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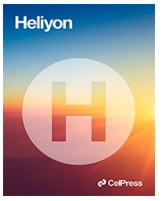

Research article

Assessing sugarcane farmers' intentions towards World Trade Organisation-driven sugar sector policy reforms in Thailand

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ABSTRACT

Given the importance of the sugarcane sector, reforms could significantly affect the structure and economy of Thai agriculture. This study evaluates the intended responses of Thai sugarcane farmers to a set of policy reforms informed by the 2016 World Trade Organization (WTO) dispute, which requires the liberalisation of Thailand's sugar sector. A mixed-methods approach, beginning with stakeholder consultations, was used to design three policy scenarios: (1) *government proposal* (2016 government reform proposals), (2) *protectionism* (higher support), and (3) *libertarian* (lower support). A survey of 462 farmers stratified by region and farm size was conducted to assess their intention to continue or exit sugarcane farming under each scenario. The results indicated that reforms, particularly under the *libertarian* scenario, could significantly reduce the number of sugarcane farmers and production areas. Approximately half (48.7 %) of the respondents indicated an intention to exit under this scenario, compared to 32.3 % under the *government proposal* and 22 % under *protectionism*. Farmers' decisions were generally binary, either maintaining the status quo or exiting entirely, with exits increasing as the support cuts deepened. Responses varied by farm size and specialisation level, with small, less-specialised farms being the most vulnerable under the *government proposal* and *protectionism* scenarios. Conversely, medium-sized farms were the most adversely impacted under the *libertarian* scenario (56.5 % indicating exit). Probit regression identified additional determinants of exit intentions, including sex, farming experience, region, harvesting and transportation methods, and the presence of a family successor and farm advisor. These findings provide crucial insights for policymakers aiming to balance WTO compliance with the sustainability of Thailand's sugarcane sector. This is the first study to incorporate stakeholder-designed policy scenarios, offering a realistic projection of farmers' responses to hypothetical, WTO-compliant reforms.

1. Introduction

As of 2019, Thailand ranks 5th in sugar production and 2nd in exports globally, with 80 % of its output sold overseas, contributing 13 % to the global sugar trade [1]. The Thai sugar industry is export-driven and contributes significantly to foreign exchange earnings. The sector generated an average annual revenue of $2.7 billion between 2016 and 2020, accounting for 17 % of the agricultural GDP contribution [2]. As the primary raw material for sugar production, sugarcane is a crucial cash crop that supports approximately 430,

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000 Thai farming households [3].

Between 2008 and 2019, the cultivated areas expanded by 74 %, increasing from 1.1 million hectares (ha) to 1.9 million ha, covering approximately 8 % of total agricultural land [4]. This is driven by several factors, including favourable geography, climate, and the high value of sugarcane [5]. However, the Thai government was the key driver. From 2006 to 2015, Thai sugarcane production increased by 123 % (approximately 47 million tonnes), thereby increasing sugar export availability. To further drive growth in sugarcane production, the 10-Year Cane and Sugar Plan (2015–2026) has been established to increase sugarcane production to 180 million tonnes, reinforcing Thailand's global market position [6]. However, government export subsidies have led other producers to challenge Thailand at the World Trade Organization (WTO). In 2016, the WTO initiated a settlement urging Thailand to reform its sugar sector regime [7].

As a WTO member, Thailand is obligated to comply with WTO agreements. Thus, the Thai government overhauled its sugar sector to advance the industry towards a more liberalised market. Thailand began a reform process for its domestic sugar regime in 2016 to comply with the WTO requirements, targeting certain regulatory modifications and amending the Cane and Sugar Act of 1984. While the WTO dispute was resolved in March 2024 owing to adjustments made by the Thai government [8], not all commitments have been finalised at the time of writing. Moreover, the Thai government recognises that any further changes to the adopted policy regime must also meet WTO objectives, as failure to comply could directly affect the Thai sugar sector's ability to engage in the global market. Thus, sugar sector reform remains a crucial policy priority. Given the sector's historical reliance on protectionist policies, a shift toward a liberalised market could reduce farm income and increase volatility, resulting in significant structural changes in the sugarcane sector. Therefore, understanding the effect of policy on farmers and production is crucial for future policy adjustments.

Macroeconomic modelling is commonly used for policy analysis, offering insights into the broader impacts of policy changes on farming and land use. However, it often neglects the nuanced behaviours of farmers, which are essential for predicting structural changes, such as exit and land-use decisions, and rural employment impacts in the Thai sugarcane sector. Viaggi et al. [9] highlight that, although such models can evaluate policy effects independently of social and economic factors, they offer a simplified representation of reality and often fail to capture farmers' complex motivations and decision-making processes. A review of past modelling studies reveals that these approaches have frequently overestimated farmers' responses to policy changes. For instance, Breen et al. [10] find that while economic models predicted substantial structural changes following the Common Agricultural Policy (CAP) reform in Ireland, analysis of farmer intention surveys suggested that production would considerably remain unchanged, reflecting the effect of inertia partly because of individual farmer characteristics. Although less common, intention surveys have been shown to align closely with actual behaviour [11–13], making them valuable for understanding potential responses and sugarcane production exit decisions.

Farmers' responses and intentions to continue or exit sugarcane production are influenced by perceived policy reform threats. However, the trajectory of policy reforms and support measures in Thailand remains uncertain. Therefore, this study employs a policy scenario-based approach to assess the potential consequences of reforms within a broader context. Drawing on evidence from the 2003 European Union (EU) CAP reform [14], which assessed the impact of policy scenarios ranging from support maintenance to elimination, this study not only forecasts outcomes but also offers a method for policymakers to explore various policy scenarios.

This study aims to assess sugarcane farmers' intended production responses to stakeholder-designed hypothetical policy reform scenarios and determine the extent to which these intentions may impact key factors, such as the number of sugarcane farmers, cultivated land area, and production volume. Additionally, this study identifies potential threshold points that could trigger significant structural changes. It also examines how structural characteristics such as farm size and specialisation influence these responses and explores the determinants of farmers' intentions to exit sugarcane farming and alternative activities post-exit.

Data on farmer intentions were obtained from a farm-level survey conducted under three different policy reform scenarios: (a) the 2016 reform proposals by the Office of the Cane and Sugar Board (OCSB) (referred to as the '*Government Proposal*' scenario), which involves the removal of domestic sugar price controls while maintaining the existing quota system and farm support measures, albeit with slight modifications; (b) a scenario that maintains the existing market and farm support measures, but with minor adjustments to ensure compliance with WTO commitments (the '*Protectionism*' scenario); and (c) a more radical scenario that eliminates all market and price support measures (the *'Libertarian'* scenario).

The innovative contribution of this study lies in its exploration of Thai sugarcane farmers' responses to reform scenarios, a country context considerably unexplored in the existing literature. Unlike numerous existing studies, which often focus solely on current government policy reform proposals, this study includes two more extreme scenarios that reflect more liberal and protectionist agricultural trade policies, enabling a comprehensive understanding of the impacts of various reform paths. Another unique aspect is the design of these hypothetical policy reform scenarios which are created to be entirely practicable in being compliant with WTO requirements. Finally, this study is the first to incorporate stakeholder input into scenario development, enhancing the scenarios' realism and relevance for policy makers.

The remainder of this paper is organised as follows. Section 2 presents an overview of Thai sugar policy, possible reforms, and relevant literature. Section 3 describes materials and methodology employed. Section 4 presents a description of scenario construction through policy stakeholder consultations, followed by the results of a large-scale farm survey, detailing farmers' responses to these scenarios and analysing the factors influencing their decisions. Finally, Section 5 presents the limitations, conclusion and policy implications of the study.

2. Literature review

2.1. Historic Thai sugar sector policies and possible reform approaches

Prior to the WTO-enforced changes, the Thai sugar policy was highly regulated under the Cane and Sugar Act of 1984. This legislation includes significant instruments such as controls on domestic sugar prices and sugar sales quotas, a price support program, direct farmer payments, low-interest credit services, revenue-sharing guarantees for millers and growers, and a border protection mechanism [15,16]. According to Meriot [15], in 2013, the Thai government allocated $1.3 billion to support sugarcane productions, with approximately 60 % allocated to indirect support through domestic sugar price controls and 40 % to direct farmer payments. The direct payment to farmers alone, at $634 million (19.028 billion baht) was closely equivalent to Thailand's allowable subsidies under the Uruguay Round Agreements Act (URAA) for the entire agricultural sector, suggesting a significant dependency of Thai sugarcane producers on government support [17].

In response to complaints by other member countries at the WTO, the Thai government enacted a sector restructuring plan in 2016, amending the Cane and Sugar Act of 1984. This plan aimed to reduce state support by eliminating fixed direct farmer payments, removing domestic sugar price controls, and revising the sugar sales quota system [18]. Despite the government's reform proposals, uncertainty remains regarding the final outcomes and future policy directions. Thus, identifying alternative reform approaches is essential for making *ex ante* assessments of the sugarcane sector in a broader context. Rooted in international trade policy analysis, the contrasting philosophies of agricultural protectionism and liberalisation were employed to establish the two alternative approaches in this study.

Central to the WTO trade policy agenda, agricultural liberalisation promotes more competitive markets and freer trade among countries by improving market access, reducing domestic subsidies, and eliminating export subsidies. As suggested by orthodox trade theories, such as David Ricardo's comparative advantage theory, liberalisation increases global economic welfare through efficient resource use and higher output [19,20]. However, to support middle-income countries, WTO agreements offer Special and Differential Treatments (SDT) that provide more time and favourable terms for trade commitments, including less aggressively bound tariff rates and exemptions for support [21].

Despite strong theoretical support for liberalisation, its implementation in agriculture has been slow compared to other sectors, particularly in lower and upper middle-income countries where agriculture is crucial for economic development. Countries such as Thailand, where 30 % of the labour force and 47 % of land resources are dedicated to agriculture, are considered critical for ensuring food security and shielding domestic production from foreign competition [22]. Agricultural protectionism is often justified by the sector's vulnerability to seasonal fluctuations, long production cycles, and climate risks, leading to widespread practices such as tariffs, quotas, subsidies, and other trade barriers designed to stimulate internal production and safeguard exports [23].

