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Promoting Food Safety in Local Value Chains: The Case of Vegetables in Vietnam

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Abstract: Background: Food quality and safety concerns in low- and middle-income countries are often addressed using stringent standards and formal contracts between farmers and buyers. Many studies have investigated the welfare implications of these control mechanisms for small-scale farmers in modern value chains, including exports and supermarkets. Conversely, few studies have focused on the potential of certification and contracts to tackle food safety issues within local traditional value chains. Methods: This study uses a discrete choice experiment to explore the preferences of vegetable farmers (n = 301) in northern Vietnam for different types of certification schemes–including third-party certification and participatory guarantee systems–and contracts. Results: Farmers are willing to accept a 49% lower price per kilogram for their vegetables to enter into a contract with a buyer, provided that pesticide use restrictions are feasible and the buyer is fully committed and trustworthy. However, they are strongly averse to organic farming, as they would require a 40% premium per kilogram to produce organically. They would also request a 21% premium to accept selling to an unknown buyer. Farmers highly value contracts that entail large purchase quantities, long duration and pesticide provision. Although the estimated willingness-to-accept values may seem very large, they make sense in the context of highly perishable produce. Conclusion: Our findings urge both policy makers and researchers to not only focus on modern value chains but also on local traditional value chains to tackle food safety issues in low- and middle-income countries, as we show that farmers are willing to produce safe vegetables for the local market when trading with buyers under beneficial conditions.

Keywords: contract farming; certification; food safety; pesticide misuse; food value chain; Asia

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1. Introduction

The agri-food sector in low- and middle-income countries is transforming rapidly [1,2]. Short 'traditional' food value chains, typically relying on spot markets, have grown into longer, 'modern' value chains, characterized by high degrees of consolidation, vertical coordination and stringent regulation through standards [3,4]. This modernization is strongly linked to the rapid diffusion of supermarkets and increased exports of high-value produce [5,6]. However, most value chains in low- and middle-income countries are in 'transition' between a traditional and modern stage. A major share of food in local markets is still supplied through traditional value chains in which spot markets dominate but concerns about food quality and safety have risen [7,8].

Assuring transparency and the transfer of reliable information on food quality and safety in local food value chains represents a daunting challenge. Most policy makers and researchers have focused on policies aimed at accelerating value chain modernization, whereby traditional markets are rapidly replaced by supermarkets [9,10]. Food quality and safety are regulated through public and private standards, often in combination with formal contracts between farmers and buyers that stipulate requirements on quantity,

quality and price [11]. However, such standards–and certification of compliance therewith–are generally complex and entail high costs related to conformity assessment. Therefore, they tend to exclude small-scale farmers from the market, who often struggle to adapt to these new regulations [12]. Moreover, poorer consumers cannot afford higher food prices of certified produce or simply prefer shopping at more traditional markets instead of supermarkets [13]. Yet, the majority of studies on contract farming and certification focus on high-value export contracts led by private firms, or modern retail companies (See [14,15]) for recent reviews of the literature on contract farming, [16] on non-contract interactions between small-scale farmers and value chain actors, and [17,18]) on certification).

In this study, we contribute to the literature by exploring the potential of contract farming and certification to tackle food safety problems in local value chains. This topic is particularly pertinent as local food systems have recently been promoted by governments and civil society organisations as a lever for change towards more inclusive and resilient food systems. Using a survey and a discrete choice experiment (DCE) among 301 vegetable farmers in peri-urban Hanoi, we compare farmers' production and marketing practices across outlet channels and analyze their preferences towards contracts and certification. DCEs have recently been used to examine these preferences, but nearly all of these studies focus on modern value chains [19–24], with [25] as important exception. DCEs are particularly useful to complement qualitative research on farmers' preferences with a quantitative assessment of acceptable trade-offs. They constitute a valuable tool for informing effective policy making and are relatively quick and cheap to implement [26,27]. We introduce some methodological improvements that previous studies have often not controlled for. We use a D-efficient partial profile design to construct the choice cards, which simplifies the choice task to be executed by the respondents and leads to more reliable results. Moreover, we control for scale heterogeneity, attribute non-attendance and ordering effects to reduce bias in estimating the utility coefficients.

Our focus on the vegetable sector in peri-urban Hanoi is highly relevant. Food safety has become a major issue in Vietnam, with consumers and policy makers increasingly concerned about the origin of agri-food produce sold domestically [28]. Using a survey among 152 consumers in northern Vietnam, [29] show that consumers mainly fear the health risks posed by the excessive and inadequate use of agro-chemicals (i.e., pesticides, fertilizers and preservatives) in vegetable production. Although bacterial contamination is commonly reported as an important cause of foodborne diseases, consumers seem to believe that they are able to avoid these risks, contrarily to residues of agro-chemicals. While the government has implemented policies to promote "safe vegetables" - vegetables produced following specific conditions and procedures, including strict adoption of integrated pest management practices, reasonable use of low-toxic pesticides and use of clean water for irrigation - through modern retail, vegetables are still mainly purchased at traditional markets—Ref [30] estimate that only 2% of total vegetables in Hanoi are sold at supermarkets. Hence, local government bodies, cooperatives and NGOs are interested in setting up new types of arrangements between farmers and local traders. These include internal control mechanisms, such as participatory guarantee systems (PGS), that are claimed to be more feasible for small-scale farmers and affordable for poorer consumers than certification by an external third party [31]. Our results are of direct relevance to these stakeholders, but are also applicable to many other low- and middle-income countries facing similar challenges in building inclusive and sustainable local food value chains.

In this context, we address three main research questions:

(1) Are farmers in northern Vietnam willing to produce safe vegetables for the local market?
(2) If so, under which conditions are they willing to do so, i.e., what specifications should a contract or certification scheme entail for farmers to accept reducing their pesticide use?
(3) Are there significant differences in preferences between contract farmers (farmers who already have an agreement with buyers) and non-contract farmers?

We hypothesize that farmers will be open to producing safe vegetables if requirements in terms of pesticide use are feasible (not completely banned) and if contracts ensure higher prices over a long period of time. In addition, we expect that farmers will be in favour of the assurance of large quantities purchased and pesticides provided by the buyer. Regarding control mechanisms, we hypothesize that farmers will prefer internal control mechanisms (such as PGS) over control by a third-party. Finally, we assume that contract farmers will be even more interested in stable contracts than non-contract farmers, based on their current marketing practices.

This article is organized as follows: following the introduction (Section 1), we provide background information on the issues of pesticide (mis)use and food safety in Vietnam (Section 2). After a comprehensive explanation of the materials and methods in Section 3, we present and discuss our empirical results in Section 4. In Section 5, we highlight policy implications of our findings. Finally, in Section 6 we provide a conclusion to our research.

