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Marketing Strategies of the Horticultural Production Chain

Edited by
Marco A. Palma

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Editor

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About the Editor

Marco A. Palma is Professor in the Department of Agricultural Economics at Texas A&M University. Dr. Palma is a Texas A&M Presidential Impact Fellow. His areas of interest are consumer economics, food choices, experimental and behavioral economics, and neuroeconomics. Dr. Palma is the Director of the Human Behavior Laboratory (http://hbl.tamu.edu), a transdisciplinary facility that integrates state-of-the-art technology to measure biometric and neurophysiological responses of human decision-making. The HBL aims to facilitate the integration of neurophysiological responses to traditional methods of studying human behavior to better understand, predict and change behavior that improves people's health and well-being.

Preface to "Marketing Strategies of the Horticultural Production Chain"

This book consists of a series of articles that present novel trends in horticulture marketing and some of the key supply chain management issues for the horticulture industry across a wide range of geographical regions. The first article evaluates the attitudes of price conscious consumers in making purchasing decisions regarding ornamental plants; it uses novel eye-tracking technology to obtain rich choice-process data of the purchasing dynamics. The second article presents an assessment of postharvest market loss in the Solomon Islands for fresh fruits and vegetables. The third article analyzes the export performance of the horticulture sector in Ethiopia using cointegration analysis to evaluate the long-run relationship among key variables and their relationship to horticultural exports. The fourth article evaluates the potential for advertising and promoting ornamental horticulture products using new media tools, including websites, social media and blogs. The fifth article evaluates how diversity of farm production affects the food consumption of households in rural Tanzania. The sixth article is a case study of postharvest loss in the tomato industry in Australia; it employs a multidisciplinary approach to quantify losses. The seventh article implements a wholesale survey to study the economic loss generated by food waste in the canning vale fruit and vegetable markets in western Australia. The eighth article evaluates the economic profitability of using different container sizes on transplanted trees. The last article is a qualitative case study of new-media marketing use with a focus on social media among garden centers in Kansas, United States. Harmonizing the supply chain from input suppliers and producers to consumers is paramount to the success of the horticultural industry. As the horticulture industry continuous to evolve and become more global, there will be challenges and opportunities for procuring abundant, nutritious, and safe products.

Marco A. Palma
Editor

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Article

Assessing Purchase Patterns of Price Conscious Consumers

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Abstract: Price greatly influences consumers' purchasing decisions. Individuals whose decisions are primarily driven by price are said to be 'price conscious'. To date, studies have focused on defining price consciousness and identifying factors that contribute to price-conscious behavior. However, research using visual attention to assess how price conscious consumers use in-store stimuli is limited. Here, consumers' purchasing decisions are assessed using a rating-based conjoint analysis paired with eye tracking technology when shopping for ornamental plants. An ordered logit model is employed to understand price conscious consumers' purchase patterns and choice outcomes. Overall, price conscious consumers are less attentive to price information. Being price conscious tends to reduce purchase likelihood, *ceteris paribus*. Increasing visual attention to price decreases consumers' purchase likelihood, which is amplified for price conscious consumers. Price conscious consumers tend to be quicker decision makers than non-price conscious consumers. Results are beneficial to retailers interested in targeting or primarily catering to price conscious consumers.

Keywords: price consciousness; visual attention; in-store signage; ornamental plants; conjoint analysis

1. Introduction

Price strongly affects consumers' purchasing decisions. Consumers who are unwilling/unable to pay a higher price or primarily focus on a product's price during the decision making process have been called 'price conscious', 'price sensitive', 'value conscious', 'value oriented', 'price oriented', 'deal prone', 'thrifty', and so on [1–7]. Here, we refer to those individuals as 'price conscious'. Consumers' level of price consciousness greatly influences their decision making processes and purchasing behaviors [8–10].

Prior research primarily focuses on defining price consciousness [7,8,10,11] and identifying key factors that influence these consumers' shopping behavior [1,5,6]. Price conscious consumers place greater emphasis on a product's price and carefully weigh the potential benefits of the purchase against the cost of the good [2,12]. Additionally, price conscious consumers exhibit similar demographic characteristics. They tend to be deal prone [13], and many factors (including income, product involvement, product quality perceptions, upbringing, age, socialization, and cognitive beliefs on saving money) have been shown to influence consumers' level of price consciousness [11,14,15]. Price consciousness has long been studied, but, to the authors' knowledge, visual attention metrics have not been used to assess this decision making style.

Understanding visual attention and its role in decision making is important since industry stakeholders spend a substantial amount of money on in-store promotions (e.g., in 1997, the food industry spent $48.7 billion on in-store promotions [16]), but only 2% of the visual field is processed

and used in decision making [17,18]. Visual attention metrics have recently been incorporated into consumer behavior research to investigate choice [17,19], examine decision making processes [20,21], and improve the econometric model fit [17,22,23]. Past studies also use eye tracking to study promotional aspects related to packaging design, nutritional information usage, and shelving strategies to optimize product design and in-store visibility [24]. However, little is known about the use of this technology to investigate price conscious consumers' visual attention to prices and purchase likelihood within the retail setting.

To price conscious consumers, the product's price is a key determinant of their purchase intentions. This raises several questions that invite closer examination. Do price conscious consumers' visual attention to in-store promotions and prices vary from non-price conscious consumers? Are price conscious consumers more or less attentive to the price attribute than non-price product attributes? How does this visual attention influence price conscious consumers' purchasing decisions? Understanding the relationship between price consciousness, visual attention, and purchasing behavior could lead to more effective price communications and in-store promotions, especially in retail outlets that target price conscious consumers (e.g., stores using everyday low price [EDLP] pricing strategies). In this manuscript, we address these questions by investigating the relationship between consumers' price consciousness and visual attention to in-store price and non-price attribute signs on ornamental plants using a conjoint analysis paired with an eye tracking experiment.

Economic theory states there is a negative relationship between higher prices and purchase likelihood. Price is an important attribute in consumers' decision making processes which can encourage [25] or discourage consumption [26,27]. Furthermore, price becomes consumers' primary information cue when information overload occurs [28].

Existing visual attention research provides mixed results on the relationship between visual attention and price attributes. On the one hand, Chen et al. [29] suggest that participants who spend more time focusing on prices are, typically, more sensitive to price. Similarly, Van Loo et al. [23] show participants' utility decreases as visual attendance to the price attribute increases and more visual attention to price indicates higher price sensitivity. Based on their estimations, each fixation on price decreases willingness to pay (WTP) by 2.3%, while each second fixation on price decreases WTP by 10.1%. On the other hand, Behe et al. [30] suggest that low involvement consumers are likely more price sensitive and, thus, look at price quicker than highly involved consumers. Huddleston et al. [31] find price information holds more visual attention (as indicated by a greater number of fixations) and that there is a positive relationship between visual attention to price and likelihood to buy.

Surprisingly, little is known about how visual attention to price impacts price conscious consumers' purchasing behavior in general. An actual price-conscious measurement has yet to be incorporated into these experiments. Studies that address the relationship between price conscious consumers' visual attention to price information and their purchasing decisions are limited and tend to be auxiliary to the primary focus of the research. For instance, Behe et al. [2] used a cluster analysis and found 16% of their sample was price-oriented and spent more time (in seconds) visually attending price-related horticultural retail displays.

2. Materials and Methods

2.1. Hypotheses Development

To investigate variances between price conscious consumers' and non-price conscious consumers' visual attention to product attributes and their subsequent purchase likelihood, four hypotheses were developed and tested in this study. First, since consumers are more visually attentive to subjectively more important attributes [2,29], we hypothesize that price conscious consumers will fixate more on price than non-price attributes (H1a). Price consciousness, by definition, is exclusively concerned with consumers' focus on searching for and paying a low price [1,5,32], thus, we hypothesize that price conscious consumers will fixate more on price than non-price conscious consumers (H1b). Price theory

suggests that price serves as an indicator of the monetary sacrifice for a specific product. The higher the price of a product, *ceteris paribus*, the less likely a consumer will be to purchase the product. In addition, as ornamental plants (which were used in the eye tracking experiments) are often perceived as luxury products as opposed to necessity goods [33], we further hypothesize that there will be a negative relationship between purchase likelihood and price conscious consumers (H2a) and that there will be a negative relationship between purchase likelihood and visual attention to price (H2b). Lastly, price conscious consumers' visual attention to price signs will inversely affect their purchase likelihood (H3).

2.2. Recruitment and Sampling

Ninety-five participants were recruited in central Florida through flyers at garden centers, an emailing list, and Facebook advertisements. Participants were prescreened when they signed up for the experiment to ensure that they had purchased ornamental plants in the past 12 months. In-person participation was required to facilitate the use of the eye tracking technology (participants received a compensation of $30 for their time and collaboration at the end of the survey). A sample size of 95 was deemed acceptable since previous studies using eye tracking metrics used far fewer subjects [19,22,34]. Participants were screened to insure they were active purchasers of the study product (ornamental plants). Participants' average age was 53 years with the majority (66%) being over 50 years old (Table 1). Thirty-nine percent were males and 55.6% earned more than $50,000 at the time of the study. The average household size consisted of approximately two people. Compared to Florida census data, the sample is slightly biased towards females at 61% [35]. However, the sample was considered acceptable since the socio-demographic results are consistent with previous studies in horticulture [2] and representative of the core consumers of ornamental plants [36].

Table 1. Socio-demographic characteristics of the sample participants (n = 96).

	Overall Mean	Price Conscious Mean	Non-Price Conscious Mean	p-Value [a]
	(n = 96)	(n = 30)	(n = 66)	
Age (in years)	52.5 (16.678)	47.267 (10.554)	54.879 (16.642)	0.00
Male	39.6% (48.7)	43.33% (49.61)	37.88% (48.53)	0.04
Household size	1.854 (1.377)	2.133 (1.589)	1.727 (1.250)	0.00
High income (>$50,000)	54.2% (49.8)	46.67% (49.94)	57.58% (49.45)	0.00

Notes: Standard deviation is reported in parenthesis. [a] p-value reports the statistical significance of the difference between price conscious consumers and non-price conscious consumers based on paired t-test statistic.

2.3. Price Consciousness Measures

The standard definition of price consciousness in economics refers to the change of consumer demand resulting from a change of price, akin to "price elasticity". However, research on "price elasticity" is primarily at an aggregate level and cannot account for sensitivity to price changes at an individual level. To measure individual consumers' level of price consciousness, Lichtenstein et al. [32,37] suggest using a price range or price thresholds to approximate consumers' reactions towards price changes. Low et al. [38,39] define the degree to which a customer's buying decisions are based on price-related aspects. Following these ideas, a price consciousness indicator was developed to measure an individual participant's price consciousness in this study. Specifically, participants indicated if the plant was eliminated from selection when the price, as an important attribute, did not fall into a certain range during their decision-making process for each plant (i.e., elimination strategy). Participants were then divided into two groups where the 'price conscious' group consisted of individuals who indicated price was used as an elimination strategy for purchasing

decisions and the 'non-price conscious' group comprising individuals who did not indicate that price was used as an elimination strategy. In other words, participants utilized a different strategy when deciding whether to purchase the product (elimination and additive strategies were explained to participants prior to answering this question).

Thirty participants (about one-third of the sample) are included in the price conscious group and 66 (two-thirds of the sample) in the not-price conscious group (Table 1). Price conscious consumers are younger, consist of a higher percentage of females, have larger households, and lower incomes than the non-price conscious group. These results align with previous studies showing price-conscious individuals tend to be younger with lower incomes and/or greater financial stressors (such as providing for a larger family) [9,12].

2.4. Conjoint Analysis Experiment Procedure

The Conjoint Analysis (CA) experiment was designed using ornamental landscape plants (i.e., bedding plants, flowering annuals, and perennials) as the product, since they generated the most plant sales in Florida in 2013 [40]. Additionally, plants were selected as a product because they typically are sold with very little in-store signage and limited brand promotions [41]. Consequently, participants' preconceptions about the products are more limited than highly branded or promoted products. Several species of plants (petunias, pentas, and hibiscus) were included in the analysis to account for differences in individual preferences (Table 2). To simulate a common retail garden center display, five plants were presented on a bench, with additional attributes (i.e., price, production method, origin, and pollinator friendly attributes) being presented as above-plant signs (Figure 1). Previous studies have successfully used this bench/attribute sign design to elicit consumers' purchasing preferences for ornamental plants [2,42,43].

Table 2. Attributes and attribute levels.

Attributes	Attribute Levels	Definition/Description
Plant type [a]	Hibiscus Penta Petunia [b]	The type of plant in the scenario image shown to participants.
Price [a]	$10.98 $12.98 $14.98	Price per plant.
Pollinator	Pollinator friendly	Indicates if the plant benefits pollinators.
	No label [b]	
Production method	Certified organic	Plants are certified as organically produced.
	Organic production	Plants are produced in an organic manner, but are not certified organic.
	Not organic (conventional) [b]	Plants are grown using conventional production methods.
Origin	In-state (Fresh from Florida)	Plants are produced in Florida
	Domestic (Grown in the U.S.)	Plants are produced in the U.S.
	Imported (Grown outside the U.S.) [b]	Plants are imported from countries outside the U.S.

[a] Plant types and price points were selected based on products and prices at several retail outlets (i.e., big box stores, independent garden centers, etc.) in the study area. [b] Indicates base variables.

In this study, three price points ($10.98, $12.98, $14.98) were used based on prices of similar plants in higher end specialty garden centers, as well as lower price points from mass retailers and box stores in the study area (Table 2). Production methods included certified organic, organic production (but not certified), and conventional levels. Origin attributes included in-state, domestic, and imported levels. The pollinator friendly attribute was either labeled or not labeled. Sign order was

randomized to eliminate order effect. Production method, origin, and pollinator friendly attributes were included to cover credence attributes that potentially add value to the products [44]. Additional attributes (such as size, care requirements, etc.) were controlled by informing participants that they were consistent across the products. A fractional factorial design was used to generate 16 product images for the Conjoint Analysis (CA) experiment to reduce participant fatigue. Participants rated their purchase likelihood for each product on a 7 point Likert scale (1 = not at all likely; 7 = very likely). While evaluating each product scenario, participants' eye movements were recorded. Participants also completed a survey with price-conscious and socio-demographic questions.

Figure 1. Example of the conjoint analysis product images.

2.5. Eye Tracking Metrics and Procedures

A stationary Tobii X1 Light Eye Tracking camera connected to the base of a computer monitor (22 inch screen with a 1920 × 1080 pixel resolution) was used to record eye movements (Figure 2). Tobii Studio Software (version 3.4.8) was used to present the CA images to participants.

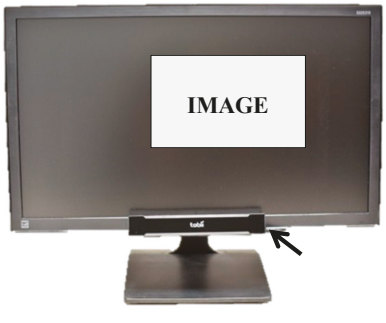

Figure 2. The experimental set-up showing the computer monitor and Eye Tracking camera.

Participants were provided instruction slides describing the experimental procedure followed by an example non-target product (i.e., tomato plant). Each CA scenario consisted of three steps (Figure 3). First, participants viewed the product image and then clicked a mouse key when they were ready to rate their purchase likelihood. Then, participants selected their purchase likelihood for the previously viewed image. Lastly, they were presented with a fixation cross that they focused on for 5 s between the first image and the subsequent image. The fixation cross served to "reset" participants' visual attention so all participants had the same visual starting point for each image [23,40].

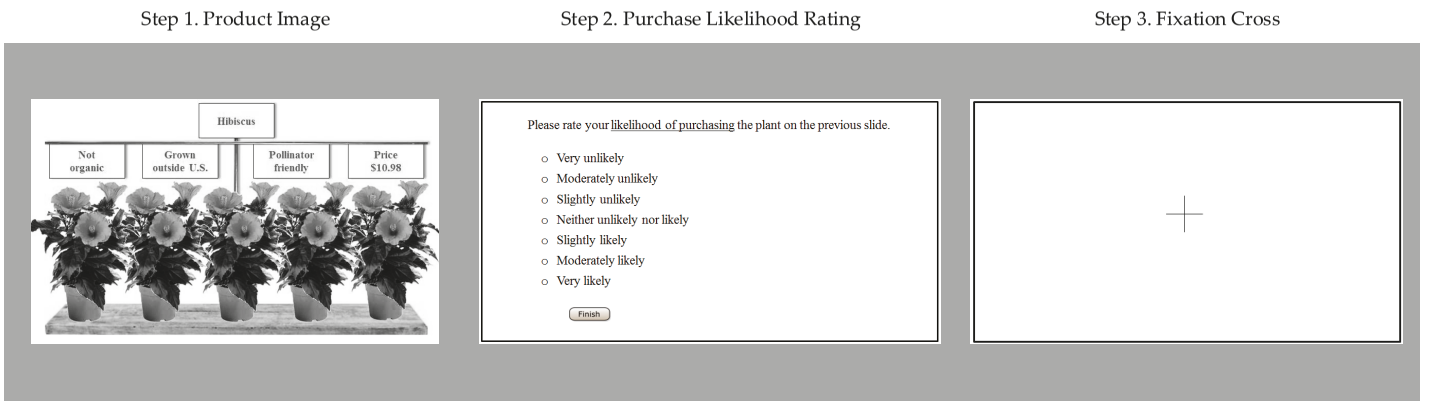

Figure 3. The three-step experimental procedure used for the 16 conjoint analysis scenarios.

After all participants had completed the experiment, areas of interest (AOI) were used to extract visual attention measures from the product images. Each AOI corresponds to a specific visual of interest (i.e., the product image or an attribute sign; Figure 4). Researchers extracted participants' fixation count (FC) for each AOI. FC is the total number of eye fixations (when the eye stops and attends to the stimuli) within each AOI. FCs are considered a reliable indicator of participants' visual attention to stimuli within each AOI [2,23].

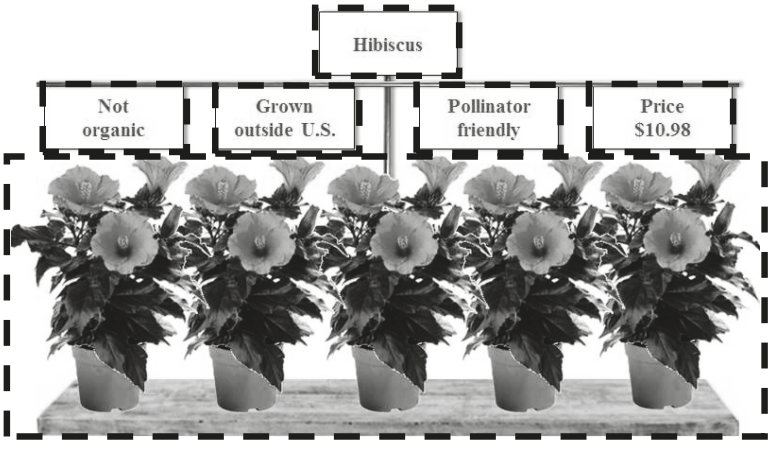

Figure 4. Designated areas of interest (indicated by the dashed lines) around the product image and attribute signs.

2.6. Econometric Model

To investigate how price-conscious consumers may behave differently in term of purchase patterns, we follow Long and Freese's [45] ordered logit model and post-estimation procedures to estimate predicted probabilities of participants' purchase likelihood. As shown in Figure 3, the purchase likelihood was measured using a 7-point Likert scale question, with 1 indicating very unlikely to purchase and 7 indicating very likely to purchase. The ordered logit model captures the nature that order of response matters. Let y_i be the ordered rating scores of purchase likelihood, which is of interest to explain. y_i is assumed to be generated by the underlying linear latent variable model:

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

where y^* is varying from $-\infty$ to ∞, i is the observation, and ε is a random error term. Our observed response categories (y_i) are linked to the latent variable using the following subsequent measurement model:

$$y_i = \begin{cases} 1 & if \quad \kappa_0 = -\infty \le y_i^* < \kappa_1 \\ 2 & if \quad \kappa_1 \le y_i^* < \kappa_2 \\ \vdots & \vdots \quad\quad \vdots \\ 7 & if \quad \kappa_6 \le y_i^* < \kappa_7 = \infty \end{cases} \tag{2}$$

where κ are thresholds that once crossed result in a category change. In the rest of the models, i is suppressed. Thus, the probability of observing $y = j$ for given values of x is:

$$\Pr(y = j|x) = \Pr\left(\kappa_{j-1} \le y^* < \kappa_j|x\right) \tag{3}$$

and $j = 1$ to J (purchase likelihood rating). Consequently, the predicted probability can be given as:

$$\Pr(y = j|x) = F(\kappa_j - x\beta) - F(\kappa_{j-1} - x\beta) \quad (4)$$

where F indicates the cumulative distribution function of ε, and for ordered logit the ε is assumed to have a logistic distribution with a mean of 0 and variance of $\pi^2/3$.

The dependent variable (purchase likelihood) is a rating score (1 = very unlikely; 7 = very likely) and the key independent variables of interest are the price-consciousness indicator and the FCs on the price sign. Other control variables include plant attributes (plant type, production method, origin) and individual socio-demographics, as well as visual data (fixation counts) on other non-price product attributes.

3. Results and Discussion

Prior to regression analysis, we first compare price conscious consumers' visual attention to price versus non-price attitudes, which were measured by FCs. With a mean FC of 2.6, price conscious consumers are typically less attentive to price than non-price attributes (compared to a mean FC of 3.3 across non-price attributes). The paired t-test statistic for each pair of price and non-price attributes (including pollinator friendly, production method, and origin) comparison is significant at 1% significant level except for when price and in-state attributes are compared. This result contradicts Hypothesis H1a that price conscious consumers would fixate more on price than non-price attributes. Further, a direct comparison of price-conscious and non-price conscious consumers' FCs is provided in Figure 5. Overall, price conscious consumers spend less time fixating on the total image, products, prices, origins, certified organic, and conventional signs than the non-price conscious group, except for the organically produced sign. The mean FC for non-price conscious consumers is 2.7, which is slightly more than that of the price-conscious group (2.6). Nonetheless, the difference is not statistically significant (pairwise t-test static is 1.20 with a p-value of 0.23). This result does not support Hypothesis H1b that price conscious consumers fixate more on price than non-price conscious consumers. Although there is no significant difference in terms of visual attention on price between price-conscious and non-price conscious groups, price conscious consumers tend to be more efficient (i.e., have fewer total fixations and fewer fixations on price and other attributes) than non-price conscious consumers when determining their purchase likelihood. Since price conscious consumers value price over other attributes [2,12], this may reduce their visual consideration time on different attributes because the attributes are less important than price. Alternatively, the price conscious consumers may have been quicker decision makers due to having preexisting reference prices and price cut-off values. Preexisting cut-off values streamlines the decision making process because if the product does not align with the reference prices, the product is eliminated from the choice set [46].

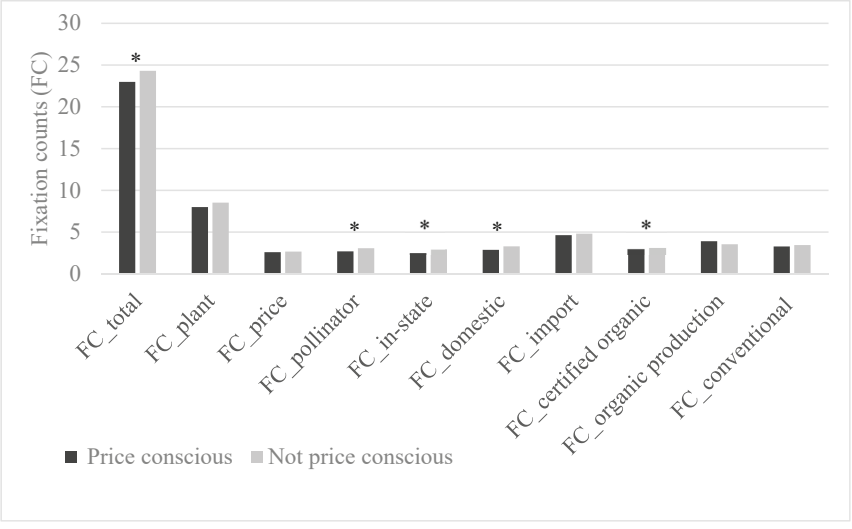

Figure 5. Mean Fixation Counts, by Price Consciousness. * indicates the mean difference between price conscious and non-price-conscious consumers is significant ($p < 0.05$) based on pairwise *t*-test.

To fully explore price conscious consumers' purchasing decisions and test Hypotheses H2a, H2b, and H3, three different specifications of the ordered logit model are estimated. Baseline Specification 1 includes only the price-conscious indicator, plant attributes, and individual demographic information. Specification 2 and Specification 3 add visual attention variables (model 2) and interaction terms between price-conscious indicators to test H2a and H2b, and visual attention variables (model 3) to test H3, respectively. Recent studies have shown attention (i.e., visual attention) provides an additional explanation for how consumers selectively process product information and is a crucial aspect that should be considered when analyzing individual choice behavior, including purchasing decisions [24,29]. The interaction terms between the price-conscious indicator and visual attention variables, specifically, the interaction between the price conscious indicator and FCs on price (PC × FC price), further distinguishes price conscious consumers from non-price conscious consumers to test H3. Indicated by the lower Bayesian Information Criterion (BIC) and Akaike Information Criterion (AIC) values (Table 3), Specification 2 and Specification 3 have largely improved the model fit and model explanation power by incorporating visual attention data.

Regression results (Table 3) from the ordered logit model indicate that price conscious consumers are significantly less likely to purchase plants in comparison with non-price conscious consumers regardless of the model specification, supporting Hypothesis H2a. The average marginal effect based on Specification 1 indicates that a price conscious consumer, *ceteris paribus*, is 1.6 percentage points more likely to rate themselves as "very unlikely" to purchase a plant, while 4.4 percentage points less likely to rate themselves as "very likely" to purchase a plant. In addition, plant attributes (plant type, price, pollinator friendly, production method, and origin), respondents' social-demographic characteristics, and visual attention variables all influence the purchase likelihood. Respondents are more likely to purchase hibiscus and pentas plants than petunia plants. As expected, price is negatively associated with purchase likelihood. Consistent with previous empirical evidence [47–50], we also find that consumers value products "being green" or sustainable. Particularly, the pollinator friendly attribute increases consumers' purchase intention. Respondents are also more likely to purchase certified organic or organically produced plants than conventionally produced plants. Regarding origin, in-state and domestically grown plants are preferred to imported plants.

In terms of social-demographic characteristics, we find purchase likelihood increases with age. Male participants are more likely to purchase products than females as shown by the positive coefficient estimates across all specifications. Respondents with higher incomes are more likely to purchase products than respondents with lower incomes. Conversely, having a larger household size discourages purchase likelihood.

