. As mentioned in section 2, Yantai sweet cherry have experienced three revolutions related to technologies. In Fushan, these revolutions are starting from "single" and moving toward "integrated".

YSCI in Fushan has achieved integrated technological embeddedness on whole value chain. In practice, hand–pollinate and protect shack technologies are basically adopted in both outdoor and greenhouse planting. Technological embeddedness in production stage has been popularized, but adoption in transportation, processing and marketing stages still has a long way to go. In Fushan, large–scale plantation shares transaction cost of low temperature cooling, cold–chain transportation and intelligent fruit selection technologies. Market–leading by government and cooperative mode helps small–scale farmers adopt these integrated technologies. More importantly, e–commerce technology is supported by Fushan mode. Sweet cherry from Fushan is available to a larger market, which can break through geographical scope and price.

The application of single technology in production stage will increase productivity of sweet cherry, and then, adoption of integrated technology through industry chain bring extra profit. Integrated technological embeddedness in Fushan has completed the goal of reducing transaction cost, and puts forward a test for capturing extra profit.

Organization structure: beyond expand to stable

Organization structure is well innovated to capture extra profit under Fushan practice. With an annual output of more than 80 thousand tons, Fushan sweet cherry is popular in international markets. Increase output is due to technological embeddedness, while expand market is owe to organizational innovation. Organizational innovation in Fushan shows stable structure, to be specific, coordination of local government, enterprise and small–scale farmer aims on improving sweet cherry quality and creating competitive sweet cherry brand to expand sale period and marketing channel. Such coordination absorbs more seasonal farmers join in harvesting period, finally achieve more revenue.

Sweet cherry fruit is fragile and hard to store. Integrated technological embeddedness sets up connection during "production – transportation – processing – marketing", makes productive relationship close. However, from field survey we found that small–scale farmers are unable to invest such a large number capital on greenhouse plantation. Long–lasting agricultural value chain finance can use social capital to reduce transaction cost and meet participants' requirement with a balanced focus on all chain actors (Villalba *et al.*, 2023). Therefore, financial support by "government – enterprise – cooperative" positively effect small–scale farmers to increase productivity.

Organization of YSCI in Fushan is established into a stable environment which connected government, enterprise, and small–scale farmers through value chain. Production stage, enterprise introduces advanced varieties and cultivation technology, and subsidy from government can help small–scale farmers to improve their application. Transportation and processing stage, government support enterprise to build warehouse and update professional equipment from land planning aspect, small–scale farmers are also available to use. Marketing stage, local government helps Fushan set up local brand and enterprise introduces network platform, e–commerce technology can broaden market and benefit every value chain stakeholder.

In conclusion, YSCI in Fushan proves that with support of "government – enterprise – cooperative", co–innovation of technology and organization through value chain is effective, stakeholder are able to maximize extra profit. Establishment of agroindustry requires coordination between productivity with productive relationship. Co–innovation of technology and organization is not only strategy to improve productivity, but also the main driving force to optimize productive relationship.

CONCLUSIONS AND SUGGESTIONS

Motivation for YSCI development comes from co–innovation of technology and organization, and organizational innovation is caused by technological embeddedness. Based on tree artificial pollination technology, fruit setting rate and yield of sweet cherry has increased sharply. When harvesting sweet cherry, insects are not active, but it is difficult to store and transportation. Compared with other fruit tree, features of sweet cherry industry including: less labor demand, high benefit, and high risk. Considering about value chain "production – transportation – processing – marketing", technological embeddedness of YSCI causes positive organizational innovation. Specifically, under the pattern of "government leads and multi coordinate" in a sufficient scale, construction of supporting department is emerged, such as: fruit distribution market, transportation and refrigeration facilities, high–quality variety cultivation, and agricultural material supply services.

From the value chain perspective, this paper takes three modes of YSCI as case study objects, proposes "technological embeddedness + organizational innovation" theoretical framework, and analyses interaction and improvement of productivity and productive relationship. The results show that (1) relying on the pathway "exploit location advantage – embed key technologies – optimize value chain structure", YSCI becomes the local pillar agroindustry and offers regional development. (2) Coupling technological embeddedness and organization innovation improves economic efficiency of new agricultural management subjects. (3) Adopting key technology copes with labor outmigration stress, furthermore, taking part in advanced organization actives small–scale farmers' interest on technology and supplies the capital gap. (4) Co–innovation of technology and organization not only reduces transaction cost, but also captures extra profit, and provides new motivation for emerging agroindustry development. During this new stage, agricultural development is supposed to pay more attention on integrated co–innovation of value chain.

In view of this, this study puts forward the following suggestions for formulation of industrial development policies in rural vitalization. First, constraint by policy, to enhance traction of government–enterprise cooperation. For emerging agroindustry represented by YSCI, government and agricultural enterprise should release labor outmigration pressure, which need to establish co–innovation environment of "technology + organization" to create better conditions for reducing transaction costs and capturing extra profits. Second, motivate by efficiency, to capture higher profit step by step. Location advantage is foundation, key technology is source, and organizational structure is guarantee. Agroindustry is supposed to follow suitable pathway to complete value chain gradually, and play a role of regional economic pillar. Third, innovate by cooperative, to explore development potential and capability. Agroindustry should not only focus on technological embeddedness, but also organizational innovation to active small–scale farmers' interest on technology and supplies the capital gap. "Government leading – enterprise driving – government and enterprise cooperation – small–scale farmer response" is an inevitable option to mobilize promotion. Fourth, improve by strength, to create new pattern of industrial development. In the future, new agricultural management subjects are expected to undertake responsibility of agroindustry development. It should be properly supported to promote integrated innovation of value chain, realize continuous increase of efficiency, and eventually become new potential energy to improve industry competitiveness.

AUTHOR CONTRIBUTIONS

Xiao Zhang designed and wrote the manuscript. Zhongxing Guo and Masahiro Moritaka participated in design of the study and co–supervised this work. Honey Lynn Lynn assisted in editing of the manuscript and approved the final version. Seifeddine Ben Taieb formed the research idea and edited the manuscript. All authors read and approved the final manuscript.

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