2. Background

Vegetable production systems in Southeast Asia have faced significant problems related to pesticide misuse in recent decades. In Vietnam, pesticides were first imported in the late 1950s, as the government saw an opportunity to boost the collective agricultural production model through increased input use. By the mid-1980s, Vietnam had reoriented its economy and agricultural policies towards a market-based approach involving privatization and globalization. Limited arable area size and property speculation pushed farmers to apply increasingly large amounts of pesticides to maximize their yields and compete on the market. As a consequence, pesticide imports–including a substantial share of toxic and illegal products–increased annually by 10.6% in volume and 18.8% in value between 2005 and 2012 [32]. Ref [33] found that, out of four Southeast Asian countries, Vietnam had the highest pesticide application rate in 2012 (16.15 kg/ha, as compared to 2.94, 0.09, and 8.38 kg/ha in Cambodia, Laos and Thailand, respectively). Pesticides are particularly applied in horticultural production, as [34] show that residue levels in fruit and vegetables exported from Vietnam were above the EU Maximum Residue Levels in 33% of the samples.

Consequences of pesticide misuse in Vietnam are three-fold. First, several toxic, often illegal pesticides are commonly used by farmers, posing a threat to human health [32]. Farmers are at risk if they do not wear adequate protective gear during pesticide application, while consumers are exposed to pesticide residues through food and water consumption [35]. Ref [36] estimate that Vietnam's annual productivity loss (due to loss of work, disability and premature death) from foodborne disease amounts to around US$ 740 million. Second, inadequate application of pesticides has led to soil and water contamination, demonstrated by high residue concentrations for several commonly applied pesticides in the environment surrounding agricultural land in northern Vietnam [37,38]. Third, farmers have been found to overuse pesticides from an economic point of view, i.e. in excess of the economic optimal level [39–41]. By reducing their pesticide use, farmers could thus increase their profit.

Over the past decades, the Vietnamese government has taken a number of policy initiatives to tackle pesticide misuse in the vegetable sector, with limited success. In 1995 the Vietnam Ministry of Agriculture launched the "safe vegetables" program, which aims at training and encouraging farmers to use less pesticides and improving their irrigation water management. The Plant Protection Department of Hanoi municipality issues safe vegetable production certificates to cooperatives and companies following compliance with restrictions on the use of pesticides and based on specific conditions of soil and water in the area. In 2016, 125 farmer cooperatives and companies in Hanoi held a safe vegetables certificate [42]. However, the enforcement mechanism within cooperatives to ensure adequate pesticide use was found unsuccessful [41]. In 2008, the government introduced a new national standard, VietGAP, a less demanding version of GlobalGAP. To become certified, farmer groups need to organize self-inspections of their members'

recorded production practices, which are then verified by an external auditor. Similar to other third-party standards, this certification scheme requires substantial effort from farmers to comply with stringent requirements. Unsurprisingly, uptake is estimated to be very low–in 2016, only 24 farmer cooperatives and companies in Hanoi were officially VietGAP certified, representing 2.8% of Hanoi's vegetable surface [42].

Apart from government initiatives, participatory guarantee systems (PGS) have recently started mushrooming across the country. PGS represent an alternative locally focused quality and safety assurance mechanism, which differs from third-party certification as local inter-groups of farmers, authorities, traders and consumers control production internally, and the administrative burden on farmers is much lower [31]. Local government bodies, cooperatives and several NGOs are currently supporting the spread of PGS in the country. Yet, scientific-based evidence on farmers' perceptions of such internal control mechanisms is still largely missing.

3. Materials and Methods

3.1. Research Area

The research area is located in northern Vietnam, in the peri-urban districts of Hanoi (Figure A1). The majority of vegetables traded in Hanoi are produced in peri-urban areas on small plots (generally 0.1–1 hectares). Vegetable production is highly diversified with the average number of different crops grown per farm estimated to be 7.5 [43]. Main vegetable types include leafy vegetables (e.g., Indian mustard, green choy sum), flower vegetables (e.g., cauliflower, broccoli), fruit vegetables (e.g., wax gourd, cucumber), root vegetables (e.g., carrot, radish) and herbs (e.g., lemongrass, chili). Leafy, fruit and herb vegetables are produced all year round, while flower and root vegetables are mainly produced in winter (November to March). Vegetable production is more profitable than cereals, like rice [44]. The value chain for vegetables in Hanoi is typically organised as follows: farmers sell their produce to either collectors or cooperatives, who then trade with modern (i.e., supermarkets, convenience stores) or traditional retailers (i.e., wholesalers, wet markets, street vendors), in turn selling to consumers. Farmers also sell their produce directly to traditional retailers or consumers. Although most of the marketing of vegetables does not occur through fixed contracts, some farmers and traders may establish informal arrangements [29]. Even though these arrangements are often oral and non-binding, they are defined as contract farming according to recent studies [14,15].

3.2. Data Collection

Data collection was organised in two phases. First, we conducted focus group discussions with farmers and semi-structured interviews with cooperative leaders and traders in July 2018 to obtain information on current production and marketing practices. Second, we conducted a survey among 301 vegetable farmers in October-November 2018, using a three-stage stratified random sampling strategy. In the first stage, we purposely selected three peri-urban districts of Hanoi Province (Gia Lam, Thanh Tri and Chuong My) based on their importance in supplying vegetables to Hanoi city. In the second stage, we randomly chose 20 communes in these districts (6 in Gia Lam, 5 in Thanh Tri and 9 in Chuong My) and in the third stage, we randomly selected between 15 and 17 farmers per commune with an oversampling of cooperative members. We used a structured, quantitative farm-household questionnaire, comprising modules on farm-household characteristics, income sources, vegetable production and marketing, and farmer group membership. The marketing channels were specified per crop type, buyer and season, which allows us to distinguish between farmers with at least one preharvest selling agreement (i.e., contract farmers) and farmers without (i.e., non-contract farmers). In our sample, 37% (n = 112) is considered as contract farmer, indicating that pre-harvest selling agreements are relatively common in the sector. At the end of the survey, farmers participated in a discrete choice experiment (DCE) to reveal their preferences for safe vegetable contracts and certification. The interviews were conducted in Vietnamese by nine trained enumerators. The selected farmers

were informed about the purpose of the research and were given the choice to participate. When they accepted, they were asked to sign an informed consent form to avoid any ethical issues. Moreover, before conducting the survey we received the University's ethical board's approval.

3.3. Choice Experiment Design

In a DCE respondents choose between several hypothetical scenarios, each characterized by a number of attributes that can take on different levels. In this study we presented three unlabeled production and marketing scenarios per choice card, including one opt-out alternative (selling independently on the market without any regulation on pesticide use). Figure A2 in Appendix A shows an example of one choice card. Each scenario consists of six attributes, taking on three to five different levels (Table 1). The attributes and levels were selected based on the literature, focus group discussions with farmers and interviews with cooperative leaders and local experts. As farmers cultivate many different types of vegetables, focusing the DCE on one specific vegetable would not reflect farmers' reality. Hence, we decided to frame the DCE on vegetables in general.