2.2. Assessing sugar sectoral policy reforms of major exporter countries

Despite the foundational liberalisation principles of the WTO's multilateral agreements, agricultural trade liberalisation remains a significant challenge. In particular, the sugar sector reforms have made limited progress. Consequently, research addressing the impact of sugar policy reforms towards liberalisation and their effects on producer behaviour remains sparse. The two most notable examples of market liberalisation occurred in Australia in the early 2000s and the EU in 2006. Rezbova et al. [24] and Benesova et al. [25] indicated that the full liberalisation of the EU sugar market triggered a significant reduction in both the numbers of farmers and production volumes, reshaping the industry's global position. Similar findings were observed in Queensland, Australia, where deregulation was considered unfavourably, as many farmers were deemed economically unviable under such conditions. Consequently, significant structural changes within the sector, such as numerous industry exits and upscaling to achieve economies of scale, were unattainable [26]. In Thailand, previous studies on sugar policy reform are now outdated and have primarily focused on multilateral (which has proven elusive in practice [27]) rather than unilateral trade liberalisation, often through macro-level modelling exercises. These models generally predict positive effects on Thai sugarcane production under hypothetical WTO-compliant regimes. For instance, Itharattana's [28] Computable General Equilibrium model projected a 10 % increase in sugar prices and an 8 % increase in production volumes owing to Thailand's relative agronomic advantages in a fully liberalised market. Country-by-country simulations undertaken by Elobeid and Beghin [29] also revealed that multilateral trade liberalisation and domestic production subsidy reform increased annual Thai sugar production by an average of 0.39 % from 2002 to 2012. However, a few studies focusing on unilateral reforms have found different outcomes. For example, the Organisation for Economic Cooperation and Development (OECD) [30] and Talukder [31] found that eliminating domestic price controls and trade barriers would reduce sugar production by 21–30 %, threatening Thailand's export surplus.

2.3. Farm exit intentions

Recent literature on sugarcane farming exit intentions under policy reforms is limited. However, insights can be drawn from broader research on farm exits. Traditional analyses often assume that farmers' exit decisions are driven solely by rational, profit-based considerations [10,32,33]. A substantial body of literature supports this assumption, indicating that subsidy reductions and eliminations accelerate structural changes in agriculture by increasing the likelihood of farm exits, particularly among less efficient farms. For instance, studies by Viaggi et al. [9], Genius et al. [34], and Latruffe and Le Mouël [35] demonstrated these outcomes in the EU following the 2003 CAP reform. Similar findings were reported by Goetz and Debertin [36], Mishra et al. [37], and Key and Roberts [38] in the US, as well as Peel et al. [39] in Australia. However, these findings are not universal. Other studies suggest that reductions in public financial support only minimally influence farm exits, as farmers often adopt strategies of minimal adjustment in response to aid cuts [10,11,13,40].

Recent analyses have suggested that while reductions in support influence farm exit decisions, these choices are heavily shaped by individual circumstances and farm characteristics [10,41,42]. Historically, the influence of farm heterogeneity on exit decisions has been neglected or treated as a control variable in studies on structural change. However, this variability is now recognised as central to understanding exit decisions, with factors such as farm size and specialisation level playing a vital role [43–47]. For example, Key and Roberts [38] observed that, while government payments were negatively associated with farm exit rates across farm scales between 1978 and 1997, the magnitude of the relationship was greater for larger farms owing to increased profits from government payments. Similarly, Storm and Mittenzwei [48] found that decreased direct payments in Norway led to proportionally greater smaller farms exits.

Highly specialised farms tend to exhibit greater resilience to income loss owing to productivity gains from economies of scale and efficient resource optimisation [43,49]. However, this resilience is often conditional on market stability. Evidence suggests that as markets become more deregulated, resulting in reduced producer support, the ability of highly specialised farms to absorb price shocks diminishes, increasing vulnerability relative to more diversified farms [50–54].

Socioeconomic factors influencing farmer exit decisions include those related to farm structure, such as the amount of labour employed, level of pluriactivity, income from the farm, and level of technological adoption. Additional factors include farmer characteristics such as age, education, family composition, tenure arrangements, identification of a family successor, geographical location, farmer retirement plans, past behaviour, use of advisory services, and availability of extension services [13,34,37,44,45,55–64].

Farm exit decisions are influenced by factors other than economic ones. Based on this, an array of socioeconomic and demographic characteristics was identified for inclusion in this study to assess the determinants of farmers' responses to sugar policy reform.

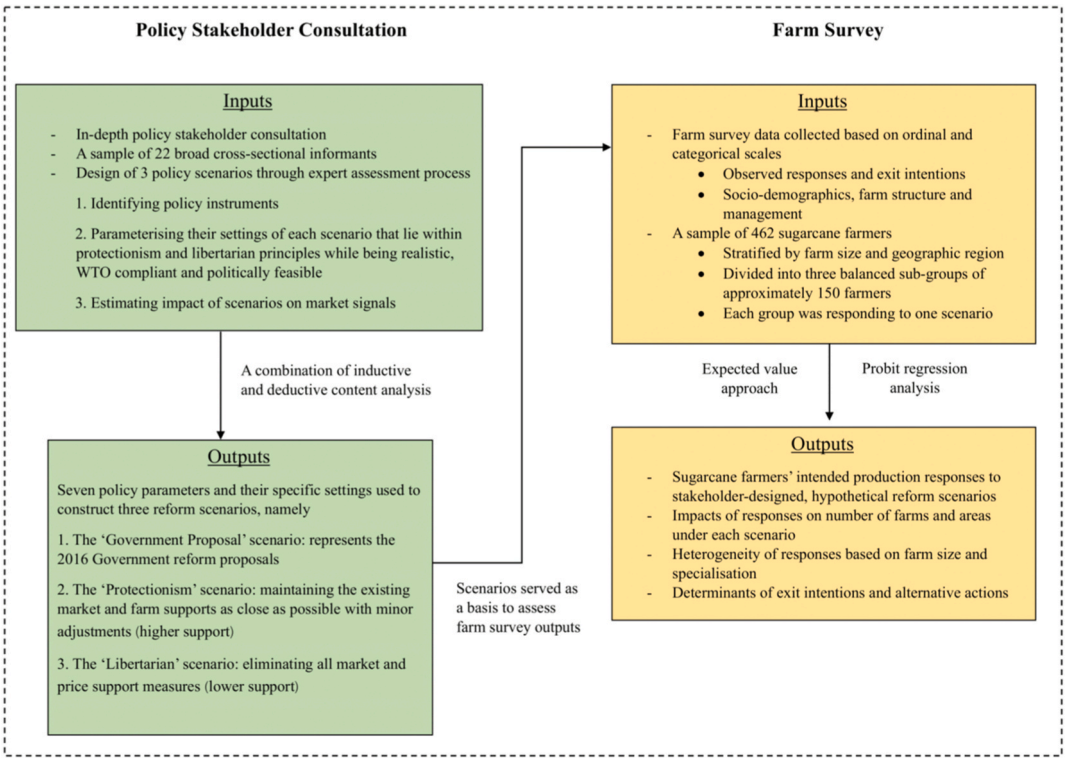

Fig. 1. Research methodology framework.

3. Materials and methods

3.1. Study design, data collection

A mixed methods approach was employed in this study. Fig. 1 presents the research methodology framework. Qualitative data were collected through in-depth interviews as part of consultations with policy stakeholders. These data were then used to construct the policy scenarios used in the quantitative data collection exercise, that is, a survey of farmers.

3.1.1. Policy consultation

To investigate sugarcane farmers' responses to different policy regimes, three hypothetical scenarios were developed using an in-depth policy stakeholder consultation process. A stakeholder sample was drawn using purposive and snowball sampling. Initial stakeholders were identified from the contacts listed on the OCSB website, followed by recommendations from this group, yielding a final sample of 22 key informants. This included nine national-level government officials, four regional officials, one director of a sugar trading organisation, four representatives from non-governmental organisations (including the Office of Cane and Sugar Fund, the Thai Sugar Millers Corporation, and the Thai Cane and Sugar Corporation), two academicians, and two farmer representatives with experience in serving as OCSB committee members. The sample was designed to capture a diverse range of perspectives on policy development and reforms, ensuring that varying perspectives were represented in the three policy scenarios.

Stakeholders were presented with qualitative outlines of the study's scenarios and asked to parameterise them. The *'government proposal'* scenario mirrors the 2016 reform plan proposed by the OCSB, representing a middle-of-the-road policy approach. The *'libertarian'* scenario emphasises agricultural liberalisation, while the *'protectionism'* scenario favours retaining support mechanisms. During the scenario construction, stakeholders were asked to identify policy instruments and settings aligned with protectionist and libertarian principles while ensuring the following constraints: (i) realistic, that is, avoiding extreme positions; (ii) WTO complaint; and (iii) politically feasible. This process involved determining whether a specific instrument, such as a sales quota, should be implemented and how it should be operated within a scenario. Stakeholders were also asked to assess the impact of these policy instruments on market signals, that is, sugarcane prices and supply, which are critical factors in farmer decision-making.

3.1.2. Farmer survey

Farmers' responses to the three policy scenarios were assessed using a large-scale intention survey conducted between May and August 2019. The sampling frame was obtained from a database of 430,817 registered sugarcane farmers held by the OCSB and the Office of Agricultural Economics (OAE) [3]. To ensure representativeness, a quota sampling technique was employed, with stratification based on farm size and geographical region. Farmers were randomly sampled from three farm size categories within each of the 20 provinces distributed across Thailand's four major sugarcane-producing regions (Northern, Northeast, Central, and East). The survey was administered to sugarcane farmers through face-to-face interviews using a structured questionnaire. The survey was primarily conducted at the Regional Cane Farmer Association Centers and supplemented by on-farm visits as necessary, resulting in a final sample of 462 farmers (see Table 1). Participation was voluntary; only farmers who were at least 18 years old and actively farming sugarcane were included. Farmers who discontinued interviews before the end of the study were removed from the sample.

To manage the cognitive load of the survey questions and minimise response times, the sample was divided into three balanced subgroups of approximately 150 farmers, each responding to one policy scenario (see Table 2).

The structured questionnaire collected data on household socio-demographics (e.g., age and education) and farm structure and management (e.g., farm size, level of specialisation, harvesting method and assessing to loans) using ordinal and categorical scales. Farmers were asked to indicate their intended responses for a given scenario, measured on 5-point Likert and semantic differential scales. For example, farmers were asked whether they intended to continue sugarcane farming within the next five years under the given scenario, rating their intention on a scale from 'Definitely Yes' to 'Definitely No'. If the response indicated an intention to exit,

Table 1
Representativeness of the sample – comparison of the distribution of the sample and the target population by stratification dimensions.

Typology	Percentage of farmers in each class	
	Population	Sample
	N = 430,817	n = 462
	Percent	Percent
Farm size class		
Small (<10 ha)	40	43.3
Medium (10–80 ha)	49	43.3
Large (>80 ha)	11	13.4
Region		
North	22	38.3
Central	33	35.7
Northeast	39	19.3
East	6	6.7

Table 2
Sample size in each farm size group under the three scenarios.

