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Unleashing the association between technical efficiency of agro- processing industry and economic growth: A pathway towards development sustainability

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Abstract
Under the influence of market rules, state intervention in development process is obviously necessary, especially in the context of emerging countries with an incomplete and non-mordern market economy toward the global race of sustainability. Applying 2590 enterprises covering 63 provinces and cities in the General Statistics Office, this study aims to evaluate the influence of state on the technical efficiency of enterprises. A fractional regression analysis model is employed purposefully since the technical efficiency of the dependent variable is an estimated randomly variable. The research findings unequivocally indicate a substantial influence of the state on the technical efficiency of livestock product processing companies. Moreover, when studying each specific aspect in isolation to gauge the role of the state, a discernible negative impact is evident on the technical efficiency of these enterprises. Consequently, this study implies that for tangilbe improvements in the technical efficiency of enterprises, the state should adopt a comprehensive approach, simultaneously implementing all aspects that demonstrate its role in the sector. By adopting such a holistic strategy, the state can create a more conducive environment toward development sustainability for improving the technical efficiency of livestock product processing enterprises.

Keywords Environmental sustainability · Technical efficiency · Economic growth · Development orientation and strategy · Environmental efficiency

1 Introduction

The agro-processing industry, including the processing of livestock products, is one of the most important sectors of the global economy [35] as it is considered an optimal solution to ensure food security, improve value and quality, and improve the competitiveness of agricultural products. It plays a significant role in transforming the agricultural production structure, contributing to the development of rural economies, and promoting agricultural integration into the global economy in today's context. Therefore, countries focus on developing the agricultural products processing industry and consider it a crucial aspect of the country's socioeconomic development [46]. However, this industry faces numerous challenges, such as changing clean lifestyle demands, high requirements for processing product quality, changing global food consumption patterns [59], societal reactions to the food system due to environmental, social, and economic

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issues, and global risks that make economic sectors more vulnerable to various uncertainties and fluctuations [30]. In the multi-dimensional trend of sustainable development across various sectors, concerns extend beyond environmental considerations to encompass economic and social aspects [66]. This poses a greater challenge within the agro-processing industry. The foremost question pertains to the responsibility of the state in balancing food security assurance for vulnerable populations with the societal engagement responsibility of relevant stakeholders and economic growth ensurance in the depletion of resources, particularly in developing countries.

Vietnam possesses significant advantage in terms of diverse and abundant natural resources as known "Forests of gold, seas of silver", coupled with a favorable climate for the agricultural development as well as agro-processing industries. However, the abundance of these natural resources has also led to gradual decline in the impetus for increasing value-added to agricultural export products in Vietnam [78]. As mechanism, agricultural export products tend to lean more towards being primary exports rather than secondary and tertiary ones, which would bring greater value for the nation's wealth. Therefore, this turns to regulatory roles and directions of the state in innovating the value potential of this agricultural sector with the fact that Vietnam possesses certain favorable conditions compared to similar countries in the Southeast Asian region. Initiatives from governments in developing countries such as Thailand, Malaysia, and Indonesia have transformed the agro-processing industry development model to enhance the efficiency of agro-processing enterprises, focusing on both small and medium-sized companies (Habibah Abdul [31]).

Over the past 20 years, Vietnam's economy has shifted from a centrally planned mechanism to market-oriented production led by the state, described as a "transition" from "socialism" to "capitalism". Within the realm of transitions research, there is a growing focus on the political and power dynamics inherent in transitions. These discussions are situated within a larger discourse surrounding the politics of sustainable development [67, 70]. Consequently, a series of theoretical and empirical inquiries into power and politics in transitions have emerged [2, 8, 57], leading to the recognition of this as significant theme within sustainability transitions research. Therefore, the Vietnam transitions have not only brought about significant historical representation changes in the interaction between social relations (including state's intervention involved) and production structures but also given the special attention to state's role in sustainable context. There open the gap in various production purposes in set of the production inputs accessibility such as land, main production assets, leading to gulfs in production technical efficiency (TE) and productivity in rural Vietnam [5]. In other words, the current market mechanism creates the potential to control technical changes and improve productivity efficiency for farmers, especially in the context of depleted natural resources in Vietnam for sustainable concers [52]. Considering the importance of technical efficiency (TE as a cornerstone within the framework of sustainable development, our investigation leverages this concept to evaluate and scrutinize the agro-processing industry in Vietnam, thereby illustrating the influence of governmental sustainable intervention toward this crucial sector. This approach aligns with the broader discourse on sustainability, wherein technical efficiency (TE is acknowledged as pivotal element encapsulating economic, social, and ecological dimensions [62, 64].

Extensive research has been conducted internationally on the analysis of TE in businesses, employing both parametric and nonparametric approaches, random variable, and frontier production function [53, 74]; meanwhile, there is scarity of research on the Vietnam samples of livestock production activities [73]. These studies have calculated various measures of TE. Although there may be certain differences in results due to variations in research methods, study subjects, and scope, these studies consistently highlight the significant impact of state support on the TE of businesses. State support in this context extends beyond financial assistance such as government subsidies [43]; price caps plan [75] and includes the creation of a favorable business environment and the stimulation of self-development for enterprises such as incentive regulation [28],regulatory conditions [23]. In other words, state management is one of the determining factors in enabling businesses to maximize their resource utilization and improve their TE [15, 76]. Thus, this study aims to clarify the influence of the state on the TE of the livestock product processing industries by different regression analysis for robustness purpose testing as well as calculate TE in this industry.

Cumulatively, this study contributes on three main fronts to the concern regarding the TE of resource utilization in the agro-processing industry. Firstly, it enriches and elucidates the results of estimating TE within this sector, addressing the limited availability of data on it in Vietnam. This serves to highlight the production status of the industry group, which significantly contributes to the socio-economic development in developing countries as Vietnam. Additionally, the calculated TE can serve as evidence for comparison with subsequent studies on the TE of industry groups that have received less attention in this research. Secondly, in terms of the state's contributing role, the study identifies five crucial roles of the state in promoting TE in the study sample in Vietnam. The variations in the structural transition of social and political relations diversify and underscore the state's role in wielding power to enhance productivity efficiency within the framework of Vietnam's market-oriented economic direction, especially in the global race for sustainability.

Consequently, the state's role in Vietnam will be delineated with the impacts on enhancing TE in this industry. Thirdly, the research results provide a clear picture of this industry in Vietnam and whether the state intervention is effective and commensurate with the actual roles of the state. Therefore, valuable policy implications are proposed to enhance the efficiency of this industry.

The rest of the paper is organized as follows: Sect. 2 presents the literature review. Section 3 explains the methodology and summarizes our data collection and variable description. Section 4 presents the estimation results and discussions. Section 5 discusses the policy implications and conclusion.

2 Literature review and research hypotheses

2.1 Environment establishment

Several studies show that the productivity of small-scale livestock processing companies in Africa is still low compared to other regions of the world, providing approximately 45% of the demand for processed meat and dairy [24, 68]. The solution here is to innovate farm-level technology, but the access and participation of farm owners is necessary, but not enough for sustainable development. Therefore, creating a favorable institutional environment is necessary to link farmers with services, creating a better value chain. Institutional issues include access to inputs and markets for processed products, and the regulatory framework surrounding production and processing is emphasized [34]. This facilitates interaction between farmers and other actors and enables linkages with decision makers to address institutional barriers, thus creating an enabling environment for innovation.