The visual attention data indicates there are statistically significant relationships between price consciousness, fixations, and purchase likelihood (Specification 2, Table 3). After controlling for consumers' visual attention, the negative impact of the price-conscious indicator on purchase likelihood remains statistically significant. Consistent with price theory and existing empirical evidence (e.g., Chen et al. [29]), increasing visual attention to the price sign discourages the likelihood of purchase, supporting Hypothesis H2b. Meanwhile, we find several positive relationships between consumers' visual attention to non-price attributes and their purchase likelihood. For example, more FCs on attribute signs, such as pollinator friendly, production method, and grown outside the United States, increases purchase likelihood. These results are in line with Van Loo et al. [23], finding that consumers fixate more on attributes that they value more and, thus, are more likely to purchase them.

Table 3. Coefficient estimates of consumers' purchase likelihood of ornamental horticultural plants from the Ordered Logit Regression Models.

Variable	Dependent Variable: Purchase Likelihood								
	Specification 1			Specification 2			Specification 3		
	Coefficient	Standard Error		Coefficient	Standard Error		Coefficient	Standard Error	
Price-conscious indicator (PC)	−0.290	(0.106)	***	−0.251	(0.108)	**	−0.254	(0.114)	**
Plant attribute									
Hibiscus	0.663	(0.116)	***	0.716	(0.120)	***	0.733	(0.121)	***
Penta	0.414	(0.110)	***	0.442	(0.114)	***	0.468	(0.112)	***
Petunia	Base			Base			Base		
Price	−0.175	(0.029)	***	−0.204	(0.030)	***	−0.208	(0.030)	***
Pollinator friendly	0.319	(0.094)	***	0.327	(0.097)	***	0.333	(0.095)	***
Certified organic	0.541	(0.115)	***	0.514	(0.118)	***	0.544	(0.120)	***
Organic production	0.722	(0.125)	***	0.699	(0.128)	***	0.7333	(0.128)	***
Conventional	Base			Base			Base		
In-state	1.061	(0.124)	***	1.156	(0.131)	***	1.222	(0.134)	***
Domestic	0.817	(0.123)	***	0.922	(0.128)	***	0.972	(0.131)	***
Import	Base			Base			Base		
Visual Attention Variables									
FC_product image				0.025	(0.009)	***	0.053	(0.011)	***
FC_price				−0.049	(0.006)	***	−0.045	(0.010)	***
FC_pollinator friendly				0.214	(0.070)	***	0.322	(0.086)	***
FC_certified organic				0.208	(0.068)	***	0.367	(0.093)	***
FC_organic production				−0.064	(0.033)	*	−0.030	(0.047)	
FC_conventional				0.159	(0.038)	***	0.168	(0.044)	***
FC_in-state				−0.033	(0.045)		−0.027	(0.053)	
FC_domestic				0.023	(0.048)		−0.180	(0.062)	***
FC_import				0.199	(0.034)	***	0.037	(0.047)	
PC interacting with Visual Attention									
PC × FC_product image							−0.143	(0.024)	***
PC × FC_price							−0.411	(0.216)	*
PC × FC_pollinator friendly							−0.780	(0.163)	***
PC × FC_certified organic							−0.042	(0.157)	
PC × FC_organic production							−0.041	(0.082)	
PC × FC_conventional							−0.135	(0.114)	
PC × FC_in-state							−0.007	(0.127)	
PC × FC_domestic							0.576	(0.107)	***
PC × FC_import							0.612	(0.087)	***

Table 3. *Cont.*

Variable	Dependent Variable: Purchase Likelihood								
	Specification 1			Specification 2			Specification 3		
	Coefficient	Standard Error		Coefficient	Standard Error		Coefficient	Standard Error	
Social-demographics									
Age	0.007	(0.004)	**	0.001	(0.004)		0.010	(0.004)	***
Gender	0.243	(0.095)	**	0.211	(0.106)	**	0.205	(0.117)	*
High income (>50 k)	0.230	(0.112)	**	0.300	(0.116)	***	0.220	(0.138)	
Household	−0.091	(0.038)	**	−0.164	(0.041)	***	−0.234	().047)	***
Threshold Parameters [a]									
Cut 1	−3.421	(0.483)		−3.723	(0.536)		−3.625	(0.559)	
Cut 2	−2.233	(0.474)		−2.444	(0.521)		−2.265	(0.542)	
Cut 3	−1.487	(0.473)		−1.658	(0.518)		−1.418	(0.539)	
Cut 4	−1.117	(0.472)		−1.259	(0.516)		−0.992	(0.538)	
Cut 5	−0.106	(0.472)		−0.139	(0.514)		0.191	(0.538)	
Cut 6	1.024	(0.473)		1.085	(0.514)		1.468	(0.541)	
Number of Obs.	1532			1472			1472		
Log likelihood	−2701.33			−2504.89			−2443.68		
BIC	5542.01			5214.03			5157.26		
AIC	5440.65			5065.78			4961.37		

Notes: Robust standard errors are reported in parenthesis. * $p < 0.10$; ** $p < 0.05$; and *** $p < 0.001$. [a] Threshold parameters are the estimated cutoff points for the latent variables used to differentiate the various levels of the dependent variable where $Pr(y = 0) = Pr(z < \text{cut } 1)$; $Pr(y = 1) = Pr(\text{cut } 1 < z < \text{cut } 2)$; $Pr(y = 7) = Pr(\text{cut } 6 < z)$.

The complete relationship between price consciousness, visual consideration, and purchase likelihood is captured by Specification 3 (Table 3). The impact of how increasing/decreasing visual attention to the price attribute may further affect price conscious consumers' purchase likelihood, which is our primary interest, is jointly determined by the coefficients in front of FCs of price (FC_ price) and the interaction term between the price-conscious indicator and FCs of price (PC × FC_price). Both coefficients are negative and statistically significant, suggesting that increasing visual attention on the price attribute will further reduce price conscious consumers' purchase likelihood. This result is in support of Hypothesis 3, which states that price conscious consumers' visual attention to price signs will inversely affect their purchase likelihood.

In addition, price conscious consumers who fixate on the product longer are less likely to purchase. Although FCs on the pollinator friendly attribute, in general, increases purchase likelihood, for price conscious consumers, more fixations corresponds with a decreased likelihood of purchase. The interaction terms between the price-conscious indicator and FCs on the three production methods (certified organic, organically produced, conventional) are not statistically significant, indicating that additional visual attention to production methods did not affect price conscious consumers' purchase decisions. In other words, visual attention does not differentiate the price-conscious group of consumers from their counterparts in terms of preferences for production methods. Nonetheless, we do find, interestingly, that price conscious consumers with increased visual consideration of the domestic and import origins are more likely to purchase the products. This result may be related to perceived price, since consumers are often willing to pay premiums for locally produced ('in-state') products [51,52]. Thus, domestic or import origins would likely be considered the less expensive options by price conscious consumers. The visual attention results indicate that product attributes, which are perceived as "less expensive", may improve price conscious consumers' visual consideration and, ultimately, purchase likelihood.

4. Conclusions

Cumulatively, when examining price conscious consumers' purchase likelihood and visual attention behavior, several patterns emerge. First, price conscious consumers typically pay less visual attention to price than other non-price information, such as plant type, production method, and origin. Compared to non-price conscious consumers, price conscious consumers spend less time on the price attribute and less time evaluating the products (in general). This may indicate that they are faster decision makers or have preconceived reference points for the various attributes that improve their speed of decision making. Second, for price conscious consumers, greater visual attention to product price information leads to a lesser purchase likelihood. As suggested by Chen et al. [29], price sensitive consumers generally spend more time visually attending to the price attribute. Our results further refine their conclusion by demonstrating that longer fixations on the price information increases price conscious consumers' price sensitivity and, thus, reduces their likelihood to buy. To the best of our knowledge, this is the first study to explore how price conscious consumers perceive and react to prices differently from non-price conscious consumers. The extent to which price conscious consumers consider the price attribute of products when shopping is important from the consumer welfare perspective.

A third pattern is that the relationship between visual attention to 'less desirable' and, potentially, 'less expensive' options (e.g., domestic origins, import origins) improved price conscious consumers' purchase likelihood. This study does not delve into these motives, but they invite attention to potential reasons behind price conscious consumers' visual attention to various products/product attributes and suggests directions for future studies. Our results also have important implications for retailers. Retailers who are interested in targeting price conscious consumers and triggering them to buy should avoid promoting attributes that are perceived as more expensive (e.g., organic, local, etc.).

Despite providing interesting insights into price conscious consumers' visual and purchasing behavior, the present study does have several limitations that must be mentioned. First, to facilitate eye

tracking, a localized sample was used. Consequently, generalizing the results to the general population should be done cautiously. Secondly, only one type of product (i.e., ornamental plants) was tested in the present study. Results will likely vary for products that are not perceived as luxury goods. Lastly, to reduce other visual inconsistencies, the experiment was conducted in a lab setting and is subject to biases typical to lab experiments. However, the lab setting provided the benefits of visual, locational, and methodological consistency, all of which become much more variable and inconsistent in a real retail setting. Conducting a comparative experiment in a retail center is one means of overcoming this bias in future experiments.

This study serves as a launching point for future studies addressing decision making styles and visual attention to in-store stimuli. For instance, future studies could use a similar methodology with frequently purchased necessities (i.e., bread, milk, etc.) to see how results change based on product type. Future studies could also assess how results vary based on experimental location (e.g., retail, lab, etc.) Finally, additional studies could build on the present study by introducing pricing promotion strategies and styles (e.g., sign size/color, type, etc.) to determine price conscious consumers' purchasing behavior based on those visual stimuli.

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A Preliminary Assessment of Horticultural Postharvest Market Loss in the Solomon Islands

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Abstract: Honiara's fresh horticultural markets are a critical component of the food distribution system in Guadalcanal, Solomon Islands. Most of the population that reside in Honiara are now dependent on the municipal horticultural market and a network of smaller road-side markets to source their fresh fruits and vegetables. Potentially poor postharvest supply chain practice could be leading to high levels of postharvest loss in Honiara markets, undermining domestic food security. This study reports on a preliminary assessment of postharvest horticultural market loss and associated supply chain logistics at the Honiara municipal market and five road-side markets on Guadalcanal Island. Using vendor recall to quantify loss, we surveyed a total of 198 vendors between November 2017 and March 2018. We found that postharvest loss in the Honiara municipal market was 7.9 to 9.5%, and that road-side markets incurred 2.6 to 7.0% loss. Based on mean postharvest market loss and the incidence of individual vendor loss, Honiara's road-side market system appears to be more effective in managing postharvest loss, compared to the municipal market. Postharvest loss was poorly correlated to transport distance, possibly due to the inter-island and remote intra-island chains avoiding high-perishable crops. Spatial mapping of postharvest loss highlighted a cohort of villages in the western and southern parts of the main horticultural production region (i.e., eastern Guadalcanal) with atypically high levels of postharvest loss. The potential importance of market-operations, packaging type, and mode of transport on postharvest market loss, is further discussed.

Keywords: food security; postharvest; post-harvest; Pacific; food loss; municipal market; road-side market; Honiara; Guadalcanal; Malaita

1. Introduction

Solomon Islands is a South Pacific archipelago consisting of six major islands and a further 986 smaller islands, atolls and reefs. Around 84% of Solomon Islanders reside in rural villages and are dependent on subsistence-based agriculture and local fisheries [1,2]. In recent times, commercial food supply chains have become increasingly important in the Solomon Islands due to a combination of rural to urban population drift [3,4], population growth [5,6], ongoing challenges associated with agricultural productivity [7], and the impacts of adverse weather events [1,2,8]. This trend is particularly acute in the capital Honiara, with only 32% of the urban population having access to a home garden [6]. Most of the population that resides in Honiara, are now dependent on the municipal horticultural market and a network of smaller road-side markets to source their fresh fruits and vegetables.

Honiara's horticultural markets not only provide important food security and human nutrition outcomes [9,10], but create opportunities for local economic development and demonstrate a strong gender participation bias in favor of women market vendors [9,11]. The income generated from these markets provides essential livelihood support for local squatter settlements in the "greater Honiara"

region [3] and are a primary source of income for many close proximity islands such as Savo Island [7] and possibly Florida Island. This combination of socio-economic, pro-gender engagement and food security and nutrition benefits, has led to an increased focus by donors on market-based interventions in the Solomon Islands [12].

The need to improve the operational efficiency and effectiveness of the Honiara municipal market have been widely recognized [2,11,12]. The Honiara municipal market is constrained by overcrowding, poor sanitation and concerns about vendor safety [12–14]. Most studies undertaken in support of the Honiara municipal markets have done so from a community resilience, gender and human security perspective [3,4,7,11,15,16]. Its only recently that the underlying horticultural supply chains have been examined in any detail [7,11,16], providing a wider understanding of farm demographics, transport logistics and vendor practice. What remains unclear, is how efficiently the Honiara markets and their associated supply chains operate in terms of postharvest horticultural loss. Unlike other South Pacific islands such as Fiji [17,18] and Samoa [19], there are no previous reported studies on postharvest market loss in any of the markets in the Solomon Islands. With generic poor postharvest handling, potentially high-levels of postharvest loss in Honiara markets could be undermining domestic food security.

This study reports on a preliminary assessment of postharvest horticultural market loss and associated supply chain logistics at the Honiara municipal market and five road-side markets on Guadalcanal Island. The inclusion of Honiara road-side markets in this study reflects an increasing recognition of their importance in the overall food distribution system in Solomon Islands [15]. This study is part of an ongoing longitudinal assessment of postharvest horticultural loss in Honiara municipal market and road-side markets (Guadalcanal Island), Auki municipal market (Malaita Island) and the Gizo municipal market (Ghizo Island).

2. Materials and Methods

2.1. Location

This study was undertaken at the Honiara municipal market and five road-side markets in the Honiara district, Guadalcanal Island and Solomon Islands (Figure 1A,B). The location of the road-side markets assessed: Henderson, Fishing village, Lungga, King George VI and the White river, is shown in Figure 1B,C.

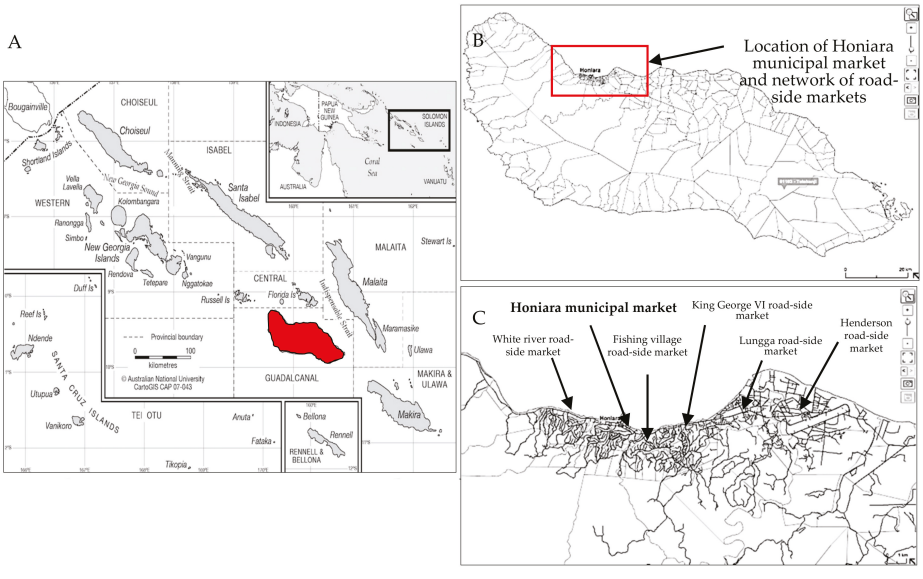

Figure 1. Map of the Solomon Islands. (**A**) Location of Guadalcanal Island (indicated in red) within the Solomon Islands archipelago (Map source: CartoGIS Services, College of Asia and the Pacific, The Australian National University, Australia, 2018); (**B**) map of Guadalcanal Island (red square indicates the study site); (**C**) location of the Honiara municipal market and the five road-side markets, Guadalcanal Island (Map source: Popgis@spc.int Solomon Islands National Statistics Office, Solomon Islands, 2018).

2.2. Survey Design and Ethics Approval

Vendor surveys were undertaken in November 2017 and March 2018. Markets were concurrently surveyed, and involved a series of enumerators from the Solomon Islands National University (SINU) to support this study. The selection of vendors to be surveyed was randomised, but excluded those vendors unable to identify where fruits and vegetables were grown (i.e., farm location) and therefore likely to be involved in inter-market trade, those vendors selling value-added or non-perishable products, and those vendors unwilling to participate in the survey. The survey design was based on semi-structured interview questions on harvesting and packaging practice, transport, market vendor practice, and postharvest loss. Enumerators received prior training in the survey methodology and ethics compliance.

A total of 198 vendors were assessed across all of the key Guadalcanal fruit and vegetable markets. This included 104 professional market vendors at the Honiara municipal market (42 vendors surveyed in November 2017 and an additional 62 vendors surveyed in March 2018). A further 94 road-side market vendors (occasional traders) were also surveyed (42 road-side vendors surveyed in November 2017 and 52 road-side vendors surveyed in March 2018). The survey was replicated across two sampling dates to partially account for potential differences in supply chain demographics and postharvest handling practice due to crop seasonality.

Surveys involved a short semi-structured interview lasting 5–10 min, commonly undertaken in the local language. All interviews were completed in compliance with the University of the Sunshine Coast Human Research Ethics Approval (A16814).

2.3. Data Collected

Postharvest market loss was determined using vendor recall, consistent with other recent Pacific market loss studies [18,19]. This method excludes on-farm loss, does not include consumer waste nor does it account for potential re-use of market loss for non-human consumption (i.e., product used for animal feed). For the purposes of this study, postharvest loss is defined as a fresh horticultural product that was permanently removed from the chain due to being of an unsaleable quality and not provided to others with the intent of human consumption [20]. Vendors were asked to quantify the level of postharvest loss of the main horticultural products on-display at their individual vendor stalls. This allowed for postharvest loss and handling practice to be further segregated and analysed according to crop type.

Transport distance from the farm (village) to the market was determined using Google Earth Pro™ Distance Calculator based on the most probable road transport route. Where the location of the village could not be directly identified, transport distance was calculated by cross referencing the map location given by the vendor with the nearest village. Village locations were further validated in discussions with the enumerators. For inter-island supply chains, transport distance was based on the most likely direct ferry route. For the intra-island transport supply chains that involved a combination of boat and road transport, such as those from southern Guadalcanal, transport distance was calculated based on a boat transport route from the farm to the nearest village with continuous road access to Honiara, and the most probable road transport route thereafter.

Product was identified as either fruits, vegetables, or fruits and vegetables, based on generic (non-botanical) crop classification (i.e., tomato and similar crops were classified as vegetables). Semi-processed, processed and non-horticultural commodities were excluded from this study.

2.4. Statistical Analysis

Data analysis was undertaken using one-way analysis of variance (ANOVA). Analysis of market vendor survey loss was undertaken using ANOVA followed by the Tukey–Kramer multiple comparison test (with consideration for uneven vendor numbers between markets). The relationship between market loss and transport distance was determined using a linear regression analysis.

3. Results

3.1. Postharvest Loss

Mean percent postharvest market loss at the Honiara municipal market was 9.5% in November 2017 and 7.0% in March 2018 (Table 1). Mean percent postharvest loss for the road-side markets in Guadalcanal was 7.9% in November 2017 and 2.6% in March 2018. The level of postharvest loss was significantly higher in the Honiara municipal markets compared to the Honiara road-side market in the March 2018 survey.

Table 1. Mean percent postharvest market loss for fresh fruits and vegetables sold in the Honiara municipal and road-side markets.

Market Type and Location	Mean Percent Postharvest Loss (November 2017)	Mean Percent Postharvest Loss (March 2018)	Vendor with No Postharvest Loss (%)
Honiara municipal market	9.5 ^{z} a ^{w}	7.0 ^{x} a	19.2
Honiara road-side markets	7.9 ^{z} a	2.6 ^{y} b	44.7

Data relates to all fruits and vegetables combined. ^{z} n = 42. ^{x} n = 62. ^{y} n = 52. ^{w} Values followed by the same letter are not statistically different at $p < 0.05$ based on Tukey-Kramer test.

The frequency of postharvest loss differed between the municipal and road-side markets (Table 1). In the municipal market, most vendors experienced some level of postharvest loss, with only 19.2% of

vendor surveyed indicating no loss (Table 1). In contrast, nearly half of the road-side vendors (44.7%) reported no postharvest loss. When road-side market vendors incurred postharvest loss, the amount of loss tended be high (often 20 to 25% loss—data not shown).

Postharvest loss for fruits was 7% to 7.6% in the municipal market and 3% to 5.2% in road-side markets (Table 2). In comparison, postharvest loss for vegetables tended to be more variable, 1.8 to 12.7%, with significantly higher postharvest loss in municipal market in the November survey (Table 2). Low, but not significant, vegetable postharvest loss observed in road-side markets in the March survey was due to fewer vendors reporting atypically high postharvest loss (data not shown).

Table 2. Mean percent postharvest market loss for fresh fruits and vegetables [z] sold in the Honiara municipal and road-side markets.

Market Type and Location	Mean Percent Postharvest Loss (November 2017)		Mean Percent Postharvest Loss (March 2018)	
	Fruit	Vegetable [y]	Fruit	Vegetable [y]
Honiara municipal market	7.0 efgh [x]	12.7 abcde	7.6 defgh	8.1 cdefgh
Honiara road-side markets	5.2 fgh	11.6 bcdef	3.0 gh	1.8 h

[z] Postharvest loss data relates to fresh fruits and vegetables but excludes all other food categories including semi-processed and cooked product. [y] Crops were defined as vegetables based on a commercial rather than botanical classification (i.e., tomato identified as a vegetable crop). [X] Values followed by the same letter within columns and rows for individual market survey dates are not statistically different at $p < 0.05$ based on Tukey–Kramer test.

The portion of fruits to vegetables being sold differed during the two survey dates, possibly reflecting seasonal supply. In November, 44% of vendors were selling fruits and 56% selling vegetables, whereas in the March survey 30% of vendors were selling fruits and 70% vegetables (data not shown).

Mean postharvest loss for inter-island and intra-island supply chains supplying the Honiara municipal market (November 2017 and March 2018 combined results) is shown in Table 3. While inter-island chains appear to have slightly higher loss, this trend could not be statistically assessed due to the limited number of inter-chains included in the survey.

Table 3. Mean percent postharvest market loss for intra-island and inter-island located farms supplying the Honiara municipal market.

Supply Chains	Mean Percent Postharvest
Guadalcanal Island to Honiara (intra-Island)	8.1 [z]
Malaita Island to Honiara	16.7 [y]
Savo Island to Honiara	11.2 [x]
Nggela Island to Honiara	16.3 [w]

[Z] n = 90 [y] n = 3; [x] n = 4; [w] n = 2.

3.2. Supply Chain Logistics

Fresh fruits and vegetables sold in the Honiara municipal market were primarily sourced from farms located to the east of Honiara, and to a lesser extent, villages on the north–west of Guadalcanal Island (Figure 2). Products sourced from farms located to the west of Honiara were more common during the November sampling period. Few farms located in the southern parts of Guadalcanal supply the Honiara municipal market. A small percentage of Honiara municipal market vendors (8.7%) were sourcing produce from Malaita, Gizo and Savo Islands (Figure 2). Inter-island sourced products were only observed in the Honiara municipal market, with the road-side markets tending to source locally-grown products.

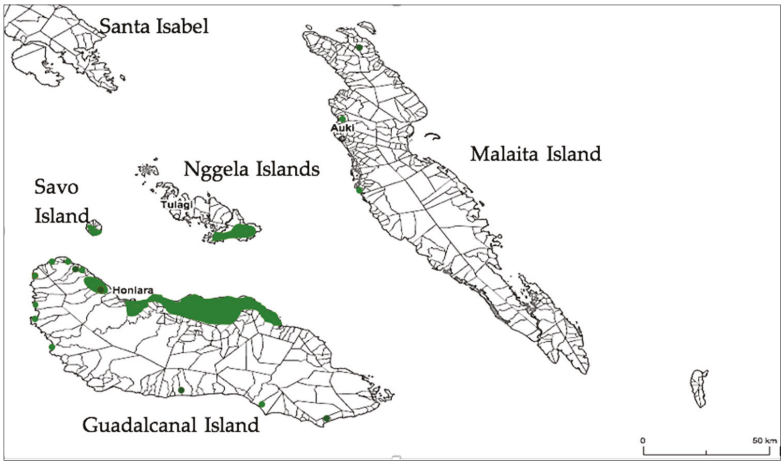

Figure 2. The locations (green marked areas) of farms supplying the Honiara municipal and road-side markets during the survey period (November 2017 and March 2018 data combined). (Source: Base map: Popgis@spc.int Solomon Islands National Statistics Office, Solomon Islands, 2018). Note location of farms are not GIS positioned.

Horticulture transport logistics into the Honiara municipal market were relatively short, with products travelling 40 to 47 km (Table 4). In comparison, products supplying the road-side markets travelled 19 to 27 km, almost half the distance. Some of this disparity can be attributed to the inclusion of inter-island supply chains into the Honiara municipal market. When the median transport distances are considered, the transport distance between farms and municipal markets or road-side markets were relatively similar in the November 2017 survey. In the March 2018 survey, mean transport supply distance for road-side markets was 17.1 km (Table 4). This reduction in transport distance implies vendors are able to source more products locally, and may explain the lower incidence of postharvest loss observed in road-side markets during this time (Table 2).

Table 4. Transport distance from the farm to the municipal or road-side markets.

Market Type and Location	Mean Transport Distance (km)	Median Transport Distance (km)
Honiara municipal market (November 2017)	40.0	32.9
Honiara road-side markets (November 2017)	26.9	28.0 [z]
Honiara municipal market (March 2018)	46.6	38.1
Honiara road-side markets (March 2018)	18.6	17.1 [z]

[z] Road-side market data represents data sourced from the Henderson, Fishing Village, Lungga, King George VI and White river road-side markets.

The mean transport distance for the individual road-side market network varied depending on the market location and the survey date (Table 5). Products sold at the Lungga and King George VI markets tended to be sourced from smallholder farmers located in close proximity to these markets (1 to 2 km away). Whereas products supplying the larger White river and Fishing village markets travelled 24 to 37 km. The comparatively shorter transport distances for the White river noted in the November survey and for the Henderson and Fishing village markets in the March survey are thought to reflect possible crop seasonal variability in the supply chains.

Table 5. Mean transport distance from the farm to the individual road-side markets.

Market Type and Location	Mean Transport Distance (km) (November 2017)	Mean Transport Distance (km) (March 2018)
Henderson	40.7	14.3
Lungga and King George VI (combined)	2.16	1.35
Fishing Village	37.7	26.8
White river	24.3	30.9

The most common mode of transport used by farmer/vendors to transport product to the Honiara markets (municipal and road-side) was by truck (Table 6). Truck-based transport systems were associated with farms located in more remote intra-island locations, with a mean travel distance of 37 km. However, there was considerable variability in transport distances involving trucks, with the shortest recorded transport distance being 6.2 km and the furthest being 64.8 km.