Typology	Libertarian	Gov't. Proposal	Protectionism
	Count (Per cent)	Count (Per cent)	Count (Per cent)
Whole sample	154 (33.3)	158 (34.2)	150 (32.5)
Small	62 (40.3)	77 (48.7)	64 (42.7)
Medium	68 (44.2)	63 (39.9)	66 (44.0)
Large	24 (15.6)	18 (11.4)	20 (13.3)

follow-up questions were asked to explore alternative activities. Although farm financial data were also necessary to supplement the survey data, having farmers enter these data themselves could be complex. To estimate the net margin impacts of these scenarios, standard net margins were calculated for various farm size groups within each scenario, using secondary data on sugarcane prices, farm aid received, and farm-size-adjusted cost structures obtained from the OCSB, the Ministry of Industry.

3.2. Analysis

3.2.1. Qualitative data analysis

A combination of inductive and deductive content analyses was employed to examine the interview transcripts and define scenarios in terms of policy parameter settings. Deductive analysis was applied to assess stakeholders' decisions regarding policy settings (e.g., determining whether current policy instruments should be maintained, altered, or discontinued, and evaluating the likelihood of these instruments being implemented in practice). Considering the majority view across all stakeholders, this process established a final set of policy parameters that were both permissible under WTO provisions and politically viable.

Subsequently, an inductive content analysis was conducted to identify specific settings for the policy parameters under each scenario, explore any additional parameters suggested by stakeholders, and capture potential farm price effects. This approach resulted in a comprehensive set of policy parameters and assumptions, which were subsequently used to assess farmers' responses to hypothetical policy scenarios. The NVivo software was used to prepare, organise, and classify the qualitative data to facilitate and structure the analyses.The interview questions and protocol used in the policy consultation can be found in Supplementary Materials.

3.2.2. Quantitative data analysis

To analyse the survey data, two tertiary variables were constructed from the survey questions. The first variable classified farmers based on their intention to continue or exit sugarcane production, whereas the second variable represented the post-decision sugarcane area following that decision.

To construct the first variable, multiple survey questions were used to classify farmers' responses into one of four groups: (i) maintaining the current production area, (ii) decreasing production area, (iii) increasing production area, or (iv) exiting sugarcane production. These classifications were used to construct a second variable. Farmers were not directly asked to estimate their future production area on their farm following the decision because of the potential uncertainty regarding the degree of change. Therefore, the expected-value approach was employed to estimate the post-decision sugarcane area using the available survey data. The detailed methodology for variable construction and area estimation is presented in the Supplementary Materials.

Using a variable that classified farmers based on their intention to continue exit, a probit analysis was conducted to explore the determinants of farmers' exit intentions. The measure of intention (the dependent variable) was represented as a binary variable (y 0,1), where 1 reflects the stated intention to exit and 0 otherwise. Because the independent variables tested in the model were initially collected based on ordinal and categorical scales, they were converted into dummy variables for incorporation into the regression analysis. There are no technical limitations to using dummy variables in a probit model, as this approach is common in studies that categorise factors, such as policy impacts, treatment versus control groups, or the presence versus absence of specific characteristics [65]. However, this approach can introduce the 'dummy variable trap', a form of perfect multicollinearity. To avoid this issue, one category of each dummy variable was dropped and treated as the reference group [66].

Following Finney [67], the functional form of the probit regression model is expressed as Equation (1):

$$Exit_i^* = \beta x_i' + \varepsilon_i \tag{1}$$

$$\varepsilon_i \sim N(0,1)$$

Where survey farmers are indexed by *i*, $Exit_i^*$ represents a latent unobserved variable, which indicates the farmers' intention to exit sugarcane farming; x' represents a vector of 25 explanatory variables used in this model, with values specific to the *i* th farmer; β denotes a vector of the parameters to be estimated; and ε_i represents the stochastic error term, which is assumed to be distributed normally with a mean of zero and standard deviation of one, given the low variation in the dependent variable and reasonable variation in the explanatory variables [66]. We assume that the latent variable $(Exit_i^*)$ is unobserved; that is, it represents the expected utility a person attaches to the exit choice. However, this can be linked to the observed binary variable as follows:

$$Exit_i = \begin{cases} 1 \text{ if } Exit_i^* > 0 \\ 0 \text{ if } Exit_i^* \leq 0 \end{cases} \quad (2)$$

The standard maximum likelihood estimation (MLE) procedure in STATA was used to estimate Equation (2) (see Refs. [66,68]). The interpretation of estimated probit regression coefficients is not as straightforward and useful as that of logit or linear regression coefficients, as it estimates the probability of an event rather than the event itself. The marginal effects for explanatory variables are not constant; they vary based on their observed values [69]. We examined the direction of the impact of independent variables and the relative magnitude of their effects and differences in probabilities. Therefore, average marginal effects (AME) were selected to express these outcomes.

4. Results and discussion

4.1. Policy reform scenarios

Table 3 summarises the seven policy parameters used to structure the three reform scenarios, together with the stakeholder estimates of the specific settings for these policy parameters under each scenario. These scenarios were used in the farm survey to determine the likely responses of farmers to specific policy contexts accurately.

4.2. Farm-level sample

Detailed descriptive statistics for the sample are presented in Table 4. At the time of the survey, three-quarters of the farm primary decision makers were male, over half of farmers had not completed secondary education, and approximately half had over 30 years of sugarcane farming experience. Approximately half of the sample (46 %) were aged 55 years or older, which is consistent with an ageing farming population [22]. Most respondents (89 %) were full-time farmers, and 56 % of farm households relied entirely on farm income. Farm incomes were low relative to other non-agricultural sectors, with 50 % of farmers earning revenue from agriculture under one million baht (approximately $29,400) annually.

Consistent with previous observations [16,70,71], sugarcane farms in the sample were typically small (43.3 % less than 10 ha), with only 13.4 % being large-scale (80 ha or more). Approximately 57 % of the small farms required no hired labour, whereas 90 % of the large farms did. Approximately 63 % of the respondents had identified a family successor, and over half of the sample reported having children under 16 years of age in their family.

A few farms were wholly rented, 44 % were wholly owned, and 46 % were partially owned. Although several farms were small-scale, most specialised in sugarcane farming, with over 75 % of the farmland devoted to this crop and 90 % of the sample reporting continuous sugarcane production. However, approximately one-third of farms had low yields (below 63 tonnes/ha); for comparison, yields in Brazil, Australia, and the U.S. range between 74 and 85 tonnes/ha [15,16,72]. While 9 % of the sample used intermediaries, most farmers (81 %) transported sugarcane directly to mills, with approximately 40 % having farms located within 20 km of a mill.

Farmers in the sample were heavily reliant on loans, with 81 % requiring credit for their daily operations. Many farms rely on the burnt harvesting method rather than the more price-paid green harvesting approach. Regarding advisory services, attending briefing meetings was the most common activity, whereas workshops and farm visits were less frequent. Although 58 % engaged with a farm advisor, two-thirds of these advisors were either family members or neighbours, and only 10 % consulted academic or government sources.

4.3. Projected impacts of the policy scenarios on number of sugarcane farmers and volume of sugarcane production

Table 5 indicates that all reform scenarios would lead to a reduction in the number of sugarcane farmers, leading to a loss of aggregate sugarcane production area. This aligns with studies on similar reforms under the EU CAP, which observed widespread farm exits following CAP payment reductions [14,61,62]. Based on farm net margins derived from supplementary secondary data (see Table 6), the significant reductions in farm numbers and production areas in this study can be attributed to the revenue losses that negatively impact farm net margins. However, the degree of impact varies by scenario. Under the *protectionism* scenario, the proportion of farmers intending to remain in sugarcane production is highest (78.0 %), whereas the *libertarian* scenario is likely to result in the greatest reduction, with approximately half of respondents (48.7 %) expected to exit.

Table 6 indicates that the average sugarcane farm would incur losses under both the *government proposal* and the *libertarian* scenarios. These data explain why the fewest exits occur under the *protectionism* scenario, where average farms can still achieve positive net margins owing to the continuation of domestic market support, albeit in a slightly modified form, with relatively modest subsidy reductions. By contrast, removing domestic support measures and trade restrictions, along with significant cuts to sugarcane prices under the *libertarian* scenario, would drive many farms of all sizes towards negative gross and net margins, triggering them to exit. These findings differ from those of previous studies which suggested that liberalising the sugar regime would positively influence Thailand's sugarcane production [28,29]. This discrepancy may stem from differences in policy specifications, data, estimation approaches, and the use of unilateral rather than multilateral liberalisation scenarios [73,74].

Of those expressing an intention to stay in sugarcane production, the majority indicated that they would not change the scale of

Table 3
Policy parameters describing the three reform scenarios, including stakeholder assumptions about change in prices, aid, and subsidy.

Policy parameters		Reform Scenarios		
		Protectionism	Gov't. Proposal	Libertarian
Sugarcane price effect	Sugarcane price change, relative to a 10-year average (MY 2009/10 - MY 2018/19), resulting from the removal of market distorting policy instruments	−9 %	−23 %	−31 %
Market support measures	Domestic sugar price control	Revised (Allows some responsiveness to global price changes)	Removed (Price floats)	Removed (Price floats)
	Quota system for sugar sales	Revised (Replace Quota A i.e. domestic quota, with 'sugar reserve' as buffer stock for domestic consumption)	Revised (Replace Quota A i.e. domestic quota with 'sugar reserve' as buffer stock for domestic consumption)	Removed
	70:30 revenue-sharing mechanism between farmers and millers	Retained	Retained	Retained
Farm support measures	Sugarcane price support program	Revised	Revised	Removed
	Direct payments to sugarcane farmers (fixed 160 Bath/tonne sugarcane revenue top-up payment)	Revised (rebranding the payment as indirect support for inputs at a flat rate per tonnage basis with no tonnage limitation)	Revised (rebranding the payment as indirect support for inputs at a flat rate per tonnage basis with no tonnage limitation)	Removed
Trade constraints	Import restriction	Maintain the level of sugar import restrictions permitted under international commitments	Maintain the level of sugar import restrictions permitted under the international commitments	Removed (Full liberalisation of trade)

Table 4
Variables used in the empirical model.