To create a favorable environment for businesses to maximize their output, the state needs to effectively implement the following three elements: Firstly, establishing a competitive environment. Therefore, the competitive environment in an industry includes factors that determine productivity. The global strategist [61] argues that there is a close relationship between the competitive environment and the operational efficiency of firms or an industry (a group of firms) in the economy. Thus, when the economy is extensively open, economic components need to compete fairly to ensure efficient resource allocation, cost-reflective pricing, encourage innovation, and improve productivity, thus improving TE. Secondly, establishing a legal and social security environment: In all economic activities, investing in a challenging sector will always involve exploration, risks, and uncertainties. If the legal system is inadequate, the operational efficiency of a business may be affected due to violations of intellectual property rights, ineffective contract enforcement, and political and economic instability. Therefore, the legal system must protect the rights and interests of economic activities such as ownership, arbitration, and contract enforcement. Additionally, when social security is ensured, economic entities will feel secure to focus on economic activities and contribute to the country's development. Some studies indicate that when rights are protected, businesses are more confident with less likelihood of posing risks to investment security [53]. Therefore, if there is trust in the legal system and social security, sectors with instability and challenges, such as the livestock product processing industry, will attract better investments, stimulate and promote development and innovation. Thirdly, establishing an administrative procedure environment: Administrative procedures are tools for the state to fulfil its responsibility for economic and social management and affect the efficiency of businesses [53]. If administrative procedures are complicated and burdensome, they will increase costs, reduce operational efficiency, erode the trust of economic entities, and particularly hinder the development of the livestock product processing industry.

Therefore, the state must establish a favorable administrative procedure environment, accelerate the application of information technology in state administrative management to enhance efficiency, and create conditions for citizens and businesses to invest in and conduct business in the livestock product processing industry. Hence, the research hypothesis is formulated as follows:

H_1: The establishment environment of the state has an impact on the TE of livestock product processing businesses.

2.2 Orientation and development strategy

Along with this population growth and development in developing countries, there will be a tremendous demand for livestock products. The majority of this demand will be met by local production. In addition to increasing demand, consumers are becoming more concerned about the negative impacts of processing livestock products on the environment, public health, and animal welfare [55]. Therefore, governments need to develop strategies to enhance collaboration among farmers, businesses, animal scientists, biotechnologists, and other experts to promote the generation

and application of modern technologies suitable for long-term operations in livestock farming and livestock product processing environments [51].

Since the Indonesian government has focused on cluster-based development for small and medium-sized enterprises (SME) processing, a positive relationship between market orientation, innovation, and business efficiency has been clearly demonstrated [50]. Market orientation has improved the innovative behavior of SME processing clusters as these businesses integrate and expand information flow to benefit from collaborative actions, thereby improving business efficiency.

The participation of the state in setting orientations for the development of livestock product processing is essential for several reasons: (1) The development of livestock product processing in a market economy is susceptible to spontaneous growth and imbalanced supply and demand. Therefore, the state must provide planning and direction for the development of this industry; (2) The development of livestock product processing contributes to overall economic development. Therefore, the state must align the development of livestock product processing with the general goals of the development of the agricultural and processed industry, as well as the overall economy; (3) The development of livestock product processing requires specific conditions and resources. Considering the limited financial resources available from the state budget, which need to be allocated to various development objectives, the state needs to have planning and direction for the development of livestock product processing to ensure a balanced and efficient utilization of resources. Therefore, the research hypothesis is as follows:

H_2: The orientation and development strategy established by the state has an impact on the TE of livestock product processing businesses.

2.3 Policy formulation and implementation

Based on the analysis of the necessary conditions and resources for the development of processed livestock products, there have also been discussions on the organization and implementation of government policies to maximize the role of processing enterprises, increase the proportion of processed livestock products, and enhance market competitiveness in domestic and international markets. Policies have been implemented, such as partially reimbursing the costs of modernizing existing meat processing plants or constructing new ones, partially reimbursing investments in modern transportation facilities such as cold storage and providing value-added tax support for processed products for export.

The negative impact of inappropriate and ineffective policy formulation and implementation on the development of processed livestock products in developed countries has been studied for a long time by the authors [29]. In New Zealand, the meat processing industry was significantly delayed due to government policies, such as restrictions on slaughter and processing facilities, export processing, expanded powers of the producer board intervention, and the imposition of minimum prices. These policies resulted in reduced number of livestock and increased domestic costs, leading to a rapid decline in the capacity of meat processing plants. In late 1985, when the government removed these policies, producers and processors were motivated to improve production capacity and processed livestock products. The result of removing these price policies was economic benefits within the production sector.

A streamlined, clear, and predictable government policy will increase investment choices and enable companies to have optimistic plans for growth and improved TE [45]. The formulation of industry-specific policies has the potential to create a "market failure gap," stimulating businesses to pursue "strategic" investments in order to benefit from state incentives. This can lead to excessive and inefficient long-term investment behavior [20]. Therefore, the hypothesis is proposed as follows:

H_3: The formulation and implementation of policies affect the TE of livestock product processing enterprises.

2.4 Operating and regulating the development process

Three main trends in the agricultural processing market for the future has identified, including: (1) the demand for new products with high technical standards and quality regulations from customers of multinational corporations (Minakov and Nikitin 2019, [49]; (2) the labor shift to absorb new technologies from SMEs (Charania and Li 2020); (3) the replication and imitation of new products (Lezoche Hernandez et al. 2020). Consequently, the government needs to take actions to steer and regulate this sector through various ministries, research centers, and universities in the country According to Poapongsakorn [60], the primary support of government for research and scientific and technological innovation has promoted this sector to achieve higher revenue, reduce production and processing costs, cope with increasing consumer food safety pressures, and seize opportunities and challenges from emerging markets. Government support

through budgetary allocation to, provides human resources in the form of leading experts in the field, and transfers new technologies from developed countries can help food processing enterprises improve their technology. As a result, food product processing enterprises have successfully innovated and updated processing technologies, production processes, organization and management, and marketing strategies.

The development of the livestock product processing industry in a market economy faces various difficulties and challenges. Therefore, the government must engage in operational and regulatory activities to promote the development of this industry in line with the intended direction and development strategies, contributing to the overall progress of the country. The research hypothesis is as follows:

H_4: The government's operational and regulatory activities have an impact on the TE of businesses involved in processing livestock-based food products.

2.5 Inspection, auditing, and violations handling

Compliance with the requirements and regulations in the livestock-based processed food products industry requires expertise, time, and financial resources from businesses. These are also the shortcomings faced by small and medium-sized enterprises in this field [25, 80]. In particular, these regulations have increased entry costs and posed greater challenges for small businesses during their establishment and growth stages [39]. Many businesses underestimate the risks associated with processed livestock products and only partially comply with regulatory requirements [19, 22]. Activities of inspection, monitoring, and handling of emerging issues contribute to the promotion of the livestock-based processed food products industry. These include comprehensive state activities aimed at detecting and addressing errors, obstacles, and difficulties, as well as identifying and capitalizing on opportunities to propel the livestock industry's strong and sustainable development [42]. This indicates that the TE of businesses involved in processing livestock-based food products is influenced by inspection, monitoring, and enforcement of violations, which requires further research [14]. Therefore, the research hypothesis is as follows:

H_5: The role of inspection, auditing, and violation handling has an impact on the TE of companies involved in processing livestock-based food products.