Table 1. Attributes and attribute levels used in the discrete choice experiment.

ATTRIBUTE	ATTRIBUTE LEVELS
PESTICIDE USE	• No restrictions (OO) • Restricted, controlled by farmer group • Restricted, controlled by third-party organisation • Banned, controlled by farmer group • Banned, controlled by third-party organisation
PESTICIDE PROVISION	• No provision (OO) • Provision in kind • Provision in cash
SHARE OF YIELD SOLD TO BUYER	• 10% (OO) • 50% • 90%
RELATION TO BUYER	• Buyer personally known (OO) • Buyer known through others • Buyer unknown
DURATION OF CONTRACT	• One week (OO) • One season • One year
SELLING PRICE	• Market price (OO) • Market price + 1000 VND/kg • Market price + 5000 VND/kg

Note: The national currency, VND, stands for Vietnamese dong and had an exchange rate to the Euro of 26,555 VND at the time of study. The average market price of vegetables at the time of study was around 9800 VND/kg. OO stands for the opt-out option.

The first attribute on pesticide use and control comprises five levels: (1) no restrictions; (2) restrictions in line with safe vegetable regulations and internally controlled by a farmer group; (3) similar restrictions but externally controlled by a third-party; (4) pesticides banned and internally controlled; and (5) pesticides banned and externally controlled. The levels represent requirements and control mechanisms that are used in existing certification schemes, including safe vegetable or organic certification, through PGS or by a third-party certifying body recognized by the government.

The second attribute on pesticide provision relates to a service provided in advance by the buyer, as part of a contract with a farmer. It consists of three levels: (1) no provision; (2) provision in kind; and (3) provision in cash. Both provision types are prevalent in the region. When pesticides are banned in the first attribute, this attribute automatically takes the level of no provision.

The third attribute relates to the share of vegetable production that the buyer agrees to purchase from the farmer before harvest. It consists of three levels: (1) 10%; (2) 50%; and (3) 90% of production. We included this attribute as farmers mentioned that being able to sell large volumes would be a major driver to enter into a contract.

The fourth attribute is defined as the relation between the farmer and buyer before their first transaction, and consists of three levels: (1) farmer knows the buyer personally; (2) farmer knows the buyer through others; and (3) farmer does not know the buyer. Farmers repeatedly mentioned during focus group discussions that mutual trust is a key factor in determining whom to sell to.

The fifth attribute concerns the duration of a contract and comprises three levels: (1) one week; (2) one season; and (3) one year. During this period the farmer has to sell his/her vegetables to the buyer under the specified terms.

The last attribute represents the selling price of vegetables and consists of three levels: (1) market price; (2) market price + 1000 VND/kg; and (3) market price + 5000 VND/kg. The market price depends on the vegetable type and the marketing channel; the year-average price of the different vegetable types across marketing channels in our sample at the time of the survey is 9800 VND/kg (0.37 €/kg) (Table 2).The price premiums are based on the actual premiums paid to certified farmers, and represent realistic ranges.

Table 2. Average prices of vegetables per type (VND/kg).

		Full Sample (n = 301)		**Contract Farmers (n = 112)**		**Non-Contract Farmers (n = 189)**		
		Mean	**(se)**	**Mean**	**(se)**	**Mean**	**(se)**	
Leafy vegetables	Average	7657	(166)	7240	(248)	7887	(217)	*
	When sold directly to consumers	8498	(188)	7868	(302)	8764	(238)	
	When sold to middlemen	7179 [a]	(162)	7020	(248)	7287 [a]	(214)	
Fruit vegetables	Average	8939	(246)	8807	(408)	9020	(311)	
	When sold directly to consumers	10,833	(242)	12,035	(478)	10,296	(268)	
	When sold to middlemen	8092 [a]	(241)	8192 [a]	(382)	8005 [a]	(316)	
Root vegetables	Average	8725	(204)	8523	(368)	8834	(244)	
	When sold directly to consumers	9227	(215)	8681	(406)	9445	(256)	
	When sold to middlemen	7730 [a]	(190)	7945	(348)	7571 [a]	(220)	
Herbs	Average	12,933	(390)	12,246	(504)	13,698	(589)	
	When sold directly to consumers	15,150	(369)	17,281	(531)	14,013	(486)	
	When sold to middlemen	12,697	(389)	12,071 [b]	(481)	13,483	(613)	
Flower vegetables	Average	10,810	(218)	9978	(336)	11,641	(281)	*
	When sold directly to consumers	11,656	(227)	10,240	(297)	12,541	(305)	*
	When sold to middlemen	10,213 [c]	(216)	9994	(370)	10,520 [c]	(259)	

Note: Prices shown in the table represent average values over the winter and summer seasons. Middlemen comprise collectors and cooperatives. The national currency, VND, stands for Vietnamese dong and had an exchange rate to the Euro of 26,555 VND at the time of study. Standard errors are reported between parentheses. Significant differences in price for contract and non-contract farmers are indicated with * $p < 0.1$ (based on a two-sample t-test); significant differences between the price paid by consumers and the price paid by retailers are indicated with [a] $p < 0.01$, [b] $p < 0{,}05$, and [c] $p < 0.1$ (based on t-tests).

We used a partial profile design to ease decision-making for the respondents and avoid fatigue, meaning only three attribute levels were allowed to differ between the two contract scenarios on one card. The opt-out option was always specified in the same way by using the base levels of the six attributes. Thirty choice cards were created in total, divided into five blocks. Each farmer was asked to evaluate six choice cards from one block, shown in a random order to factor in possible order and starting point effects. To ensure that respondents understood the DCE, they had to first evaluate a choice card with a clear dominant choice before they could start the DCE.

3.4. Choice Experiment Analysis

Econometric analysis of DCEs is based on random utility theory, which decomposes utility into a deterministic part and a stochastic (random) part, capturing unobserved factors that determine an individual's choice. The deterministic part can be further decomposed into a choice-specific part and an individual-specific part:

$$U_{ij} = V_{ij} + \varepsilon_{ij} = \beta X_j + \alpha Z_i + \varepsilon_{ij}$$

where, U_{ij} represents the utility derived from alternative j for farmer i, V_{ij} the deterministic part of U_{ij} and ε_{ij} its stochastic part. X_j is the vector of attributes of contract j, Z_i is the vector of farmer i's characteristics and β and α their associated coefficients [45,46].