Variable	Description	Measurement scale used in Probit modelling	Sample distribution across variable categories	
Dependent variable				
Exit intentions	Intention to exit	1 if farmers intended to exit, 0 otherwise	No	65.6 %
			Yes	34.4 %
Independent variables				
Farmer and household characteristics				
Sex	Sex of main decision-maker	Dummy variable where the reference is female	Female	26.2 %
			Male	73.8 %
AGE	Farmer age	Dummy variable where the reference is age being less than 55	Less than 55	54.3 %
			≥55	45.7 %
EDU	Educational level	Dummy variable where the reference is education being lower than high school	Did not complete high school	52.4 %
			Completed high school	47.6 %
Fam_workers	Household labour	Dummy variable where the reference is only one member	Only one member	26.2 %
			2 household labours	34.6 %
			More than 2	39.2 %
Fam16	Having household member age <16	Dummy variable where the reference is no member age <16	No	45.9 %
			Yes	54.1 %
Full_time	Employment on farm (full or part time)	Dummy variable where the reference is being a full time sugarcane farmer	Full-time	89.0 %
			Part-time	11.0 %
Experience	Sugarcane farming experience	Dummy variable where the reference is having experiencc >30 years	≤10 years	14.9 %
			11–30 year	33.6 %
			More than 30 years	51.5 %
Avg_f_inco	Average annual income from agriculture	Dummy variable where the reference is having average annual income from	<1 million Baht	55.6 %
			≥1 million Baht	44.4 %

(*continued on next page*)

Table 4 (*continued*)

Variable	Description	Measurement scale used in Probit modelling	Sample distribution across variable categories	
		agriculture <1 million Baht (≈$29,400)		
Off_f_income	Having off-farm income	Dummy variable where the reference is no off-farm income	No	55.8 %
			Yes	44.2 %
Farm structure characteristics				
Labour	Labour employed	Dummy variable where the reference is no labour employed	None	34.4 %
			1–9 persons	42.9 %
			≥10 persons	22.7 %
Region	Region	Dummy variable where the reference is East and Northeast regions	East and Northeast	26.2 %
			Central	39.0 %
			North	34.8 %
Farm_size	Farm size	Dummy variable where the reference is large-scaled farm	Small	43.3 %
			Medium	43.3 %
			Large	13.4 %
Distance	Dominant mode and distance of sugarcane transportation	Dummy variable where the reference is delivering through collecting centre operated by middlemen	Through middlemen Directly_distance ≤20 km	8.9 %
			Directly_distance ≤21–40 km	36.4 %
			Directly_distance >40 km	32.3 %
				22.5 %
Land_own	Land ownership	Dummy variable where the reference is wholly rented farm	Wholly rented farm	10.0 %
			Wholly owned farm	44.3 %
			Mixed	45.7 %
Cane_special	Sugarcane farming area as proportion of total farmland	Dummy variable where the reference is devoting ≤75 % of farmland to sugarcane production	≤75 %	26.4 %
			More than 75 %	73.6 %
Yield	sugarcane yield	Dummy variable where the reference is yielding less than 10 tonnes/rai	≤10 tonnes/rai	35.5 %
			10–15 tonnes/rai	32.9 %
			≥ than 15 tonnes/rai	31.6 %
Farm management characteristics				

(*continued on next page*)

Table 4 (*continued*)

Variable	Description	Measurement scale used in Probit modelling	Sample distribution across variable categories	
Past_behaviour	Having farmed sugarcane continuously for the last five years	Dummy variable where the reference is sugarcane farming non-continuously for the last five years	No Yes	9.3 % 90.7 %
Borrowing	Accessing to loans	Dummy variable where the reference is no access to loans	No Yes	19.5 % 80.5 %
Farm_visit	Participating in farm visits	Dummy variable where the reference is no	No Yes	53.0 % 47.0 %
Workshop	Participating in workshops	Dummy variable where the reference is no	No Yes	57.1 % 42.9 %
Cane_meeting	Participating in sugarcane-related meetings	Dummy variable where the reference is no	No Yes	6.3 % 93.7 %
Family successor	Whether a family successor has been identified	Dummy variable where the reference is no family successor identified	Not identified Identified	36.8 % 63.2 %
Farm_advisor	Whether a farm advisor has been identified	Dummy variable where the reference is no farm advisor identified	Not identified Identified	41.8 % 58.2 %
Cane_burning	Whether engaging in sugarcane burning	Dummy variable where the reference is no engage in sugarcane burning	No Yes	46.3 % 53.7 %

their sugarcane production, with only a few (range, 3–8 %) considering area reduction across the three scenarios. Relatively few farmers would expand their sugarcane cultivation areas under any scenario. The *libertarian* scenario would lead to the greatest production area loss (36.6 %), followed by the *government proposal* (22.8 %) and *protectionism* (20.2 %). This suggests that under less favourable trading conditions, Thai sugarcane farmers are likely to either exit the sector altogether or maintain the status quo. While some farmers may remain profitable under these reforms and may simply maintain the status quo, others may respond in the same manner despite negative net margins because of risk aversion, limited adaptive capacity, or lack of alternatives. The reasons for this inertia have been discussed by Jansuwan and Zander [75], who described Thai farmers as both risk averse and constrained in terms of crop choices by geographical, environmental, and financial conditions. Additionally, studies [14,61] suggested that farmers may be locked into current land uses because of the underlying fixity of their agricultural assets and high exit costs, including outstanding loans, the specialised nature of sugarcane farming skills, and limited education. This suggests limited adaptive capacity among Thai sugarcane farmers. Although the Thai sugarcane sector demonstrated considerable resistance to change, this study identified a threshold, lying between the *government proposal* and *libertarian* scenarios where substantial changes in farmer responses occurred.

Table 5
Projected change in the number of farms producing sugarcane and area of sugarcane production under the three policy scenarios compared to the 2018/19 baseline.

Impacts[a]	Libertarian	Gov't. Proposal	Protectionism
	Per cent		
Percentage change in land under sugarcane production	**−36.6**	**−22.8**	**−20.2**
Area loss (full exit)	(-33.5)	(-22.7)	(-15.4)
Area loss (remain in production with a reduced area)	(-3.5)	(-0.8)	(-5.9)
Increased area from production expansion	(0.5)	(0.6)	(1.1)
Percentage of farms remaining in sugarcane production	**51.3**	**67.7**	**78.0**
% of farmers intended to continue with same production size	(42.2)	(62.0)	(68.0)
% of farmers intended to continue but reduce production size	(8.4)	(3.2)	(8.0)
% of farmers intended to expand sugarcane production	(0.7)	(2.5)	(2.0)

[a] Compared with the 2018/19 reference area, that is, 1.96 million ha res nationally (at the point of survey) collected.

Table 6
Projected revenues and gross and net margins (Thai Baht (THB) per Rai[a]) of Thai sugarcane farms (population average) under the three policy scenarios.

	Reference (THB/Rai)	Protectionism (THB/Rai)	Gov't. Proposal (THB/Rai)	Libertarian (THB/Rai)
Revenue	9413	9469	8077	7241
		(0.6)	(-14.2)	(-23.1)
Aid and subsidy	1263	557	557	0
		(-55.9)	(-55.9)	(-100.0)
Total receipts	10676	10026	8634	7241
		(-6.09)	(-19.13)	(-32.17)
Gross margin[b]	2823	2173	780	−612
		(-23.0)	(-72.4)	(-121.7)
Net margin[c]	910	260	−1132	−2525
		(-71.4)	(-224.4)	(-377.4)

[a] 1 Rai = 0.16 ha.
[b] Gross margin = (Revenue + Aid and subsidy) – Variable cost.
[c] Net margin = (Revenue + Aid and subsidy) – (Variable + Fixed costs). Figures are based as MY2016/17-MY2019/20 average prices (Reference price). Percentage changes are provided in parentheses.

Once this threshold was reached, the number of farmers maintaining the status quo dropped substantially, with the *libertarian* scenario likely triggering increased exits.

4.4. Variation in farmer responses by level of specialisation and farm size

The heterogeneity of responses based on the level of specialisation and farm size was also investigated. Farmers in the sample who devoted more than 75 % of their farmland to sugarcane production were classified as highly specialised, while others were classified as more diversified. Fig. 2 shows that the proportion of highly specialised farmers intending to exit sugarcane production was lower than that of diversified farms in all scenarios. However, the percentage of these highly specialised farmers who intended to remain in sugarcane production decreased significantly, from 83.2 % to 53 %, when moving from *protectionism* to *libertarian* scenarios. From the perspective of farm size, Fig. 3 reveals that small-scale farmers were most affected under the *government proposal* and *protectionism* scenarios, with 42 % and 27 % of farmers indicating that they would cease sugarcane production, respectively. However, mid-sized farms appear to be the most adversely impacted under the more extreme *libertarian* scenario (56.5 %).

The greater resilience of specialised farms observed in this study contradicts previous research on farm exits in Switzerland [76], Greece, and Hungary [34]. These previous studies suggest that specialised farms are more vulnerable to market volatility. However, in Thailand, the sugarcane sector may offer greater market stability than alternatives, such as cassava [77] or rice [64]. This is because it is the only agricultural product supported by a policy regime backed by law and because of the widespread use of contracts for sales, even under deregulation. Under these assumptions, larger specialised farms may avoid market exit by leveraging higher resource-use efficiency and economies of scale, enabling profitability despite lower market prices and reduced support under these scenarios. By contrast, smaller farms face greater challenges, such as insufficient household income from land constraints, limited technology access, and weaker bargaining power, thereby reducing profit margins across scenarios.

Fig. 3 reveals that under the extreme *libertarian* scenario, mid-sized farms (56.5 %) are the most vulnerable to exit, rather than the smallest. A possible explanation for this is provided by a cost analysis using secondary cost data (See Table 7), which reveals that mid-sized farms incur the highest variable costs but the lowest fixed costs among the three size classes. This is likely because mid-sized farms are sufficiently large to employ hired labour, thereby increasing costs; however, they lack major capital investment compared to larger farms.

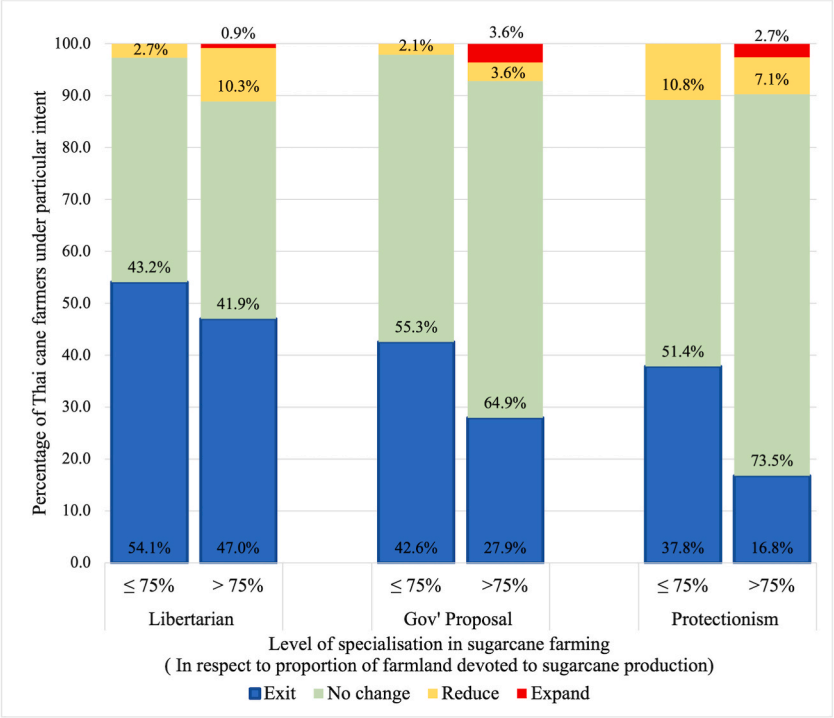

Fig. 2. Intended responses of sugarcane farmers, by level of specialisation, to the different policy scenarios.