2.6 Control variables

2.6.1 Firm size

The impact of firm size on the TE of enterprises has been widely studied [12, 65]. Ajibefun et al. [4] argue that smaller-scale businesses in the northern region of Italy exhibit lower TE compared to larger businesses Athukorala [7] found a positive and significant relationship between size and TE of the farm, in particular, farms with a larger number of workers had higher TE than farms with a small number of workers. There are three explanations for the negative relationship between firm size and TE in large businesses: (1) Large-scale firms may maintain labor allocations based on habits, which can lead to boredom and limited labor productivity; (2) Decision-making speed and flexibility are lower; (3) Coordination costs between departments are higher. However, on the contrary, the scale of the firm has also been shown to improve TE (Penrose & Penrose, 2009) because larger firms have greater financial resources to recruit and train labor, larger sales volumes that reduce fixed costs, and better resources for innovation and productivity enhancement. Due to the lack of such resources, smaller firms are forced to adjust their investment decisions and often miss out on costly upgrading and innovation, resulting in lower efficiency [53].

2.6.2 Age of business owner/manager

The age and managerial experience of the leaders have a substantial impact on the effectiveness of agricultural cooperatives in Indonesia [37]. This study is supported by the notion that as the manager's age increases, the efficacy of cooperatives increases by 0.01 unit [63]. Older managers have more experience managing and operating cooperatives. Furthermore, senior managers have an in-depth understanding of the principles and core values that enable the long-term viability and growth of corporate operations [33, 81].

2.6.3 Using management software

The application of information technology in production and business as a key input factor has the potential to influence production capabilities [1]. Although specific components of information technology, including hardware and software, have different impacts, they all contribute positively to firm efficiency [13]. The authors argue that firms that use software (information technology) tend to promote decentralisation, thereby enhancing operational efficiency. Analyzing the productivity and efficiency of 4000 Italian firms revealed that investing in software directly increases the average labor productivity [10]. Software is more closely related to practical applications and thus has the potential to impact business value-added through input factors, implying that the use of software does not completely alter the production process, but rather upgrades input factors and ultimately improves the enterprise's TE [58].

2.6.4 Applying automation processes

Automation techniques have been proven to be highly effective in improving the operational efficiency of industries worldwide [56]. These technologies are now highly praised for their ability to improve safety and reduce risks [69], lower costs, increase productivity and efficiency [17]. Integration of automation techniques has also paved the way for reducing human errors [9]. As a result, with repeated activities combined with quality standards, automation can liberate the labor force, delivering significant and consistent efficiency to commercial operations. However, due to concerns about the costs of procurement, deployment, upgrades, and maintenance, many small and medium-sized firms in developing nations frequently oppose the incorporation of automation techniques [6].

2.6.5 Apply innovation

Innovation and creativity have a significant impact on the performance of businesses in the manufacturing and processing sectors by enabling them to develop new products and services that are not yet available on the market or improve existing ones [18]. Innovation is particularly important when a business seeks to enter new markets or create barriers to market entry for competitors, allowing the business to achieve long-term sustainability and stable growth [32, 40]. Innovation can bring significant profits to businesses and enable them to establish market dominance [36]. However, not all innovation activities have a positive impact on businesses [48]. For example, businesses may encounter difficulties if new products or services developed through innovation are not accepted on the market [11]. Furthermore, innovation does not always result in immediate performance improvements in the short term,rather, it is considered an investment activity with long-term benefits [27].

Therefore, the research hypotheses are as follows:

H6a: The size of the enterprise has an impact on the role of the state in the TE of the livestock product processing businesses.

H6b: The experience of the business owner has an impact on the role of the state in the TE of livestock product processing businesses.

H6c: The use of management software has an impact on the role of the state in the TE of livestock product processing businesses.

H6d: The implementation of automation has an impact on the role of the state in the TE of livestock product processing businesses.

H6e: The application of innovative and creative practices has an impact on the role of the state in the TE of livestock product processing businesses.

Taken together, Fig. 1 illustrates synthesized theoretical framework following state's role impacts on TE of livestock product processing enterprises.

3 Data and methodology

3.1 Study area

The scope of the research area for this study encompasses all 63 provinces and cities nationwide in Vietnam, covering the seven economic regions in the country. The initial dataset comprises more than 600,000enterprises, including both newly

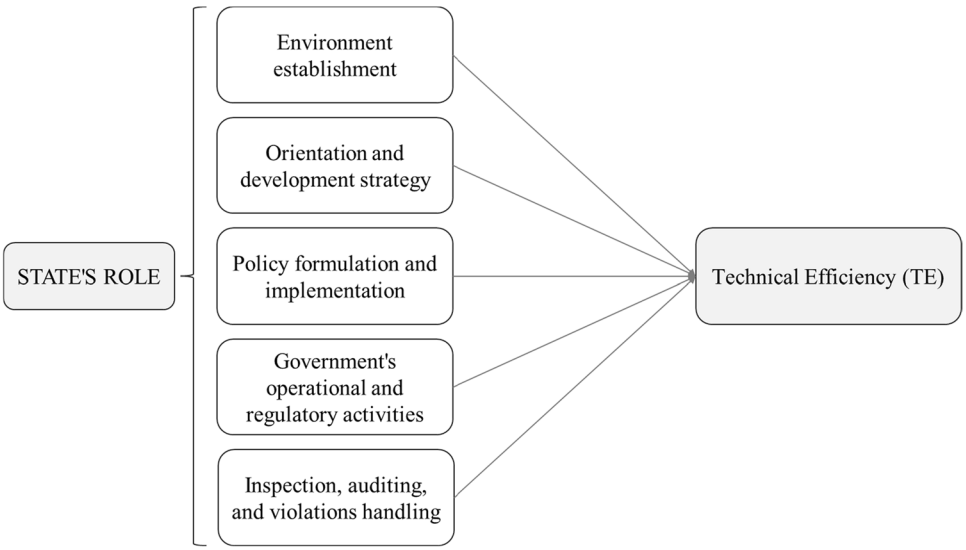

Fig. 1 Analytical framework of this study

surveyed establishments and pre-existing enterprises that meet the presscribed criteria of the General Statistics Office for revenue, assets, or profits during the previous years. Nevertheless, given that the study applies production function calculation through stochastic frontier models, the inclusion of data from generalized firms may introduce estimation bias. As a result, the research has excluded these enterprises and opted to retain a subset of more than 200,000 enterprises. Within this subset, there 6,246 enterprises primarily engaged in the processing of livestock products.

Subsequent to the data cleansing process, additional criteria were employed. These criteria ensure that the selected enterprises meet specific conditions: they must have been established and operating for a minimum of two years prior to the survey, which helps exculde outliers and exceptional case; administrative costs should demonstrate positive value, ensuring that the surveyed businesses are actively managed; and the dataset must contain no missing information. Consequently, the refined data consists odd 2590 enterprises that conform to these stringent requirements.

Table 1 shows the study area distribution by region. The numbers indicate that the Red River Delta, South Central Coast, and Southeast regions have the highest sample sizes, accounting for 30,89%, 19,85%, and 18,22%, respectively (equivalent to 800 enterprises, 514 enterprises, and 472 enterprises). In contrast, the sample sizes in the Central Highlands and North Central Coast regions are relatively small, comprising 2,97% and 4,21%, respectively (equivalent to 77 enterprises and 109 enterprises).

3.2 Data

The dataset used in the study includes 2590 enterprises in the livestock product processing sector. In this study, most of the companies in the sample belong to the small-scale category and fall into Cooperatives. The classification results of the research sample-based enterprises scale and type are presented in Table 2.