We estimate mixed logit (MXL) models to assess farmers' preferences. They account for preference heterogeneity among respondents by allowing for random taste variation [46]. This implies that MXL models do not only estimate the mean value of each coefficient, but also the standard deviation of the coefficient's distribution around its mean value. The probability of farmer i choosing alternative j (among Ji alternatives) on choice card t is given by:

$$P_{ijt} = \frac{\exp(\beta_i X_{jt})}{\sum_{j=1}^{Ji} \exp(\beta_i X_{jt})};\ \beta_i = \beta + \Delta s_i + \varepsilon_i \quad (1)$$

where β_i is a vector of coefficients associated with preferences for attributes X_{jt}, while s_i represents a vector of standard deviations and ε_i the error term [46,47]. We include an alternative-specific constant (ASC), coded 0 for the opt-out option and 1 for the two other scenarios. Hence, a positive ASC coefficient indicates a preference for selling under a safe vegetable contract, rather than independently on the market. We define all attributes and the ASC as random parameters with a normal distribution. We perform several robustness checks in addition to the MXL model (including scale heterogeneity and attribute non-attendance), which are explained in detail in Appendix B.

We explain preference heterogeneity among farmers using a split-sample model, analyzing the MXL model separately for contract and non-contract farmers. We report this method and not other commonly used methods, such as latent class (LC) models and MXL models with interaction terms between attributes and variables, for two reasons. First, the results of these models do not provide added insights into potential drivers of preference heterogeneity. Moreover, rather than fully exploring all sources of preference heterogeneity, we are mostly interested in understanding differences between contract and non-contract farmers. Second, in case of the MXL model with interactions, we notice large inconsistencies in coefficients' sign and significance when changing the order of the interaction terms. Such ordering effects stem from the simulation noise inherent in the numerical procedure and have recently been raised by [48]. While this can have far-reaching effects on the replicability and robustness of previously published studies, very few (if any) authors control for this. We analyze all models with Stata 16.1 software using 500 Halton draws. The basic MXL model for all farmers was first ran using 1000 and 2000 Halton draws. The sign, magnitude and significance of all coefficients did not vary substantially between 500 and 2000 Halton draws; hence, we proceeded with 500 Halton draws for all models analyzed in this paper for computational efficiency reasons.

The estimated coefficients allow us to derive values of willingness-to-accept (WTA), which represent the marginal rate of substitution between a considered attribute and price [49]. WTA estimates are interpreted as the monetary value of each attribute level with positive (or negative) WTA values indicating how much the price per kilogram of vegetables should be raised (or reduced) for respondents to accept a particular attribute level. They are calculated directly at the estimation stage using a WTA-space model and are derived as follows:

$$\text{marginal WTA} = -\frac{\beta_{\text{attribute}}}{\beta_{\text{price}}} \quad (2)$$

3.5. Limiting Hypothetical Bias

DCEs can suffer from hypothetical bias and may therefore overestimate utility [26]. In this DCE, hypothetical bias may be the strongest for the attribute on pesticide use due to social desirability effects, which have been reported to be significant in surveys among Vietnamese citizens (as in other post-socialist countries) [50]. To minimize this bias, the purpose of the experiment was carefully explained to respondents beforehand and a cheap talk script was provided. Moreover, enumerators insisted on the anonymous nature of the study.

4. Results and Discussion

4.1. Characteristics of Vegetable Farmers

Table 3 presents farms' and farmers' characteristics of our sample, with farmer defined as the main decision-maker in vegetable production and marketing in the household. Significant differences between contract and non-contract farmers are indicated with * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$ (based on a two-sample *t*-test for continuous variables, and a pr-test for dummy variables). Most farmers are relatively well-educated (89%, $n = 269$, has obtained a high-school certificate). Women represent the large majority of the sample (73%, $n = 220$). Farmers are, on average, 55 years old and are part of a five person household with a dependency ratio of almost 50%. Cooperative membership is quite common among farmers (65%, $n = 195$) with contract farmers more likely to be member (77%, $n = 86$) than non-contract farmers (58%, $n = 110$). Cultivated areas allocated to vegetable production are very small (0.4 ha on average). Over 90% of farmers in our sample ($n = 272$) cultivate leafy vegetables, while less than half of them cultivate either fruit, root, herbs or flower vegetables. Contract farmers cultivate on a slightly larger area and are less likely to cultivate leafy vegetables. Average net annual income from vegetable production is 57 million VND, representing about 40% of total household income. Contract farmers derive both in absolute and relative terms more income from vegetable production than non-contract farmers, but there are no differences in their total income. This is probably because non-contract farmers are more likely to be off-farm employed (82%, $n = 155$) than contract farmers (69%, $n = 77$). Farmers spend about five million VND per hectare yearly on pesticides for vegetable production–with no significant difference between contract and non-contract farmers –, which is relatively low compared to the net income of 179 million VND per hectare, indicating that either prices of pesticides are very low or that applied quantities are small. Unfortunately, we cannot disentangle this from our data. In sum, contract farmers tend to specialize more in vegetable production than non-contract farmers, but they do not necessarily apply more pesticides.

4.2. Marketing of Vegetables

Table 4 describes farmers' marketing practices of vegetables. On average, contract farmers sell a larger proportion of their harvest to collectors (78%) in comparison with non-contract farmers (56%). The latter sell a greater share of their harvest to consumers directly (28%) than contract farmers (8%). Consequentially, contract farmers are more likely to sell to fewer buyers (50% ($n = 56$) sells to less than ten buyers versus 18% ($n = 34$) of non-contract farmers) and buyers they know (28% ($n = 31$) versus 11% ($n = 21$). Overall, farmers sell less than 3% of their harvest to cooperatives. This is because cooperatives in the area generally take on more responsibilities related to production, including provision of training and inputs, and support with irrigation (i.e. activating the collective pump system and maintaining ditches). Sixty-six percent of contract farmers ($n = 74$) sell the majority of their production at farm gate (where collectors pick up their purchases), while only 23% of non-contract farmers do so ($n = 43$). Farmers who do not sell at farm gate mostly trade their produce on local markets, with only a few in Hanoi city (6%, $n = 17$).

Table 3. Farm and farmer's characteristics.

	Full Sample (*n* = 301)		**Contract Farmers (*n* = 112)**		**Non-Contract Farmers (*n* = 189)**		
	Mean	**(se)**	**Mean**	**(se)**	**Mean**	**(se)**	
Farmer characteristics							
Age (years)	55.05	(0.48)	56.00	(0.68)	54.49	(0.64)	
Experience with vegetable production (years)	25.42	(0.73)	25.12	(1.21)	25.60	(0.92)	
Female (dummy)	0.73		0.67		0.77		*
Obtained high-school certificate (dummy)	0.89		0.90		0.89		
Household size (#)	4.97	(0.13)	5.13	(0.21)	4.88	(0.16)	
Dependency ratio	0.46	(0.03)	0.44	(0.04)	0.47	(0.03)	
Cooperative member (dummy)	0.65		0.77		0.58		***
Farm characteristics							
Cultivated area with vegetables (ha)	0.40	(0.03)	0.46	(0.04)	0.36	(0.04)	*
Cultivates leafy vegetables (dummy)	0.91		0.87		0.94		**
Cultivates fruit vegetables (dummy)	0.48		0.47		0.48		
Cultivates root vegetables (dummy)	0.42		0.38		0.45		
Cultivates herbs (dummy)	0.33		0.40		0.28		**
Cultivates flower vegetables (dummy)	0.32		0.37		0.29		
Cultivates other non-vegetable crops (dummy)	0.81		0.81		0.81		
Net income from vegetable production (million VND/year)	57.08	(4.16)	73.50	(8.20)	47.36	(4.38)	**
Net income from vegetable production per hectare (million VND/year)	178.55	(11.65)	200.75	(20.74)	165.40	(13.86)	
Net household income (million VND/year)	168.94	(13.15)	183.38	(18.97)	160.39	(17.67)	
Share of income from vegetable production (%)	39.75	(1.26)	45.50	(1.95)	36.34	(1.58)	***
Pesticides cost (million VND/year)	1.55	(0.16)	1.79	(0.26)	1.40	(0.20)	
Pesticides cost per hectare (million VND/year)	4.73	(0.70)	4.46	(0.58)	4.90	(1.06)	
Off-farm employment (dummy)	0.77		0.69		0.82		***