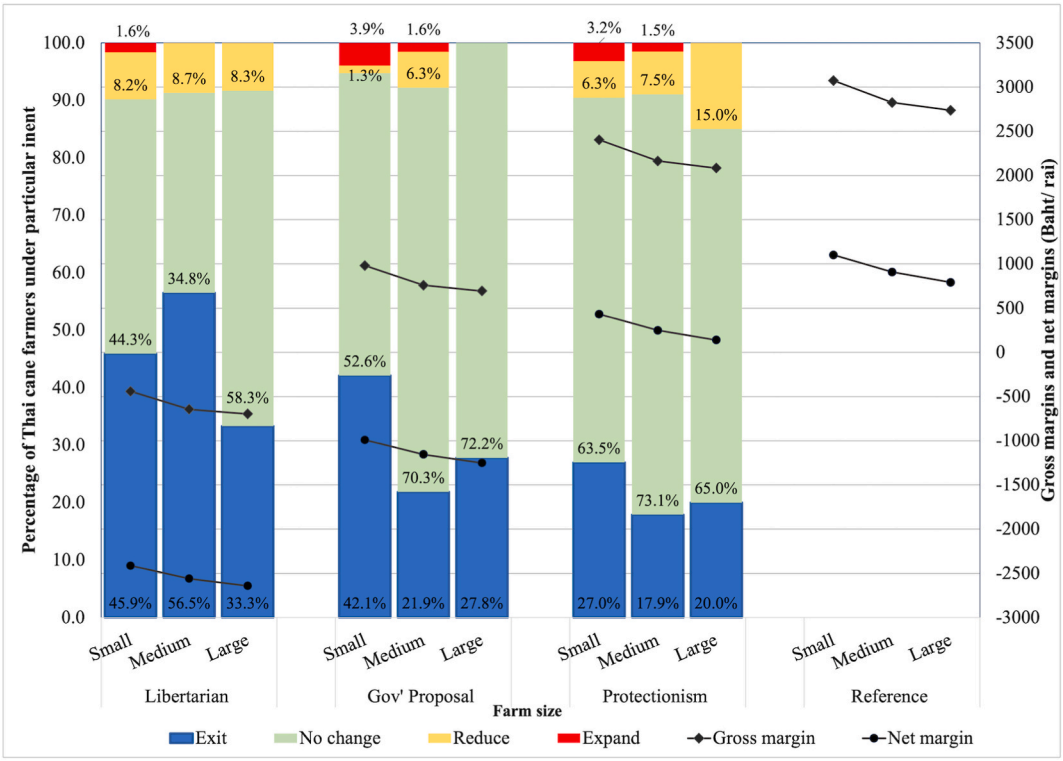

Fig. 3. Intended responses of sugarcane farmers and farm profit margins, by size class, to the policy scenario.

Table 7
Estimated total, variable, and fixed costs per Rai[a] (Thai Baht-THB), by farm size class.

	Small-scaled	Medium-scaled	Large-scaled
Total cost	9811	9862	9870
Variable cost	7839	7947	7925
Fixed cost	1972	1915	1945

[a] 1 Rai = 0.16 ha. Data is based as MY2016/17-MY2019/20 average prices.

Table 8
Results of the probit model on exit intention, plus marginal effects for explanatory variables.

Intention to exit sugarcane farming (1 if exit, 0 if remain)			
Variables	Parameter estimates	Sig.	Marginal effects[a]
Gov' proposal	−0.4782	[b]	−0.1443
Protectionism	−0.7944	[b]	−0.2398
Farm_size_Small	0.0471		0.0142
Farm_size_Medium	0.1250		0.0377
Sex	0.3756	[c]	0.1134
AGE	0.0299		0.0090
EDU	−0.1874		−0.0566
Fam_workers_2persons	−0.2559		−0.0772
Fam_workers_>2persons	−0.1931		−0.0583
Having_member_age_16	0.1506		0.0455
Full_time	0.1909		0.0576
Experience_≤10	−0.4248		−0.1283
Experience_11-30	−0.3659	[c]	−0.1104
Avg_f_inco	−0.0350		−0.0106
Off_f_income	0.1812		0.0547
Past behaviour	−0.7570	[b]	−0.2285
Labour_1to9	0.2452		0.0740
Labour_from 10	0.1373		0.0414
Region_North	−0.2638		−0.0796
Region_Central	−0.4057	[c]	−0.1225
Distance_20 km	−0.7291	[b]	−0.2201
Distance_21-40 km	−0.5614	[c]	−0.1695
Distance_>40 km	−0.6816	[c]	−0.2057
Land_own_mixed	−0.1072		−0.0324
Land_own_wholly_owned	−0.0543		−0.0164
Cane_special	0.2248		0.0679
Yield_between 10-15	0.3217		0.0971
Yield_≥15	0.1423		0.0430
Borrowing	0.0776		0.0234
Farm_visit	0.0159		0.0048
Workshop	−0.1291		−0.0390
Cane_meeting	−0.2797		−0.0844
Successor	−0.3290	[c]	−0.0993
Farm_advisor	0.2898	[c]	0.0875
Cane burning	0.3552	[c]	0.1072
Log likelihood	−246.20		
No.f obs	462		
LR chi^2(35)	102.43		
Pseudo R^2	0.1722		

The constant terms are omitted from the table.
[a] Average Marginal effects.
[b] 1 % significance level.
[c] 5 % significance level.

4.5. *Factors affecting exit intentions and alternative actions of the farmers who intended to exit*

A probit regression model (Table 8) was used to identify the factors that determined farmer intentions to exit sugarcane production. Consistent with the findings of previous studies on the impacts of agricultural policy reform, particularly the EU CAP reform [61,62], this study found that the policy scenarios significantly impacted the likelihood of exit from production, with the likelihood of exit varying by scenario. The marginal effects estimates showed that the *government proposal* and *protectionism* scenarios, which offered higher sugarcane prices and state protection, decreased the probability of exit by 14 % and 24 %, respectively, compared to the *libertarian* scenario.

Concerning the influence of socioeconomic and demographic characteristics on exit decisions, farming practices and management

appear to have considerable influence. Consistent with previous studies [59,62], this study found that farmers who had consistently farmed sugarcane over the past five years (see variable 'past behaviour' in Table 8), were less likely to exit than those who had occasionally farmed sugarcane. The 'past behaviour' effect has a stronger influence on exit intentions than any other socio-economic and demographic factors. It also exerts an influence on exit intention compared to that of policy scenarios. This suggests that sugarcane production has become habitual for some farmers, regardless of the reasons. This result is consistent with the findings of Ouellette and Wood [78].

With decreasing farm support, the transportation mode and harvesting method of sugarcane both affected exit likelihood. Consistent with Arjchariyaartong [79], farmers who transported sugarcane directly to mills, regardless of transport distance, were less likely to exit than those using intermediaries, as the latter causes delivery delays, thereby reducing the sweetness content of sugarcane (CCS) and therefore the sale price. Using burning during harvest also reduces CCS compared to green harvesting and so increased the probability of exit by 10.7 %.

The presence of a farm advisor increased the probability of exit by 8.6 %. This unexpected finding may be owing to sample farmers' reliance on advice from their own social group (e.g., neighbouring farmers, family members, and sugar millers) rather than on scientific-professional sources, as observed in other studies [14,60,80,81]. Thus, even farmers who are open to change and proactive in seeking decision-making support may exhibit higher exit rates because the advice they receive is not science-based.

Among the household characteristics measured, only sex and length of sugarcane farming experience had a significant effect on exit decisions. Male farmers were 11 % more likely to consider exiting than female farmers. Given that most female-headed households observed in the survey were generally less educated than their male counterparts, this may have limited them to sugarcane farming because of the lack of viable livelihood alternatives [82]. Conversely, farmers with over 30 years of experience in sugarcane farming exhibited higher exit intentions than those with 11–30 years of experience. This effect may be related to the fact that farmers with more than 30 years of experience, being older, are much closer to retirement, and have fewer personal and physical resources. For these farmers, advancing retirement would be a valid response to challenging long-term trading conditions. This effect increases when older farmers have no identified family successors to whom they can transfer the farm (see Table 8).

Among farm structure variables, only regional location was found to be a significant determinant of intention to exit, with central region farmers demonstrating a lower likelihood of exit than those in the Northeast and East (with a −0.12 marginal effect). This could be due to higher production risks, such as frequent droughts, limited irrigation access [83–85], higher production costs, and structural disadvantages arising from the predominance of small farms [70], which are more prevalent in the Northeast and East.

Among farmers who intended to exit sugarcane production (34.4 % of the sample), the most common alternative activity, by some margin, was switching to another crop (43.4 %), followed by passing farmland to their family successor (23.3 %). Few farmers considered selling (4.4 %) or renting out their farmland (3.8 %), and seeking off-farm employment appeared to be almost irrelevant (1.3 %). It is possible to hypothesise that farmers in middle-income countries such as Thailand may find it challenging to exit their lifetime jobs in agriculture because of a lack of alternative occupations in rural areas. One implication of this finding is that sugarcane policy reform is unlikely to result in any transformation in the structure of rural employment. However, it is likely to trigger widespread agricultural land use changes owing to the switch from sugarcane to alternative major crops. Previous studies have demonstrated that concerns over sugarcane farming, switching costs, crop prices, size of owned assets, extent of liabilities, and government policy factors significantly influence Thai farmers' decisions to switch between rice and sugarcane cultivation [64,86]. Similarly, Prasara-A and Gheewala [77] reported that cassava cultivation outperformed sugarcane cultivation among small-scale farmers who neither own farms nor machines. This suggests that a switch driven by policy reform, as examined in this study, does not always result in lower net margins.