Table 1 Number of observations by region

Region	Propotion of enterprises (%)	Observation
Northern midland and mountainous	7,84	203
Red river delta	16,02	415
North Central coast	4,21	109
South Central coast	19,85	514
Central highlands	2,97	77
Southeast region	18,22	472
Mekong river delta	30,89	800

Table 2 Classification of research samples

Firm size[a]	Sample size	Ratio (%)
Super small	842	32,51
Small	1191	45,98
Medium	222	8,57
Large	335	12,93
Total	2590	100,00
Type of enterprises	Sample size	Ratio (%)
State-owned enterprises	105	4,11
Cooperatives	207	8,09
Private enterprises	2245	87,80
Foreign enterprises	33	1,27
Total	2.590	100,00

[a]**Firm size:** Super small: Number of employees ≤ 10 people; Small: Number of employees from 10 to 100 people; Medium: Number of employees from 101 to 200 people; Large: Number of employees over 200 people

The primary focus lies in evaluating how these factors impact the TE of enterprises, encompassing key aspects such as environment establishment, orientation and development strategy, policy formulation and implementation, operating and regulating the development process, inspection, auditing and violations handling, which are descriptively characterized in Table 3 as well as control varibles employed in this study.

3.3 Methodology

Stochastic frontier models have been widely introduced in research work [3, 47]. This is a method that uses random parameters to estimate the efficiency of using input factors to produce output products for each enterprises. The production function with TE and random factors can be represented as follows:

Table 3 Descriptive statistics of variables

Variable	Obs	Mean	Std. dev	Min	Max
Profit	3.140	19015,960	215794,200	0,010	10700000
Cost					
Labor	3.147	16195,770	90722,710	1,000	3671924
Management	3.136	7591,781	44840,110	0,130	1687649
Financial	2.592	4755,635	22190,940	0,010	435357
Selling	3.136	18375,130	241939,900	0,010	12400000
Goods sold	3.147	268526,100	1018117,000	1,010	26100000
Type	3.147	2836	0,494	1	4
Size	3.147	1911	0,936	1	4
Age	3.147	49,871	10,517	22	95
Gender	1.167	1151	0,358	1	2
Utilize software	3.147	1505	0,500	1	2
Apply	3.147	1832	0,374	1	2
Innovation	3.147	1893	0,309	1	2
Role	3.147	65,051	3,002	59,608	75,086
ENVI	3.147	0	1,223	− 2,934	2,651
STRAT	3.147	0	1,040	− 2,847	3,056
ENACT	3.147	0	1,183	− 2,133	3,454
MONI	3.147	0	1,053	− 1,978	2,656
AUDIT	3.147	0	1,222	− 2,769	3,621

$$y_i = f\left(x_i;\beta\right).\exp\left(-u_i\right).\exp\left(v_i\right)$$

In which, y_i are production outputs, x_i are production inputs, $f(.)$ are the transformation function from input to output with β the coefficients of input factors. v_i is the noise component and is generally considered to be normally distributed, u_i is a non-negative technical inefficiency. This component represents the level of inefficiency of a firm, where higher values of u_i indicate greater inefficiency and deviation from the optimal production frontier, while more efficient enterprises will have lower values of u_i. Therefore, it is possible to understand that $TE = \exp(-u_i)$. TE will have a value in the range from 0 to 1. The calculated TE value will be the dependent variable in the second part of the study, where the authors examine the specific impact of state-related factors on TE, while other factors of firm characteristics are controlled.

To achieve this goal, the author uses a fractional regression analysis model since the dependent variable TE is a variable that is randomly estimated and has a value between 0 and 1. The basic linear regression model can be represented as:

$$TE_i = \beta_o + \beta_1 ENVI_j + \beta_2 STAT_j + \beta_3 ENACT_j + \beta_4 MONI_j + \beta_5 AUDIT_j + \gamma X_i + \epsilon_i.$$

In which TE represents the estimated production efficiency derived from the production function discussed earlier, ENVI represents the environmental effect, STRAT represents the strategic orientation effect, ENACT represents the policy enactment and enforcement effect, MONI represents the operational regulation effect, and AUDIT represents compliance auditing and violation handling effect. X_i is the matrix of control variables related to firm characteristics such as Type, Size, and whether the business engages in innovation activities,… From this model, we also adjusts by adding, removing or replacing the content of variables to check the robustness of the model. We uses three models from the original model above, including:

$$TE_i = \beta_o + \beta_1 ENVI_j + \beta_2 STAT_j + \beta_3 ENACT_j + \beta_4 MONI_j + \beta_5 AUDIT_j + \epsilon_i \quad (1)$$

Shows the mere impact of the content variables representing the state's role on the TE of enterprises without controlling factors.

$$TE_i = \beta_o + \beta_1 ENVI_j + \beta_2 STAT_j + \beta_3 ENACT_j + \beta_4 MONI_j + \beta_5 AUDIT_j + \gamma_1 Type_i + \gamma_2 Size_i + \epsilon_i \quad (2)$$

shows the impact of the content variables on the state's role while controlling the type and size of enterprises.

$$TE_i = \beta_o + \beta_1 POLI_j + \gamma X_i + \epsilon_i \quad (3)$$

shows the combined effect of the variables representing the state role from the above five contents on the TE of enterprises with all variables of enterprise characteristics controlled.

4 Results and discussion

4.1 Technical efficiency of livestock product processing enterprises

The results of the stochastic frontier regression analysis using the Translog production function with the output of enterprise's post-tax profit in 2020 are presented in Table 4. Stochastic frontier analysis is not only conducted to determine the factors affecting the output of businesses, but also to calculate the TE of the businesses. Therefore, input factors, including total labor costs, business management costs, financial costs, sales costs, and cost of goods sold, are examined to assess their impact on the output of businesses. In addition to the conventional analysis of individual effects, the authors also extend the analysis to include squared terms of input variables and their interactions to provide a comprehensive assessment that is not limited by linear assumptions. Furthermore, the impact of business type and size is also considered in this estimation.

The estimated results presented in Table 4 indicate that three input factors, namely administrative costs, selling costs, and the cost of goods sold, have a significant impact on the production activities of livestock product processing companies. Specifically, both administrative costs and the cost of goods sold have statistically significant estimated coefficients at a 1% significance level and are positively correlated with after-tax profit. Interestingly, when analyzing the squared logarithmic values of these variables, the authors obtained similar results. Therefore, it can be concluded that the positive impact of administrative expenses and cost of goods sold on after-tax profit is strong and exhibits nonlinear

Table 4 Estimation results of the stochastic frontier production function of livestock product processing enterprises

Variables	Coef.	Std. Err
LnLabor	0.020	0.172
LnAdministrative	0.302*	0.143
LnFinancial	− 0.014	0.056
LnSelling	− 0.132**	0.051
LnGoods sold	0.253*	0.129
$LnLabor^2$	0.027	0.016
$LnAdministrative^2$	0.058***	0.012
$LnFinancial^2$	− 0.001	0.003
$LnSelling^2$	− 0.003	0.003
$LnGoods\ sold^2$	0.024**	0.009
LnLabor × LnAdministrative	− 0.025	0.022
LnLabor × LnFinancial	− 0.014*	0.007
LnLabor × LnSelling	0.016***	0.006
LnLabor × LnGoods sold	0.003	0.020
LnAdministrative × LnFinancial	0.011***	0.006
LnAdministrative × LnSelling	− 0.007	0.006
LnAdministrative × LnGoods sold	− 0.061***	0.016
LnFinancial × LnSelling	0.001	0.002
LnFinancial × LnGoods sold	0.003	0.006
LnSelling × LnGoods sold	0.012***	0.005
Constant	0.558	0.739
Lnsig2v	0.412	0.069
Type		
Cooperative	− 0.728**	0.265
State-owner	0.138	0.214
Private	0.086	0.435
Size		
Small	− 0.341***	0.106
Medium	− 0.440***	0.176
Large	− 0.847***	0.205
Constant	1.447	0.229

*, **, *** represents the 10%, 5% and 1% significance level

relationship. This impact does not diminish or reverse even when these factors increase. This finding is noteworthy and worth discussing, since previous studies have consistently claimed that the cost of goods sold reduces a firm's profit because it is deducted from revenue. On the other hand, although selling expenses is also statistically significant at a 5% level, it is negatively correlated with after-tax profit, which is consistent with finding of [54] on the sample of Vietnamese enterprises. This means that when selling expenses increase by 1% while keeping other factors constant, the after-tax profit of the firm will decrease by nearly 0.13%. It is logical considering that if an enterprise can save on selling expenses, it can somewhat lower the product's price, and thereby increase the firm's profit. The remaining input variables, including total labor cost and financial cost, are not statistically significant. This implies that changes in these cost categories do not have a significant impact on the after-tax profit of livestock product processing firms.