Note: The national currency, VND, stands for Vietnamese dong and had an exchange rate to the Euro of 26,555 VND at the time of study. Standard errors are reported between parentheses. Significant differences between groups are indicated with * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$ (based on a two-sample *t*-test for continuous variables, and a pr-test for dummy variables).

Table 4. Marketing of vegetables.

	Full Sample (*n* = 301)		**Contract Farmers (*n* = 112)**		**Non-Contract Farmers (*n* = 189)**		
	Mean	**(se)**	**Mean**	**(se)**	**Mean**	**(se)**	
Share sold to cooperative (%)	2.82	(0.65)	5.31	(1.50)	1.34	(0.51)	***
Share sold to collectors (%)	63.83	(1.92)	77.72	(2.21)	55.59	(2.59)	***
Share sold directly to consumers (%)	20.50	(1.62)	8.03	(1.24)	27.90	(2.31)	***
Share used for self-consumption or lost (%)	12.85	(0.69)	8.94	(0.97)	15.17	(0.89)	***
Sells to less than 10 buyers (dummy)	0.30		0.50		0.18		***
Sells to unknown buyers (dummy)	0.82		0.72		0.89		***
Sells majority at own farm (dummy)	0.39		0.66		0.23		***
Sell majority at market in own village or commune (dummy)	0.47		0.23		0.60		***
Sells majority at market in Hanoi (dummy)	0.06		0.03		0.07		*

Note: Standard errors are reported between parentheses. Significant differences between groups are indicated with * $p < 0.1$, *** $p < 0.01$ (based on a two-sample *t*-test for continuous variables, and a pr-test for dummy variables).

Table 2 shows average selling prices of vegetables per type and marketing channel (middlemen, comprising both collectors and cooperatives, or consumers). Separate market prices for summer and winter season are not shown because of too few observations in some cases, but are available upon request. Interestingly, non-contract farmers get a higher price for their produce than contract farmers, especially for leafy vegetables (9% higher) and flower vegetables (17% higher). This is likely due to non-contract farmers selling a larger proportion of their produce directly to consumers, who buy smaller quantities but at a higher price. However, selling to consumers is much more time consuming than selling

to collectors, which partly explains why contract farmers derive a higher net income from vegetable production.

4.3. Farmers' Preferences for Safe Vegetable Contracts and Certification

Table 5 shows the results of the MXL model. The coefficient of the ASC is significantly positive, indicating that farmers generally prefer selling under a contract, rather than independently on the market. Farmers are indifferent to restricting their pesticide use; however, they are strongly against organic farming, whether through internal or external control. Farmers are more likely to engage in contracts that last longer and where the buyer pays a higher price, provides pesticides (whether in kind or cash), buys larger quantities and is known personally. This is all in line with our hypotheses, corroborating our choice of attributes and levels. Most standard deviations in the full sample model are significant, pointing to preference heterogeneity and justifying the use of a MXL model. When analyzing the MXL model for contract and non-contract farmers separately, we do not find large differences between the two groups, besides for pesticide use and provision. Contract farmers are indifferent to restricting their pesticide use, while non-contract farmers seem to be slightly in favor of doing so. In addition, non-contract farmers prefer in kind provisions of pesticides while they are indifferent to cash provisions.

Table 5. Basic MXL estimates (uncorrelated) for all farmers, contract farmers, and non-contract farmers.

	MXL All Farmers				**MXL Contract Farmers**				**MXL Non-Contract Farmers**			
	Mean (se)		**SD (se)**		**Mean (se)**		**SD (se)**		**Mean (se)**		**SD (se)**	
ASC	2.45	***	4.20	***	2.04	**	4.54	***	3.36	**	5.02	***
	(0.65)		(0.50)		(0.98)		(1.03)		(1.41)		(1.92)	
Selling price (1000 VND/kg)	0.51	***	0.48	***	0.502	***	0.352	**	0.92	***	1.02	***
	(0.09)		(0.12)		(0.16)		(0.17)		(0.30)		(0.33)	
Pesticides restricted, internal control	0.03		−0.92	**	−0.44		1.42		0.63	*	−1.85	**
	(0.19)		(0.41)		(0.38)		(1.05)		(0.38)		(0.83)	
Pesticides restricted, external control	0.22		−0.60		−0.11		1.75	**	0.62	*	−0.14	
	(0.21)		(0.58)		(0.40)		(0.72)		(0.36)		(0.44)	
Pesticides banned, internal control	−2.27	***	−2.17	***	−2.24	**	−3.08	**	−4.30	***	−4.77	***
	(0.39)		(0.59)		(0.91)		(1.50)		(1.42)		(1.77)	
Pesticides banned, external control	−1.94	***	−2.37	***	−2.49	**	2.71	*	−2.18	**	−4.05	***
	(0.42)		(0.73)		(1.04)		(1.57)		(0.94)		(1.44)	
Pesticide provision: in kind	0.97	***	0.39		1.29	***	0.54		1.09	***	0.49	
	(0.24)		(0.45)		(0.47)		(0.74)		(0.39)		(0.39)	
Pesticide provision: in cash	1.27	***	1.96	***	2.13	**	2.48	***	0.63		−2.13	**
	(0.37)		(0.46)		(0.83)		(0.83)		(0.53)		(0.89)	
Buyer buys 50% of production	1.49	***	0.06		1.24	***	−0.61		2.44	***	0.64	
	(0.23)		(0.37)		(0.44)		(0.59)		(0.63)		(0.52)	
Buyer buys 90% of production	2.70	***	1.09	**	3.74	***	1.31		3.87	***	2.83	***
	(0.36)		(0.45)		(1.25)		(1.15)		(0.97)		(0.93)	
Buyer is known through others	−0.49	**	−0.09		−0.75		−0.13		−0.78	*	−0.93	*
	(0.22)		(0.37)		(0.52)		(0.48)		(0.44)		(0.54)	
Buyer is not known	−1.06	***	−1.82	***	−1.54	**	1.98	**	−1.23	**	3.79	***
	(0.29)		(0.39)		(0.65)		(0.86)		(0.57)		(1.24)	
Agreement lasts for a season	1.33	***	0.38		1.25	***	0.32		2.44	***	2.23	***
	(0.22)		(0.58)		(0.46)		(0.54)		(0.76)		(0.78)	
Agreement lasts for a year	2.99	***	−1.40	***	3.02	***	−1.54		4.60	***	2.32	***
	(0.38)		(0.41)		(0.94)		(1.33)		(1.00)		(0.90)	
Observations	5373				1977				3396			
Log likelihood	−1206				−452				−738			

Note: MXL stands for mixed logit; ASC for alternative specific constant; and SD for standard deviation. Standard errors are reported between parentheses. Significant effects are indicated with * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$ (based on a two-sample *t*-test for continuous variables, and a pr-test for dummy variables).