Table 6. Mode of transport used and mean transport distance for all markets and all survey dates.

Mode of Transport	Mean Transport Distance (km)	Percent of Farmers/Vendors Using Specific Mode of Transport (%)
Ferry/boat	88.9 a [z]	6.7
Truck	37.0 bcde	54.2
Car	25.2 cde	4.5
Minivan/public bus	20.5 de	14.5
Taxi	8.5 e	13.4
Walk	1.3 f	6.7

[z] Values followed by the same letter are not statistically different at $p < 0.05$ based on Tukey–Kramer test.

Mean transport distance involving cars or minivans/public buses was 20 to 25 km (Table 6). There was also considerable variability in the transport distance by car—ranging from 3.7 to 44.7 km, and transport distance by minivan/public bus—ranging from 0.5 to 41.2 km.

Transport by taxi was limited to farmers located relatively close to the market, with a mean transport distance of 8.5 km (Table 6).

3.3. Potential Contributions to Postharvest Loss

There was a weak correlation between transport distance and postharvest loss (Figure 3). Farms with very high levels of postharvest loss (>30% loss) were primarily located within 50 km of the markets. Conversely, most supply chains with a transport distance of 100 to 200 km had less than 10% loss.

The location of farms with moderate (10 to 19%) to very high levels (>30%) of postharvest horticultural loss are shown in Figure 4. Elevated postharvest loss was more prevalent in supply chains sourcing products from the far eastern part of the main production center (see Figures 2 and 4). There were multiple supply chains sourcing products from Tutumu, Tenaru, Vatukukau, Ruavatu, Siara, Binu, Aola, Tasimboko, Dadai villages on Guadalcanal Island, and Matakwara and Buma villages on Malaita Island with moderate to very high levels of postharvest loss. While there are relatively few farms located on the southern and far western parts of Guadalcanal supplying the Honiara markets (Figure 2), none of these had elevated postharvest loss (Figure 4).

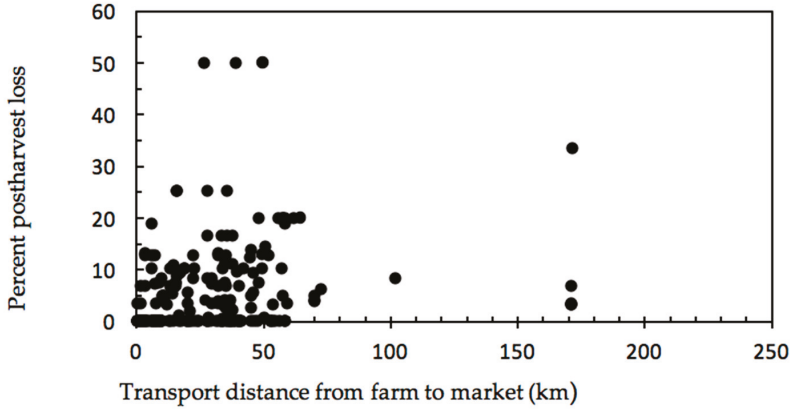

Figure 3. A linear regression analysis of percent postharvest loss verses transport distance for all vendors, markets and survey dates (n = 346). R^2 = 0.2503.

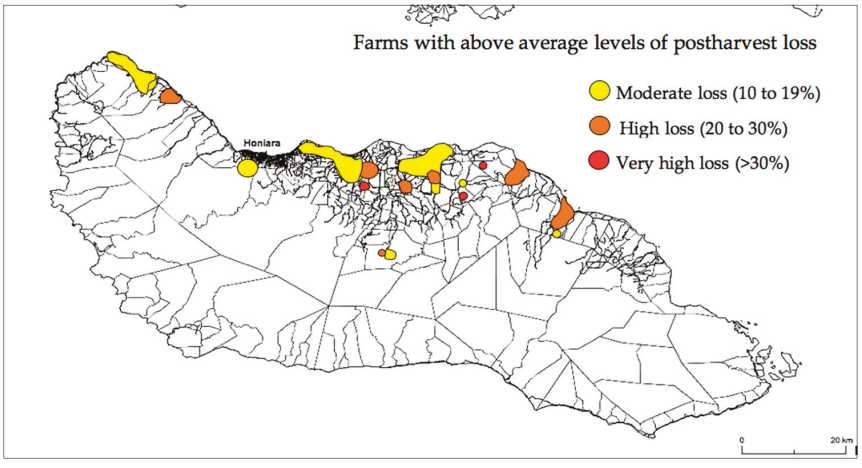

Figure 4. The locations of farms supplying the Honiara municipal or road-side markets with elevated levels of postharvest loss. (Source: Base map: Popgis@spc.int Solomon Islands National Statistics Office, Solomon Islands, 2018). Note farm locations are not GIS positioned.

The type of products being sourced by market vendors differed depending on farm location (Figure 5). Inter-island supply chains and those chains sourcing from the remote farms on Guadalcanal Island were less likely to include vegetables. Vendors instead tended to source vegetables from closer proximity intra-island located farms, especially those in the "greater Honiara" region and north-eastern Guadalcanal.

The most commonly sourced product from remote farms (>50 km) was watermelon, green banana and English cabbage (Table 7). Highly-perishable crops sourced from remote farms on Guadalcanal tended to be higher-value Asian leafy vegetables such as Pak choi and Choy sum (Table 7). Mean postharvest loss for these chains was 13.2% with half the consignments incurring ≥20% loss (data not shown).

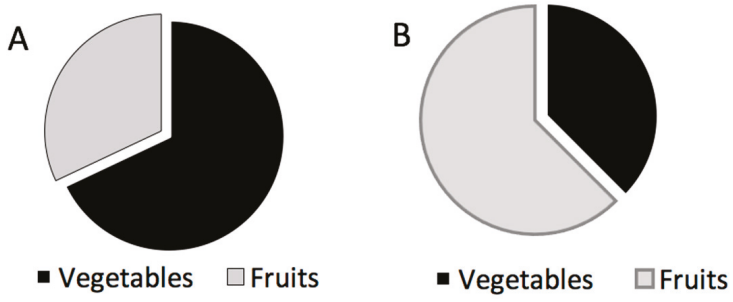

Figure 5. The commodity composition (vegetables to fruits ratio) of consignments sourced from intra verses inter-island located farms. (**A**) Intra-island supply chains (Guadalcanal) into the Honiara market; (**B**) Inter-island supply chains into the Honiara market. Data is based on number of consignments, rather than consignment volume or weight.

Table 7. The most common commodities being sourced by vendors at the Honiara municipal market from remote located farms (>50 km from farm to market).

Commodity	Rank Order
Watermelon	13.3%
Green banana, English cabbage	11%
Pak choi, pineapple	8.9%
Cucumber, shallots	6.7%
Choy sum, citrus	4.4%

A wide range of different packaging types were observed in the markets (Table 8). Large sacks (≥40 kg) were the most common type of packaging, especially for leafy indigenous vegetables. Higher value crops such as tomato and Asian vegetables tended to be limited to smaller (<20 kg) packing units. Postharvest loss was highest in very large packing units (Table 8).

Table 8. Mean postharvest loss based on packaging type.

Package Type	Mean Postharvest Loss (%)	Percentage of Supply Chains Using Packaging Type [y]
Very large sacks (>100 kg net weight)	10.9 a [z]	8.4%
Large sacks (approx. 40 kg)	4.9 b	34.0%
Medium sacks (20 kg)	5.5 ab	17.9%

[z] Values followed by the same letter are not statistically different at $p < 0.05$ based on Tukey–Kramer test. [y] Vendors also used a range of other packaging options: plastic trays (14.2% of vendors), small plastic bags (5–10 kg) (10.5%), plastic crates (1.5%), plastic buckets (3%), steel basins (8.4%), locally woven baskets (1.5%) and nil packaging (1.5%).

4. Discussion

Horticultural postharvest loss in the Honiara municipal market was 7.9 to 9.5%. In comparison, postharvest loss in the Honiara road-side markets tended to be lower (2.6 to 7.0%) but more variable. This level of loss was consistent with other South Pacific municipal markets, with Reference [19] reporting a 6.2% loss in the central municipal market in Samoa. Most municipal market vendors in Honiara experienced some level of postharvest loss, whereas road-side market vendor loss tended to be less common. Based on mean postharvest market loss and the incidence of individual vendor loss, Honiara's road-side market system appears to be more effective in minimising postharvest loss, compared to the municipal market.

The potential contributors to postharvest market loss in Guadalcanal markets and reasons for reduced loss in the road-side markets are likely to be multifaceted. Diverse market participation (commercial-scale farmers through to semi-subsistence farm surplus), poor road infrastructure, the lack of a cool chain, limited or poor packaging, and inadequate market storage facilities needs to balance against potential supply chain practices that seek to mitigate or lessen potentially elevated postharvest loss. While the contributors to generic postharvest loss in horticultural markets have been widely reported [19,21–24], the inclusion of possible vendor or farmer strategies to reduce this loss are often overlooked.

Intuitively, it would be logical to assume that transport distance would have a significant effect on the level of postharvest loss seen in the market, consistent with the findings in other postharvest supply chain studies [24,25]. While inter-island supply chains appear to have higher levels of postharvest loss compared to intra-island chains, we found that postharvest loss was poorly correlated to transport distance. Farms with very high levels of postharvest loss (>30% loss) tend to be located within 50 km of the markets, most supply chains with a transport distance of greater than 100 km have less than 10% loss, and loss associated with very remote intra-island supply routes was similarly less than 10%. These observations would suggest that the distance horticultural produce needs to travel from the farm to market is not a good indicator of potential market postharvest loss in Guadalcanal.

The type of crops sourced from inter-island and remote intra-island farms and their associated supply chain practice may provide some insight into the disconnect between transport distance and postharvest loss. Most inter-island supply chains included in this study were dominated by semi-perishable crops such as watermelon, pineapple and citrus. Such crops are often considered to be more tolerant of challenging transport logistics and potentially prolonged market storage. In the more remote Malaita to Guadalcanal inter-island supply chains, the product was sourced from two fruit production centers, watermelons from Buma and pineapples from Bina. These chains involved commercial-scale farms with relatively predictable transport logistics, with resultant postharvest loss being relatively low (<5%). Georgeou et al. [11] reported that the most commonly traded crops from Savo and Nggela Islands into the Honiara markets were fruits, nuts and root crops. In remote intra-island chains, such as products sourced from Mbalo on the far south-eastern part of Guadalcanal and Tangarare on the far south eastern part of Guadalcanal, there was a similar dominance of semi-perishable crops such as watermelon and citrus. While this might simply reflect local agronomic production conditions favouring certain crops, it is also possible that there is deliberate strategy by farmers supplying the Honiara market to avoid highly perishable cash crops if the associated transport logistic is likely to incur high-levels of postharvest loss.

Vegetable supply chains still represented a significant portion of the overall inter-island trade into Honiara. A recent study of the Savo to Honiara market supply chains [16] reported not only semi-perishable crops but also highly perishable leafy vegetables being traded. Savo farmers indicated high levels of postharvest loss due to in-transit damage and delays in accessing transport [16], even though Savo Island is only about 35 km from Honiara. The presence of inter-island trade of perishable vegetable crops in spite of high-levels of postharvest loss is interesting. Georgeou et al. [16] reported that much of the trade from Savo Island into the Honiara municipal market was due to opportunistic market participation due to surplus local production [16]. Faced with possibly few alternative local market opportunities on Savo Island, potentially high postharvest loss does not appear to disincentivise market participation.

When intra-island vendor loss was analysed in terms of where produce was grown, we found that there was a cohort of villages in the western and southern parts of the main horticultural production (which is located in eastern Guadalcanal) which were consistently associated with atypically high levels of postharvest loss. This result might reflect the type of crops grown in these locations, with Reference [11] reporting that most of the perishable leafy vegetables sold in the Honiara municipal market were sourced from farms located in north-eastern Guadalcanal. An alternative or additional possibility is a lack of reliable commercial transport options in these villages, or generic poor harvesting

and handling practice. Further studies are required to better understand on-farm postharvest practice and supply chain logistics within these villages. Spatial mapping of high-loss postharvest chains has not been previously reported in the South Pacific, and provides useful information in terms of helping to better target possible future technical farmer assistance and supply chain remediation.

Supply chain modes of transport associated with Honiara's markets reflect the diversity of agronomic production systems, from the commercial-scale through to semi-subsistent trade farm surplus. The most common form of transport was open trucks, consistent with the findings reported by Reference [11]. Nearly all of the supply chains sourcing products from eastern Guadalcanal were dependant on trucks, possibly reflecting the volume of trade, poor road conditions and some level of local transport coordination. In Samoa and Vanuatu, where there is a relatively well maintained road-network and small production volumes, public buses, minivans and private vehicles are more commonly used [19]. While the mode of transport is interesting, the specific postharvest transport conditions need to be better understood. How crops are loaded and the load configuration within the truck, the volume being transported, other possible items being co-transported can also have a significant influence on postharvest loss. More work is required to better understand transport logistics especially between eastern Guadalcanal and the Honiara markets as a possible contributor to postharvest loss.

A range of packing types were used by farmers, the most common of which was 40 kg of woven sacks. Given the large diversity of crops and packaging options, only a superficial assessment of the implication of packaging type on loss could be undertaken. As anticipated, very large agricultural sacks (>100 kg) used transport traditional leafy vegetables incurred significantly high levels of postharvest loss compared to smaller sizes of the same packaging type. Most heavy produce (such as pineapples, watermelon) were transported loose (no packaging). In the case of pineapples, the product was often tied into bundles of up to 40 fruit and carried using wooden poles. Plastic crates were rarely observed. Plastic buckets and steel trays were used for crops prone to damage during transport (such as tomato and papaya). The packing options used by farmers and vendors is thought to simply reflect the type of packaging readily available, with Reference [23] noting that vendors in Malaita Island were aware of the adverse implication of poor packaging.

Comparatively low postharvest loss (4 to 5%) associated with a commonly used form of packaging (i.e., woven sacks $\leq$40 kg) would suggest that while packing is far from ideal, for most farmers packing had little effect on resultant postharvest loss. However, damage associated with poor packaging can be latent and, therefore, not immediately evident when product arrivals at the market. Georgeou et al. [11] reported that product in the Honiara municipal market is commonly sold with 1/2 to 1 day or arriving at the market. It is possible that the potential full implications of poor packaging may be somewhat negated due to rapid market-throughput.

How efficiently the market-to-consumer food system operates directly influences postharvest supply chain loss. Noting high tropical ambient conditions, prolonged market storage has been reported to significantly elevate postharvest loss in other Pacific horticultural markets [19]. The observation by Reference [11], that most vendors in the Honiara municipal market sell their produce within 1/2 to 1 day is therefore significant. Honiara's road-side markets are likely to experience even more rapid product throughput due to fewer vendors and smaller volumes of product being sold, reducing vendor competition, and road-side markets located close to the resident's areas increasing potential consumer accessibility. In comparison, a product traded through the municipal market in Samoa is often stored for 2 to 3 days before it can be sold [19]. In Samoa, the benefits of comparatively good on-farm postharvest handling practice and shorter transport distances are being undermined by prolonged market storage [19]. In the Honiara markets, rapid market throughput of a perishable product is thought to be an important factor in avoiding potentially higher-levels of postharvest loss due to poor on-farm and transport practice. Fast on-selling by vendors in the Honiara municipal market is not the result of a better designed market infrastructure. Instead, high market vendor fees, over-crowding, poor market storage conditions, and significant concerns over vendor safety and

hygiene create tangible incentives for Honiara vendors to sell their produce as quickly as possible. Further studies are required to better understand road-side market trading practices and whether this further contributes to slightly lower postharvest loss in these markets. The implications of current vendor practice on postharvest loss at the consumer-end of the value chain also warrants further investigation.

One variable that needs to be considered when interpreting market survey data in this study is the potential for inter-market trade (particularly between the Honiara municipal market and the various road-side markets). Georgeou et al. [11] reported that approximately 30% of consumers at the Honiara market were on-selling products in other markets. In this study, we sought to exclude vendors who had sourced products from other markets from the survey, however, 2.6% of market vendors surveyed were unable to identify the farm location where the product was sourced. However, given that Reference [11] further highlighted ongoing tension between farmer vendors and re-sellers, suggesting that re-sellers may not self-identify when surveyed, we cannot exclude the possibility of some level of data error based on vendors providing deliberately inaccurate survey responses.

5. Conclusions

Horticultural postharvest loss in the Honiara municipal market is consistent with the level of loss in the Apia municipal market, Samoa. Guadalcanal's road-side vendors appear to experience less postharvest loss than vendors in the municipal market; however, the reasons for this are still unclear. The level of loss observed in Guadalcanal's postharvest markets is thought to be due to a combination of poor packaging, the type of crops being sold and possible opportunistic market participation associated with trade farm surplus. While the types of transport used by smallholder farmers were documented, their contribution to postharvest loss is unclear. We believe that potentially higher market loss is being mitigated by market vendor practice. Rapid market throughput-associated fast on-selling of the product reduces the time a product requires to be stored in the market. Farmers with potentially challenging transport supply chain logistics, which are likely to incur high postharvest loss, appear to be avoiding highly perishable crops in favor of semi-perishable fruit and starchy root crops. The observation of a series of farms toward the western and southern margins of the main production center with atypically high levels of postharvest loss warrants further investigation. Similarly, further work is required to better understand on-farm harvest and postharvest practices and possible elevated loss at the consumer-end of the chain.

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Analyzing the Export Performance of the Horticultural Sub-Sector in Ethiopia: ARDL Bound Test Cointegration Analysis

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Abstract: High dependency on traditional primary agricultural commodities and recurrent world market price fluctuations had exposed Ethiopia to foreign earnings instability. To reduce the high dependence on primary agricultural commodities and the associated vulnerability of negative price declines, diversification of trade from primary agricultural commodities into high-value horticultural commodities has attracted the attention of policy makers. The developments made in this area have brought the sector to the position of fifth largest foreign revenue generator for the country. However, given the comparative advantage in marketing and the potential to achieve trade gains that the country possesses, the benefit from the horticultural sub-sector is far below its potential. In this regard, knowledge of the determinants of the industry's development is very important. So far, no attempt was made to examine factors influencing the export performance of the sector, taking the long period performance of the sector into consideration. Consequently, this study was proposed to examine the factors that have influenced the horticultural export performance of Ethiopia for the period from 1985–2016. Secondary data collected from National Bank of Ethiopia, Ethiopia Horticulture Producer Exporter Association, Ministry of Agriculture of Ethiopia, FAOSTAT, UNCTAD, and the World Bank were used in this study. The short-run and long-run relationships among the series were investigated using the autoregressive-distributed lag (ARDL) bound test cointegration approach. The model result of the Error Correction Model (ECM (-1)) was revealed as negative and significant, whereby it confirmed the existence of cointegration among the series. Its coefficient value was 0.472, which showed 47% of the adjustment will be made in the first year and it will return to its long-run equilibrium after 2.12 years. The model results also showed that the real effective exchange rate, the real GDP of Ethiopia, foreign direct investment (FDI), prices, and the structural break had significantly influenced the horticultural export performance both in the short-run and the long-run. Foreign GDP and real interest rates were revealed significant only in the long-run. Finally, important policy measures deemed to improve the horticultural export performance of Ethiopia were recommended.

Keywords: horticulture; export performance; ARDL bound test cointegration; Ethiopia

1. Introduction

Developing countries are highly dependent on export earnings to satisfy their import requirements and for the development of their economy [1,2]. Consequently, instability of such proceeds will significantly influence output by constraining input and production planning. Furthermore,

fluctuations in quantity and price of exports could create a serious problem in balance-of-payments, national income, investment, as well as the overall growth of less developed countries [2]. Susceptibility to this problem is high in SSA (Sub-Saharan African) countries as their international trades are mainly based on exporting primary agricultural commodities, whey they possess comparative advantages due to cheap labor [3].

Similarly, in Ethiopia, the export structure is highly concentrated to a few traditional agricultural commodities, such as coffee, hides, skins, oilseeds, and pulses. Over a long period of time, coffee was the dominant export earning commodity, followed by non-coffee commodities such as hides, skins, oilseeds, pulses, and chat. Over two-thirds of the export earnings were obtained from the export of these few commodities [4]. However, since the mid-1990s, the relative importance of these commodities, particularly coffee, in total export revenue has declined drastically. Coffee's contribution to export earnings declined to 45% in 2003, from a high of 70% in the mid-1990s, due to the high volatility of coffee prices. This would have a detrimental effect on the economic planning and economic development of the country. From this, it can be understood that export earnings instability was one of the chronic economic problems facing Ethiopia. Since the 1970s, many other Less Developed Countries (LDC) have also experienced strong volatility and declines in the international prices of their primary commodities exports [5]. Therefore, high dependence on a few agricultural export commodities added with the high volatility of prices left the countries' export earnings extremely vulnerable.

In countries like Ethiopia, that mainly depend on primary agricultural commodities for their export earnings, vertical diversification through establishing agricultural processing industries which produce value-added quality export products is difficult. However, diversification horizontally into the export of non-traditional high-value agricultural commodities was one of the possible ways to reduce over-reliance on a few low-value traditional products and tackle the problem of export income instability.

Consequently, due to the declining export earnings from traditional exports, horticulture and other non-traditional, high-value, agricultural export expansions represent an important area of potential income growth [5]. In this regard, Ethiopia was considered to have the potential to achieve trade gains in these sub-sectors [6]. This is because Ethiopia has diverse agro-ecological zones that can easily fit the production of different agricultural export commodities, with minimum adjustment to the existing production systems [1,7]. As a result, promoting the production and export of horticultural products (fruits, vegetables, and flowers) has caught the attention of the federal government of Ethiopia. These high-value and labor-intensive cash crops can contribute to the fast and successful diversification of the export base towards non-traditional agricultural commodities to attain export earnings stability.

Production of horticultural products is a new sector in Ethiopia, as the production of these crops has been undertaken for decades. The sector comprises of large state farms supplying fruits and vegetables to the local market and for export [8]. Fruit and vegetable crops with a significant potential for domestic consumption, export markets, and industrial processing are produced in the country [6]. In this regard, the Ethiopian government, sector organizations, and donors have played a great role to identify potential for the further development of the fruits and vegetable sector in Ethiopia, both for the domestic and export market [8].

The export destination of Ethiopia's fruits and vegetables are mostly neighboring countries like Djibouti, Sudan, and Somalia. High-value fresh vegetables were exported to the United Kingdom, the United Arab Emirates, and the Netherlands, which may create an opportunity for the improvement of the fruit and vegetable sectors in the country [6]. According to statistics in Reference [9], in 2004/2005, export income generated from the subsector was 28.55 million USD. In 2015/16, the sector provided employment opportunities for approximately 183,000 persons and generated earnings of about 274.62 million USD, making the sector the fifth largest foreign revenue generator for the country.

Given Ethiopia's endowment of natural resources and other competitive advantages, the export performance was still low despite the existence of blooming prospects for the development of the sub-sector. Consequently, although export diversification through horticultural produce was

advocated as an alternative export promotion strategy, the performance of this sector has been generally unsatisfactory. In this regard, knowledge of the determinants of industry's development has paramount importance. However, so far different empirical works [2,3,10–15] have mostly emphasized the export performance of traditional export commodities, with less consideration on examining the factors affecting the export performance of the horticulture sub-sector. Some others had tried to describe [4,16] and analyze the production and marketing aspects [1] of the sector in a limited part of the country. Effective policy intervention to promote the performance of this potential and promising sub-sector needs knowledge of the determinants of the industry's development. Consequently, the objective of this study was to assess factors affecting the export performance of the Ethiopian horticulture sub-sector, which in turn will enable the sector to be competitive in the global horticulture market and stabilize export earnings of the country.

2. The Ethiopia's Horticulture Export Share

Ethiopia's economy heavily depends on agriculture leading to the structure of Ethiopian exports to be dominated by agricultural products for a long period of time. Consequently, Ethiopia's external trade was characterized by high sectoral (agriculture) and commodity concentration (coffee) dependence. This is clearly seen in Table 1, where the contribution of coffee to foreign earnings played a great role. There were limited attempts to diversify both the commodity concentration and high geographic concentration. Such commodity and geographic concentration were the major causes for the instability of Less Developed Countries' (LDC's) export earnings to which Ethiopia is not an exception. The vulnerability to external shocks was exacerbated by recurrent weather changes, swinging the export value and volume. Consequently, diversification of both commodities and markets for the country are an urgent issue. With regards to commodity diversification, the horticultural sub-sector had recently attracted the attention of policy makers, and had been performing well. In this regard, the export performance of horticulture, on average, nearly accounted for 258.44 million USD over the last five to six years [17]. This had propelled the sub-sector to be the fifth most important generator of foreign earnings [7].

Table 1. Average value of export earnings from major export commodities (in Millions of USD).

Period	1985/86–1989/90	1990/91–1994/95	1995/96–1999/00	2000/01–2004/05	2005/06–2008/09	2009/10–2012/13	2013/14–2015/16
Coffee	247.07	265.99	149.8	318.21	419.725	737.075	739.2
Oil Seeds	10.31	5.69	3.58	26.26	243.425	398.625	546.4
Hides & Skins	44.21	59.74	38.88	44.87	84.775	97.675	125.57
Pulses	11.68	8.65	6.01	12.81	85.4	165.05	234.33
Meat & Meat Products	3.06	1.7	0.34	3.63	20.375	62.55	87.93
Horticulture	5.91	6.72	10.98	13.99	95.55	220.05	258.44
Live animals	6.61	9.78	1.22	1.18	39.5	152.925	161
Chat	12.14	8.45	14.8	46.62	107.175	239.675	277.4
Gold	n.a	27.44	25.99	41.34	84.575	482.475	355.2
Others	44,03	28.51	32.29	76.17	94.3	188.4	261.4
Grand Total export	397.43	399.26	274.67	517	1274.75	2744.525	3047.27

Source: NBE and authors own computations.

3. Literature Review

Analyzing the export performance of the horticultural sub-sector, with a special focus on the determinants of horticultural exports, had attracted the attention of both policymakers and researchers in different parts of the world, particularly in developing countries. This is because the export of horticultural products provides a good opportunity to diversify the export base of many developing countries, which are mainly dependent on exports of tea, coffee, and cocoa [18]. This, in turn, will reduce dependence on a narrow range of primary products by developing countries.

The prospects for export diversification in Ethiopia were assessed empirically to investigate the main determinants of the country's exports (dominated by traditional commodities). Using the Error Correction Model (ECM), the estimation of the export determination model revealed that the real exchange rate was the significant determinant of the country's exports in the long-run [1]. The findings of this study were inconsistent with the results of Reference [11]. However, the work of many researchers in different part of the world had confirmed that the real exchange rate was among the most important determinants of export performance [3,18–24]. In addition, the study by Reference [10] had also stressed the existence of promising opportunities for export diversification in the country. References [3] and [11] had also stressed the need and importance for diversifying the export base of the country and breaking away from the export of traditional agricultural commodities.