When analyzing the interaction effects between input variables on after-tax profit, the authors found that the combination of total labor cost and financial cost, as well as the combination of administrative expenses and cost of goods sold, have statistical significance and negative correlation coefficients. This implies that inefficient production processes or constraints that prevent livestock product processing enterprises from achieving their potential profit may stem from ineffective human resource management in balancing financial costs and suboptimal management costs, leading to unfavorable cost of goods sold for the business. Conversely, the combination of total labor cost and selling expenses, administrative expenses and financial cost, and selling expenses and cost of goods sold all exhibit statistically significant positive association coefficients with after-tax profit. These findings suggest that certain operational and financial factors

Table 5 Technical efficiency of Vietnam animal product processing enterprises

Min	Mean	Max	Std. Dev
0,001	0,363	0,769	0,164

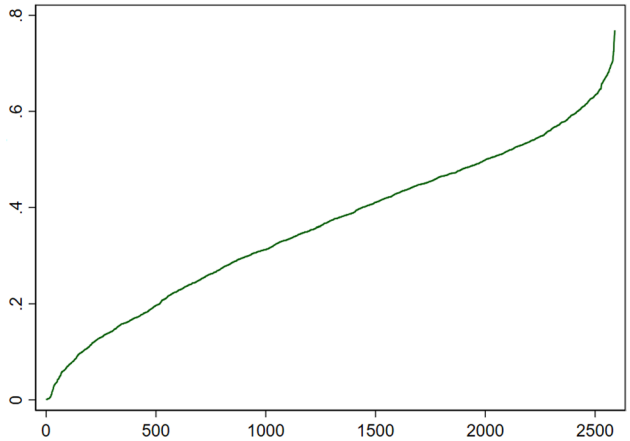

Fig. 2 Technical efficiency of Vietnam livestock product processing enterprises

are positively correlated with after-tax profit, indicating that as these expenses or costs rise, the firm's profitability tends to improve. This finding is consistent with discovery of [26, 77] regarding the positive relationship between the efficiency of operating costs and financial resources and after-tax profitability.

The after-tax profit of the business is also influenced by the type and size of the enterprise. Both of these factors have statistically significant negative correlation coefficients. Specifically, it can be observed that as the size of the business increases (the number of employees in the enterprise grows), holding other factors constant, the after-tax profit of the business will decrease significantly. This partially reflects those businesses have not yet achieved economies of scale or cost advantages. This phenomenon may occur because as businesses expand their scale, they encounter difficulties in management and operation, or some activities inherently cannot achieve maximum efficiency on a large scale. Furthermore, technical infrastructure may not always be available in sufficient quantities, restricting the enterprise's growth.

The results of the calculation of the estimate of the Translog production function in Table 5 and Fig. 2 show that the average TE of the livestock product processing enterprises in Vietnam in 2020 reached 36.3%. Therefore, although they belong to the key manufacturing sector, their production efficiency falls short of meeting expectations regarding their role and position in the national economy, as actual output only reaches approximately 36% of potential output. This may be due to the businesses lacking the necessary technology to increase productivity and improve operational efficiency, as well as a lack of appropriate operational and management mechanisms. Furthermore, the inadequate technological efficiency of these companies may be the result of disadvantages related to the business environment, economic institutions, and governmental administrative procedures. Therefore, to improve the TE of companies, efforts from companies alone are insufficient. It requires the attention and support of both government and policy makers.

4.2 Impact of the state's role on the TE of livestock product processing enterprises

To comprehensively evaluate the influence of the state's role on the TE of livestock processing enterprises in Vietnam, the study conducted an analysis of the state's impact in 2020 on the TE of livestock processing enterprises.

Table 6 presents the influence of the expected impact of five indicators of government role in the development of TE of Vietnam's livestock product processing. Most of the indicators are expected to have statistically significant effects on the TE of companies. Notably, although the current operations and regulations do not currently have an impact, they are expected to have a negative impact on the businesses' TE in the future. On the contrary, inspection, testing, and violation handling indicators are expected to change from having a statistically significant negative impact to having no statistically significant impact.

When controlling for the additional effects of two control variables, namely business type and business scale, the regression results mentioned above do not change significantly. The expected impact of ENVI and ENACT still has positive and statistically significant correlation coefficients with the TE of the businesses, with coefficients of 0.050 and

Table 6 Estimation of the role of the state on the technical efficiency of Vietnam livestock product processing enterprises

	Model (1)		Model (2)		Model (3)	
	Coef.	Std. Err	Coef.	Std. Err	Coef.	Std. Err
ENVI	0.053**	0.016	0.050**	0.015	0.033	0.027
STRAT	− 0.097***	0.011	− 0.081***	0.012	− 0.096***	0.021
ENACT	0.061***	0.014	0.044**	0.014	0.032	0.024
MONI	− 0.095***	0.016	− 0.087***	0.016	− 0.087**	0.029
AUDI	− 0.026	0.020	− 0.016	0.020	0.009	0.036
Type						
Cooperative			0.256***	0.050	0.176*	0.093
State-owned			0.010	0.047	− 0.079	0.087
Foreign			0.053	0.090	− 0.209	0.171
Size						
Small			0.057**	0.020	0.026	0.034
Medium			0.133***	0.034	0.053	0.067
Large			0.254***	0.026	0.109*	0.055
Age					− 0.023*	0.011
Age^2					0.002*	0.000
Gender					0.046	0.037
Utilize software					0.012	0.031
Apply					− 0.071*	0.038
Innovation					− 0.103*	0.044
Constant	-0.361***	0.009	− 0.463***	0.047	0.343	0.310

*, **, *** represents the 10%, 5% and 1% significance level

0.044, respectively. The positive impact similarity of environmental establishment with TE has been identified in studies by [21, 71, 72]. These studies collectively indicate that the creation of a conducive environment is essential for keeping pace with technology [21] or reinforcing corporate confidence in legal systems and social welfare to attract investment for development and innovation [53]. This is indeed crucial for promoting the livestock processing industry in Vietnam. Similarly, the effectiveness of formulation and enforcement of institutional identity positively influences TE of businesses. This finding aligns with the research of [29, 45]. Placed within the context of macroeconomic conditions, the uncertainty of economic policies hampers the tax incentives that the state issues to promote TE [79]. In other words, the inefficiency in the formulation of administrative policies acts as a barrier to the enhancement of TE.