Table 6 reports WTA values for the full and split samples. To ease interpretation, we express these values as the relative difference compared to the market price of 9800 VND/kg. We derive five main findings.

Table 6. Willingness-to-accept (WTA) estimates (VND/kg) in WTA-space, based on MXL model estimates.

	Full Sample (*n* = 301)			**Contract Farmers (*n* = 112)**			**Non-Contract Farmers (*n* = 189)**		
	Mean	**(se)**		**Mean**	**(se)**		**Mean**	**(se)**	
ASC	−4832	(1512)	***	−4066	(2345)	*	−3642	(1209)	***
Pesticides restricted, internal control	−57	(409)		867	(883)		−687	(582)	
Pesticides restricted, external control	−431	(450)		226	(967)		−673	(543)	
Pesticides banned, internal control	4466	(854)	***	4467	(2038)	**	4659	(1206)	***
Pesticides banned, external control	3824	(832)	***	4947	(2279)	**	2366	(1057)	**
Pesticide provision: in kind	−1915	(545)	***	−2566	(1337)	*	−1180	(620)	*
Pesticide provision: in cash	−2507	(858)	***	−4235	(2235)	*	−681	(824)	
Buyer buys 50% of production	−2936	(677)	***	−2472	(1322)	*	−2646	(862)	***
Buyer buys 90% of production	−5316	(1013)	***	−7448	(3234)	**	−4200	(1326)	***
Buyer is known through others	971	(442)	**	1486	(1219)		841	(520)	
Buyer is not known	2094	(575)	***	3070	(1470)	**	1329	(859)	
Agreement lasts for a season	−2611	(574)	***	−2485	(1256)	**	−2648	(807)	***
Agreement lasts for a year	−5891	(1093)	***	−6002	(2581)	**	−4984	(1773)	***

Note: The national currency, VND, stands for Vietnamese dong and had an exchange rate to the Euro of 26,555 VND at the time of study. Non-significant values of WTA are indicated as NS. Significant values are indicated with * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$ (based on a *t*-test rejecting the null hypothesis). No significant differences in WTA values are observed between contract and non-contract farmers (based on a two-sample *t*-test for each attribute level).

First, farmers are willing to accept a 49% lower price per kilogram for their vegetables if they can enter into a contract with a buyer. This is in line with other studies on farmers' preferences for contracts in local traditional value chains [24]. Studies focusing on export or supermarket value chains typically find that farmers require a premium to enter into a contract, e.g., [22,23], which suggests that contracts in local value chains are perceived to be more feasible or attractive to small-scale farmers. Through contracts, vegetable farmers in peri-urban Hanoi may considerably reduce their marketing transaction costs as they enter into more stable agreements with buyers.

Second, farmers do not mind restricting their pesticides use, meaning they do not demand a higher price to do so. However, they do require a 40 to 45% premium to produce organically, which is in line with findings from the rice sector in Benin [24]. In tropical regions, organic farming may lead to lower yields, as heavy rainfall and a high incidence of pests during the hot season may damage crops and decrease productivity [44,51]. Furthermore, consumers' demand for organic vegetables in northern Vietnam is still rather limited, especially in traditional value chains [52,53]. This explains why farmers are not in favor of producing organically.

Third, farmers seem to be indifferent towards the control mechanism of production practices, i.e., by a third-party or by a farmer group, which is indicated by non-significant differences in WTA values for pesticide use attribute levels. This may be linked to the fact that certification by both third-party organizations and by farmer groups is not common practice in the area yet. Hence, both types of certification methods could be envisaged to foster safe vegetable production.

Fourth, farmers require a 21% increase in price to enter into a contract with a buyer they do not know, and a 10% increase for a buyer known through others. The strong aversion of farmers to sell to unknown buyers is in line with other studies on farmers' preferences (e.g., [23,25] and with farmers' own statements on the importance of trust during focus group discussions. However, [41] find that only a third of surveyed vegetable farmers

in northern Vietnam in 2008 considered a close relation with buyers of vital importance, indicating that trust relations within the local value chain may have evolved over the last decade.

Fifth, other non-monetary benefits of contracts matter, as has been shown by other studies [19,21–24]. Farmers are willing to accept an approximatively 20% lower price for their vegetables in case pesticides are provided, whether in kind or cash. This increases to 43% for cash provisions to contract farmers, while non-contract farmers are indifferent towards this type of provision. This suggests that access to credit is more important for contract farmers, which might stem from a less diversified livelihood into off-farm employment. Farmers are willing to receive 30% and 54% less for a contract that ensures 50% and 90% of their vegetables bought, respectively. Moreover, they would accept a 27% lower price if a contract were to last for a season, and 60% for a year.

Although the estimated WTA values may seem very large, they make sense in the context of highly perishable produce. Since farmers have to sell their vegetables within two or three days of the harvest, they are willing to receive a substantially lower price in exchange for a stable, long-lasting contract ensuring no produce will be left unmarketed. It is worth noting that establishing a contract with a buyer outweighs less appealing aspects, like organic production or selling to unknown buyers. Thus, farmers can be incentivized if they are offered secure contracts that provide additional services.

5. Policy Implications

Our findings entail some specific implications for government bodies and development agencies aiming at stimulating inclusive and sustainable local value chains. While this study focuses on safe vegetables in Vietnam, our findings also apply to other peri-urban areas in low- and middle-income countries that face the challenge of ensuring access to healthy and nutritious food for all. We show that even in traditional value chains, farmers are willing to reduce their pesticide use. This is in sharp contrast with current policies in Vietnam and other similar countries of promoting modern value chains and supermarkets to encourage safe vegetable production and consumption [9,13]. Given that the vast majority of vegetables are still traded through traditional value chains, this opens possibilities to upscale production and reach more farmers and consumers. Farmers do not require higher prices for safe vegetables, which is also beneficial for poorer consumers, but they therefore demand to enter into stable, long-lasting agreements with buyers, preferably including pesticide provision. Development programs can support the establishment of (local) multi-stakeholder hubs suited to setting up such partnerships between farmers and traders [54–56]. Farmers' aversion to sell to unknown buyers suggests that there are some mistrust issues between farmers and traders. Hence, NGOs that promote internal certification methods such as PGS should target well-functioning, established cooperatives that can act as facilitators to help establish trust relations within farmer groups and with traders.