5. Conclusion, policy implications, and limitations

The analysis of farmers' intentions in response to policy reforms in this study is based on a sample surveyed in 2019.This may raise concerns about the relevance of the findings following the 2024 WTO settlement. To address this, this study includes two scenarios which capture more extreme potential shifts in policy within WTO compliance and political feasibility limits. While precise figures for farmer exits and area reductions may differ from the projections, the direction and magnitude of policy effects should align with our findings, even in this context. The hypothetical nature of the scenarios may have introduced bias if the farmers perceived them as unrealistic. However, given that the surveyed farmers had already experienced policy changes, such as government sugarcane price cuts in response to the WTO challenge, this risk appears minimal. The sample also slightly overrepresented the northern region and underrepresented the northeastern region, which may have affected the generalisability of the findings. However, the Northern region includes two of the largest sugar-producing provinces, accounting for 14 % of Thai cultivation, and has shown smallest fall in the sugarcane production area over the past five years [87,88], validating its sample inclusion despite the imbalance. The regression model explained 17.2 % of the variance in exit intention (pseudo $R^2 = 0.172$), suggesting that the survey did not capture many influencing factors. However, low R^2 values are common in studies examining farmers' intentions [61,62,89], and the model offers valuable insights into the key drivers of farmers' policy responses.

The Thai sugarcane sector is at a key juncture, facing policy reforms after a long period of stability under protectionist regimes. Three hypothetical policy scenarios were developed through one-on-one consultations with policy experts. Each scenario reflects coherence with international trade philosophies, WTO compliance, and political feasibility. Subsequently, these scenarios serve as a basis for assessing farmers' exit intentions and impacts of these intentions on number of sugarcane farms and production areas and identifying the key factors determining the likelihood of exit.

This study finds that future sugar policy reforms, if moving towards free trade, are likely to induce the restructuring of the sugarcane industry. This restructuring will result in a reduction in the number of sugarcane farmers and farmlands under cultivation, with the most pronounced effects in the *libertarian* scenario, where revenue losses are expected to be severe for those remaining in production. The expectation that restructuring would mirror the EU experience, where fewer but larger and more efficient farms emerged [24,25,90], appears unlikely in the Thai context. The analysis also reveals that farmers' choices are binary; that is, they either maintain the status quo or exit sugarcane farming entirely. Thus, any hope that WTO-compliant policy reform might result in maintained sugarcane farm numbers while scaled-back production is unlikely. If reforms result in sugarcane farming becoming unprofitable relative to alternative crops, farmers are likely to abandon sugarcane unless there is a rotational justification to remain or a family successor to take over the farm. Furthermore, this study indicates that most farmers intending to exit sugarcane farming expressed a preference for remaining in agriculture, suggesting that exits could be temporary and may be reversed if trading conditions improve in the sugar sector. This is relevant in middle-income countries where farming is often a lifelong occupation for rural populations with few alternative income sources, making transitioning out of agriculture challenging. Consequently, policy reforms involving significant reductions in prices and income support could lead to substantial land-use changes and secondary effects on alternative crop production in the short term, such as increased supply and falling farm prices for some non-sugarcane crops.

The results suggest that the evolution of sugarcane prices and government support are the most important factors influencing exit decisions. However, under WTO constraints, limited capacity exists for government intervention in the market to further support farmers. Therefore, these negative effects cannot be eliminated. However, targeted support aimed at the most vulnerable farmers identified in this analysis—such as less sugarcane-specialised, passive, small-, and medium-scale farmers, particularly those nearing retirement, or operating in marginal areas without family successors—could help prevent catastrophic losses of sugarcane farmers that might result from future reforms.

Suitable interventions would need to be aimed at enhancing productivity and cost efficiency for this vulnerable group. Interventions might be considered to encourage greater specialisation in sugarcane farming, the adoption of green harvesting methods, and the establishment of temporary village-level sugarcane purchasing centers operated by contracting sugar mills to reduce delivery times and avoid losses due to declining sugar content. Schemes to promote these innovations must combine measures to increase capital availability and knowledge transfer to farmers. Considering the proclivity of these farmers to rely on their own social networks for advice, schemes could adopt 'social learning' approaches, that is, knowledge transfer within farmers' social networks. For example, promoting knowledge and innovation exchange among contract millers, community-leading farmers, and their social connections. However, for older farmers nearing retirement, subsidised early retirement programmes, similar to those in the EU [91,92], could facilitate the transition of farms to younger family successors and encourage long-term viability.

Because the possibility of future direct government interventions to support sugarcane farm incomes is low, owing to WTO restrictions, the results of this study suggest that to avoid large-scale and undesirable structural changes within the sugarcane farming sector, removing existing supports should be phased in, rather than abrupt. A gradual withdrawal, accompanied by safety nets for vulnerable farmers, would provide farmers, particularly those in the most vulnerable groups, time to plan and adjust to forthcoming changes before a loss of income is realised. Once income is lost, the capacity to invest in diversification or efficiency improvements is significantly reduced. This study suggests that the outcome of the *'protectionism'* scenario would align closest with the government's 10-Year Cane and Sugar Plan (2015–2026) objectives for the sugarcane sector, to an even greater extent than the government's own proposal, as it reduces the scale of the negative reform outcomes. The removal of government support beyond those seen in the *government proposal* scenario is likely to result in detrimental outcomes, particularly without major government intervention to increase the resilience and productivity of vulnerable groups.

Future research should enhance realism in the design of hypothetical policy scenarios by incorporating additional factors that affect farmers' responses, such as input prices and technological changes. This approach would facilitate a more nuanced exploration of government interventions designed to enhance technical efficiency and bolster resilience within a sector, particularly in vulnerable subgroups. Furthermore, incorporating farmer cognition into survey analysis could yield valuable insights into path dependency. Integrating this micro-level analysis with macro-level modelling would provide a comprehensive understanding of global market dynamics and feedback mechanisms. Finally, conducting ex-post farm-level assessments of post-2024 settlement impacts would offer crucial insights, capturing alignment with ex-ante projections and enhancing policy cycle evaluation. This study offers insights for policymakers and aids in identifying both effective reform measures and areas requiring additional support to prevent unintended impacts.

CRediT authorship contribution statement

Savita Tangwongkit: Writing – original draft, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Chittur S. Srinivasan:** Writing – review & editing, Supervision, Methodology. **Philip J. Jones:** Writing – review & editing, Supervision, Methodology.

Ethics statement

Approval to conduct interviews to collect data from policy stakeholders and farmers was obtained separately from the School of Agriculture, Policy, and Development (APD) at the University of Reading, United Kingdom. Research permits were granted by the University Research Ethics Committee and issued under APD ethical clearance application reference numbers 00941P (policy consultation issued on February 13, 2019) and 001030P (farm survey issued on May 09, 2019). Participants in both data collection exercises received a participation information sheet explaining their rights with respect to the interview and the data provided. This included information on the voluntary nature of participation, anonymity of their data, and right to withdraw from the interview at any time, including the right to withdraw their data after collection. Verbal consent to participate was obtained from all participants prior to the interviews due to the need to maintain anonymity and the varying levels of literacy among participants. The study was conducted in accordance with the ethical guidelines provided by the University of Reading to ensure compliance with ethical standards.

Data availability statement

The raw data supporting this study are included in the article's Supplementary Materials and are freely available via Mendeley Data at DOI (10.17632/tg72w6s5c2.1″ title = "doi:DOI (10.17632/tg72w6s5c2.1">DOI (10.17632/tg72w6s5c2.1) or directly at https://data.mendeley.com/datasets/tg72w6s5c2/1. Further inquiries can be directed to the corresponding author.

Declaration of generative AI in scientific writing

The writing of this article was prepared with the assistance of ChatGPT 4o in order to enhance language quality and readability, with caution. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the published article. The final manuscript underwent editing and proofreading by Editage, a professional English language editing service.

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Appendix A. Supplementary data

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References

[1] USDA Foreign Agricultural Service, Sugar: World Markets and Trade (2023). Available from: https://downloads.usda.library.cornell.edu/usda-esmis/files/z029p472x/4x51k466h/r207w7721/sugar.pdf.
[2] Bank of Thailand BOT, EC_XT_009_S3 Value and volume of exported products by production activities (US dollar) (2024) (In Thai), https://app.bot.or.th/BTWS_STAT/statistics/BOTWEBSTAT.aspx?reportID=979&language=TH. (Accessed 23 September 2024).
[3] Office of Agricultural Economics OAE, Information: agricultural economics by product 2020, Agricultural Statistics Document No. 402, Office of Agricultural Economics Ministry of Agriculture and Cooperatives, Thailand (2021) (In Thai), http://www.oae.go.th/assets/portals/1/files/ebook/2563/commodity2562.pdf.
[4] Office of the Cane and Sugar Board OCSB, Cane area and yield report (2024) (In Thai), https://www.ocsb.go.th/report_area_yield/. (Accessed 15 October 2024).
[5] P. Manivong, E. Bourgois, White Paper: Thai Sugarcane Sector and Sustainability, FairAgora, 2017. Available from: https://www.bonsucro.com/wp-content/uploads/2017/08/Thai-White-Paper-FINAL-LowRes.docx.pdf.
[6] K. Chow, Prospects looking sweet for growing the Thai sugar industry, RaboResearch (2016). Available from: https://research.rabobank.com/publicationservice/download/publication/token/MEP9ir97sDzw2CJdtpAs.
[7] World Trade Organization WTO, Thailand – subsidies on sugar request for consultations by Brazil, G/AG/GEN/131;G/L/1146;G/SCM/D110/1;WT/DS507/1 (2016). Available from: https://docs.wto.org/dol2fe/Pages/FE_Search/FE_S_S009-DP.aspx?language=E&CatalogueIdList=304487,228305,228243,227996&CurrentCatalogueIdIndex=3&FullTextHash=&HasEnglishRecord=True&HasFrenchRecord=True&HasSpanishRecord=True.

[8] World Trade Organization WTO, Thailand – Subsidies On Sugar Notification Of A Mutually Agreed Solution. G/AG/GEN/131/Add.1;G/L/1146/Add.1;G/SCM/D110/1/Add.1;WT/DS507/4 (2024). Available from: https://docs.wto.org/dol2fe/Pages/FE_Search/FE_S_S009-DP.aspx?language=E&CatalogueIdList=304487,228305,228243,227996&CurrentCatalogueIdIndex=0&FullTextHash=&HasEnglishRecord=True&HasFrenchRecord=True&HasSpanishRecord=True.

[9] D. Viaggi, M. Raggi, S. Gomez y Paloma, Farm-household investment behaviour and the CAP decoupling: methodological issues in assessing policy impacts, J. Pol. Model. 33 (1) (2011) 127–145, https://doi.org/10.1016/j.jpolmod.2010.10.004.

[10] J.P. Breen, T.C. Hennessy, F.S. Thorne, The effect of decoupling on the decision to produce: an Irish case study, Food Policy 30 (2) (2005) 129–144, https://doi.org/10.1016/j.foodpol.2005.03.001.

[11] D.R. Harvey, Farmers' intentions survey, 1994-1997: final report, in: Special Studies in Agricultural Economics No. 47, University of Newcastle, Upon Tyne, Newcastle upon Tyne, 2000. Available from: https://www.cabdirect.org/cabdirect/abstract/20003013102.