On the other hand, STRAT and MONI to the livestock products processing development are expected to have a statistically significant negative correlation with the businesses'TE. Specifically, a 1% increase in STRAT and MONI is expected to lead to an approximate 8% decrease in the businesses'TE. Interestingly, these results contrast with the findings of Najib et al. [50] in their study on SMEs in Indonesia. While Najib et al. [50] indicate that state market orientation has enhanced the innovation behavior of SME clusters as they integrate and broaden information flows to benefit from collaborative actions, thereby improving business efficiency, this study points out otherwise. In Vietnam, the application of advanced technology or key technologies remains limited and lacks coherence in enterprises [41]. Therefore, the state-directed strategy has not been able to fully leverage the expected effectiveness in enhancing TE. This is because as Kelly et al. [38] has demonstrated that the implementation of key technologies at the farm level and the parallel national strategic direction have an impact on TE. Moreover, these results indicate the existence of subjectivity, lack of determination and misalignment with practicality in the process of strategic development, direction setting, and operational regulation of the development of livestock products processing in Vietnam.

At this stage, the results also show that the business scale is expected to have a positive influence on the TE. Numerous studies have also indicated similarly positive results in the relationship between TE and the scale of enterprises such as [16, 44]. As the scale of the business increases and the number of employees within the business grows, the TE is expected to improve. Furthermore, businesses belonging to cooperatives types are likely to have a positive impact on TE.

When controlling for all control variables, the results indicate that in the future the impact of ENVI and ENACT will no longer be significant for TE. However, STRAT and MONI are still expected to have the potential to reduce the TE.

Table 7 Effects of simultaneous effects of the state's role on the TE of Vietnam livestock product processing enterprises

	Coeff.	Std. Err
Role	0.019*	0.008
Type		
Cooperative	0.242**	0.090
State-owned enterprises	− 0.076	0.084
Foreign enterprises	− 0.211	0.174
Size		
Small	0.043	0.034
Medium	0.088	0.066
Large	0.146**	0.054
Age	− 0.023*	0.011
Age^2	0.002*	0.000
Gender	0.037	0.037
Utilize software	0.021	0.032
Automation	− 0.063*	0.038
Innovation	− 0.083*	0.043
Constant	0.264	0.309

*, **, *** represents the 10%, 5% and 1% significance level

Additionally, enterprises classified as cooperatives and private enterprises are expected to have positive and negative impacts, respectively, on the TE of firms. Nevertheless, the firm size is likely to no longer have a strong impact on the TE as before. The firm size only significantly increases the TE if the firm has over 200 employees. The nonlinear impact from the owner's age on the TE is expected to maintain the current trend, gradually shifting from negative to positive over time. Specifically, the "Owner age" variable and its associated coefficients (-0.023) suggest a relationship between the age of the owner and technical efficiency. The negative coefficient (-0.023) for "Age" indicates that as the owner's age increases, there is a statistically significant decrease in TE. Meanwhile, the positive coefficient for "Age2" suggests that the rate of decrease in TE with increasing age is diminishing, although it is very small. This implies that while older owners may exhibit lower technical efficiency, the rate of decline becomes less pronounced as they age further. The application of automation and innovation by businesses is also believed to contribute to a decrease in their TE. This partially implies that the current implementation of automation and innovation by businesses is not yet truly effective, and if they continue to follow the current methods and approaches, it will only further reduce their TE.

When considering the expected impact, the simultaneous impact of the government role indicators is expected to still have a statistically significant positive effect in the future (Table 7). Specifically, when this simultaneous impact increases by 1%, it is expected that the TE of the businesses will increase by 1.9%, which is expected to be less significant than the current impact ($0.019 < 0.059$).

In terms of control variables, enterprise entities in cooperatives and large scale are predicted to have a favorable impact on the enterprise's TE. Furthermore, the age of the business owner, the installation of automation, and the application of innovation inside the firm are expected to maintain their existing patterns and effect directions. While the negative impact of automation grows, the negative impact of innovation decreases. To improve technological efficiency, medium and small-sized livestock products processing enterprises in Vietnam should prioritize investment in innovation and creativity in management and production processes, rather than relying primarily on automation in processing and manufacturing.

5 Conclusion and policy implications

This study estimates the role of the state in the TE of livestock product processing enterprises in Vietnam with aim toward both sustainbale govermental acts and industry. The data includes 2590 enterprises in 2020 across all 63 provinces and cities in Vietnam. According to the research findings, the overall TE in the processing of livestock products in Vietnam is estimated at 36,3%. This indicates that approximately 63% of the maximum production capacity in the processing of livestock products remains untapped in Vietnam. Clearly, there is a significant scope for improving TE. The analysis of the

state's role reveals that the inefficiency issue stems from the lack of synchronization among the five roles of the state, including ENVI, ENACT, STRAT, MONI, and AUDIT. Moreover, this study has shown the close-knit relationship between 5 main state role and TE in the livestock product processing industry.

The essence of developing the livestock product processing industry lies in enhancing the TE of the enterprises. This implies that simultaneous impacts of the five roles of the state should target the management capacity and organization of processing enterprises. Promoting state interventions aimed at improving TE in the processing of livestock products tends to generate inclusive growth, sustainable development, and achieve goals related to food security, poverty eradication, and address challenges in the development of agriculture, rural areas, and farmers. From the research results, the research paper aims to derive policy implications for the state equivalent to its roles. Specifically, the solutions comprise five groups: a group of solutions to create a favorable business environment; solutions to enhance the effectiveness of orientation and development strategy formulation; solutions to improve the efficiency in policy formulation and enforcement organization; enhance the efficiency of regulating the development process; and a group of solutions to improve the efficiency of inspection, examination, and violation handling. In establishing a conducive environment for businesses such as investment, production, and attracting investment capital, firstly, the state must research and develop innovative and unique policies for the development of livestock and poultry processing industries. Secondly, support for enterprises across all economic sectors, especially the development of large private companies in processing and trading renowned livestock products on an international scale, such as chicken and pork. Thirdly, encourage the development of small and medium-sized livestock and poultry processing enterprises to consume products locally for farmers; refine investment attraction policies for each region with specific characteristics of regions, industries, and sectors. Fourthly, reconsider the elimination of unnecessary and irrational administrative barriers, procedures, and business conditions; support businesses and promote healthy competition. Fifthly, establish a production environment for raw materials, develop production-processing linkages, and promote the consumption of processed livestock products, as well as construct favorable policy mechanisms to attract investment for product structure transformation. Furthermore, the state needs to enhance the development of related support services in building a comprehensive innovation system. This is evident in the continuous innovation and improvement of policies such as land, finance, credit and insurance, trade policies, and integration. Additionally, transparency and public disclosure in the issuance and implementation of policies for the development of livestock product processing technology need to be enhanced. In the role of management and regulation of the development process of livestock product processing industries, the state should strengthen economic integration, expand the market for agricultural processing industries to improve the efficiency and effectiveness of sector management. Simultaneously, there is a need for timely action in the state's role in inspecting, examining, and handling violations in the livestock product processing industry in Vietnam to ensure quality and compliance with international standards.

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Data availability Data will be available corresponding author upon reasonable request.

Declarations

Competing interests The authors declare no competing interests.

Appendix 1

See Table 8 here.