The study by Reference [2] analyzed Ethiopia's export earnings instability by employing country-specific models, taking advantage of a sufficiently large sample period from 1962 to 2008. The study tried to identify the contributions of major traditional agricultural export commodities, such as coffee, hides, skins, oilseeds, and pulses. Attempts have also been made to make comparisons between the sub-periods of the Imperial, Derg, and Post-Derg periods, since these sub-periods experienced distinct trade and foreign policies. The study finds that the Post-Derg period was characterized by a higher level of instability and diversification of exports. This calls for the reconsideration of the direction of the diversification policy towards commodities that are negatively correlated with the traditional export commodities of the country.

The study by Reference [11] examined the performance and trend of merchandise (and manufacturing) exports, and its determinants during the period from 1981–2008 in Ethiopia. The findings of the study indicated that merchandise export volumes were significantly influenced by gross capital formation (proxy for production capacity) and share of trade in GDP (proxy for trade liberalization). In addition, manufacturing exports supply was found to be negatively and significantly affected by foreign income and positively affected by gross capital formation. The impact of foreign income was also revealed as negative in References [21,25]. However, many empirical works had obtained a positive impact of trading partners' income on the export performance of the exporting country [20,26,27].

Using cross-sectional data, Reference [16] also described the export performance of fruit and vegetable exporters and found that the sector was in its infancy and there was much to be done to increase gains from the sector. Ethiopian fruit and vegetable exporters were challenged by the lack of managerial and technical skills, and lack of commitment by employees, respectively. Externally, fruit and vegetable exporters were hindered by lack of credit facilities, supply of inputs, followed by lack of infrastructure. Finally, it was recommended that policymakers should design different schemes to enhance export performance, especially of fruits and vegetables. However, for the effectiveness of policy measures, an empirical work on the factors affecting the export performance of sub-sectors is still missing.

In the empirical work, Reference [18] analyzed the export performance of the horticultural sub-sector in Kenya. The findings of the study indicated that agricultural GDP and real interest rates were the important factors that influenced horticultural exports from Kenya. Agricultural GDP had a positive influence on Kenyan horticultural exports, whilst real interest rates had a negative influence on horticultural exports. The implication of the findings were that since real interest rates had a negative relationship with horticultural exports, an increase in real interest rates would lead to a decrease in

Kenya's horticultural exports by increasing the cost of borrowing. In addition, it was emphasized that the significance of the cost of borrowing in influencing horticultural exports can be attributed to the fact that the horticultural sub-sector is relatively more capital intensive, compared to other agricultural sub-sectors. A significant amount of capital is required to set up greenhouses, cooling facilities, pack houses, irrigation systems, as well as the purchase of fertilizers, agrochemicals, and other inputs. The result was consistent with the findings of Reference [28], wherein real interest rates were found to have a significant impact on the volume of cotton exports.

Using the cointegration test, Reference [28] examined factors that affected tobacco and cotton exports in Zambia. The results of the study revealed that the factors that affected the growth of exports were crop specific. For instance, foreign direct investment had a significant impact on the volume of tobacco exports, both in the short-run and long-run, though tobacco exports were more responsive to movements in this factor in the long-run, than in the short-run. Consequently, policy measures like scaling up incentives in the form of tax holidays, should be taken to attract foreign direct investment. This result was consistent with References [21,25]. Furthermore, Reference [29] stated that the impact of foreign direct investment (FDI) depends on its motive, whereby export-oriented FDI will promote the export performance of the exported commodities. In addition, the uni-directional Granger causality of agricultural exports to the share of agricultural gross domestic product for both tobacco and cotton in Zambia, implied that the two sectors should be prioritized in terms of increased budgetary allocations, which will raise agricultural GDP and drive the economy towards export diversification [28].

4. Econometric Method

4.1. Description of Data

The study used time series data from References [9,17,30]. Data on real exchange rates, foreign direct investment, real GDP of Ethiopia, real GDP of trading partners, price, and real interest rates were obtained from References [27], whilst data on horticultural exports was obtained from References [9,17]. These data were analyzed using Eviews Version 9.0 (IHS Global Inc., Englewood, CO, USA).

4.2. Cointegration Test

Cointegration is a powerful way of detecting the presence of long-run relationships or steady-state equilibrium between variables [31]. Different cointegration techniques were developed to determine the long-run relationships between the time series [32–34]. In all these cointegration techniques, the most important restriction is that all the series must be of the same ordered integrations. However, a recently developed cointegration approach, namely the autoregressive-distributed lag (ARDL), also known as the bounds test, eliminates this restriction [35]. The ARDL approach allows the regressors to be stationary in levels (I (0)) or the first-differenced (I (1)). Owing to this convenience, the ARDL method has been used in many empirical works, and it was also used to obtain the long-run relationship among the series in this study. The long-run ARDL equation was specified as follows:

$$\begin{aligned} \ln \exp_t = {} & \beta_0 + \sum_{i=0}^{m} \beta_{1i} \ln \exp_{t-1-i} + \sum_{i=0}^{n} \beta_{2i} \ln ER_{t-i} + \sum_{i=0}^{o} \beta_{3i} \ln RDGP_{t-i} + \sum_{i=0}^{p} \beta_{4i} \ln FDI_{t-i} \\ & \sum_{i=0}^{q} \beta_{5i} \ln FGDP_{t-i} + \sum_{i=0}^{r} \beta_{6i} \ln \Pr ice_{t-i} + \sum_{i=0}^{r} \beta_{8i} \ln RIR_{t-i} + \omega DU_t(T_b) + \varepsilon_t \end{aligned} \quad (1)$$

where exp: represents horticultural exports, FDI: foreign direct investment, ER: real effective exchange rate, RGDP: real GDP of Ethiopia, FGDP: foreign GDP, Price: world average price of fresh fruits and vegetables, DU_t: Dummy variable representing the Structural break (T_b (break year) = 2005 in this case), and RIR: real interest rate.

The F-test was employed to test co-integration among the variables, where the null hypothesis that the betas were jointly equal to zero (i.e., $\beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = \beta_6 = \beta_7 = \beta_8 = 0$) was tested. Reference [32] provided critical *F*-values; one for the lower bound and the other for the upper bound,

for testing whether there was co-integration. If the computed *F*-value was less than the *F*-value for the lower bound, then the null hypothesis cannot be rejected. If the computed *F*-value exceeded the *F*-value for the upper bound, then the null hypothesis of no co-integration was rejected, otherwise the test was inconclusive.

To select the lag values m, n, o, p, q, and r in Equation (1), model selection criteria, such as AIC, SIC, Hannan-Quinn information criteria, Adjusted R-squared were used. The short-run dynamics of the variables was described by employing the Error Correction Model (ECM) [24]. The ECM representation was specified as follows:

$$\Delta \ln \exp = \alpha_0 + \sum_{i=0}^{m} \lambda_i \Delta \ln \exp_{t-1-i} + \sum_{i=0}^{0} \varphi_i \Delta \ln ER_{t-i} + \sum_{i=0}^{n} \theta_i \Delta \ln RGDP_{t-i} + \sum_{i=0}^{n} \gamma_i \Delta \ln FDI_{t-i} + \sum_{i=0}^{p} \psi_i \Delta \ln FGDP_{t-i} + \sum_{i=0}^{q} \eta_i \Delta \ln RIR_{t-i} + \sum \partial \Delta \Pr ice_{t-i} + \omega \Delta DU_t(T_b) + \lambda ECM_{t-1} + \varepsilon_t \quad (2)$$

The coefficient of the ECM_{t-1}, λ in Equation (2) shows the speed of adjustment of a parameter, indicating how quickly the series can come back to its long-run equilibrium. The sign of the coefficient must be negative and significant. Diagnostic tests which include serial correlation and heteroscedasticity tests were conducted to ensure the acceptability of the model. In addition, cumulative sum (CUSUM), the cumulative sum of squares (CUSUMQ), and recursive coefficient estimates were also applied to the series to assess stability of the coefficients and this was illustrated using graphics.

4.3. Independent Variables Included in the Model and their Expected Signs

Foreign direct investment (FDI): It was defined as new investment made by foreign investors in horticultural sub-sectors. The results of the reviewed literature show varied results with regards to the impact of FDI on export performance. However, in Ethiopia, the government have given due attention to attract foreign investors into this potential sub-sector. Consequently, the expected sign of FDI in this study was expected to be positive.

ER: the real effective exchange rate was defined as the product of the nominal effective exchange rate and domestic consumer price index divided by the foreign consumer price index. An increase in the real effective exchange rate (depreciation) makes the exports cheap in the international market, thereby increasing the exports of the country. The opposite happens when it increases. Consequently, in this study, the expected sign of the real effective exchange rate was positive.

FGDP: Foreign GDP was defined as the average real GDPs of the major importers of horticultural crops. Diversification of both commodities exported and importing countries were considered by many as an important means of improving export performance in developing economies. Consequently, foreign income was hypothesized to influence horticulture export performance positively.

RIR: Real interest rate was defined as the nominal lending rate adjusted for inflation. The higher the interest rate, the lower the investment in production of horticultural crops and the less will be the volume of exports. Consequently, a negative relationship was expected between horticultural exports and the real interest rate.

RGDP: It was defined as the real GDP of the exporting country which was Ethiopia in this case. The higher the real GDP of the country, the higher will be its export performance. Consequently, real GDP of the exporting country was expected to influence export performance positively.

PRICE: It was the average world price of fresh fruits and vegetables (dollars/kg) sourced from the World Bank and FAO statistics. It was hypothesized to have positive effects on horticultural export performance, since increases in output prices will lead to increased revenues.

BREAK: This was a dummy variable included in the model to capture the impact of the structural break that occurred in 2005. It was expected to have a positive impact on the export performance of the horticultural sub-sectors.

5. Results and Discussion

5.1. Trend Analysis of Independent Variables

The trend of real interest rates from 1985–2016 is shown in Figure 1. In this period, the value of real interest rates recorded both negative and positive values. According to NBE (2013/14), in recent years, despite the negligible change in nominal interest rates, the rate of real interests showed a significant improvement from the past year because of the drop in year-on-year headline inflation. In addition, despite the recent uptick, inflation has been kept within single digit levels largely aided by tight monetary and prudent fiscal policy stances.

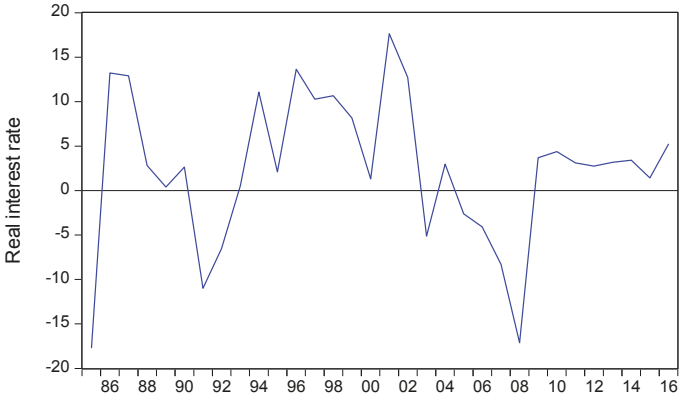

Figure 1. Trends in real interest rates in Ethiopia, 1985–2016.

Despite some fluctuation, the trend of foreign direct investment was increasing in Ethiopia throughout the period. In this regard, different actors like the Ethiopian government (MoARD), the sector organizations (EHPEA), and donors (USAID, SNV) have played a great role by identifying areas for further development of the fruits and vegetable sector in Ethiopia, both for the domestic and export market. Furthermore, in addition to the comparative advantage that the country possesses due to its proximity to the Middle Eastern and European markets, supportive government policies and favorable investment incentives had attracted foreign investors to invest in the growing sectors of the country. The trend of LnFDI is shown Figure 2.

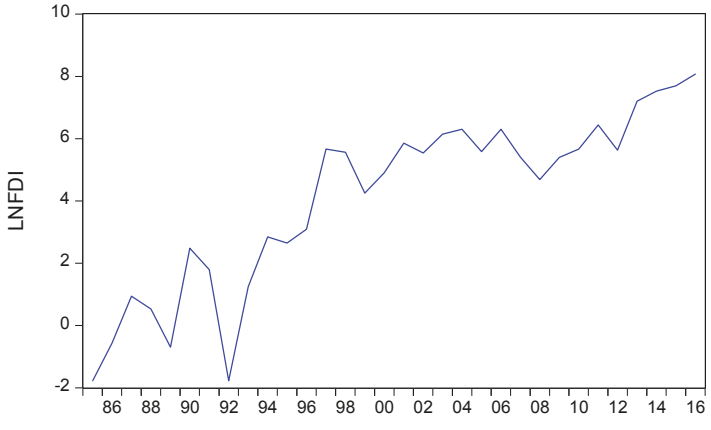

Figure 2. Trends in LnFDI in Ethiopia, 1985–2016.

Over a long period of time, the export performance of the horticultural sector was unsatisfactory. This by itself demonstrates the fact that the country's foreign earnings were dominated by a few agricultural commodities. In this regard, coffee remained the largest contributor to foreign earnings of the country. However, there has recently been a positive move by both government and donor countries to diversify the export base of the country. The horticulture sub-sector attracted the attention of policy intervention. As a result, export earnings from the horticultural sub sector had shown improvement in recent years, as shown by its trends in Figure 3.

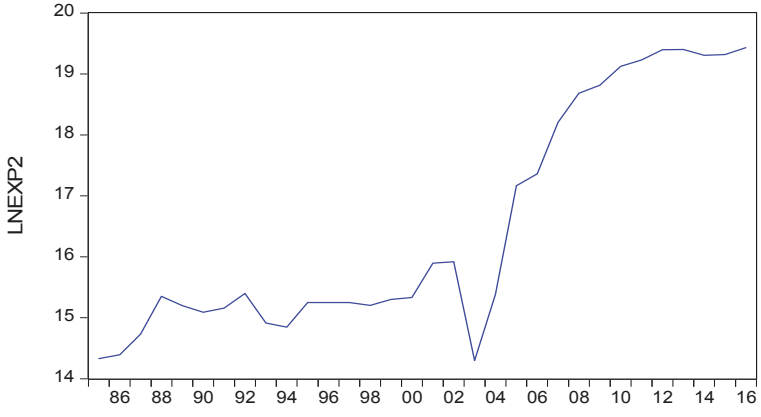

Figure 3. Trends in Lnexp in Ethiopia, 1985–2016.

The trend of LnRGDP shown in Figure 4 was rising over the last two decades. There was rapid and sustainable economic growth, especially over the last 15 years, as shown by the trends in Figure 4. This emanated from the fact that even though there was a gradual and steady shift in the structure of the economy by developing the manufacturing sectors; government policies of promoting export-led growth had focused on modernizing agricultural sectors which have long dominated the country's economic base. LnFGDP shown in Figure 5 was also rising throughout the period.

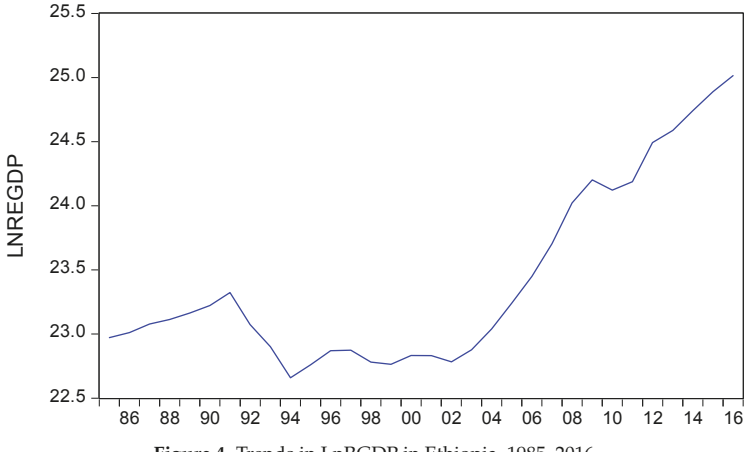

Figure 4. Trends in LnRGDP in Ethiopia, 1985–2016.

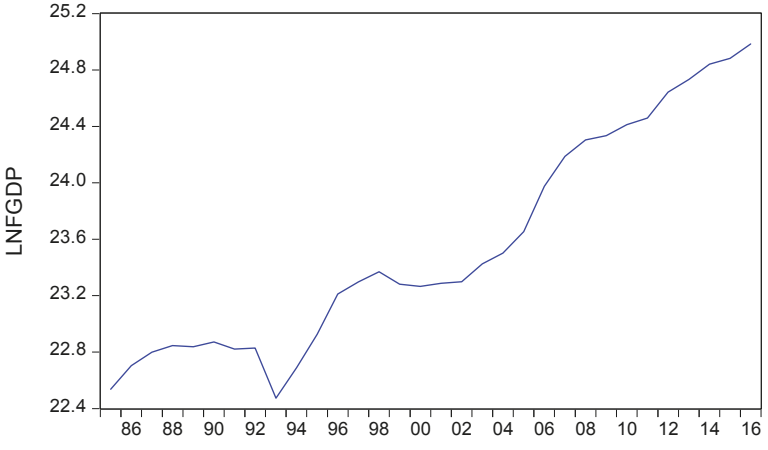

Figure 5. Trends in LnFGDP

5.2. Stationarity Tests

The values of all economic variables were transformed into logarithmic values and tested for the stationarity of the series. The test results of the Augmented Dickey-Fuller (ADF) and Phillips Perron (PP) tests presented in Table 2 show that there was no stationarity in the level data for export, real exchange, Real GDP, price, and foreign direct investment. The absolute value of their test statistics was less than the absolute value of 5 percent critical value of −2.927. However, the first differences of the series (Table 3) were stationary, implying that they were all integrated of degree 1 (I (1)). Foreign GDP and real interest rate were stationary at the level data (I (0)). This indicated that the series were integrated of different levels, such that the Auto Regressive Distributed Lagged (ARDL) bounds test approach proposed by Reference [32] is an appropriate method for analyzing the long-run relationship between the series. Consequently, the ARDL bound test approach was used for this study.

Table 2. Unit root tests at the levels of the variables.

Variables	ADF Test Statistic	Philips Perron Test Statistic	Order of Integration
Lnexp	−1.654927	−1.625208	
lnER	−0.964869	−0.477526	
LnFDI	−0.987362	−1.737795	
lnRGDP	0.449684	1.224389	
LnPrice	−1.083376	−1.264349	
lnRIR	−5.052738 **		0
lnFGDP	−3.480684 **		0

Note: ** are significance at 0.05 significance level for the critical value of −2.960411.

Table 3. Unit root tests at the first differences of the variables.

Variables	ADF Test Statistic	Philips Perron Test Statistic	Order of Integration
Lnexp	−5.531821 **	−5.329959 ***	1
lnRGDP	−3.549835 **	−3.233472 **	1
lnER	−3.320375 **	−3.102866 **	1
LnPrice	−4.963577	−4.964973	1
LnFDI	−8.629207 **	−6.919586 **	1

Note: *** and ** are significance level at 1% and 5% respectively. Critical value at 0.05 level, −2.967767.

5.3. Structural Break Analysis

Production and processing of horticultural crops, vegetables, and fruits have been placed by the Government of Ethiopia on the list of high priority areas, and various incentives have been provided for investors. A package of incentives under regulation No. 84/2003 was developed for both foreign and domestic investors engaged in new enterprises and expansions. This includes a 100 percent exemption from import customs duty and other tax levied on imports on investment capital goods and construction materials necessary for the establishment of a new enterprise. In addition, the Ethiopia Horticulture Producers and Exporters Association (EHPEA) was established in 2002 to facilitate private sector horticultural exports. It represents the horticulture sector in the country, as well as internationally, and it also organizes trade fairs. The Ethiopian Development Bank (EDB), the key institution financing the expansion of the sector, provides loans with a grace period and at relatively low interest rates. Furthermore, to boost the horticultural sector further, the Ethiopian Horticulture Development Agency was established on 6 June 2008, as an autonomous Federal Government Agency under the Ministry of Agriculture [36].

The cumulative effect of these policy measures were tested to check whether it had brought any significant structural break in the performance of the horticultural sub-sector. In this regard, the Zivot-Andrew test of structural break analysis was applied to the series to examine the structural break in horticultural export performance (Figure 6). The results of the test presented in Table 4 showed that there was a structural break in the year 2005. The test statistic for 2005 (−5.21) was at a minimum level in the graph. This test statistic was less than the 5% critical value. Therefore, it can be concluded that the structural break that occurred in the year 2005 was a significant structural break. Thus, this confirms that developments that had occurred before and after 2005 had resulted in the structural break in 2005, with regards to the performance of the horticultural sub-sector.

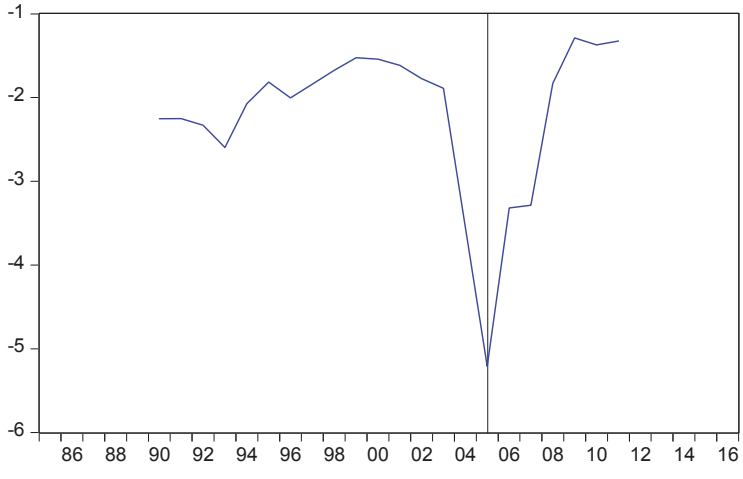

Figure 6. Zivot-Andrew breakpoints test results.

Table 4. Zivot-Andrews Unit Root Test results.

Chosen Break Point: 2005		
	***t*-Statistic**	**Prob. ***
Zivot-Andrews test statistic	−5.209580	7.13×10^{-5}
1% critical value:	−5.34	
5% critical value:	−4.93	
10% critical value:	−4.58	

* Probability values are calculated from a standard *t*-distribution and do not take into account the breakpoint selection process.

5.4. Co-Integration Tests

The presence of cointegration among the series was tested by employing the bound test approach. Accordingly, the results presented in Table 5 show that the computed *F*-statistic (7.105) was greater than the *F*-critical value at 1%, 5%, and 10%, respectively. Consequently, the result supported the rejection of the null hypothesis, which indicated the existence of a long-run relationship between the variables. This implies that there is cointegration among the series in the model. The existence of cointegration among the series aids in analyzing the short-run and long-run relationship of the factors that affected the growth of horticulture exports in the country.

Table 5. ARDL bounds test results for Cointegration.

K	**F**	**Critical Values at 1% Level of Significant**		**Critical Values at 5% Level of Significant**		**Critical Values at 10% Level of Significant**	
		I (0)	**I (1)**	**I (0)**	**I (1)**	**I (0)**	**I (1)**
7	7.105 ***	2.73	3.9	2.17	3.21	1.92	2.89

Note: *** is the significance level at 1%.

Using AIC, SIC, and Hannan-Quinn information criteria, ARDL (2, 2, 2, 0, 1, 0, 0, 2) was revealed as the best model for the series. The Breusch-Godfrey Serial Correlation LM Test results presented in Table 6 show that there were no problems of serial autocorrelation. In addition, the diagnostic test for heteroscedasticity also showed the absence of such problem (Table 7). This indicates that the model was good enough for the study of cointegration among the variables.

Table 6. Breusch-Godfrey Serial Correlation LM Test.

F-statistic	0.878345	Prob. *F*(2,11)	0.4427
Obs*R-squared	4.131220	Prob. Chi-Square(2)	0.1267

Table 7. Heteroskedasticity Test: Breusch-Pagan-Godfrey.

F-statistic	0.771213	Prob. *F*(16,13)	0.6927
Obs*R-squared	14.60895	Prob. Chi-Square(16)	0.5534
Scaled explained SS	1.698353	Prob. Chi-Square(16)	1.0000

5.5. Factors Affecting the Growth of Horticultural Crops

Based on ARDL (2, 2, 2, 0, 1, 0, 0, 2), the model results of the short-run and long-run estimates of factors affecting the growth performance of horticultural crops were presented in Tables 8 and 9, respectively. Accordingly, real effective exchange rate, real GDP, FDI, price, and structural break (which occurred in 2005) were revealed as significant, both in the short-run and the long-run. In addition, the result also showed that Foreign GDP was insignificant in the short-run, but significant in the long-run. However, the real interest rate was revealed as insignificant, both in the short-run and long-run.

Table 8. Long-run estimates.

Variable	Coefficient	Std. Error	*t*-Statistic	Prob.
LNER	9.232 ***	2.238	4.125	0.0012
LNEGDP	25.927 ***	3.728	6.954	0.0000
LNFDI	0.605 **	0.217	2.794	0.0152
LNFGDP	7.221 *	3.207	2.251	0.0423
LNRIR	−0.738 *	0.374	−1.975	0.0604
DU	4.672 ***	0.727	6.425	0.0000
LNPRICE	8.614 **	2.969	2.901	0.0124
C	−437.313 ***	51.730	−8.454	0.0000

Note: ***, ** and * are significance level at 1%, 5% and 10% respectively.

Table 9. Short-run estimation.

Selected Model: ARDL(2, 2, 2, 0, 1, 0, 0, 2)				
Dependent Variable: Δlnexp				
Variable	**Coefficient**	**Std. Error**	***t*-Statistic**	**Prob.**
D(LNEXP (-1))	0.263 ***	0.068	3.860	0.0020
D(LNER)	14.286 ***	2.081	6.866	0.0000
D(LNER (-1))	20.738 ***	3.476	5.966	0.0000
D(LNEGDP)	9.447 ***	2.105	4.488	0.0006
D(LNEGDP (-1))	13.505 ***	2.065	6.540	0.0000
D(LNFDI)	0.743 ***	0.123	6.014	0.0000
D(LNFGDP)	1.179	2.056	0.573	0.5761
D(LNRIR)	−0.136	0.159	−0.854	0.4084
D(DU)	5.297 ***	0.733	7.224	0.0000
D(LNPRICE)	5.539 *	3.017	1.836	0.0893
D(LNPRICE (-1))	5.623 *	2.610	2.154	0.0506
CointEq (-1)	−0.472 ***	0.057	−8.281	0.0000

Note: *** and * are significance level at 1% and 10% respectively.