[12] R. Tranter, L. Costa, T. Knapp, J. Little, M. Sottomayor, Asking farmers about their response to the proposed bond scheme, in: A. Swinbank, R. Tranter (Eds.), A Bond Scheme for Common Agricultural Policy Reform, CABI Publishing, Wallingford, 2004, https://doi.org/10.1079/9780851997445.0127.

[13] E. Douarin, A. Bailey, S. Davidova, M. Gorton, L. Latruffe, Structural, location and human capital determinants of farmers' response to decoupled payments, Working papers hal-02822652 (2007). Available from, https://hal.science/hal-02822652/.

[14] M. Raggi, L. Sardonini, D. Viaggi, The effects of the common agricultural policy on exit strategies and land re-allocation, Land Use Policy 31 (2013) 114–125, https://doi.org/10.1016/j.landusepol.2011.12.009.

[15] A. Meriot, T, hailand's sugar policy: government drives production and export expansion (2015). No. SE 1404 -10, the American Sugar Alliance, USA, https://sugaralliance.org/wp-content/uploads/2021/02/Meriot-Thai-Subsidy-062015.pdf.

[16] N. Khumla, S. Sakuanrungsirikul, P. Punpee, T. Hamarn, T. Chaisan, L. Soulard, P. Songsri, Sugarcane breeding, germplasm development and supporting genetics research in Thailand, Sugar Tech 24 (1) (2022) 193–209, https://doi.org/10.1007/s12355-021-00996-2.

[17] H.G. Jensen, H. Zobbe, Consequences of reducing limits on aggregate measurements of support, in: K. Anderson, W. Martin (Eds.), Agricultural Trade Reform & the Doha Development Agenda, Palgrave Macmillan, New York, 2006. https://documents1.worldbank.org/curated/pt/202871468318342109/841401968_200510313024112/additional/34206.pdf.

[18] USDA Foreign Agricultural Service, Thailand sugar annual 2017. GAIN report number: th7045, 2017, Available from, https://apps.fas.usda.gov/newgainapi/api/report/downloadreportbyfilename?filename=Sugar%20Annual_Bangkok_Thailand_4-12-2017.pdf.

[19] K. Siddiqui, International trade, WTO and economic development, WRPE 7 (4) (2016) 424–450, https://doi.org/10.13169/worlrevipoliecon.7.4.0424.

[20] P.R. Krugman, Is free trade passé? JEP (J. Environ. Psychol.) 1 (2) (1987) 131–144, https://doi.org/10.1257/jep.1.2.131.

[21] World Trade Organization WTO, Understanding the WTO, fifth ed., WTO Publications, Geneva, 2015.

[22] International Labour Organization ILO, Working and employment conditions in the agriculture sector in Thailand: A survey of migrants working on Thai sugarcane, rubber, oil palm and maize farms. Thailand (2021). Available from: https://www.ilo.org/sites/default/files/wcmsp5/groups/public/%40asia/%40ro-bangkok/documents/publication/wcms_844317.pdf.

[23] I. Marković, M. Marković, Agricultural protectionism of the European Union in the conditions of international trade liberalization, EP 61 (2) (2014) 423–440, https://doi.org/10.5937/ekoPolj1402423M.

[24] H. Řezbová, M. Maitah, O. Sergienko, EU quota sugar market concentration–the main drivers of EU sugar market, Agris On-line Pap. Econ. Inform. 7 (4) (2015) 131–142, https://doi.org/10.22004/ag.econ.231900.

[25] I. Benešová, H. Řezbová, L. Smutka, K. Tomšík, A. Laputková, European sugar market–impact of quota system, Acta Univ. Agric. Silvic. Mendelianae Brunensis 63 (6) (2015) 1825–1838, https://doi.org/10.11118/actaun201563061825.

[26] J. Windle, J. Rolfe, Growers' perspectives on the viability of sugarcane farming systems in central Queensland, Australas Agribus Re 13 (2005), https://doi.org/10.22004/ag.econ.126401.

[27] T. Josling, Issues for Upcoming Multilateral Negotiations on Agriculture and Recommendations for CARICOM Preparatory Work, IICA Biblioteca, Venezuela, 1998. Available from: https://repositorio.iica.int/bitstream/handle/11324/15375/BVE21041092i.pdf?sequence=1&isAllowed=y.

[28] K. Itharattana, Effects of trade liberalization on agriculture in Thailand: institutional and structural aspects, in: Working Paper No.39, The CGPRT Centre, Bangkok, 1999. https://repository.unescap.org/bitstream/handle/20.500.12870/5878/ESCAP-1999-WP-Effects-trade-liberalization-agriculture-Thailand.pdf?sequence=4. (Accessed 14 December 2022).

[29] A. Elobeid, J. Beghin, Multilateral trade and agricultural policy reforms in sugar markets, J. Agric. Econ. 57 (1) (2006) 23–48, https://doi.org/10.1111/j.1477-9552.2006.00030.x.

[30] OECD, Sugar Policy Reform in the European Union and in World Sugar Markets, OECD Publishing, Paris, 2007, https://doi.org/10.1787/9789264040212-en.

[31] D. Talukder, A survey on agricultural trade liberalisation in Thailand, Southeast Asian, J. Econ. 1 (1) (2013) 49–66. Retrieved from, https://so05.tci-thaijo.org/index.php/saje/article/view/48749.

[32] M.C. Ahearn, J. Yee, P. Korb, Effects of differing farm policies on farm structure and dynamics, Am. J. Agric. Econ. 87 (5) (2005) 1182–1189, https://doi.org/10.1111/j.1467-8276.2005.00805.x.

[33] K. Happe, A. Balmann, K. Kellermann, C. Sahrbacher, Does structure matter? The impact of switching the agricultural policy regime on farm structures, J. Econ. Behav. Organ. 67 (2) (2008) 431–444, https://doi.org/10.1016/j.jebo.2006.10.009.

[34] M. Genius, G. Karagiannis, V. Tzouvelakas, Assessing European farmers' intentions in the light of the 2003 CAP reform, in: 109th European Association of Agricultural Economics (EAAE) Seminar "The CAP After the Fischer Reform: National Implementations". Impact Assessment and the Agenda for Future Reforms, 2008, pp. 1–16, 20-21 November 2008; Viterbo, Italy.

[35] L. Latruffe, C. Le Mouël, Capitalization of government support in agricultural land prices: what do we know? J. Econ. Surv. 23 (4) (2009) 659–691, https://doi.org/10.1111/j.1467-6419.2009.00575.x.

[36] S.J. Goetz, D.L. Debertin, Why farmers quit: a county-level analysis, Am. J. Agric. Econ. 83 (4) (2001) 1010–1023, https://doi.org/10.1111/0002-9092.00226.

[37] A.K. Mishra, J.M. Fannin, H. Joo, Off-farm work, intensity of government payments, and farm exits: evidence from a national survey in the United States, can, J. Agric. Econ. 62 (2014) 283–306, https://doi.org/10.1111/cjag.12027.

[38] N.D. Key, M.J. Roberts, Do government payments influence farm size and survival? J. Agric. Resour. Econ. 32 (2) (2007) 330–348, https://doi.org/10.22004/ag.econ.8645.

[39] D. Peel, H.L. Berry, J. Schirmer, Farm exit intention and wellbeing: a study of Australian farmers, J. Rural Stud. 47 (2016) 41–51, https://doi.org/10.1016/j.jrurstud.2016.07.006.

[40] M. Gorton, E. Douarin, S. Davidova, L. Latruffe, Attitudes to agricultural policy and farming futures in the context of the 2003 CAP reform: a comparison of farmers in selected established and new member states, J. Rural Stud. 24 (3) (2008) 322–336, https://doi.org/10.1016/j.jrurstud.2007.10.001.

[41] L. Saint-Cyr, Accounting for unobserved farm heterogeneity in modelling structural change: Evidence from France [PhD thesis], Loire Bretagne University, France, 2016.

[42] E. Paroissien, L. Latruffe, L. Piet, Early exit from business, performance and neighbours' influence: a study of farmers in France, Eur. Rev. Agric. Econ. 48 (5) (2021) 1132–1161, https://doi.org/10.1093/erae/jbab008.

[43] J.-P. Chavas, Chapter 5 structural change in agricultural production: economics, technology and policy, Handb. Agric. Econ. 1 (Part A) (2001) 263–285, https://doi.org/10.1016/S1574-0072(01)10008-3.

[44] A. Kimhi, R. Bollman, Family farm dynamics in Canada and Israel: the case of farm exits, Agric. Econ. 21 (1) (1999) 69–79, https://doi.org/10.1016/S0169-5150(99)00015-8.

[45] A. Zimmermann, T. Heckelei, I.P. Domínguez, Modelling farm structural change for integrated ex-ante assessment: review of methods and determinants, Environ. Sci. Pol. 12 (2009) 601–618, https://doi.org/10.1016/j.envsci.2009.01.014.

[46] G. Stokstad, Exit from farming and land abandonment in northern Norway, in: The 116th EAAE Seminar "Spatial Dynamics in Agri-food Systems: Implications for Sustainability and Consumer Welfare, 2010, pp. 1–6, https://doi.org/10.22004/ag.econ.95343, 27th-30th October; Parma, Italy.

[47] S. Neuenfeldt, A. Gocht, T. Heckelei, P. Ciaian, Explaining farm structural change in the European agriculture: a novel analytical framework, Eur. Rev. Agric. Econ. 46 (5) (2019) 713–768, https://doi.org/10.1093/erae/jby037.

[48] H. Storm, K. Mittenzwei, Farm survival and direct payments in the Norwegian farm sector. Discussion paper No. 2013-5, Norway (2013). Available from, https://core.ac.uk/reader/285987560.

[49] J.M. MacDonald, P. Korb, R.A. Hoppe, Farm Size and the Organization of US Crop Farming. ERR-152, United States Department of Agriculture, Washington D. C., 2013. Available from: https://www.ers.usda.gov/webdocs/publications/45108/39359_err152.pdf.

[50] K. De Roest, P. Ferrari, K. Knickel, Specialisation and economies of scale or diversification and economies of scope? Assessing different agricultural development pathways, J. Rural Stud. 59 (2018) 222–231, https://doi.org/10.1016/j.jrurstud.2017.04.013.

[51] C.R. Weiss, W. Briglauer, Determinants and dynamics of farm diversification, in: The Xth EAAE Congress 'Exploring Diversity in the European Agri-Food System', 2002, pp. 1–15, https://doi.org/10.22004/ag.econ.24929, 28th-31st August; Zaragoza, Spain.

[52] V. Chatellier, Price volatility, market regulation and risk management: challenges for the future of the CAP (2011) [University work] auto-saisine, https://hal.science/hal-01466968/document.