Table 8 Definition of variable

Variables	Definition
Profit	Profit after tax
Cost	
Labor	Labor cost
Administrative	Administrative cost
Financial	Financial cost
Selling	Selling cost
Goods sold	Cost of goods sold
Type	Type of enterprise (1 = State-owned, 2 = Cooperatives, 3 = Private, 4 = Foreign)
Size	Size of enterprise (1 = Super, 2 = Small, 3 = Medium, 4 = Large)
Age	Age of owner/manager
Gender	Gender of owner/manager (1 = Male, 2 = Female)
Utilize software	Enterprise utilize software or not (1 = Yes, 2 = No)
Apply automation	Enterprise apply automation or not (1 = Yes, 2 = No)
Innovative	Enterprise have innovative practices or not (1 = Yes, 2 = No)
Role	Stimultaneous impact of the content showing the role of the state in 2020
ENVI	Environmental effect
STRAT	Strategic orientation effect
ENACT	The policy enactment and enforcement effect
MONI	Operational regulation effect
AUDIT	Compliance auditing and violation handling effect

References

1. Acemoglu D, Autor D. Skills, tasks and technologies: Implications for employment and earnings. Handbook of Labor Econ. 2011;4:1043–171.
2. Ahlborg H. Towards a conceptualization of power in energy transitions. Environ Innov Soc Trans. 2017;25:122–41.
3. Aigner D, Schmidt P, Lovell C. Formulation and estimation of stochastic frontier production function models. J Econ. 1977;6(1):21–37.
4. Ajibefun IA, Daramola AG, Falusi AO. Technical efficiency of small scale farmers: an application of the stochastic frontier production function to rural and urban farmers in Ondo State. Nigeria Int Econ J. 2006;20(1):87–107.
5. Akram-Lodhi AH. Vietnam's agriculture: processes of rich peasant accumulation and mechanisms of social differentiation. J Agrar Chang. 2005;5(1):73–116.
6. Ametepey O, Aigbavboa C, Ansah K. Barriers to successful implementation of sustainable construction in the Ghanaian construction industry. Proced Manuf. 2015;3:1682–9.
7. Athukorala W. Identifying the role of agricultural extension services in improving technical efficiency in the paddy farming sector in Sri Lanka. Sri Lanka J Econ Res. 2017;5:63–78.
8. Avelino F, Grin J, Pel B, Jhagroe S. The politics of sustainability transitions. J Environ Planning Policy Manage. 2016;18(5):557–67.
9. Barreca F, Cardinali GD. ITACAFood: a model to certificate the sustainability of food processing facilities. Sustainability. 2019;11(17):4601.
10. Becchetti L, Bedoya DAL, Paganetto L. ICT investment, productivity and efficiency: evidence at firm level using a stochastic frontier approach. J Prod Anal. 2003;20:143–67.
11. Bhatt P, Ahmad AJ, Roomi MA. Social innovation with open source software: user engagement and development challenges in India. Technovation. 2016;52:28–39.
12. Biswas B, Mallick B, Roy A, Sultana Z. Impact of agriculture extension services on technical efficiency of rural paddy farmers in southwest Bangladesh. Environ Chall. 2021;5: 100261.
13. Bloom N, Garicano L, Sadun R, Van Reenen J. The distinct effects of information technology and communication technology on firm organization. Manage Sci. 2014;60(12):2859–85.
14. Buckley JA. Food safety regulation and small processing: a case study of interactions between processors and inspectors. Food Policy. 2015;51:74–82.
15. Chan S-G, Aktan B, Burton B, Koh EH. The impact of soft information and institutional quality on foreign bank efficiency: evidence from ASEAN-5 countries. Int Rev Econ Financ. 2021;74:23–32.
16. Charoenrat T, Harvie C, Amornkitvikai Y. Thai manufacturing small and medium sized enterprise technical efficiency: evidence from firm-level industrial census data. J Asian Econ. 2013;27:42–56.
17. Chen Q, de Soto BG, Adey BT. Construction automation: research areas, industry concerns and suggestions for advancement. Autom Constr. 2018;94:22–38.
18. Choi S, Yoo J. The impact of technological innovation and strategic CSR on firm value: implication for social open innovation. J Open Innov. 2022;8(4):188.
19. Clayton DA, Griffith CJ, Price P, Peters AC. Food handlers' beliefs and self-reported practices. Int J Environ Health Res. 2002;12(1):25–39.
20. Dai Y, Hou J, Li X. Industry policy, cross-region investment, and enterprise investment efficiency. Res Int Bus Financ. 2021;56: 101372.

21. Das GG, Drine I. Distance from the technology frontier: How could Africa catch-up via socio-institutional factors and human capital? Technol Forecast Soc Chang. 2020;150: 119755.
22. Deborah AC, Christopher JG. Observation of food safety practices in catering using notational analysis. British Food J. 2004;106(3):211–27.
23. Dong F, Hennessy DA, Jensen HH, Volpe RJ. Technical efficiency, herd size, and exit intentions in US dairy farms. Agric Econ. 2016;47(5):533–45.
24. Dutilly C, Alary V, Bonnet P, Lesnoff M, Fandamu P, De Haan C. Multi-scale assessment of the livestock sector for policy design in Zambia. Journal of Policy Modeling. 2020;42(2):401–18.
25. Fielding L, Ellis L, Beveridge C, Peters AC. An evaluation of HACCP implementation status in UK small and medium enterprises in food manufacturing. Int J Environ Health Res. 2005;15(2):117–26.
26. Gaertner FB. CEO after-tax compensation incentives and corporate tax avoidance. Contemporary Accounting Research 2014;31(4):1077–1102.
27. Gassmann O, Enkel E, Chesbrough H. The future of open innovation. R&D Management. 2010;40(3):213–21.
28. Goto M, Tsutsui M. Technical efficiency and impacts of deregulation: an analysis of three functions in US electric power utilities during the period from 1992 through 2000. Energy Economics. 2008;30(1):15–38.
29. Griffith GR, Moore WB. Livestock production policies and meat processing margins: the case of New Zealand, 1967–1988. Aust J Agric Econ. 1991;35(1):21–48.
30. Gupta AK, Dey AR, Shinde C, Mahanta H, Patel C, Patel R, Verma S. Theory of open inclusive innovation for reciprocal, responsive and respectful outcomes: coping creatively with climatic and institutional risks. J Open Innov. 2016;2(3):16.
31. Habibah Abdul Talib H, Anuar Mohd Ali K, Idris F. Critical success factors of quality management practices among SMEs in the food processing industry in Malaysia. J Small Bus Enterp Dev. 2014;21(1):152–76.
32. Hagedoorn J. Innovation and entrepreneurship: Schumpeter revisited. Ind Corp Chang. 1996;5(3):883–96.
33. Hassan MU, Iqbal Z, Shakir K. Impact of ICT training and education on women's employability and entrepreneurial skills: Achieving the sustainable development goals. Int J Bus Forecast Mark Intell. 2020;6(2):157–66.
34. Hornum ST, Bolwig S. A functional analysis of the role of input suppliers in an agricultural innovation system: the case of small-scale irrigation in Kenya. Agric Syst. 2021;193: 103219.
35. Jeong H, Shin K, Kim E, Kim S. Does open innovation enhance a large firm's financial sustainability? A case of the Korean food industry. J Open Innov. 2020;6(4):101.
36. Johnson LD, Pazderka B. Firm value and investment in R&D. Manag Decis Econ. 1993;14(1):15–24.
37. Kaswanto GN, Waluyati LR. Performance and efficiency of village unit co-operatives in Madiun Regency. J Agribusiness Manag Dev. 2018;1(1):117–27.
38. Kelly P, Shalloo L, Wallace M, Dillon P. The Irish dairy industry–recent history and strategy, current state and future challenges. Int J Dairy Technol. 2020;73(2):309–23.
39. Klapper L, Laeven L, Rajan R. Entry regulation as a barrier to entrepreneurship. J Financ Econ. 2006;82(3):591–629.
40. Korauš A, Haviernikova K, Gombar M, Černak F, Felcan M. Dimensions and their elements affecting the innovative activities of agricultural SMEs toward their sustainable development. Entrep Sustain Issues. 2020;8(2):1142.
41. Le V, Vu XB, Nghiem S. Technical efficiency of small and medium manufacturing firms in Vietnam: a stochastic meta-frontier analysis. Econ Anal Policy. 2018;59:84–91.
42. Lee E. Information, interest intermediaries, and regulatory compliance. J Public Adm Res Theory. 2011;21(1):137–57.
43. Lin B, Luan R. Do government subsidies promote efficiency in technological innovation of China's photovoltaic enterprises? J Clean Prod. 2020;254: 120108.
44. Lundvall K, Battese GE. Firm size, age and efficiency: evidence from Kenyan manufacturing firms. J Dev Stud. 2000;36(3):146–63.
45. Malesky E, Taussig M. Out of the gray: the impact of provincial institutions on business formalization in Vietnam. J East Asian Stud. 2009;9(2):249–90.
46. Mazungunye PP, Punt C. Industrialisation for structural transformation: economy-wide impacts of agro-processing development in Tanzania. Dev South Afr. 2022;39(3):400–23.
47. Meeusen W, van den Broeck J. Technical efficiency and dimension of the firm: some results on the use of frontier production functions. Empirical Economics. 1977;2:109–22.
48. Min BS, Smyth R. How does leverage affect R&D intensity and how does R&D intensity impact on firm value in South Korea? Appl Econ. 2016;48(58):5667–75.
49. Mirabelli G, & Solina V. Blockchain and agricultural supply chains traceability: Research trends and future challenges. Procedia Manufacturing 2020;42:414–421.
50. Najib M, Kiminami A, Yagi H. Competitiveness of Indonesian small and medium food processing industry: does the location matter? Int J Business Manag. 2011;6(9):57.
51. Neethirajan S, Kemp B. Digital livestock farming. Sensing Bio-Sensing Res. 2021;32: 100408.
52. Nguyen CH, Nguyen AT, Truong QH, Dang NT, Hens L. Natural resource use conflicts and priorities in small islands of Vietnam. Environ Dev Sustain. 2022;24(2):1655–80.
53. Nguyen-Anh T, Hoang-Duc C, Nguyen-Thi-Thuy L, Vu-Tien V, Nguyen-Dinh U, To-The N. Do intangible assets stimulate firm performance? Empirical evidence from Vietnamese agriculture, forestry and fishery small-and medium-sized enterprises. J Innov Knowl. 2022;7(3):100194.
54. Nguyen VC, Nguyen TNL, Pham TH, & Vu SH. The impacts of selling expense structure on enterprise growth in large enterprises: A study from Vietnam. Journal of Risk and Financial Management 2019;13(1):4.
55. Ochs DS, Wolf CA, Widmar NJ, Bir C. Consumer perceptions of egg-laying hen housing systems. Poult Sci. 2018;97(10):3390–6.
56. Oke AE, Aliu J, Fadamiro PO, Akanni PO, Stephen SS. Attaining digital transformation in construction: an appraisal of the awareness and usage of automation techniques. J Build Eng. 2023;67:105968.
57. Partzsch L. 'Power with'and 'power to'in environmental politics and the transition to sustainability. Environ Politics. 2017;26(2):193–211.
58. Pedersen T, Scedrova A, Grecu A. The effects of IT investments and skilled labor on firms' value added. Technovation. 2022;116: 102479.