6. Conclusions

Our study examines the potential of contracts and certification in local value chains for improving food safety. Using survey data and a DCE among 301 vegetable farmers in peri-urban Hanoi, we investigate small-scale farmers' preferences for the production and marketing of safe vegetables. We find that farmers are willing to produce safe vegetables, when entering into a contract with a known, trustworthy buyer committed to purchasing large quantities over a long period. Pesticide provision from the buyer represents an additional incentive. While we do observe differences between contract and non-contract farmers in terms of specialization and marketing, we do not find large differences in their stated preferences.

It is important to note some limitations of our study. First, DCEs are prone to hypothetical bias, possibly leading to an overestimation of utility [26]. To minimize this bias, we used a cheap talk script to insist on the actual implications that the hypothetical scenarios could have on farmers. Second, we acknowledge the lack of diversity in our sample (i.e., in

farmers' individual characteristics). However, through our three-stage stratified random sampling strategy, we believe our sample to be quite representative of vegetable farmers in the area. Third, our case study approach does not allow to generalize our findings. Still, our results urge both policy makers and researchers to not only focus on modern value chains, including exports and supermarkets, but also on local traditional value chains to tackle food safety issues in low- to middle-income countries. Future research could focus on other actors in the value chain, such as collectors and other middlemen, and how trust can be improved between farmers and traders.

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Data Availability Statement: The data presented in this study are available on request from the corresponding author. The data are not publicly available due to ethical issues.

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Conflicts of Interest: The authors declare no conflict of interest.

Appendix A. Figures

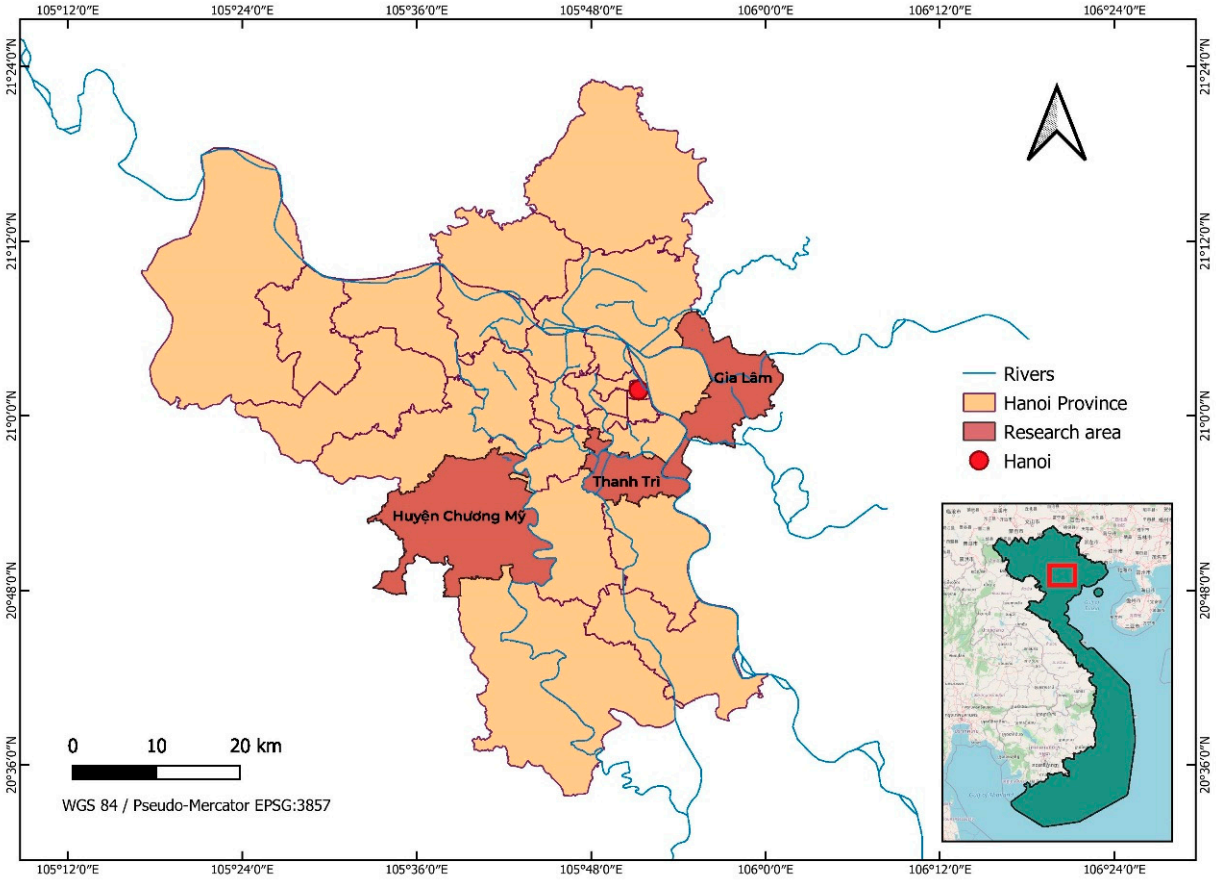

Figure A1. Map of the research area. (Source: Authors based on OpenStreetMap data).