Exchange rate affects the performance of the exports through volatility and depreciation or appreciation in its value. Depreciation in the value of the local currency makes the exports of a country relatively cheaper such that more revenue will be obtained. Consequently, according to the results presented in Table 8, the partial elasticity of horticulture exports to the change in the real effective exchange rate was positive and significant at the 10% probability level. The long-run coefficient value of 9.232 for the real effective exchange rate showed that a 1% increase (depreciation in the value of local currency) in the real effective exchange rate increased the export of horticultural crops by 9.232%. In the short-run, the responsiveness of exports to a 1% increase in the real effective exchange rate was an increase of 14.286%. The lag of the variable also had a significant impact on horticulture exports. This implies that policy measures regarding the exchange rate have paramount importance in improving horticulture exports in both the short- and long-run. Contrasting to the findings of this study, other researchers have found that the impact of the exchange rate in explaining the export performance was revealed as insignificant or weak [10,11,37,38]. However, the findings of several researchers were consistent with the results of this study [3,13,14,19–23,26]. They all concluded that depreciation in the value of money had significantly affected export performance of the respective country. Furthermore, other groups of researchers confirmed that volatility in exchange rates had negatively affected the export performance in both the short-run and long-run [39,40].

The real GDP was another important variable which had significantly affected the horticultural export performance of the country, both in the short-run and long-run. İts partial elasticity was 9.447 and 25.927 in the short-run and long-run, respectively. This showed that a 1% increase in real GDP of the country will increase the export performance of the horticultural sub-sector by 9.447% and 25.927% in the short-run and long-run, respectively. The lag of the variable also had a significant role

in explaining the export performance of the sector. This confirmed that as the real GDP of a country grows, more horticultural exports will be produced which will increase the possibilities of increasing horticultural exports. The results of this study were consistent with the empirical works of different researchers [11,13,18].

The partial elasticity of foreign direct investment was 0.743 and 0.605 in the short-run and long-run, respectively. It was revealed to be significant in both the short-run and long-run. The sign of the coefficient was also positive in both periods in line with the hypothesis of the study. In the short-run, a 1% increase in foreign direct investment will increase horticultural exports by 0.743%. However, the results of the literature reviewed indicate conflicting results regarding the impact of FDI on export performance. The findings of References [21,25] were positive, whilst References [11] and [19] were insignificant, and the results of Reference [29] were negative. However, Reference [29] emphasized that the impact of FDI depends on its motive. Export-oriented investments would generally contribute to export growth, whilst investments aimed at capturing domestic markets would dampen trade.

The income of the importing country was also among the important variables hypothesized to influence the horticultural export performance of the country. Even though it was revealed as insignificant in the short-run, it had influenced the export performance of the country positively at a 10% probability level in the long-run. The long-run coefficient indicated that a 1% increase in foreign income of the importing country would increase the export of horticulture by 7.221% in the long-run. The findings of many researchers are consistent with the results of this study [20,26,27]. However, some researchers had obtained a negative impact [21,25], whilst others obtained an insignificant impact of foreign income on export performance [11,14].

The real interest rate was revealed insignificant in the short-run but significant in the long-run. The price elasticity of export to one percent change in the real interest rate was 0.738% in the long-run. The sign of variable was shown negative in both periods similar to the hypothesis of the study. This result was inconsistent with the result of [21]. However, in the study by [18], real interest rate had negatively influenced the horticulture export performance of Kenya.

The significant structural break that had happened in the year 2005 was also included in the model to test the significance of the break on horticultural export performance of the country. The model results summarized in Tables 8 and 9 showed that the structural break was significant. This shows the importance of policy intervention for the improvement of the sub-sector both in the short and long-run. Thus, it can be inferred that policy development in horticultural sub-sector that had occurred before and after 2005 resulting in structural break in 2005 had significantly affected the export performance of the sub-sector.

The price coefficient was also shown as significant and positive, both in the short-run and in the long-run. An increase in international prices of horticulture exports will increase the export performance of the horticulture sub-sector by 5.539% and 8.614% in the short-run and in the long-run, respectively. The result was consistent with the results obtained in Zambia [21] and in Ghana [19].

According to the model results presented in Table 9, the coefficient of the Error Correction Model (ECM (-1)) was negative and significant confirming the existence of cointegration among variables in the model. The coefficient value of 0.472 showed that a 47% of adjustment will be made in the first year and it takes 2.12 years to return to its long-run equilibrium. After these years, the series will be at its long-run equilibrium. Finally, the stability test results of the cumulative sum of recursive residuals (CUSUM) and the cumulative sum of squares of recursive residuals (CUSUMSQ) showed that the model was correctly specified and stable. The result is shown using Figures 7 and 8. The recursive least squares graphs for the long-run model (Figure 9) also showed that the individual parameters are stable.

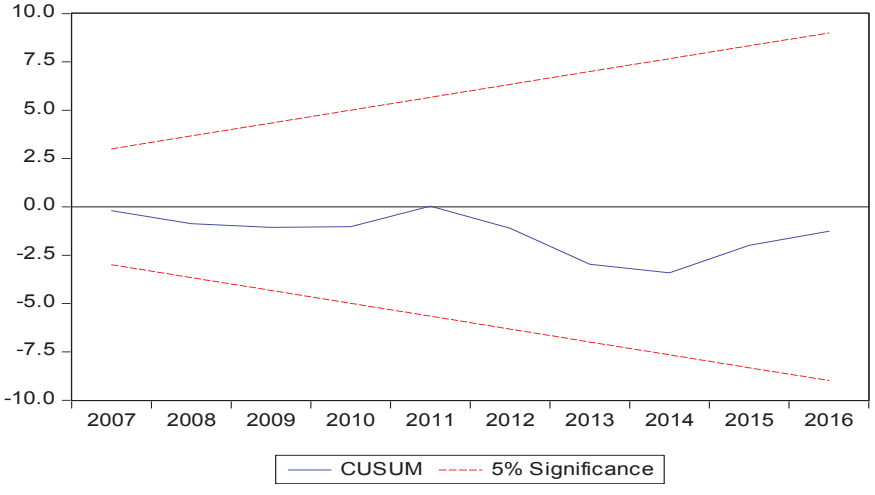

Figure 7. Cumulative sum (CUSUM).

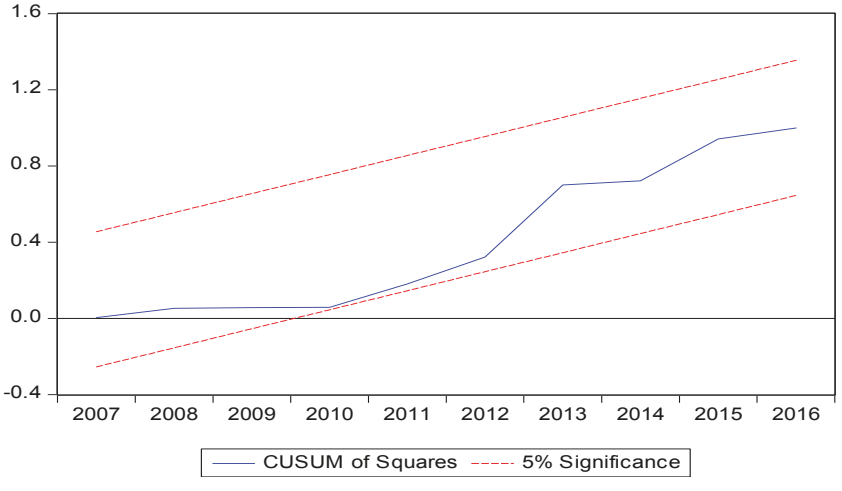

Figure 8. Cumulative sum of squares (CUSUMQ).

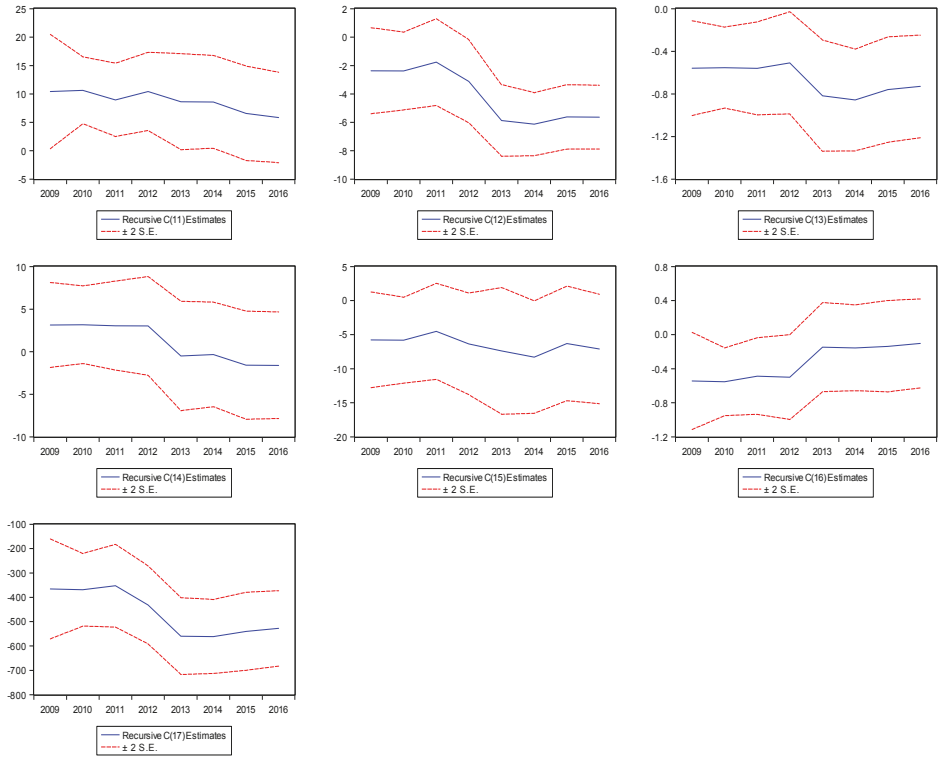

Figure 9. Recursive least squares graphs for the long-run model.

6. Conclusions

High dependency on traditional primary agricultural commodities and recurrent world market price fluctuations have exposed Ethiopia to export earnings instability. To overcome this problem of detrimental export earning fluctuations, different policy measures were taken to diversify the export base of the country. More importantly, horizontal diversification of trade from primary agricultural commodities into production and processing of high-value horticultural commodities have been placed by the Government of Ethiopia on the list of high priority areas. Various incentives have been provided for both foreign and domestic investors engaged in new enterprises and expansions. In addition, different institutions working in the sub-sector like the Ethiopia Horticulture Producers and Exporters Association (EHPEA) and the Ethiopian Horticulture Development Agency have been established to boost the horticultural sector. These institutions represented the sub-sector in the country, as well as internationally, and they also organized trade fairs. Furthermore, the key institution (Development Bank of Ethiopia) financing the expansion of the sector provided loans with a grace period and at relatively low interest rates. Consequently, this growing sector had recently become the fifth most important foreign earnings source for the country. However, the performance of the sector is far below its potential given the comparative advantage of the country in the region. Consequently, this study had attempted to empirically examine the factors that affected the horticulture export performance of Ethiopia, using the data for the period 1985–2016. The Autoregressive Distributed Lag (ARDL) bound test approach proposed by [35] was chosen to analyze the cointegration between horticultural exports and hypothesized variables. The results of the model showed that the real effective exchange rate, the real GDP of Ethiopia, foreign direct investment (FDI), prices, and the structural break had significantly influenced the horticultural export performance both in the short-run and the long-run.

Foreign GDP and real interest rates were revealed significant only in the long-run. These significant variables have an important policy implication in improving the horticultural export performance of the country. The important policy implications of this study included: Flexibility in the exchange rate movements in line with the fundamentals of the economy, strengthening the performance of the domestic economy, attracting export-oriented investments which would contribute to export growth, and diversification of both commodities and importing countries. These are considered important policy measures to improve the horticultural export performance of Ethiopia.

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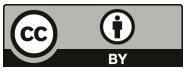

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Trends in the Use of New-Media Marketing in U.S. Ornamental Horticulture Industries

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Abstract: Ornamental horticulture businesses in the United States (U.S.) face challenges to stay economically viable, particularly in rural areas. Marketing with new-media tools (e.g., websites, HTML newsletters, social media, and blogs) has the potential to increase sales over traditional methods of advertising. A survey was conducted to gauge the extent of the use of new-media marketing by ornamental horticulture businesses across the U.S. Responses from 161 businesses showed that marketing practices varied widely across business size in terms of expenses and the labor hours allocated. A majority of the sample (89%) were involved in new-media marketing, and all new-media users made use of at least one new-media tool. Facebook was used by more than 90% of new-media users, followed by the business' own website, which was used by 82% of respondents. Respondents' perception of how various new-media marketing tools affected sales followed the extent of use, in general.

Keywords: ornamental horticulture businesses; nurseries; garden centers; landscape businesses; social media; marketing costs

1. Introduction

Ornamental horticulture businesses ranked among the fastest growing segments of U.S. agriculture in 2004, as a result of two decades of steady growth [1]. However, sales by individual nurseries have decreased over the last decade, mainly attributed to the Great Recession [2]. From 2007 to 2012, total sales of U.S. nursery and garden center products shrunk by 12.7%, whereas the number of nurseries and garden centers increased by 3.9% [3]. The ornamental horticulture industry is faced with numerous challenges to maintain successful businesses, including competition from mass merchants, which have acquired almost half the market share from smaller, local garden centers [4]. Ornamental horticulture business owners need to reevaluate marketing practices to meet changing consumer preferences, especially with the integration of the internet in the everyday lives of consumers [5,6].

New-media marketing—using digital methods including websites, HTML newsletters, and social media [7]—has provided new opportunities in the last decade for businesses to engage with customers. Marketing through social-media platforms such as Facebook and Pinterest, in particular, has allowed businesses to build and maintain stronger relationships with clientele based on customer-generated content [7,8]. In other sectors, businesses have incorporated social media into marketing practices at a rapid pace. A 2010 survey showed more than three-quarters (79%) of the 2100 organizations

surveyed reported having adopted, or were preparing, social-media initiatives [9]. According to a 2014 national survey of marketers, with 2800 respondents, 89% had adopted social media within the last five years [10].

The reasonable costs associated with deploying new-media marketing strategies are encouraging to family-owned horticulture businesses [6]. In the *Marketing in a Digital World, Small- and Medium-Sized Business and Consumer Survey*, Karr [11] showed that a majority of businesses surveyed (59%) spent less than $100 per year to use social-media marketing on various channels. Onishi and Manchanda [12] noted new media, involving user-generated content, are primarily available for free, which is in contrast to traditional media. Moreover, new-media marketing tools can be used in conjunction with traditional-media marketing tools to increase business sales [12].

Little is known about the extent of new-media marketing activities in ornamental horticulture industries. One study, examining the level of Pinterest use by agricultural producers and businesses, showed considerable differences, between agricultural segments, in the degree of Pinterest use to reach customers [13]. The specialty crop segment, which includes ornamental horticulture industries, accounted for 9.1% (39 out of 428) of users, suggesting low use of new-media marketing tools by ornamental horticulture businesses. This study further indicated that agribusinesses and agricultural organizations were not using new-media marketing tools to their full potential.

This study aimed to explain how ornamental horticulture businesses are currently using new-media marketing, including engagement with customers, so that future outreach programs can be designed to help them make the most of new-media marketing efforts. Since this is the first study of its kind, it is limited in scope to get benchmark data on ornamental horticulture businesses. A questionnaire was developed to understand the scope of business, marketing practices, perceptions of new-media marketing, and the technological environment of business operators.

2. Materials and Methods

A questionnaire was developed to collect information from ornamental horticulture businesses. It consisted of 40 questions pertaining to businesses' online new-media marketing practices (we used the term "online" in the questionnaire, which was likely more familiar to the respondents than "new media," but we use the terms interchangeably), including their relationships with customers. Questions were formulated around four factors: (1) Business characteristics, (2) overall marketing practices, (3) online marketing practices, and (4) respondent demographics. The questionnaire was described in the introductory email as covering business characteristics and marketing practices, requesting respondents to collaborate with colleagues, if needed, to complete the questionnaire.

The questionnaire was designed to account for three types of respondents: Those not using any new-media marketing; those using some new-media marketing, but not social-media marketing; and those using new- and social-media marketing. After collecting information about their scope of business, a question asked what the frequency of use of various marketing venues was, including "print advertisements" (newspapers, store circulars, and postal mailings), "personal interactions" (phone calls, emails, and visits), "television/radio," "fairs/trade shows/garden shows," and "online marketing" (websites, blogs, social media, and e-newsletters). Those who indicated that they never used online marketing were routed to answer reasons for their non-use. Those who indicated they had used online marketing at least once proceeded to answer additional questions about their new-media marketing practices. Then, a question asked for the frequency of reaching their customers through different online marketing tools, including "websites," "HTML newsletters" (e.g., Constant Contact and MailChimp), "blogs," and "social-media platforms" (e.g., Facebook and Twitter). Those who indicated some use of social-media platforms proceeded to answer questions related to their experience with social-media marketing, while those who never used any social-media platforms were diverted to answering questions related to their reasons for not using social media.

The questionnaire was designed and distributed using Qualtrics software (Qualtrics, LLC, Salt Lake City, UT, USA), which was compatible for access on computers and mobile devices [14].

Following Dillman et al. [14], respondents could return to previous questions, and forced responses were imposed on 23 key questions, including marketing expenses, annual gross sales, and perceived importance of social media, to ensure that responses were provided. Responses to multiple-choice questions were randomized to minimize order effects [15]. The questionnaire was pre-tested by a nursery-marketing specialist and two other people with no relationship to ornamental horticulture industries. Suggestions made by these respondents were considered for the final version of the questionnaire.

According to the 2012 Economic Census, there were 13,928 establishments classified as nursery, garden center, and farm supply stores (NAICS code 444220) nationwide, and 634 in the North Plains region, including Kansas [16]. (The Northern Plains region is one of twelve regions defined by the USDA National Agricultural Statistics Service and includes North Dakota, South Dakota, Nebraska, and Kansas.) Without a comprehensive directory of these businesses coupled with the exploratory nature of the study, convenience sampling was adopted. Distribution of the questionnaire was planned with a goal to reach as many ornamental horticulture businesses, including nurseries, garden-center businesses, and landscape businesses, as possible in the 48 contiguous states of the United States, in both rural and urban areas. Businesses did not have to be new-media users to participate.

After obtaining approval from the Institutional Review Board at Kansas State University, data were collected in two waves in March and September of 2015. The questionnaire link was distributed through 87 regional and national ornamental horticulture associations and trade publications or magazine email lists. Instructions to obtain a paper copy of the questionnaire were included in the email invitation to participate in the study. The link was also emailed to email addresses for ornamental horticulture businesses that could be collected from publicly-available directories of "live plant dealer licensees" in the North Central United States region, followed by two reminders sent at weekly intervals [14]. Participants were invited to enter into a drawing for two $50 Amazon (www.amazon.com, Seattle, WA) gift cards as an incentive to take the survey, as recommended by Dillman et al. [14]. At the beginning of the second wave, those with postal addresses received a postcard with the link, followed by two email reminders sent at weekly intervals to those with email addresses.

3. Results

3.1. Sample Characteristics

Of the 192 responses obtained, 161 were complete and were included in the subsequent analysis at a 95% confidence rate, which indicated a confidence interval of 7.68. Responses were obtained from all USDA National Agricultural Statistics Service regions, with the largest number of responses (40.5%) from the Northern Plains states where the survey was administered, followed by 15.7% from the Northeastern states. Sixty-five responses from the Northern Plains region would represent 10.3% of the establishments identified by the 2012 Economic Census. There were also four responses from Canada. Based on the zip codes of the business location, 42.9% were located in communities with less than 10,000 people.

Respondents represented businesses of various sizes, with a disproportionate number of businesses grossing sales over $500,000 annually (Table 1), compared to the distribution of horticultural specialty operations in the 2014 Census of Horticultural Specialties [17] across the sales categories. More than half (57.1%) of the businesses in the sample sold $500,000 or more in 2014, with the median response category of sales being between $500,000 and $1 million. In comparison, 8.7% sold less than $25,000. For reference, the average market value of products sold by nurseries, greenhouses, and floriculture farms, according to the 2012 Census of Agriculture, was $353,788 [3]. While the Census data are likely skewed to the right, suggesting the average would exceed the median, our sample was skewed to the left.

Table 1. Total gross business sales in 2014 of the ornamental horticulture industry respondents in the study.

Total Gross Business Sales	(*n* = 161)	2014 Census of Horticultural Specialties (*n* = 23,211)
Less than $25,000	8.7%	24.9%
$25,000 to $49,999	6.8%	18.1%
$50,000 to $99,999	3.7%	16.3%
$100,000 to $249,999	11.8%	14.4%
$250,000 to $499,999	11.8%	9.2%
$500,000 to $999,999	13.7%	6.9%
$1 million to $4,999,999	28.6%	5.9%
$5 million or greater	14.9%	4.3%

Most businesses (87.6%) in the sample were well established, having been in operation for more than 10 years. Overall, response categories were represented almost uniformly in the sample, with a small number of businesses having been in operation for more than 100 years (5.0%). Nearly two-thirds (64.0%) of businesses were open year-round.

The primary marketing channel was retail to consumers, accounting for 90% or more of total sales for half of the respondents (Table 2). The second most popular marketing channel was wholesalers to landscapers, other garden centers, and re-wholesalers. "Re-wholesalers" generally do not own production facilities, but instead buy products wholesale from producers to sell at a wholesale price to allied horticulture industry businesses, such as landscapers and garden centers. In contrast, 95.6% of respondents did not sell any of their products through the mass merchandisers' channel. Respondents also reported selling up to 10% of their products through channels not listed in the questionnaire including construction and maintenance firms, municipalities, universities, and non-profit organizations.

Table 2. Distribution of 2014 business sales, across marketing channels, of ornamental horticulture industry respondents in the study questionnaire.

	Retail (Direct to Consumers)	Landscapers	Other Garden Centers	Re-Wholesalers	Mass Merchandisers
			% Sales		
Average	69.6%	12.0%	5.4%	3.1%	0.3%
Median	90.0%	4.0%	0.0%	0.0%	0.0%
Min	0.0%	0.0%	0.0%	0.0%	0.0%
Max	100.0%	100.0%	100.0%	90.0%	10.0%

Adopting the description of ornamental horticulture-industry products and services by Hall et al. [1], the questionnaire asked respondents to identify products and services their business offered. Consistent with the marketing channels, retail product offering was the most prevalent (Table 3). Within the retail product category, bedding and nursery stock was offered by 73.3% of respondents, followed by lawn and garden products (54.7%), general merchandise (54.0%), and landscape materials (42.2%). Bedding and nursery stock and landscape materials were the most common products among those who wholesaled. According to the 2012 Agricultural Census, nursery stock crops and bedding and garden plants were the highest valued ($5 billion and $3.6 billion, respectively) in ornamental horticulture industries [3]. Respondents mentioned various other activities including pottery, gift and jewelry retail, herbs, vegetables, pet shop, agritourism, educational services, and vocational training for individuals with disabilities.

Individuals who responded to the questionnaire on behalf of the businesses were on average 50 years of age, with slightly fewer female respondents (48.5%) than male respondents. More than half of the respondents held a baccalaureate degree (67.1%), with most (88.8%) attending some amount of college. Nearly two-thirds (63.4%) of the respondents were business owners, while 23.6% were managers. Thirteen respondents (8.1%) were marketing managers. This low representation of

marketing managers might suggest that either owners or managers conduct their own marketing activities, including social media, or contract their marketing services to third-party consultants. Other respondent roles included extension master gardener, office manager, sales manager, and search engine optimizer. The majority (62.7%) of respondents had worked at the business for 10 years or more. Only 3.1% of the respondents had joined or owned the business within one year. Most owners (76%) had worked at their business for at least 10 years.

Table 3. The percentage of ornamental horticulture industry respondents that indicated they carry these general categories of items or provide these services.

Categories	(*n* = 161)
Retail bedding and nursery stock	73.3%
Greenhouse/annuals	58.4%
Retail lawn and garden products	54.7%
Retail general merchandise	54.0%
Retail landscape materials	42.2%
Nursery container and field	41.0%
Landscape services/build	34.8%
Landscape architecture/design	28.6%
Wholesale bedding and nursery stock	26.7%
Retail garden equipment	17.4%
Wholesale landscape materials	13.7%
Other (specify)	11.8%
Retail florist and florist supplies	10.6%
Retail food and beverage	9.9%
Lawn and garden equipment	6.2%
Wholesale lawn and garden products	6.2%
Wholesale florist and florist supplies	2.5%
Wholesale garden equipment	1.2%

3.2. Marketing Practices

The extent of marketing efforts, in terms of expenses and hours, was asked in open-ended questions. Reported marketing expenses for 2014 ranged from $0 to $1 million, with an average of $53,050 and median of $10,000 (Table 4, first column). On the lower end, nearly half (42.9%) reported marketing expenses under $4,000, almost half (43.5%) of which reported less than $500. On the upper end, 11 businesses (6.8%) reported marketing expenses over $200,000. In terms of hours allocated to marketing efforts, the businesses reported spending on average 13.7 h per week performing various marketing activities, with half of the businesses spending four or fewer hours. Six businesses reported spending 40 to 60 h per week, suggesting two individuals were allocating at least half of their time to marketing, while five businesses reported more than 90 h per week, suggesting more than one full-time individual was assigned to marketing efforts.

Given the large disparity in size, businesses were grouped into three sales categories (less than $250,000, $250,000 to less than $1 million, and $1 million or more) for additional insight. The categories corresponded to intervals used in the Census report, placing 50, 41, and 70 businesses into the respective sales categories. Though the subsamples were too small to establish any statistical significance of differences observed, the categorization offered additional insight.

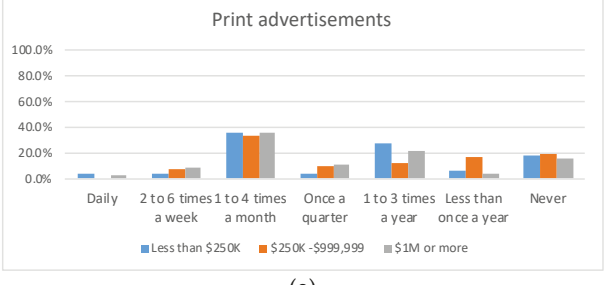
In Table 4, responses by the three groups are reported in respective columns. The average marketing expenses for the smallest businesses ($2,844) was 18.9% of that for the large businesses (grossing $250,000 or more, but less than $1 million), and 2.6% of that for the largest businesses (grossing $1 million or more). While there were businesses that spent at least 10% of their sales on marketing, there were some reporting $0 and zero hours for marketing efforts, even among businesses selling more than $1 million. Similarly, in terms of hours allocated to marketing efforts, the largest businesses had, on average, one half-time person tasked with marketing, while marketing activities at smaller businesses were mostly carried out by individuals with other primary tasks.

Table 4. Marketing efforts of ornamental horticulture industry, in terms of expenses and hours allocated, as reported by respondents in the study questionnaire.