59. Pingali P. Westernization of Asian diets and the transformation of food systems: implications for research and policy. Food Policy. 2007;32(3):281–98.
60. Poapongsakorn N. R&D and performance of the Thai agriculture and food processing industry: the role of government, agribusiness firms, and farmers. Agricultural development, trade regional cooperation in developing East Asia. 2011; 401–475.
61. Porter ME. New global strategies for competitive advantage. Plan Rev. 1990;18(3):4–14.
62. Pourzand F, Bakhshoodeh M. Technical effici ency and agricultural sustainability–technology gap of maize producers in F ars province of Iran. Environ Dev Sustain. 2014;16:671–88.
63. Purmiyati A, Handoyo RD. Technical efficiency analysis: Management factor as determinants of saving and credit cooperatives' health. J Co-operative Org Manag. 2022;10(2): 100186.
64. Quan C, Yu S, Cheng X, Liu F. Comprehensive efficiency evaluation of social responsibility of Chinese listed logistics enterprises based on DEA-Malmquist model. Oper Manag Res. 2022;15(3):1383–98.
65. Rahman K, Mia M, Bhuiyan M. A stochastic frontier approach to model technical efficiency of rice farmers in Bangladesh: an empirical analysis. Agriculturists. 2012;10(2):9–19.
66. Roseland M. Sustainable community development: integrating environmental, economic, and social objectives. Prog Plan. 2000;54(2):73–132.
67. Scrase I, Smith A. The (non-) politics of managing low carbon socio-technical transitions. Environ Politics. 2009;18(5):707–26.
68. Serra R, Kiker GA, Minten B, Valerio VC, Varijakshapanicker PW, Abdrahmane. Filling knowledge gaps to strengthen livestock policies in low-income countries. Glob Food Sec. 2020;26: 100428.
69. Shanti MZ, Cho C-S, de Soto BG, Byon Y-J, Yeun CY, Kim TY. Real-time monitoring of work-at-height safety hazards in construction sites using drones and deep learning. J Safety Res. 2022;83:364–70.
70. Swyngedouw E. Impossible sustainability and the post-political condition. Making Strat Spat Planning. 2010. https://doi.org/10.1007/978-90-481-3106-8_11.
71. Tateishi HR, Bragagnolo C, de Faria RN. Economic and environmental efficiencies of greenhouse gases' emissions under institutional influence. Technol Forecast Soc Change. 2020;161:120321.
72. Theriault V, Serra R. Institutional environment and technical efficiency: a stochastic frontier analysis of cotton producers in West Africa. J Agric Econ. 2014;65(2):383–405.
73. Tung DT. Measuring the technical efficiency of livestock production in Vietnam. Outlook on Agriculture. 2016;45(2):132–139.
74. Turovets Y. Intangible assets and the efficiency of manufacturing firms in the age of digitalisation: the Russian case. Eng Manag Prod Serv. 2021;13(1):7–26.
75. Uri ND. Technical efficiency, allocative efficiency, and the implementation of a price cap plan in telecommunications in the United States. J Appl Econ. 2001;4(1):163–86.
76. Volchek D, Jantunen A, Saarenketo S. The institutional environment for international entrepreneurship in Russia: reflections on growth decisions and performance in SMEs. J Int Entrep. 2013;11:320–50.
77. Vintilă G, Gherghina ŞC, & Păunescu RA. Study of effective corporate tax rate and its influential factors: Empirical evidence from emerging European markets. Emerging Markets Finance and Trade 2018;54(3):571–590.
78. Vuong TT, Semerák V, Vuong QH. The Vietnamese economy at the crossroads. Southeast Asia ASEAN Econ Commun. 2019;2019:91–143.
79. Wan Q, Chen J, Yao Z, Yuan L. Preferential tax policy and R&D personnel flow for technological innovation efficiency of China's high-tech industry in an emerging economy. Technol Forecast Soc Chang. 2022;174: 121228.
80. Worosz MR, Knight AJ, Harris CK, Conner DS. Barriers to entry into the specialty red meat sector: the role of food safety regulation. J Rural Soc Sci. 2008;23(1):8.
81. Yitayaw MK. Determinants of profitability and financial sustainability of saving and credit cooperatives in Eastern Ethiopia. Int J Rural Manag. 2021;17(2):239.