[53] I. Darnhofer, Resilience and why it matters for farm management, Eur. Rev. Agric. Econ. 41 (3) (2014) 461–484, https://doi.org/10.1093/erae/jbu012.

[54] R.A. Hoppe, Structure and Finances of US Farms: Family Farm Report, 2014 Edition. EIB-132, United States Department of Agriculture, Washington D.C., 2014. Available from: https://www.ers.usda.gov/webdocs/publications/43913/50364_eib-132.pdf?v=.

[55] M. Boehlje, Alternative models of structural change in agriculture and related industries, Agribusiness 8 (3) (1992) 219–231, https://doi.org/10.1002/1520-6297(199205)8:3<219::AID-AGR2720080303>3.0.CO;2-T.

[56] E. Goddard, A. Weersink, K. Chen, C.G. Turvey, Economics of structural change in agriculture, can, J. Agric. Econ. 41 (4) (1993) 475–489, https://doi.org/10.1111/j.1744-7976.1993.tb03772.x.

[57] M. Lobley, C. Potter, Agricultural change and restructuring: recent evidence from a survey of agricultural households in England, J. Rural Stud. 20 (4) (2004) 499–510, https://doi.org/10.1016/j.jrurstud.2004.07.001.

[58] G. Breustedt, T. Glauben, Driving forces behind exiting from farming in Western Europe, J. Agric. Econ. 58 (1) (2007) 115–127, https://doi.org/10.1111/j.1477-9552.2007.00082.x.

[59] M. Lobley, A. Butler, The impact of CAP reform on farmers' plans for the future: some evidence from South West England, Food Policy 35 (4) (2010) 341–348, https://doi.org/10.1016/j.foodpol.2010.04.001.

[60] A.K. Mishra, M. Raggi, D. Viaggi, Determinants of farm exit: a comparison between Europe and United States, in: The 114th EAAE Seminar 'Structural Change in Agriculture', 2010, pp. 1–26, https://doi.org/10.22004/ag.econ.61075, 15th-16th April; Berlin, Germany.

[61] L. Latruffe, A. Dupuy, Y. Desjeux, What would farmers' strategies be in a no-CAP situation? An illustration from two regions in France, J. Rural Stud. 32 (2013) 10–25, https://doi.org/10.1016/j.jrurstud.2013.04.003.

[62] A. Barnes, L.-A. Sutherland, L. Toma, K. Matthews, S. Thomson, The effect of the common agricultural policy reforms on intentions towards food production: evidence from livestock farmers, Land Use Policy 50 (2016) 548–558, https://doi.org/10.1016/j.landusepol.2015.10.017.

[63] S.J. Goetz, M. Davlasheridze, State-level cooperative extension spending and farmer exits, AEPP 39 (1) (2017) 65–86, https://doi.org/10.1093/aepp/ppw007.

[64] R. Suchato, A. Patoomnakul, N. Photchanaprasert, Alternative cropping adoption in Thailand: a case study of rice and sugarcane production, Heliyon 7 (12) (2021) e08629, https://doi.org/10.1016/j.heliyon.2021.e08629.

[65] J.M. Wooldridge, Econometric Analysis of Cross Section and Panel Data, second ed., MIT press, Massachusetts, 2010. Available from: http://www.jstor.org/stable/j.ctt5hhcfr.

[66] W.H. Greene, Econometric Analysis, fifth ed., Prentice Hall, New Jersey, USA, 2003. https://www.ctanujit.org/uploads/2/5/3/9/25393293/_econometric_analysis_by_greence.pdf.

[67] D.J. Finney, Probit Analysis: a Statistical Treatment of the Sigmoid Response Curve, Cambridge university press, Cambridge, 1952.

[68] G. Young, Maximum likelihood estimation and factor analysis, Psychometrika 6 (1) (1941) 49–53, https://doi.org/10.1007/BF02288574.

[69] W.E. Becker, D.M. Waldman, A graphical interpretation of probit coefficients, J. Econ. Educ. 20 (4) (1989) 371–378, https://doi.org/10.2307/1182687.

[70] Khon Kaen University KKU, Project on Production Cost Management and Knowledge Transfer to Reduce Farmers' Sugarcane Production Costs in Crop Year 2014/15, Final report, Thailand, 2014 (In Thai), https://old.ocsb.go.th/upload/learning/fileupload/5336-6947.pdf.

[71] K. Kuldilok, The determination of organic practice and adoption in sugarcane farming in Thailand, Kasetsart J Soc. Sci. 42 (3) (2021) 694–701. Retrieved from, https://so04.tci-thaijo.org/index.php/kjss/article/view/253495.

[72] Office of Agricultural Economics OAE, Agricultural Statistics of Thailand 2021 (2021) (In Thai). Thailand, https://www.oae.go.th/assets/portals/1/files/jounal/2565/yearbook2564.pdf.

[73] Food and Agriculture Organization of the United Nations FAO, FAO Trade Policy Technical Notes No. 6- Sugar: the Impact of Reforms to Sugar Sector Policies a Guide to Contemporary Analyses, Food and Agriculture Organization of the United Nations (FAO), Italy, 2004. Available from: https://www.fao.org/3/j5586e/j5586e00.pdf.

[74] A. Gohin, J.-C. Bureau, Modelling the EU sugar supply to assess sectoral policy reforms, Eur. Rev. Agric. Econ. 33 (2) (2006) 223–247, https://doi.org/10.1093/erae/jbl006.

[75] P. Jansuwan, K.K. Zander, What to do with the farmland? Coping with ageing in rural Thailand, J. Rural Stud. 81 (2021) 37–46, https://doi.org/10.1016/j.jrurstud.2020.12.003.

[76] A. Ferjani, A. Zimmermann, A. Roesch, Determining factors of farm exit in agriculture in Switzerland, Agric. Econ. Rev. 16 (1) (2015) 59–72, https://doi.org/10.22004/ag.econ.253691.

[77] J. Prasara-A, S.H. Gheewala, An assessment of social sustainability of sugarcane and cassava cultivation in Thailand, Sustain. Prod. Consum. 27 (2021) 372–382, https://doi.org/10.1016/j.spc.2020.11.009.

[78] J.A. Ouellette, W. Wood, Habit and intention in everyday life: the multiple processes by which past behavior predicts future behavior, Psychol. Bull. 124 (1) (1998) 54–74, https://doi.org/10.1037/0033-2909.124.1.54.

[79] W. Arjchariyaartong, The Competitiveness of the Sugar Industry in Thailand [Phd Thesis], Universität Göttingen, Germany, 2007.

[80] A. Hejnowicz, M. Rudd, P.C. White, A survey exploring private farm advisor perspectives of agri-environment schemes: the case of England's environmental stewardship programme, Land Use Policy 55 (2016) 240–256, https://doi.org/10.1016/j.landusepol.2016.04.005.

[81] A. Daxini, M. Ryan, C. O'Donoghue, A.P. Barnes, Understanding farmers' intentions to follow a nutrient management plan using the theory of planned behaviour, Land Use Policy 85 (2019) 428–437, https://doi.org/10.1016/j.landusepol.2019.04.002.

[82] B. Agarwal, A. Agrawal, Do farmers really like farming? Indian farmers in transition, Oxf. Dev. Stud. 45 (4) (2017) 460–478, https://doi.org/10.1080/13600818.2017.1283010.

[83] W. Sawaengsak, S.H. Gheewala, Analysis of social and socio-economic impacts of sugarcane production: a case study in Nakhon Ratchasima province of Thailand, J. Clean. Prod. 142 (2017) 1169–1175, https://doi.org/10.1016/j.jclepro.2016.08.148.

[84] M. Udomkerdmongkol, N. Chalermpao, Thai agricultural sector: from problems to solutions, United Nations Thailand (2020) [Accessed 8 Novermber 2022]; Available from: https://thailand.un.org/en/103307-thai-agricultural-sector-problems-solutions.

[85] J. Prasara-A, S.H. Gheewala, Sustainability of sugarcane cultivation: case study of selected sites in north-eastern Thailand, J. Clean. Prod. 134 (2016) 613–622, https://doi.org/10.1016/j.jclepro.2015.09.029.

[86] J. Sasarose, P. Naraphorn, W. Papis, K. Piya, Factors affecting crop choices in Thailand: Rice or sugarcane? IEMS 22 (3) (2023) 244–258, https://doi.org/10.7232/iems.2023.22.3.244.

[87] Office of the Cane and Sugar Board OCSB, Report on Sugarcane Cultivation Situation 2022/23, Bangkok, Thailand, 2023 (In Thai), https://www.ocsb.go.th/wp-content/uploads/2023/06/%E0%B8%A3%E0%B8%B2%E0%B8%A2%E0%B8%87%E0%B8%B2%E0%B8%99%E0%B8%AA%E0%B8%96%E0%B8%B2%E0%B8%99%E0%B8%81%E0%B8%B2%E0%B8%A3%E0%B8%93%E0%B9%8C%E0%B8%81%E0%B8%B2%E0%B8%A3%E0%B8%9B%E0%B8%A5%E0%B8%

B9%E0%B8%81%E0%B8%AD%E0%B9%89%E0%B8%AD%E0%B8%A2%E0%B8%9B%E0%B8%B5%E0%B8%81%E0%B8%B2%E0%B8%A3%E0%B8%9C%E0%B8%A5%E0%B8%B4%E0%B8%95-2565-66.pdf.

[88] Krungsri, Industry Outlook 2023-2025: Sugar Industry, Krungsri Research, Thailand, 2023. Available from: https://www.krungsri.com/en/research/industry/industry-outlook/agriculture/sugar/io/sugar-2023-2025.

[89] D. Bougherara, L. Latruffe, Potential impact of the EU 2003 CAP reform on land idling decisions of French landowners: results from a survey of intentions, Land Use Policy 27 (4) (2010) 1153–1159, https://doi.org/10.1016/j.landusepol.2010.03.005.

[90] J. Nobel, Policy Scenarios for EU Sugar Market Reform. IP/B/AGRI/IC/2012-60 PE 495.823, The European Parliament, Brussels, 2012. Available from: https://policycommons.net/artifacts/1333900/policy-scenarios-for-eu-sugar-market-reform/1938735/.

[91] K. Pietola, M. Väre, A.O. Lansink, Timing and type of exit from farming: farmers' early retirement programmes in Finland, Eur. Rev. Agric. Econ. 30 (1) (2003) 99–116, https://doi.org/10.1093/erae/30.1.99.

[92] J. Davis, P. Caskie, M. Wallace, Promoting structural adjustment in agriculture: the economics of new entrant schemes for farmers, Food Policy 40 (2013) 90–96, https://doi.org/10.1016/j.foodpol.2013.02.006.