	Full Sample	Less than $250,000 in 2014 Sales	$250,000 to $999,999 in 2014 Sales	$1 Million or More in 2014 Sales
n	(*n* = 161)	(*n* = 50)	(*n* = 41)	(*n* = 70)
Annual expense				
Average	$53,050	$2844	$15,081	$111,150
Median	$10,000	$875	$10,000	$50,000
Min	$0	$0	$100	$0
Max	$1,000,000	$25,000	$60,000	$1,000,000
Weekly hours allocated				
Average	13.7	4.0	8.3	23.7
Median	4.0	2.0	2.5	8.0
Min	0.0	0.0	0.0	0.0
Max	200.0	20.5	50.0	200.0

Figure 1 depicts the frequency of use of selected marketing channels for the smallest, large, and largest businesses. Use of print advertisements and personal interactions were relatively similar across the groups. About 35% of businesses used print advertisements one to four times per month, and 17% did not use these at all. Nearly half (47.8%) reported reaching out to their customers with phone calls, emails, and visits more than once a week. In contrast, use patterns varied by sales category for fairs and trade/garden shows and online marketing. Nearly 60% of businesses grossing $250,000 or more attended fairs and trade/garden shows at least once a year, whereas 58% of the smaller businesses never did. Average proportions of non-users of online marketing varied from 14% among smaller businesses to 5% of large businesses and 1.4% of the largest businesses. Among online marketing users, larger businesses used it more frequently than smaller businesses.

Delving deeper into use of online marketing, Table 5 summarizes the status of online-platform accounts used by businesses. Facebook was the predominant platform, regardless of business size (Table 5). The use of Twitter and blogs was limited among the smallest and large businesses, with blogs being the least popular platform for both size groups. Conversely, more than 40% of the largest businesses were actively using Twitter and blogs. The use of HTML newsletters was linearly associated with business size, currently by 30%, 54%, and 83% of the smallest, large, and largest businesses, respectively. The variation in use of blogs, Twitter, and HTML newsletters, between small, medium, and large business, might reflect that these tools require specific writing skills and a significant time commitment, for which only larger business can afford to seek out and allocate resources to actively and effectively use these platforms.



(**a**)

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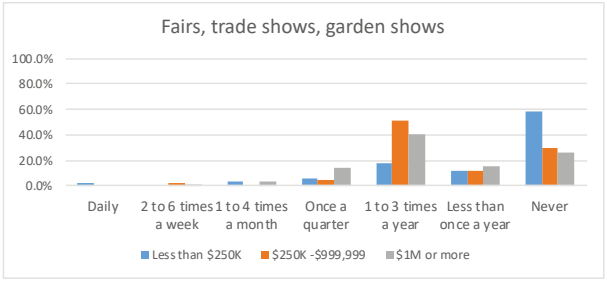

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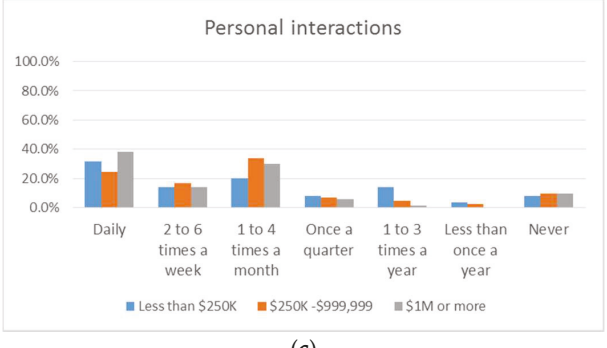

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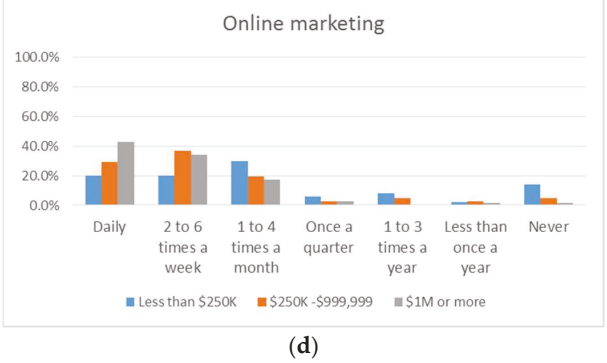


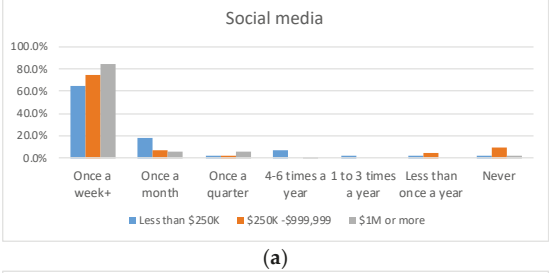
(**d**)

Figure 1. Frequency of use of various traditional marketing venues by ornamental horticulture industry respondents in the study questionnaire: (**a**) print advertisements, (**b**) fairs/trade or garden shows, (**c**) personal interactions, and/or (**d**) online marketing. Categorized by 2014 sales: less than $250,000 ($n$ = 50); $250,000–$999,999 (n = 41); and $1 million or more ($n$ = 70).

Figure 2 illustrates the frequency of use of online platforms to reach customers. The three charts show similar trends across platforms in all sales categories, with the most frequent activity being on social media, followed by websites, HTML newsletters, and blogs. In general, larger businesses used all platforms more frequently than smaller businesses, except a larger portion of the middle-size businesses were less frequently active on blogs than the smallest businesses. Overall, 76.2% of businesses used social media once a week or more, while 9.3% of businesses (14.0% of smaller businesses and about 7% of both groups of larger businesses) used social media once a quarter or less. Frequency of posting is a difficult concept to manage and depends on the needs of each businesses' customer, but posting once a quarter may make it appear that a business is inactive and/or no longer in business [18,19].

Table 5. Status of online platform accounts of ornamental horticulture industry respondents in the study questionnaire.

	Facebook	Twitter	HTML Newsletters	Websites	Blogs
	% Responses				
Full sample (n = 161)					
Currently using	91.40%	29.80%	60.30%	81.50%	23.20%
No longer active	5.30%	26.50%	6.00%	7.30%	15.90%
Never signed up	3.30%	43.70%	33.80%	11.30%	60.90%
Less than $250,000 in 2014 sales ($n$ = 50)					
Currently using	90.70%	20.90%	30.20%	69.80%	9.30%
No longer active	4.70%	20.90%	14.00%	7.00%	11.60%
Never signed up	4.70%	58.10%	55.80%	23.30%	79.10%
$250,000 to $999,999 in 2014 sales ($n$ = 41)					
Currently using	84.60%	12.80%	53.80%	71.80%	5.10%
No longer active	10.30%	30.80%	2.60%	12.80%	15.40%
Never signed up	5.10%	56.40%	43.60%	15.40%	79.50%
$1 million or more in 2014 sales (n = 70)					
Currently using	95.70%	44.90%	82.60%	94.20%	42.00%
No longer active	2.90%	27.50%	2.90%	4.30%	18.80%
Never signed up	1.40%	27.50%	14.50%	1.40%	39.10%



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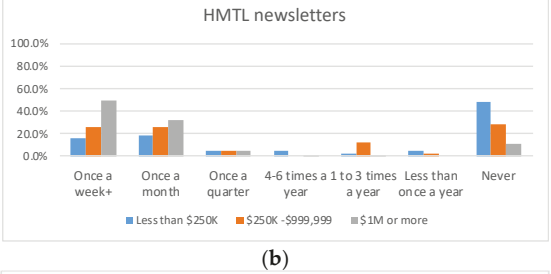

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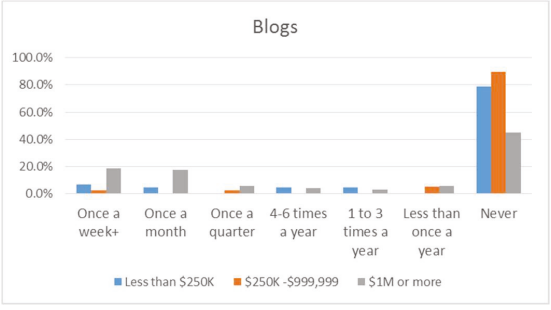

(**d**)

Figure 2. Frequency of use of new-media marketing tools by ornamental horticulture industry respondents in the study questionnaire: (**a**) Social media, (**b**) HTML newsletters, (**c**) websites, and (**d**) blogs. Categorized by 2014 sales: less than $250,000 ($n$ = 43); $250,000–$999,999 (n = 39); and $1 million or more ($n$ = 69).

Specifically related to social media, all businesses that engaged in online marketing reported using some form of social media, with the range of use from one to 15 years, and a median of five years. This may indicate that the sample included more businesses that had a social-media presence. Eighty-nine point six percent of businesses indicated their social-media account was created by the owner, manager, or an employee. Others (6.3%) received free help from friends or family, while a few (3.5%) hired a consultant or third-party company.

Twelve point six percent of respondents hired a third party to conduct their social-media activity in 2014. Social-media marketing expenses through consulting services averaged $11,700, representing 22% of total marketing expenses. This result indicated that new-media marketing generally received less attention from ornamental horticulture businesses than traditional marketing venues. The Pearson correlation coefficient between the amount allocated to social-media services and the sales dollar amount was 0.58, indicating that bigger firms allocated more resources to social-media marketing.

3.3. Perceptions of New-Media Marketing

To assess perceived usefulness of new-media marketing by ornamental horticulture industries, respondents were asked to rank online-marketing venues based on their perceived impacts on sales. Table 6 reports the aggregated response, because responses were similar across businesses of different size. The new-media marketing tool that received the largest percentage (45.0%) of first rankings was social media, followed by websites and HTML newsletters, which mirrors how intensively these channels are currently being used. The notable exception was HTML newsletters, which was not as frequently used but was ranked as having a relatively high impact. This may be reflective of the tool itself, as HTML newsletters typically follow an editorial calendar with release dates that vary [7].

Table 6. Ranking of perceived impacts on sales of ornamental horticulture industry respondents in the study questionnaire (n = 131).

New-Media Marketing Tools	% Responses				
	First	Second	Third	Fourth	Fifth
Websites	26.0%	33.6%	30.5%	8.4%	1.5%
HTML newsletters (e.g., Constant Contact, MailChimp)	26.0%	27.5%	24.4%	18.3%	3.8%
Blogs	0.8%	7.6%	17.6%	58.8%	15.3%
Social-media platforms (Facebook, Twitter, etc.)	45.0%	25.2%	22.9%	6.1%	0.8%
Other	2.3%	6.1%	4.6%	8.4%	78.6%

Again, specifically on social media, respondents were asked to indicate its perceived importance on various aspects of the business, including customer engagement elements, using a five-point scale (Table 7). The strongest agreement was on its importance "to build a positive community with customers." They also agreed on its importance "to have an active online presence" and "to educate consumers," but the support was less among smaller businesses. This may be a result of smaller businesses investing less time in social media. Notably, it was the smallest businesses that believed in social media's value "to improve sales" and "to increase customer traffic into the store." Among the list of aspects provided to respondents, businesses placed the lowest value on social media as a means "to learn about the marketplace." Results suggested the prevalence of perceptions, particularly among larger businesses, that social media is used only to push their messages out and are underutilizing it as a resource for two-way customer interaction.

Table 7. Perceived importance of social media by ornamental horticulture industry respondents in the study questionnaire [a].

	Full Sample	Less Than $250,000 in 2014 Sales	$250,000 to $999,999 in 2014 Sales	$1 Million or More in 2014 Sales	$250,000 or More in 2014 Sales
	(*n* = 144)	(*n* = 42)	(*n* = 41)	(*n* = 70)	(*n* = 102)
To build a positive community with customers	4.22	4.24	4.14	4.24	4.21
To have an active online presence	4.14	4.05	4.09	4.22	4.18
To educate customers	4.06	4.00	3.91	4.18	4.09
To improve sales	3.93	4.21	3.83	3.81	3.81
To increase customer traffic into the store	3.92	4.12	3.80	3.87	3.84
To learn about the marketplace	3.51	3.64	3.23	3.58	3.46

[a] Average scores: 1 = "not at all important," 2 = "slightly important," 3 = "moderately important," 4 = "quite important," and 5 = "extremely important".

3.4. Technical Environment

To understand their technical environment at work, respondents were asked to identify the type of internet connection available at the business location, as well as the device used for their new-media marketing activities. Regarding the type of connection, wireless (45.3%), cable (30.4%), and digital subscriber line (DSL) (24.2%) were the connections respondents reported using. Results also show that more than one type of connection was available in many businesses. Pertaining to the device used for new-media marketing, desktops (73.3%) and smartphones (62.1%) were the most prominent, followed by laptops (51.6%) and tablets (34.2%). Similar to the type of connection, businesses used more than one device for their new-media marketing activity.

As a measure of online activeness, respondents were asked for the number of businesses they followed online on a regular basis. The term "regularly" stressed a relatively permanent contact with the group. "Number of businesses monitored online" represents the breadth of their online network, a group from which the business owner or manager can learn online marketing tips or imitate what peers are doing by observing. For all businesses in the sample, the numbers of businesses were relatively uniformly distributed over the network size, from one to six, but the network size on average was bigger for larger businesses. One-third of the large and largest businesses had a network size of 10 or more, compared to 14.0% among the smallest businesses, and 8.7% of the largest businesses had a network size of 0 compared to 14.0% and 12.8% among the smallest and large businesses, respectively.

The individual's technical environment at home was assessed by way of their personal use of social media, and the size of their personal online network was measured by the number of people (likes or friends on Facebook, Twitter, LinkedIn, etc.) they personally followed on a regular basis. More than half of the respondents (58.4%, *n* = 161) were daily social-media users, while only 11.2% did not use social media for personal purposes. There was a notably large proportion (22.0%) of individuals at large businesses who were non-users for personal purposes, and consequently had no personal online network. Otherwise, the size of the personal online network tended to be positively

correlated with the size of the business, averaging 126 and 256 individuals among the smallest and the largest businesses, respectively.

3.5. Why Not Using New-Media Marketing

Although most respondents were new-media users, 17 ornamental horticulture businesses did not carry out marketing activities through new media. These respondents were asked to identify how applicable each reason, from a list, was for their business not using social-media marketing at that time. Results show that a preference for direct interactions with customers and lack of time were the two main reasons precluding businesses incorporating social media into their marketing efforts (Table 8). In contrast, 47% of non-social-media users reported that lack of training did not prevent them from using social media.

Table 8. Reasons "why not using social-media marketing" of ornamental horticulture industry respondents in the study questionnaire [a].

Reasons	(*n* = 17)
I would prefer face-to-face interactions with my customers.	4.06
I don't have time.	3.47
Returns from social-media marketing are low.	3.35
Returns from social-media marketing are uncertain.	3.29
My customers do not think it is important.	3.24
It is a costly investment.	2.88
I do not think it is important.	2.88
Technology changes so quickly that I cannot keep up with it.	2.76
I do not know how to get started.	2.65

[a] Average scores: 1 = "strongly disagree," 2 = "disagree," 3 = "neither agree or disagree," 4 = "agree," and 5 = "strongly agree."

4. Discussion

Ornamental horticulture industries mirror other businesses in their use of online- and social-media marketing, with only 17 of the 161 businesses reporting that they did not use online tools to market to customers, and 144 (89.4%) of the businesses reporting using online and social media to market their business. This is similar to a 2014 national (U.S.) survey of marketers, with 2,800 respondents, where 89% had adopted social media for marketing purposes [10].

One striking feature of the study sample was its range in size of business. Responses showed clearly that marketing practices and the approach to new-media marketing vary by size of business. Any educational program to assist ornamental horticulture businesses with new-media marketing, as well as studies to examine the impact of new-media marketing efforts on business performance, must account for business size.

In contrast, rankings of various new-media channels regarding their perceived impact on sales were consistent across businesses of all sizes. The new-media channel that received the largest percentage of first rankings was social media, followed by websites and HTML newsletters, which mirrors how intensively these channels are currently being used. The notable exception is HTML newsletters, which was not as frequently used but was ranked as having a relatively high impact. A qualitative study of garden centers indicated this was a medium that businesses spent time planning to use strategically; that is, it would take more time to create and would be released less often, but it would be more impactful [7].

The respondents' perceived importance of social media aligns with past findings. In particular, the strongest argument for using social-media marketing was due to its ability to build a positive community with customers, and the weakest argument of use was to learn about the marketplace, suggesting that garden centers were not learning about their customers online [7]. Notably, it was the smaller businesses that believed in social media's value to improve sales and to increase customer

traffic into the store. Whether social-media marketing is indeed effective in improving profits needs to be further examined. Stebner et al. [6] showed that both large and small businesses used social media to increase profits, even though they did not know if it actually was increasing their profits because they were not measuring it.

Larger businesses spent considerably more on marketing efforts and smaller businesses were spending markedly less, which was expected. While this study did not ask specifically about dollars allocated to new- and social-media marketing, it did ask about dollars spent on social-media consultants, which was 22% of the total marketing expenses. This may indicate that ornamental horticulture businesses are not allocating as many dollars, or focusing as much time, on new- and social-media marketing as traditional marketing, which aligns with Behe et al. [20]. It is also similar to the small and medium businesses surveyed in *The Marketing in a Digital World Small- and Medium-Sized Business and Consumer Survey* [11], which found a majority (59%) spent less than $100 to conduct social-media marketing. Social media offers a way for small businesses to compete with larger businesses through targeted social-media campaigns, building relationships with customers, and brand loyalty [8] with a lower investment than traditional media.

Although new-media marketing is increasingly being adopted by small and medium businesses, observations reveal little interest or understanding among rural ornamental horticulture businesses. Only a few maintain a social-media account or a website. For the non-users in the study, direct interactions with customers and lack of time were the two main reasons precluding them from incorporating new media into their marketing efforts. This is consistent with Stebner et al. [6], indicating businesses lacked time to use new media and that they enjoyed doing other aspects of their job more, such as interacting with customers in person. This study shows varying numbers of hours and expenses spent on new-media marketing, reflecting availability and allocation of resources. Other reasons for this seeming reticence could be lack of expertise, particularly related to new-media management, and risk aversion. New-media marketers faced five main issues related to social media management: Finding the most effective tactics, engaging audiences, measuring the return, picking the best management tools, and finding their target audience [10].

5. Conclusions

This study examined the current state of the use of new-media marketing among ornamental horticulture businesses. The sample of 161 businesses, while lacking in representativeness of those that are involved in new-media marketing without social media, offers insight that can be used to develop outreach programs or future research projects.

New-media marketing, with its cost structure and extensive reach, offers a game-changing opportunity, particularly for smaller businesses in ornamental horticulture industries. Studies suggest enormous potential if a new-media marketing strategy is skillfully employed. For example, the search for gardening information through the internet increased a customer's likelihood to purchase horticultural products online by 19% [5]. The task ahead is for research efforts to assist the ornamental horticulture industries in identifying the most effective practices for its members of various size and by specific business type.

As with any study, there were some limitations that should be noted. The sampling in the study was limited to those business that responded, which resulted in 161 total usable responses. This offered a reasonable amount in order to generalize to the larger population, with a confidence interval of 7.68 at a 95% confidence rate. However, there are likely some businesses who do not match the findings in this study. Future work to build on this exploratory study should seek a stratified random sample across all ornamental horticulture business types. Additionally, there were some variables that would have been valuable to the study that were left out due to survey length. These include items such as details about business-type and economic data beyond self-reported data.

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analyzed the data and revised the manuscript. C.B. assisted with survey deployment to stakeholders across the United States, corresponded, and finalized the manuscript.

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Implications of Smallholder Farm Production Diversity for Household Food Consumption Diversity: Insights from Diverse Agro-Ecological and Market Access Contexts in Rural Tanzania

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Abstract: Owing to persistent challenges of food and nutritional insecurity, recent literature has focused on the role diversity of farm production has on food consumption diversity, particularly for smallholder households. Yet, the relationship between farm production diversity and household food consumption diversity remains complex and empirical evidence is, so far, mixed. The present article assesses this relationship using two districts—Kilosa and Chamwino—with contrasting agro-ecological and market contexts in rural Tanzania. These districts represent the majority of farming systems found in Tanzania as well as in several countries within the region. We used household data and employed descriptive as well as multivariate regression analyses. The results indicated a positive role of farm production diversity for food consumption diversity in the district with relatively harsh climatic and agro-ecological characteristics and poor access to markets. Furthermore, increased farm production diversity was generally associated with seasonal food consumption diversity. However, results suggested a lesser role of farm production diversity in the presence of better agro-ecological and market access characteristics. These findings imply that promoting farm production diversity should consider the existing agro-ecological and market characteristics. In addition, achieving increased food consumption diversity among rural households may require effective market related infrastructure and institutions.

Keywords: smallholders; farm production diversity; food consumption diversity; seasonal food consumption; Tanzania

1. Introduction

For most developing countries, smallholder agriculture plays a pivotal role in enhancing rural livelihoods including households' food security [1,2]. This is mainly achieved through production of own food and incomes from sales of agricultural produce [3]. Despite recent significant strides in agricultural production, challenges such as food insecurity, under-nutrition and volatile food prices have persistently affected most smallholders [4–6]. In the wake of these challenges, there has been increased support for diversification of smallholder production as a strategy to enhance rural households' food security through increased food sufficiency and diversity [3,7–11].

At the farm level, production diversity entails smallholders maintaining a variety of species for both plants and animals [12]. The logical argument put forth is that increased diversity of smallholder production (for both crops and livestock) will enhance access to a diverse portfolio

of food for consumption at the household level, thereby improving the dietary diversity of smallholder households. Fundamentally, a considerable body of research notes that agricultural diversity is vital in enhancing overall sustainability of food and agricultural systems by promoting agricultural lands' stability, productivity and resilience to shocks [13]. However, the debate on the role of smallholder farm production diversity on household food consumption diversity is far from conclusive. While some recent studies find a positive influence in this relationship [3,8,14], others have had mixed results [9,11]. Essentially, besides smallholder farm production diversity, household food consumption diversity may be influenced by market access and opportunities for off-farm income, among other factors [3,9]. Moreover, the implications of farm production diversity on food consumption of rural households may vary depending on, among other factors, agro-ecological characteristics which determine cropping systems pursued by smallholders [11,15].

Nevertheless, despite increased promotion of agricultural diversification for smallholders, empirical evidence on its role and implications in different smallholder contexts has lagged behind. In particular, evidence from diverse agro-ecological and market access settings is rare. We therefore use household data from diverse agro-ecological and market access contexts in rural Tanzania to answer three questions: (1) what is the nature and extent of farm production diversity among smallholders in the study regions? (2) What determines the observed farm production diversity? and (3) how does farm production diversity influence household food consumption diversity?

This article adds on previous literature in two ways. First, we use data from two distinct agro-ecological and market access contexts to analyze the farm production diversity-food consumption diversity relationship. This is important since this relationship may be masked by analyses that use national averages (such as Pellegrini and Tasciotti [8]). The objective is then to get insights on the nature and role of farm production diversity on food consumption diversity from diverse contexts as smallholder agriculture is inherently heterogeneous. Secondly, we use data on seasonal food consumption to further assess the potential of farm production diversity in contributing to seasonal food consumption diversity. In principle, smallholder households' consumption is inherently seasonal [16,17], with food insecurity being more prevalent in planting and pre-harvest season. Potentially, farm production diversity may enhance access to a variety of crops in different seasons [18], and hence improve food consumption diversity during different seasons.

The remainder of this article is organized as follows: The next section reviews related literature followed by section three which presents the study area, data and empirical strategy. Results are then presented in Section 4 and a discussion in Section 5. Section 6 gives a summary of main findings and draws emerging conclusions.

2. Literature Review

2.1. Farm Production Diversity in Smallholder Agriculture

Smallholder farming systems particularly in Sub-Saharan Africa are characterized by a considerable amount of diversity, owing to heterogeneous biophysical and socio-economic environments [19]. Consequently, smallholders are confronted with multiple constraints and opportunities in their environments, which ultimately shape the diversity of their strategies [19,20]. As argued by Barrett [20], diversification of assets, activities or incomes by farm households may be due to "push factors" such as land or liquidity constraints and high transaction costs or "pull factors" where new opportunities may provide higher returns and thus enable improvement of livelihoods. Farm production diversity constitutes part of smallholder diversification strategies. Fundamentally, farm production diversity, which falls within the broader concept of agro-biodiversity, entails not only maintaining a variety of species for both plants and domestic animals but also genetic diversity within each species [12].

The level of farm diversity maintained by smallholders depends on households' socio-demographic characteristics (such as age, gender and education) and assets such as land and

labor [21,22]. Households' productive assets can be, in particular, important in enhancing the capacity of households to exploit the advantages of production diversity such as through crop-livestock integration. Equally important, agro-ecological characteristics, access to markets and available infrastructure are also instrumental in influencing the level of farm production diversity [22,23]. Corral and Radchenko [24], for example, note that in Nigeria, decisions by households regarding diversification are driven by factors in the local environmental such as constraints in infrastructure and weather shocks. Depending on existing agro-ecological characteristics, smallholders may be inclined to maintain a high diversity in their production due to presence of climatic and other agricultural risks. Similarly, smallholders may substantially rely on self-provision of food in less accessible villages due to high costs of accessing markets, thereby maintaining a higher diversity at the farm. Following on the "push factors" argument, farm production diversity can be used as a way of mitigating risks by smallholders, especially in presence of output market imperfections and harsh agro-ecological environments [8,25].

2.2. Linking Production Diversity to Consumption Diversity

The wider benefits of maintaining diversity of various species—both plants and animals—by smallholders are well argued in the literature. The contribution of this diversity includes enhancing resilience of food production, provision of important nutritional benefits and supporting the overall sustainability of food systems [12]. However, despite these unarguably important benefits, promotion of farm production diversity for improved nutrition has confronted several challenges. An example is the existence of agricultural and food security policies in many developing countries which promote a few cereal staples. This follows decades of implementation of Green Revolution policies, which focused primarily on cereal-based systems—involving mainly maize, rice and wheat—to enhance calorie availability [12]. In addition, Hunter and Fanzo [26] argue that there is a general lack of empirical evidence that links biodiversity and improved nutrition outcomes such as dietary diversity.

In recent empirical literature, several studies show a positive influence of farm production diversity on household food consumption diversity. For example, in a wide study involving eight developing countries, Pellegrini and Tasciotti [8] assessed the role of crop diversification and found a positive correlation between the number of crops cultivated and indicators of dietary diversity. Similarly, Oyarzun et al. [27] observed that on-farm species diversity is positively correlated with household-level dietary diversity in the Ecuadorian rural highlands. Also using a nationally representative sample of farming households in Malawi, Jones et al. [3] found that farm production diversity is positively associated with dietary diversity. However, these results may be context driven and thus promoting farm production diversity cannot be viewed as a blanket policy to enhance dietary diversity of most rural smallholders. In addition, this literature acknowledges that the relationship may be complex given influences of household characteristics, market orientation and the nature of farm diversity. In Tanzania, Herforth [18] offers first insights into the relationship between farm production diversity and food consumption diversity at the household. Using household data from northern Tanzania and central Kenya, the study found that crop diversity was positively associated with household dietary diversity. However, it does not offer insights on diverse contexts as it was based on areas with largely similar agro-ecological and market access characteristics. Also, farm diversity was limited to crop diversity (i.e., the number of crops grown by a household).