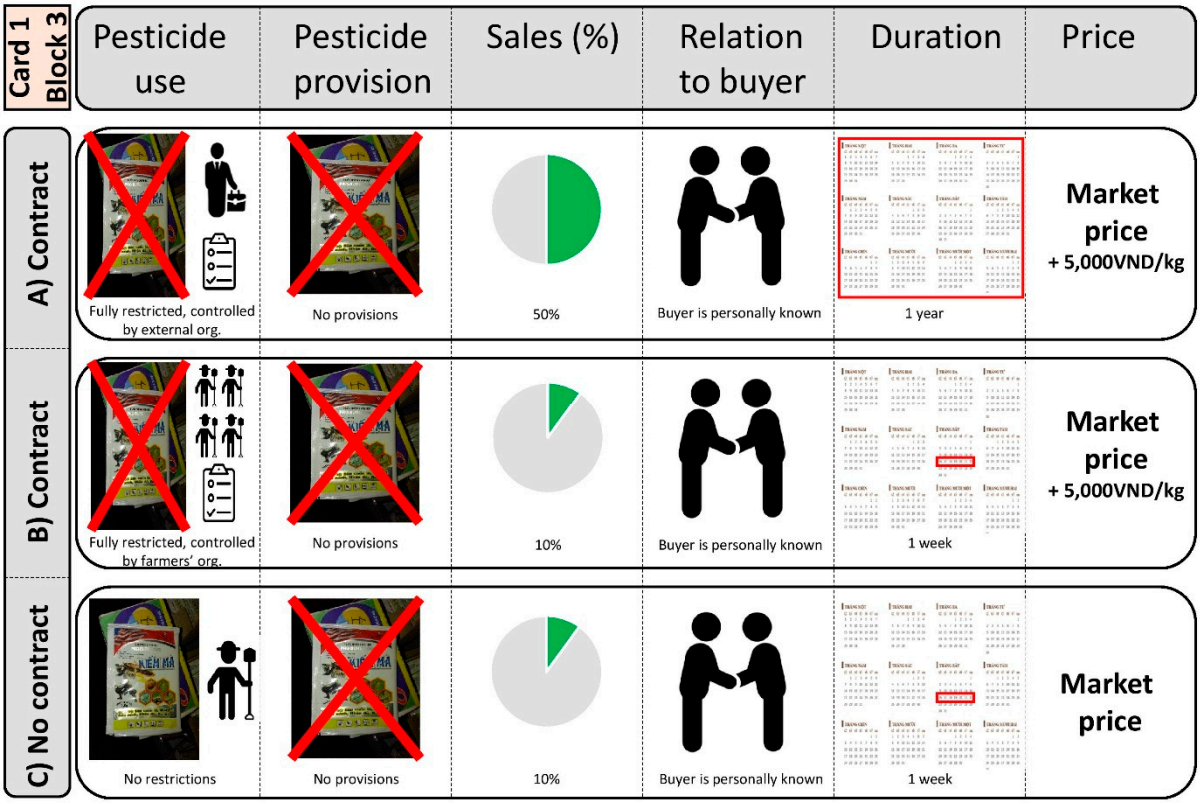

Figure A2. Example of choice card used for the DCE.

Appendix B. Robustness Checks

We perform robustness checks to verify the results of the MXL model. First, we control for scale heterogeneity by estimating an unrestricted generalized multinomial logit (GMNL) model. GMNL models account for all types of correlation among utility coefficients, including scale heterogeneity, which arises when choice consistency varies across respondents [57,58]. As recommended by [57]), we scale the coefficients of all attribute levels and the ASC. Second, we account for attribute non-attendance (ANA), which may occur when respondents do not consider all attributes in a DCE when opting for a particular scenario [59]. We control for stated ANA by setting the coefficients for the self-reported ignored attributes at zero during the estimation.

Results from the GMNL model indicate that the obtained correlation parameter τ is significant and has a value of 0.92 pointing to substantial correlation among attributes. However, the sign and significance level of all mean estimates in the GMNL model align with the MXL model, suggesting that the latter is robust to all sources of correlation in the data. As only 8% of the sample state that they ignored at least one attribute, the results from the stated ANA model are highly similar to the MXL model. In sum, our control models suggest that the MXL model is robust to scale heterogeneity and ANA, so we base our discussion and analysis of the data on this model (Table A1).

Table A1. MXL basic model estimates compared to models tested as robustness check.

	MXL Basic (Uncorrelated)				GMNL (Unrestricted)				MXL Corrected for Stated ANA			
	Mean		SD		Mean		SD		Mean		SD	
ASC	2.45	***	4.20	***	2.78	***	2.48	**	2.48	***	4.19	***
	(0.65)		(0.50)		(0.77)		(1.06)		(0.61)		(0.52)	
Selling price (1000 VND/kg)	0.51	***	0.48	***	0.84	***	−0.49	**	0.52	***	0.49	***
	(0.09)		(0.12)		(0.20)		(0.22)		(0.09)		(0.12)	

Table A1. *Cont.*

	MXL Basic (Uncorrelated)				GMNL (Unrestricted)				MXL Corrected for Stated ANA			
	Mean		SD		Mean		SD		Mean		SD	
Pesticides restricted, controlled by FG	0.03		−0.92	**	−0.28		0.96	**	0.05		−0.85	*
	(0.19)		(0.41)		(0.33)		(0.46)		(0.19)		(0.44)	
Pesticides restricted, external control	0.22		−0.60		0.04		−0.34		0.24		0.54	
	(0.21)		(0.58)		(0.32)		(0.25)		(0.21)		(0.77)	
Pesticides banned, controlled by FG	−2.27	***	−2.17	***	−3.77	***	0.69	*	−2.30	***	−1.99	***
	(0.39)		(0.59)		(0.92)		(0.38)		(0.39)		(0.64)	
Pesticides banned, external control	−1.94	***	−2.37	***	−3.28	***	0.98	*	−2.02	***	−2.09	***
	(0.42)		(0.73)		(0.83)		(0.51)		(0.40)		(0.74)	
Pesticide provision: in kind	0.97	***	0.39		2.26	***	0.75	*	0.85	***	0.20	
	(0.24)		(0.45)		(0.63)		(0.41)		(0.22)		(0.46)	
Pesticide provision: in cash	1.27	***	1.96	***	2.83	***	2.32	**	1.01	***	1.90	***
	(0.37)		(0.46)		(0.92)		(1.04)		(0.36)		(0.52)	
Buyer buys 50% of production	1.49	***	0.06		2.08	***	0.33	*	1.47	***	0.10	
	(0.23)		(0.37)		(0.52)		(0.18)		(0.23)		(0.38)	
Buyer buys 90% of production	2.70	***	1.09	**	3.84	***	−0.66	*	2.71	***	0.95	***
	(0.36)		(0.45)		(0.83)		(0.34)		(0.33)		(0.31)	
Buyer is known through others	−0.49	**	−0.09		−1.10	***	−0.16		−0.43	**	−0.14	
	(0.22)		(0.37)		(0.40)		(0.16)		(0.22)		(0.39)	
Buyer is not known	−1.06	***	−1.82	***	−1.65	***	2.67	**	−1.00	***	−1.94	***
	(0.29)		(0.39)		(0.58)		(1.19)		(0.27)		(0.37)	
Agreement lasts for a season	1.33	***	0.38		2.08	***	−0.80	**	1.40	***	0.35	
	(0.22)		(0.58)		(0.49)		(0.34)		(0.22)		(0.67)	
Agreement lasts for a year	2.99	***	−1.40	***	3.89	***	0.71	*	3.01	***	−1.28	***
	(0.38)		(0.41)		(0.75)		(0.37)		(0.36)		(0.35)	
Observations	5373				5373				5373			
Log likelihood	−1206				−1195				−1206			

Note: MXL stands for mixed logit; GMNL for generalized multinomial logit model; ANA for attribute non-attendance; ASC for alternative specific constant; and SD for standard deviation. Standard errors are reported between parentheses. Significant effects are indicated with * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$ (based on a *t*-test for each attribute level). For the GMNL model, τ, the correlation parameter, is 0.92 *** with a standard error of 0.19.

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