Conversely, mixed results have also been documented. KC et al. [11] observed in three agro-ecological regions of Nepal that crop diversity was more beneficial in enhancing food self-sufficiency for households in low agricultural potential areas and with poor market access compared to those in agro-ecological zones with higher agricultural potential and market access. Also, Sibhatu et al. [9] conducted a study using household-level data from Malawi, Kenya, Ethiopia and Indonesia. They observed that on-farm production diversity was not positively associated with dietary diversity in all cases and that this relationship depended on the level of production diversity and the nature of market access. In addition, the relationship between farm production diversity and

food consumption diversity was insignificant, and even negative, at higher levels of diversification, implying foregone income from specialization. With this, specialization and market access could also be argued to play an even stronger role in enhancing food consumption diversity. However, context still matters. Radchenko and Corral [24], for example, in a study looking at agricultural commercialization and food security in Malawi, found that higher agricultural incomes from cash cropping did not translate to higher food expenditures and better diets. The transmission from agricultural income to higher nutrition-related expenditures was rather weak. Other studies find no significant associations between farm diversity and dietary diversity. For instance, Ng'endo et al. [28] found no strong association between on-farm diversity and dietary diversity among smallholders in western Kenya. Instead, socioeconomic factors such as household wealth and education played a stronger role in influencing dietary diversity.

Accordingly, in assessing the links between the nature of farm production diversity and food consumption diversity, an emerging realization is the significant role of opportunities and constraints provided for by household socio-economic factors and the existing market characteristics and agro-ecological environment. The theorized links are summarized in the conceptual framework presented in Figure 1. Food security outcomes (such as food consumption diversity) are assumed to be influenced by the level of agro-biodiversity (represented here by farm production diversity). In addition, farm production diversity and food consumption diversity are also influenced by household socio-economic factors together with the existing agro-ecological and market access characteristics.

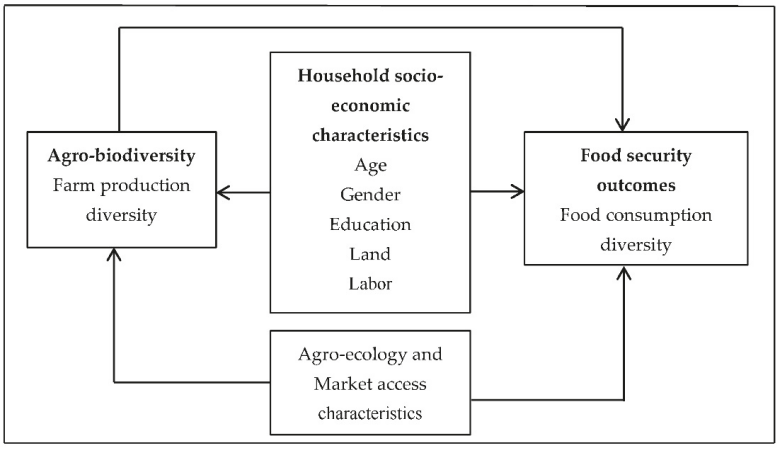

Figure 1. Conceptual framework (Authors' construction based on KC et al. [11]).

3. Materials and Methods

3.1. Study Area and Data

Tanzania has diverse climatic and ecological zones which support different agricultural systems [29]. Given the focus of this article, we use data from Kilosa and Chamwino Districts within two Regions in Tanzania (Morogoro and Dodoma). These regions are situated in two distinct agro-ecological zones and, in general, represent about 70%–80% of the types of farming system found in Tanzania [30]. Table 1 provides a summary of main characteristics of the study areas in terms of agro-ecology, agricultural potential, access to major markets and cropping as well as livestock systems. The two study areas also differ with regards to food security. Morogoro fairs better but has areas with varying levels of food security while most areas in Dodoma are characterized by high food insecurity.

Table 1. Summary of main characteristics of study area.

	Morogoro (Kilosa District—Rural)	Dodoma (Chamwino District—Rural)
Agro-ecology	Semi-humid (Rainfall 600–800 mm)	Semi-arid (Rainfall 350–500 mm)
Agricultural potential	Relatively good	Relatively poor
Access to major markets	Relatively good	Relatively poor
Cropping system	Cereals and legumes (Maize, Rice, Peas and Sesame) Fruit and vegetables (Tomatoes, Okras, Eggplants, Onions, Cabbage, Chilies, Amaranths and Pumpkins)	Drought resistant cereals, legumes and seeds (Sorghum, Millet, Groundnuts and Sunflower) Fruit and vegetables (Tomatoes, Onions, Spinach, Grapes, Pawpaws)
Livestock system	Little livestock keeping (poultry, goats)	Heavy integration of livestock (Cattle, goat, poultry)

Sources: Environment statistics [29], National sample census Morogoro [31], National sample census Dodoma [32].

3.2. Data Collection

To enable a comparative analysis, two focus districts were selected from each region namely Kilosa in Morogoro and Chamwino in Dodoma (see Figure 2). In each district, three villages were chosen based on having relatively similar (1) village sizes (800–1500 households), (2) climatic conditions, (3) livestock integration and (4) rain-fed cropping systems. The selected villages were Ilolo, Ndebwe and Idifu for Chamwino district and Changarawe, Nyali and Ilakala for Kilosa district.

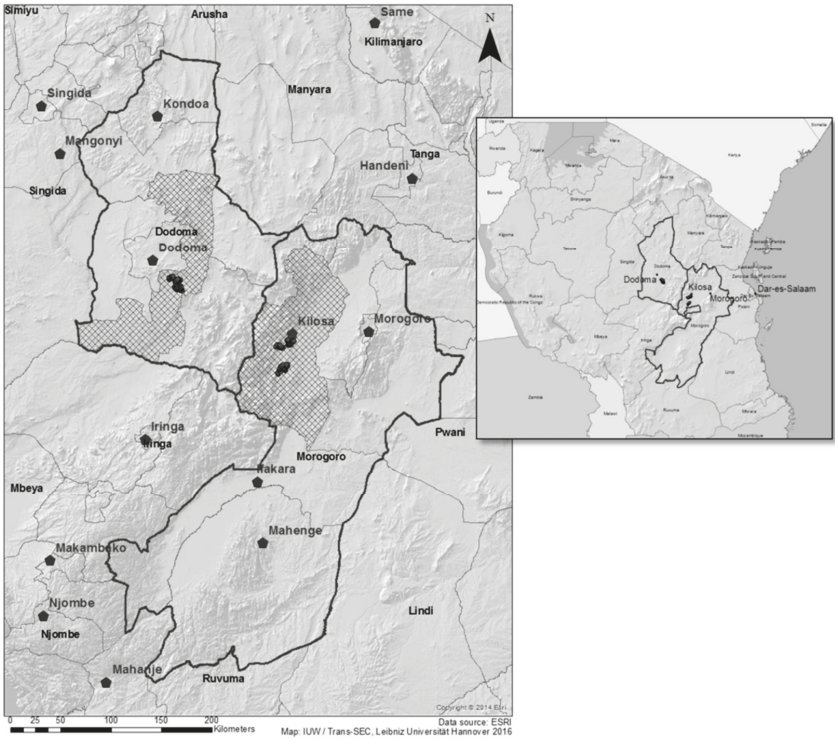

Figure 2. Study sites in Morogoro and Dodoma regions, Tanzania (Source: Trans-Sec [33]).

A primary household survey was then conducted in the six villages. Using household lists prepared by local agricultural extension officers in collaboration with village heads, 900 households

were randomly selected, proportional to sub-village sizes. A total of 150 households were interviewed from each village. A detailed structured questionnaire was used to collect data at the household level. Apart from socio-demographic information, the questionnaire contained comprehensive sections on agriculture, livestock, off-farm employment, non-farm self-employment and food consumption and expenditure. It also captured seasonal aspects of food consumption at the household level.

3.3. Measures of Diversity

We use several variables to measure farm production diversity and household food consumption diversity. With respect to farm production diversity, we use two indicators. The first is based on species count for both crops and livestock, as recommended by Last et al. [34] and used in several recent studies (see, for example, Jones et al. [3]; Pellegrini and Tasciotti [8]; Sibhatu et al. [9]). In this indicator, a household cultivating three crops (e.g., maize, sorghum and groundnuts) and keeping cattle only will have a crop-livestock count of 4. The second measure uses the number of food groups produced on the farm to generate production diversity scores. Based on our data, we use 9 food groups (cereals; roots, tubers and plantains; pulses, seeds and nuts; fruit; vegetables; fish; meat; eggs; and milk and dairy products). In this case, a household cultivating only maize, rice and sorghum will have a production diversity score of 1, because all crops belong to cereals. Conversely, if a household cultivates maize and groundnuts and keeps goats, the diversity score will be 3, as they fall under different food groups. This indicator addresses the fact that crops and livestock produced on a farm might have different nutritional functions and hence affect household food consumption diversity differently [35,36]. In general, these indicators are suitable for comparison among farms and regions [34] and also allow for a comprehensive analysis of a typical smallholder farm production, which, in most cases, integrates crops and livestock. Alternative indicators in the literature include (1) the Simpson's Index, which measures species diversity and accounts for both, species richness and evenness and (2) the modified Margalef species richness index [34,37]. However, the use of these indicators in the present analysis would limit the scope to crops only as both measures require land area in their computation. For household food consumption diversity, we also use two indicators. These are the Household Dietary Diversity Score (HDDS) and the Food Variety Score (FVS). Following Swindale and Bilinsky [38], HDDS is constructed from the number of different food groups consumed by a household in a specified reference period, in our case a 7-day period. We use 9 food groups as those used in the indicator for production diversity above. We also extend the HDDS indicator to capture household dietary patterns during planting, pre-harvest and post-harvest seasons. For this, households were asked how many days in a normal week they would eat foods from a certain food group for each season in the past year. Overall, although the HDDS does not measure dietary quality, it is widely used as an indicator of household economic access to a variety of foods [39]. On the part of the FVS, this indicator records the number of different food items eaten during a specified reference period [40]. A 7-day recall period is also used based on the previous normal week.

3.4. Empirical Strategy

In assessing the relationship between farm production diversity and household food consumption diversity, we first examine determinants of farm production diversity and then analyze how this diversity is associated with household food consumption diversity outcomes.

3.4.1. Analyzing the Determinants of Farm Production Diversity

Observed farm production diversity may be influenced by different household, farm, institutional and locational characteristics. Farm production diversity is represented as a score for both diversity indicators i.e., crop-livestock count, and the number of food groups produced. We therefore use a Poisson regression model which is suitable for analyzing count variables. Following Green [41], the model is specified as:

$$E(y_i|x_i) = \exp(\alpha + X'\beta)\, y_i = 0, 1, \ldots, i \quad (1)$$

where y_i represents the level of farm production diversity by household i, X_i represents a vector of explanatory variables and β is a vector of parameters to be estimated.

Drawing from literature on farm production diversity, the predicting variables include household, farm and locational characteristics. Household socio-demographic characteristics such as age and gender are important in influencing the skills, experiences, risk attitude, willingness and ability to maintain different levels of diversity in their production [22]. These may influence farm production diversity either positively or negatively. For example, while older household heads may be less able and eager to maintain higher diversity especially for new crop or livestock varieties as compared to younger ones, the accumulated skills and experience in farm production may influence farm production positively. Also, depending on the level of control of household productive assets such as land, labor and equipment, female headed households may maintain more or less diversity at the farm. Education, on the other hand, is expected to influence farm production diversity positively as it enhances skills and use of information for maintaining different varieties of crops and livestock [22]. Household productive assets such as land and labor are expected to have a positive influence on farm production diversity [22]. Locational factors are equally important. As distances to key services and markets increase, transaction costs increase thus compelling households to allocate land to more diverse production to cater for expected consumption [8,22].

3.4.2. Analyzing the Influence of Farm Production Diversity on Consumption Diversity

Food consumption diversity may be influenced by farm production diversity as well as a set of other factors. Specifically, household socio-economic characteristics (such as age, gender and education) and market related factors are important when analyzing diversity of food consumption at the household beyond farm production diversity. For example, gender of the household may determine the control of household resources and how they are allocated [3]. Household income in female-headed household may be spent more on quality diets than that of male-headed households. Household productive assets such as land, labor and livestock may also enhance household's production capacity and thus influencing food consumption diversity positively. Household wealth is expected to play a strong positive role in enhancing food consumption diversity because it increases the ability of households to afford diverse diets [3]. Households with higher consumption expenditure are therefore expected to have higher food consumption diversity. Equally important is the fact that food consumption diversity may also be influenced by market access [9]. Proximity to markets and purchasing power to access different food items are expected to raise household food consumption diversity. Proximity to markets enables market-oriented smallholders to take advantage of lucrative product markets thereby enhancing incomes which may be spent on accessing diverse diets [3]. In addition, income from non-farm self-employment and other sources is essential in raising household's purchasing power, thus expected to enhance food consumption diversity.

In assessing the link between food consumption diversity and farm production diversity, we also use a Poisson regression model following the basic specification in Equation (1). In this, food consumption diversity is measured as a score based on HDDS and FVS. However, Poisson regressions assume equi-dispersion (that is, the conditional mean of the dependent variable is equal to its variance). In absence of equi-dispersion, the estimates from Poisson regression may be inefficient and biased [41]. A negative binomial regression model is appropriate in this case as it can be used in case of violation of the equi-dispersion assumption. This model is given by:

$$E(y_i|x_i,\varepsilon) = \exp(\alpha + X'\beta + \varepsilon) \text{ With variance } Var(y_i|x_i,\varepsilon) = \hat{\lambda}_i - \alpha\lambda_i^2 \quad (2)$$

From its functional form, a negative binomial regression model relaxes the assumption of equi-dispersion and thus suitable in cases of over-dispersion. We therefore employ this regression model, when tests suggest that a Poisson regression model is inappropriate.

Furthermore, we test for potential collinearity among independent variables and also use robust standard errors to address problems of heteroscedasticity in the estimates. Given the cross-sectional nature of the data, our analysis is restricted to potential relationships between key explanatory factors and food consumption diversity. Thus, results should not be interpreted as causal but rather correlational.

4. Results

4.1. Descriptive Results

4.1.1. Sample Characteristics

Table 2 presents the characteristics of the sample at the household and farm-level for Kilosa and Chamwino, as well as a pooled sample covering the two districts. In the two districts, farm level characteristics showed important differences. In particular, households in Chamwino district possessed more land and livestock and have more cultivated plots and crops grown, on average, as compared to those in Kilosa district. Levels of self-provision of food seemed to also be higher in Chamwino evidenced by higher share of home consumption from total output. Furthermore, greater distance to paved roads suggests poor access to markets and key services. This was not the case for Kilosa which has a better proximity to markets.

Table 2. Selected household and farm characteristics.

Variable	Kilosa District—Semi Humid with Better Market Access (n = 450)	Chamwino District—Semi Arid with Poor Market Access (n = 449)	Pooled Sample
	Mean (SD)	Mean (SD)	Mean (SD)
Household characteristics			
Age of HH head (years)	48.20 (17.28)	49.10 (16.94)	48.65 (17.11)
Gender of HH head (Male = 1)	0.81 (0.39)	0.77 (0.42)	0.79 (0.41)
Education of HH head (School years)	4.89 (3.30)	3.96 (3.48)	4.42 (3.42)
Labor (Worker equivalents)	2.84 (1.43)	3.19 (1.49)	3.01 (1.47)
Access to off-farm employment (Yes = 1)	0.20 (0.40)	0.47 (0.50)	0.33 (0.47)
Access to non-farm self-employment (Yes = 1)	0.16 (0.37)	0.35 (0.48)	0.25 (0.44)
Non-food expenditure (Per capita/month-PPP $)	34.11 (34.97)	23.49 (20.31)	28.81 (29.07)
Food expenditure (Per capita/ month PPP $)	13.65 (19.18)	9.94 (11.33)	11.81 (15.86)
Share of home consumption from total output	0.45 (0.38)	0.68 (0.42)	0.57 (0.42)
Distance to nearest paved road (Km)	1.94 (1.16)	10.18 (2.74)	6.15 (4.72)
Farm characteristics			
Land size owned (ha)	1.47 (1.56)	1.95 (1.91)	1.71 (1.76)
Number of plots cultivated	2.2 (0.7)	3.2 (1.3)	2.6 (1.11)
Livestock owned (Tropical Livestock Unit)	0.53 (6.06)	1.26 (2.70)	0.90 (4.71)
Number of crops cultivated	2.66 (1.28)	4.47 (1.80)	3.56 (1.81)

Worker equivalents used to capture labor available at the household were calculated by weighting household members: less than 9 years = 0, 9–15 = 0.7, 16–49 = 1 and above 49 years = 0.7; All monetary variables have been converted from local currency Tanzanian Shilling (TZS) to 2010-based purchasing power parity United States Dollars (PPP $).

4.1.2. Comparison of Farm Production Diversity by Agro-Ecology and Market Access

Figure 3 provides a comparison of farm production diversity indicators based on agro-ecological and market access characteristics in Kilosa and Chamwino districts. It also presents the overall levels of farm production diversity using data pooled from the two districts. Overall, significant differences in farm production diversity can be observed between the two districts. Specifically, diversity based on crop-livestock count was significantly lower for Kilosa compared to that of Chamwino. Similarly, diversity based on the number of food groups produced showed the same pattern. In both districts, however, cereals constituted the main food group that is produced. In Kilosa, the second, third and

fourth most important food groups produced were pulses, seeds and nuts. In Chamwino, on the other hand, the 'pulses, seeds and nuts' food group ranked second in terms of production after cereals.

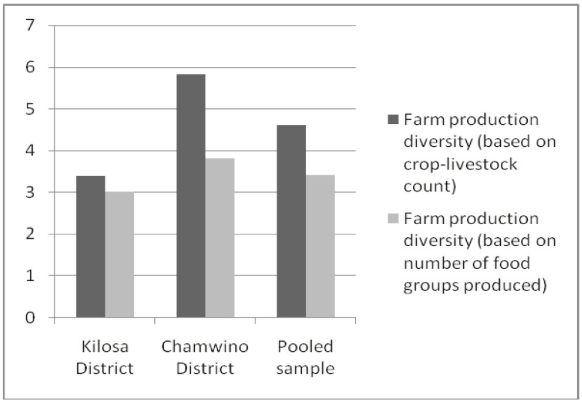

Figure 3. Comparison of mean farm production diversity by agro-ecology and market access in Kilosa and Chamwino Districts.

4.1.3. Comparison of Food Consumption Diversity in Kilosa and Chamwino Districts

Food consumption diversity was higher for households in Kilosa district, compared to those in Chamwino (see Figure 4). This was despite the low farm production diversity observed in Kilosa. Notwithstanding the high farm production diversity in Chamwino, the household food consumption diversity was relatively low compared to Kilosa, consistently for both measures of food consumption diversity (HDDS and FVS) and for the planting, pre-harvest and post-harvest agricultural seasons. A deeper look into the data shows that among the food groups, cereals dominated in terms of consumption for both districts. Additionally, although Kilosa fared better in terms of food consumption diversity, vegetables, and pulses, seeds and nuts were important food groups that were consumed in both districts. However, meat, and milk and dairy products food groups were least consumed in the districts.

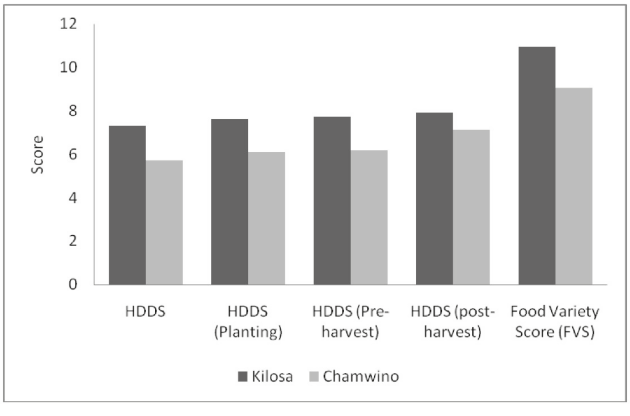

Figure 4. Mean HDDS and FVS in Kilosa and Chamwino districts.

We also compared food consumption diversity based on low and high farm production diversity of households (Table 3). To achieve a simplified comparison, the threshold for high and low diversity was determined by median values of the crop-livestock diversity indicator. Households with crop-livestock diversity above the median were classified as having high production diversity while those below the median were considered to have low production diversity. For Kilosa district, crop-livestock diversity ranges from 1 to 12 with the median value of 3. For the case of Chamwino district, the median crop-livestock diversity was 4 with diversity ranging from 1 to 14. Consistently, results showed that households with high production diversity had higher food consumption diversity based on HDDS and FVS in both districts, though this difference was not significant in a few cases. In Chamwino, the difference was far more significant thus suggesting a stronger role of farm production diversity. Despite the difference in food consumption diversity between the low and high production diversity households, cereals, vegetables, and pulses, seeds and nuts still dominate in both groups as the main food groups consumed.

Table 3. Comparison of food consumption diversity based on crop-livestock diversity.

Food Consumption Diversity Indicator	Kilosa				Chamwino			
	Low Production Diversity (n = 133)		High Production Diversity (n = 317)		Low Production Diversity (n = 213)		High Production Diversity (236)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
HDDS	7.32	1.94	7.32	1.78	5.15	1.79	6.25 ***	1.73
HDDS (Planting)	7.41	1.66	7.71 ***	1.41	5.59	1.97	6.54 ***	1.79
HDDS (Pre-harvest)	7.53	1.63	7.82 ***	1.41	5.71	2.01	6.57 ***	1.66
HDDS (post-harvest)	7.82	1.44	7.95 **	1.29	6.77	1.76	7.38 ***	1.53
Food Variety Score (FVS)	10.81	3.45	11.00	3.36	7.80	3.61	10.14 ***	3.68

Wilcoxon-Mann-Whitney non-parametric two-sample test used to examine differences between low and high production diversity; ** and ***: Significant difference at 10%, 5% and 1%-levels respectively.

4.2. Determinants of Farm Production Diversity

In the analysis of factors determining the observed farm production diversity, we present results based on crop-livestock count and the number of food groups produced—our primary indicators of farm production diversity—as dependent variables. Despite a few differences, the results from the two indicators of diversity provided a similar picture. Here we interpret the Poisson regression results based on crop-livestock count for both regions and the pooled sample (Table 4).

Results showed that farm production diversity is positively and significantly influenced by age of household head, availability of labor in the household and access to credit, for both Kilosa and Chamwino districts. For Kilosa, column (1), education of the household head and access to non-farm self-employment were also significantly and positively associated with increased farm production diversity. Interestingly, increased distance to nearest paved road had a significant positive influence on production diversity only for Kilosa with better market access suggesting an increased role of self-sufficiency for households far from market opportunities. However, for Kilosa and the pooled sample, agricultural shocks were negatively associated with farm production diversity. This could suggest that resource-constrained households may opt for a few highly resistant crops and livestock—or even venture into non-agricultural activities—after the experience of agricultural shock. In addition, the onset of an agricultural shock (such as drought, crop pests or unusually heavy rainfall) may have severe and negative impacts which may further reduce their agricultural production including its diversity. For Chamwino, the preparedness of a household to undertake risk, availability of land and other assets were significant in raising farm production diversity. Locational dummies also confirm the pattern observed in descriptive analysis, where residing in villages in Kilosa was negatively related to farm production diversity, unlike in Chamwino.

Table 4. Determinants of farm production diversity.

Variable	(1) Kilosa		(2) Chamwino		(3) Pooled	
	Crop-Livestock Count	Number of Food Groups Produced	Crop-Livestock Count	Number of Food Groups Produced	Crop-Livestock Count	Number of Food Groups Produced
Age of HH head (years)	0.003 *	0.002	0.002 *	0.001	0.002 ***	0.002 **
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Gender of HH head (Male = 1)	0.057	0.087	0.088 *	0.037	0.087 **	0.066 *
	(0.062)	(0.064)	(0.047)	(0.040)	(0.038)	(0.035)
Education of HH head (School years)	0.012 *	0.008	0.003	0.005	0.006	0.007
	(0.007)	(0.007)	(0.006)	(0.005)	(0.004)	(0.004)
Risk attitude (scale: 1–10)	0.001	−0.004	0.019 ***	0.010 **	0.015 ***	0.005
	(0.010)	(0.009)	(0.006)	(0.005)	(0.005)	(0.004)
Land size owned (ha)	0.027	0.011	0.059 ***	0.038 ***	0.051 ***	0.028 ***
	(0.019)	(0.016)	(0.008)	(0.006)	(0.007)	(0.006)
Labor (Worker equivalents)	0.040 ***	0.028 *	0.038 ***	0.033 ***	0.038 ***	0.030 ***
	(0.013)	(0.014)	(0.011)	(0.010)	(0.009)	(0.008)
Access to off-farm employment (Yes = 1)	−0.085	−0.043	0.045	0.042	0.004	0.005
	(0.056)	(0.059)	(0.037)	(0.031)	(0.030)	(0.028)
Access to non-farm self-employment (Yes = 1)	0.105 *	0.136 **	0.049	0.042	0.068 **	0.076 ***
	(0.058)	(0.056)	(0.037)	(0.031)	(0.032)	(0.028)
Distance to nearest paved road (Km)	0.024 *	0.032 **	0.000	0.011	0.012	0.025 ***
	(0.014)	(0.014)	(0.013)	(0.011)	(0.010)	(0.009)
Access to credit (Yes = 1)	0.144 *	0.132 **	0.165 ***	0.109 ***	0.150 ***	0.103 ***
	(0.074)	(0.061)	(0.045)	(0.041)	(0.037)	(0.033)
Access to market information (Yes = 1)	0.005	0.002	0.000	0.002	0.001	0.002
	(0.004)	(0.005)	(0.002)	(0.001)	(0.001)	(0.001)
Agricultural shocks (Yes = 1)	−0.110 *	−0.177 ***	−0.047	−0.027	−0.067 **	−0.072 **
	(0.058)	(0.068)	(0.037)	(0.032)	(0.031)	(0.029)
Household asset holding (asset score)	0.000	−0.000	0.000 *	0.000 ***	0.000 **	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Household resides in Ilolo village			0.075	0.031	0.124 **	0.086
			(0.077)	(0.068)	(0.063)	(0.058)
Household resides in Ndebwe village			0.001	−0.009	0.009	0.005
			(0.042)	(0.037)	(0.042)	(0.037)
Household resides in Changarawe village	−0.102 *	−0.047			−0.376 ***	0.036
	(0.055)	(0.050)			(0.114)	(0.105)
Household resides in Ilakala village					−0.291 ***	0.074
					(0.110)	(0.102)

Table 4. *Cont.*

Variable	(1) Kilosa		(2) Chamwino		(3) Pooled	
	Crop-Livestock Count	Number of Food Groups Produced	Crop-Livestock Count	Number of Food Groups Produced	Crop-Livestock Count	Number of Food Groups Produced
Household resides in Nyali village	−0.150 ***	−0.176 ***			−0.403 ***	−0.073
	(0.056)	(0.056)			(0.095)	(0.089)
Constant	0.854 ***	0.817 ***	1.127 ***	0.800 ***	1.041 ***	0.681 ***
	(0.142)	(0.134)	(0.166)	(0.156)	(0.130)	(0.128)
Observations	450	450	449	449	899	899
Wald chi2	80.79	49.70	201.86	135.46	690.71	239.01
Probability > chi2	0.00	0.00	0.00	0.00	0.00	0.00
Pseudo R2	0.023	0.016	0.060	0.024	0.107	0.030

All models are estimated with Poisson regressions; ***, ** and * indicate a significance level of 1%, 5%, and 10%, respectively; Values shown in parentheses are standard errors.

4.3. The Role of Farm Production Diversity on Household Food Consumption Diversity

In the analysis of the role of farm production diversity on food consumption diversity of households, we used several regression models. As pointed out earlier, the aim was to assess this relationship based on the two regions with distinct agro-ecological and market access characteristics as well as to ascertain whether farm production diversity plays a role in influencing seasonal food consumption diversity. For farm production diversity, we used crop-livestock count and the number of food groups. To get insights on food consumption diversity and its seasonal nature, the dependent variables were HDDS and FVS; and HDDS (planting), HDDS (pre-harvest) and HDDS (post-harvest) respectively. All regression models were estimated with Poisson regression except for FVS which were estimated with negative binomial regressions. In the latter regressions, the test of the over-dispersion parameter indicated that alpha is significantly different from zero, suggesting inappropriateness of Poisson regression. Table 5 presents these results showing the determinants of food consumption diversity.

Taking the case of crop-livestock count, results showed that farm production diversity had an overall positive and significant influence on household food consumption diversity. Going beyond farm production diversity, results also showed that household food consumption diversity was also influenced by market access characteristics. Access to market information and income from non-farm self-employment was significantly associated with increased food consumption diversity. Similarly, per capita food expenditure per month was positively related to food consumption diversity indicating that sourcing of different varieties of food from markets seems to be a relevant factor. Distance to nearest paved road was negatively related to food consumption diversity suggesting that market access plays an important role. Specifically, residing far from markets lowers the level of food consumption diversity in the households. A largely similar pattern of influences was observed for results of regressions using the number of food groups produced as an indicator of farm production diversity (see Table 6).

While results for district-specific regressions (presented in Tables A1–A4) showed almost consistent positive effects of farm production diversity on household food consumption diversity for Chamwino district, the same effects were not observed for Kilosa, except for HDDS (planting). The magnitudes of effects are also consistently higher for the former than the latter. The results suggest that the role of farm production diversity is more pronounced in Chamwino, which has relatively poor market access and agricultural potential as compared to Kilosa district with better market access. Additionally, the crop-livestock indicator showed that farm production diversity had a positive effect on seasonal food consumption diversity. However, the role of market access was less pronounced for Chamwino district. Despite a significant influence of access to market information on food consumption diversity, distance to nearest paved road and access to income from non-farm self-employment (except for HDDS for post-harvest) were insignificant. However, there was still a

significant positive association between per capita food expenditure per month and household food consumption diversity.

Table 5. Effects of farm production diversity on household food consumption diversity—Pooled sample (Farm production diversity indicator: Crop-livestock count).

	HDDS	HDDS (Planting)	HDDS (Pre-Harvest)	HDDS (Post-Harvest)	FVS
Crop-livestock count	0.022 ***	0.019 ***	0.015 ***	0.010 ***	0.037 ***
	(0.004)	(0.004)	(0.004)	(0.003)	(0.006)
Age of HH head (years)	−0.002 ***	−0.002 ***	−0.001 **	−0.001 ***	−0.004 ***
	(0.001)	(0.001)	(0.001)	(0.000)	(0.001)
Gender of HH head (Male = 1)	−0.003	0.033	−0.012	−0.024	−0.001
	(0.024)	(0.023)	(0.022)	(0.018)	(0.029)
Education of HH head (School years)	0.004	−0.001	0.003	0.002	0.004
	(0.003)	(0.003)	(0.003)	(0.002)	(0.004)
Land size owned (ha.)	0.006	0.010 **	0.006	0.006	0.004
	(0.005)	(0.004)	(0.004)	(0.003)	(0.007)
Livestock owned (TLU)	−0.001	0.001	0.001	0.001	−0.003
	(0.001)	(0.001)	(0.001)	(0.001)	(0.003)
Labor (Worker equivalents)	0.002	−0.001	0.001	0.008 *	0.009
	(0.006)	(0.006)	(0.006)	(0.004)	(0.008)
Food consumption expenditure quintile					
Per capita per month: Low-middle	0.044	0.010	−0.008	−0.005	0.062 *
	(0.029)	(0.030)	(0.029)	(0.022)	(0.037)
Per capita per month: Middle	0.063 **	0.094 ***	0.072 ***	0.038 *	0.088 **
	(0.029)	(0.028)	(0.026)	(0.021)	(0.036)
Per capita per month: High-middle	0.118 ***	0.098 ***	0.075 ***	0.046 **	0.158 ***
	(0.029)	(0.028)	(0.026)	(0.021)	(0.036)
Per capita per month: High	0.142 ***	0.126 ***	0.095 ***	0.054 ***	0.179 ***
	(0.028)	(0.027)	(0.026)	(0.020)	(0.037)
Share of home consumption	−0.031	−0.018	−0.016	−0.015	−0.030
	(0.022)	(0.021)	(0.020)	(0.017)	(0.028)
Access to market information (Yes = 1)	0.101 ***	0.084 ***	0.095 ***	0.062 ***	0.108 ***
	(0.020)	(0.019)	(0.018)	(0.015)	(0.024)
Distance to nearest paved road	−0.027 ***	−0.021 ***	−0.021 ***	−0.012 ***	−0.027 ***
	(0.003)	(0.003)	(0.003)	(0.002)	(0.004)
Access to off-farm employment (Yes = 1)	−0.036 *	−0.006	−0.024	−0.000	−0.039
	(0.020)	(0.019)	(0.019)	(0.015)	(0.026)
Access to non-farm self-employment (Yes = 1)	0.046 **	0.033 *	0.022	0.047 ***	0.049 *
	(0.020)	(0.018)	(0.018)	(0.014)	(0.026)
Household asset holding (asset score)	0.000	0.000	0.000 *	0.000	0.000 *
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Household resides in Ilakala village	−0.018	0.026	0.032	−0.006	−0.037
	(0.026)	(0.023)	(0.023)	(0.020)	(0.036)
Household resides in Nyali village	0.010	0.102 ***	0.097 ***	0.044 **	0.023
	(0.026)	(0.022)	(0.022)	(0.018)	(0.035)
Household resides in Ilolo village	−0.100 ***	−0.090 ***	−0.079 ***	−0.054 **	−0.089 **
	(0.028)	(0.028)	(0.029)	(0.022)	(0.036)
Household resides in Ndebwe village	0.021	0.012	0.052 *	0.019	0.043
	(0.034)	(0.034)	(0.032)	(0.027)	(0.039)
Constant	1.903 ***	1.864 ***	1.903 ***	2.004 ***	2.256 ***
	(0.060)	(0.057)	(0.055)	(0.046)	(0.072)
ln(alpha)					−4.945
					(0.726)
Alpha					0.802
					(0.132)
Observations	899	899	899	899	899
Wald chi2	456.17	338.94	321.60	153.50	250.30
Probability > chi2	0.00	0.00	0.00	0.00	0.00
Pseudo R2	0.044	0.035	0.032	0.013	0.051

***, ** and * indicate a significance level of 1%, 5%, and 10%, respectively; Values shown in parentheses are standard errors; Negative binomial model used for FVS regression: Likelihood-ratio test of alpha = 0; chibar2 (01) = 258.20; Prop > = chibar2 = 0.000. This suggests that alpha is non-zero rendering Poisson model less appropriate.

Table 6. Effects of farm production diversity on household food consumption diversity – Pooled sample (Farm production diversity indicator: Number of food groups produced).

	HDDS	HDDS (Planting)	HDDS (Pre-Harvest)	HDDS (Post-Harvest)	FVS
Number of food groups produced	0.030 ***	0.025 ***	0.023 ***	0.012 *	0.041 ***
	(0.007)	(0.008)	(0.008)	(0.007)	(0.009)
Age of HH head (years)	−0.002 ***	−0.002 **	−0.001 *	−0.001 *	−0.003 ***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Gender of HH head (Male = 1)	0.011	0.053 *	−0.002	−0.027	−0.002
	(0.026)	(0.029)	(0.027)	(0.023)	(0.030)
Education of HH head (School years)	0.003	−0.001	0.005	0.004	0.004
	(0.003)	(0.003)	(0.003)	(0.003)	(0.004)
Land size owned (ha.)	0.010 *	0.018 ***	0.012 **	0.009 *	0.012 *
	(0.005)	(0.006)	(0.005)	(0.005)	(0.007)
Livestock owned (TLU)	−0.001	0.003 *	0.003 *	0.003 *	−0.002
	(0.001)	(0.002)	(0.001)	(0.002)	(0.002)
Labor (Worker equivalents)	−0.002	−0.007	−0.005	0.007	0.011
	(0.007)	(0.008)	(0.007)	(0.006)	(0.008)
Food consumption expenditure quintile					
Per capita per month: Low-middle	0.044	−0.001	−0.014	0.004	0.068 *
	(0.030)	(0.036)	(0.035)	(0.028)	(0.037)
Per capita per month: Middle	0.086 ***	0.105 ***	0.092 ***	0.058 **	0.099 ***
	(0.031)	(0.034)	(0.033)	(0.027)	(0.037)
Per capita per month: High-middle	0.135 ***	0.090 **	0.084 **	0.063 **	0.166 ***
	(0.032)	(0.035)	(0.034)	(0.028)	(0.036)
Per capita per month: High	0.151 ***	0.134 ***	0.105 ***	0.066 **	0.192 ***
	(0.031)	(0.035)	(0.034)	(0.027)	(0.038)
Share of home consumption	−0.024	−0.054 **	−0.035	−0.042 *	−0.043
	(0.023)	(0.026)	(0.026)	(0.022)	(0.028)
Access to market information (Yes = 1)	0.094 ***	0.108 ***	0.116 ***	0.074 ***	0.114 ***
	(0.021)	(0.024)	(0.023)	(0.020)	(0.024)
Distance to nearest paved road	−0.027 ***	−0.020 ***	−0.022 ***	−0.013 ***	−0.023 ***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.004)
Access to off-farm employment (Yes = 1)	−0.041 *	−0.016	−0.027	−0.009	−0.038
	(0.022)	(0.024)	(0.024)	(0.020)	(0.026)
Access to non-farm self-employment (Yes = 1)	0.036 *	0.032	0.020	0.069 ***	0.050 *
	(0.022)	(0.024)	(0.023)	(0.019)	(0.027)
Household asset holding (asset score)	0.000 **	0.000 **	0.000 **	0.000	0.000 *
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Household resides in Ilakala village	−0.040	−0.004	0.013	−0.030	−0.042
	(0.029)	(0.031)	(0.031)	(0.027)	(0.036)
Household resides in Nyali village	−0.027	0.097 ***	0.101 ***	0.035	0.020
	(0.029)	(0.029)	(0.028)	(0.025)	(0.035)
Household resides in Ilolo village	−0.074 **	−0.102 ***	−0.088 ***	−0.067 **	−0.041
	(0.030)	(0.033)	(0.033)	(0.028)	(0.035)
Household resides in Ndebwe village	0.043	−0.015	0.035	0.012	0.052
	(0.034)	(0.040)	(0.039)	(0.033)	(0.039)
Constant	1.570 ***	1.642 ***	1.665 ***	1.789 ***	2.225 ***
	(0.065)	(0.073)	(0.071)	(0.060)	(0.074)
ln(alpha)					−4.697
					(0.579)
Alpha					0.398
					(0.067)
Observations	899	899	899	899	899
Wald chi2	411.99	337.48	311.61	151.31	231.70
Probability > chi2	0.00	0.00	0.00	0.00	0.00
Pseudo R2	0.035	0.039	0.037	0.016	0.047

***, ** and * indicate a significance level of 1%, 5%, and 10%, respectively; Values shown in parentheses are standard errors; Negative binomial model used for FVS regression: Likelihood-ratio test of alpha = 0; chibar2 (01) = 197.16; Prop > = chibar2 = 0.000. The estimated alpha coefficient for the Negative binomial model is significant suggesting absence of equi-dispersion which would favor the use of a Poisson model.

5. Discussion

5.1. The Nature and Drivers of Farm Production Diversity

Typical to smallholder farming systems, our results showed that households' farm production is rather diverse, constituting of a variety of crops and livestock species. Farm production diversity was substantially higher in Chamwino district which has a semi-arid agro-ecology with less agricultural potential and market access compared to Kilosa district. The agro-ecology of Chamwino district supports a 'pastoralist/agro-pastoralist' farming system [42]. This partly contributed to the observed higher levels of farm production diversity. In addition, unlike in Kilosa, the semi-arid nature of Chamwino implies that households may experience more frequent periods of food insecurity and other shocks such as drought. In areas with fragile agro-ecologies farm production diversity has been argued to be an important strategy. Thus, smallholders may diversify their agricultural production as a risk mitigation strategy from the negative effects of weather shocks and other agro-ecological conditions [5].

Regarding determinants of farm production diversity within the two agro-ecological regions, results suggest that households' socio-economic characteristics and endowments in terms of land and labor play an important role. These results were also in line with the results of Benin et al. [21] and Di Falco et al. [22]. In addition to age and education, households' preparedness to undertake risk was correlated with increased farm production diversity especially in Chamwino district which has a relatively fragile agro-ecology. Farm production diversity was also significantly associated with access to land and labor, together with other agricultural assets. Interestingly, occurrence of agricultural shocks was associated with decreased diversity of farm production. As noted, this may be particularly the case for resource-constrained households. Porter [43], for example, argued that when households lack access to assets or credit markets, shifting labor resources to other non-agricultural activities may be the only coping strategy at their disposal in the event of agricultural shocks. Similar to observations by Benin et al. [21], our results also underscored the role of location, particularly with respect to agro-ecological conditions and proximity to markets. Fundamentally, ecological characteristics of different locations—such as soil, climate, water availability and altitude—are instrumental in enhancing or diminishing diversity in farms, villages and agro-ecological zones [13]. Also, in line with the findings of Sibhatu et al. [9], market access equally played an important role in influencing farm production diversity. Households in villages which were least accessible to markets have higher farm production diversity, even within the same agro-ecological region signaling increased self-provisioning of food through increased diversity of farm production.

5.2. The Influence of Farm Production Diversity on Food Consumption Diversity

Farm production diversity has increasingly been considered important in improving food consumption especially for smallholder rural households [8,9,12,13]. Results from our analysis showed that this role is largely dependent on agro-ecological characteristics and market considerations. While farm production diversity played a significant and positive role for household food consumption diversity in Chamwino district, this role was rather small in Kilosa district. This was observed for both indicators of food consumption diversity, that is, HDDs and FVS. The significant role of farm production diversity in Chamwino may be partly attributed to the challenging agro-ecological characteristics and low market access. In these contexts, households resort to subsistence production to cater for food consumption needs. KC et al. [11] also observed the same pattern in a study in Nepal, where the role of crop diversity on food self-sufficiency was stronger in agro-ecological regions which are less accessible and with low market access. Similarly, Di Falco and Chavas [37] found that the benefits of crop biodiversity were more pronounced in ecologically fragile agricultural systems. Kilosa, on the other hand, has relatively better agro-ecology and subsequently a higher agricultural potential. The region has, however, far less diversity of production with mainly maize-legume cropping system

with little livestock integration. Cereals, vegetables, and pulses, seeds and nuts constitute the main groups of crops produced in the district.

5.3. The Role of Market Access in Food Consumption Diversity

Recent studies have also shown that food consumption diversity for smallholder households may be influenced by factors beyond farm production. In essence, most smallholders are neither strictly subsistence-oriented nor market-oriented [3]. As noted earlier, our analysis shows that household food consumption expenditure was positively associated with food consumption diversity. This partly suggests that households with higher food consumption expenditure spend on more diverse food items that are available in food markets. In Kilosa district where the contribution of farm production diversity was largely insignificant, access to markets, both for selling of agricultural produce and purchases of food, appeared to play a significant role in influencing household food consumption diversity. Descriptive analysis showed that, despite low farm production diversity, households in Kilosa had higher food consumption diversity compared to those in Chamwino. This may be associated with better agricultural potential and market access in Kilosa as compared to Chamwino. As noted by Sibhatu et al. [9], increased market transactions tend to lower the role of farm production diversity on food consumption. They note that better access to markets enable households to not only purchase diverse foods but also use their comparative advantage to produce and sell food and cash crops and hence generate higher agricultural incomes.

5.4. Farm Production Diversity and Seasonal Food Consumption

As aforementioned, farm production diversification has received increased attention due to its potential for enhancing seasonal food consumption. As Herforth [18] argued, for example, different crops may grow in different agricultural seasons and consequently increased farm production diversity may be beneficial in cases of seasonal food insecurity. Results from our regression models showed that both farm production diversity indicators were positively associated with increased food consumption diversity in the planting, pre-harvest and post-harvest seasons. Specifically, results showed that in Chamwino, where the role of markets was low, and production was oriented towards food crops and livestock, farm production diversity had a significant positive role in seasonal food consumption diversity. However, with an exception for the planting season, this relationship was not significant for Kilosa which had lower farm production diversity. Nevertheless, the results from Chamwino and the pooled sample offer insights on the potential positive role of farm production diversity can play in enhancing food consumption diversity.

5.5. Limitations

Several potential limitations are worth highlighting. First, the link between farm production diversity and household food consumption diversity is a complex one. As Jones et al. [3] observes, this relationship is influenced by many factors. While we attempted to include the relevant aspects in line with the literature and the focus of the present article, these factors may not be entirely exhaustive. For example, cultural values may influence consumption of particular food items, but this may be difficult to capture in the analysis. Second, HDDS is an indicator that is based on household recall of food consumption in the previous 24 h or 7 days. Given the cost and time limitations for collecting data on seasonal food consumption in each agricultural season, we rely on recall also for seasonal food consumption diversity. Therefore, our modified HDDS for planting, pre-harvest and post-harvest relies on relatively long recall periods. Apart from this, however, the indicator provides a similar pattern of food security in our sample as other indicators used such as the normal HDDS and FVS. Despite these potential limitations, the analysis provides unique empirical insights on the smallholder households' production-consumption link using two distinct agro-ecological and market access contexts.

6. Conclusions

This article assessed how farm production diversity influences household food consumption diversity in two districts (Kilosa and Chamwino) with distinct agro-ecological and market access contexts in rural Tanzania. Specifically, (1) it examined the nature and extent of farm production diversity, and its determinants, and (2) it analyzed the role of farm production diversity on household food consumption diversity.

Findings reveal that smallholder households maintain a considerable diversity in their production, both for crops and livestock. However, significant differences exist between the two agro-ecological regions with regards to farm production diversity and food consumption diversity. While low farm production diversity was observed in Kilosa district, households in Chamwino districts had significantly higher farm production diversity in terms of crops and livestock. Regarding the role of farm production diversity in household food consumption diversity, our results underscore findings from earlier studies that this relationship is largely dependent on agro-ecological characteristics and market contexts, among other factors. Results showed that, while farm production diversity was significantly associated with increased food consumption diversity in Chamwino, the same relationship was not observed in Kilosa. This influence was also observed for seasonal food consumption diversity, particularly in Chamwino which suggests additional benefits for smallholder farm production diversification. These observations suggest a stronger role of farm production diversity on food consumption diversity in areas with challenging agro-ecological characteristics and low market accessibility, and a lesser role in presence of better agro-ecological and market access characteristics.

These findings imply that, strategies geared at promoting farm production diversity should consider the existing agro-ecological and market characteristics. In challenging agro-ecological settings and less accessible rural communities, farm production diversity can be more beneficial in enhancing food security and, most importantly, seasonal food consumption diversity. In addition, to achieve increased food consumption diversity in farm households, the focus of policy should not only be on increasing diversity of smallholder farm production but also aim at improvements in market related infrastructure and institutions.

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Appendix A

Table A1. Determinants of food consumption diversity in Chamwino (Production diversity indicator used: crop-livestock count).

Variable	HDDS	HDDS (Planting)	HDDS (Pre-Harvest)	HDDS (Post-Harvest)	FVS
Crop-livestock count	0.032 *** (0.006)	0.016 *** (0.006)	0.018 *** (0.006)	0.011 ** (0.005)	0.051 *** (0.009)
Age of HH head (years)	−0.004 *** (0.001)	−0.003 *** (0.001)	−0.003 *** (0.001)	−0.002 *** (0.001)	−0.006 *** (0.001)

Table A1. *Cont.*

Variable	HDDS	HDDS (Planting)	HDDS (Pre-Harvest)	HDDS (Post-Harvest)	FVS
Gender of HH head (Male = 1)	−0.022 (0.035)	0.044 (0.036)	−0.039 (0.033)	−0.027 (0.027)	−0.030 (0.045)
Education of HH head (School years)	0.003 (0.004)	−0.005 (0.004)	0.001 (0.004)	0.001 (0.003)	0.004 (0.006)
Land size owned (ha.)	0.001 (0.008)	0.008 (0.006)	0.005 (0.006)	−0.001 (0.005)	−0.003 (0.010)
Livestock owned (TLU)	0.005 (0.004)	0.011 *** (0.004)	0.007 * (0.004)	0.007 ** (0.003)	0.003 (0.007)
Labor (Worker equivalents)	−0.001 (0.009)	0.000 (0.009)	−0.001 (0.010)	0.008 (0.007)	0.009 (0.013)
Per capita per month: Low-middle	0.025 (0.040)	0.051 (0.049)	0.002 (0.043)	0.003 (0.033)	0.021 (0.054)
Per capita per month: Middle	0.020 (0.045)	0.163 *** (0.049)	0.075 * (0.044)	0.033 (0.034)	0.041 (0.057)
Per capita per month: High-middle	0.124 *** (0.044)	0.209 *** (0.046)	0.124 *** (0.044)	0.075 ** (0.033)	0.157 *** (0.055)
Per capita per month: High	0.114 ** (0.048)	0.225 *** (0.052)	0.147 *** (0.052)	0.073 ** (0.036)	0.161 ** (0.066)
Share of home consumption	−0.006 (0.033)	−0.007 (0.034)	0.008 (0.033)	−0.001 (0.026)	−0.002 (0.043)
Access to market information (Yes = 1)	0.123 *** (0.029)	0.124 *** (0.029)	0.147 *** (0.029)	0.079 *** (0.023)	0.131 *** (0.037)
Distance to nearest paved road	0.000 (0.009)	−0.005 (0.009)	0.003 (0.009)	−0.005 (0.008)	0.003 (0.012)
Access to off-farm employment (Yes = 1)	−0.012 (0.029)	0.044 (0.029)	−0.005 (0.028)	−0.006 (0.022)	0.005 (0.038)
Access to non-farm self-employment (Yes = 1)	0.044 (0.028)	0.039 (0.027)	0.014 (0.027)	0.056 *** (0.020)	0.031 (0.038)
Household asset holding (asset score)	0.000 *** (0.000)	0.000 ** (0.000)	0.000 ** (0.000)	0.000 (0.000)	0.000 *** (0.000)
Household resides in Ilolo village	0.048 (0.054)	−0.001 (0.055)	0.059 (0.054)	−0.024 (0.047)	0.065 (0.078)
Household resides in Ndebwe village	0.035 (0.035)	0.026 (0.036)	0.082 ** (0.034)	0.023 (0.028)	0.045 (0.045)
Constant	1.556 *** (0.132)	1.597 *** (0.132)	1.605 *** (0.126)	1.934 *** (0.104)	1.908 *** (0.175)
ln(alpha)					−3.673 (0.369)
Alpha					0.785 (0.095)
Observations Wald chi2 Probability > chi2 Pseudo R2	449 166.31 0.00 0.034	449 130.43 0.00 0.032	449 117.44 0.00 0.027	449 72.48 0.00 0.013	449 127.74 0.00 0.052

Table A2. Determinants of food consumption diversity in Chamwino (Production diversity indicator used: Number of food groups produced).

	HDDS	HDDS (Planting)	HDDS (Pre-Harvest)	HDDS (Post-Harvest)	FVS
Number of food groups produced	0.048 *** (0.013)	0.015 (0.014)	0.030 ** (0.014)	0.014 (0.012)	0.061 *** (0.016)
Age of HH head (years)	−0.004 *** (0.001)	−0.003 *** (0.001)	−0.002 * (0.001)	−0.002 ** (0.001)	−0.005 *** (0.001)
Gender of HH head (Male = 1)	0.001 (0.036)	0.068 (0.043)	−0.025 (0.041)	−0.025 (0.034)	−0.026 (0.046)
Education of HH head (School years)	0.001 (0.004)	−0.006 (0.005)	0.001 (0.005)	0.003 (0.004)	0.003 (0.006)

Table A2. *Cont.*

	HDDS	HDDS (Planting)	HDDS (Pre-Harvest)	HDDS (Post-Harvest)	FVS
Land size owned (ha.)	0.007 (0.007)	0.016 * (0.008)	0.011 (0.008)	0.001 (0.007)	0.010 (0.010)
Livestock owned (TLU)	0.007 (0.006)	0.021 *** (0.005)	0.015 *** (0.005)	0.013 *** (0.004)	0.007 (0.007)
Labor (Worker equivalents)	−0.004 (0.009)	−0.005 (0.011)	−0.012 (0.012)	0.010 (0.009)	0.013 (0.013)
Per capita per month: Low-middle	−0.004 (0.041)	0.027 (0.054)	−0.024 (0.052)	0.012 (0.040)	0.034 (0.055)
Per capita per month: Middle	0.042 (0.045)	0.171 *** (0.055)	0.081 (0.052)	0.054 (0.042)	0.060 (0.058)
Per capita per month: High-middle	0.124 *** (0.045)	0.211 *** (0.054)	0.143 *** (0.054)	0.112 *** (0.042)	0.167 *** (0.056)
Per capita per month: High	0.116 ** (0.050)	0.239 *** (0.060)	0.166 *** (0.064)	0.100 ** (0.047)	0.197 *** (0.068)
Share of home consumption	−0.001 (0.033)	−0.050 (0.040)	−0.003 (0.040)	−0.029 (0.032)	−0.023 (0.044)
Access to market information (Yes = 1)	0.125 *** (0.030)	0.169 *** (0.035)	0.177 *** (0.035)	0.093 *** (0.028)	0.141 *** (0.038)
Distance to nearest paved road	−0.006 (0.009)	−0.012 (0.010)	−0.004 (0.011)	−0.013 (0.010)	−0.000 (0.013)
Access to off-farm employment (Yes = 1)	−0.000 (0.030)	0.067 * (0.035)	0.009 (0.035)	−0.012 (0.028)	0.014 (0.039)
Access to non-farm self-employment (Yes = 1)	0.038 (0.030)	0.028 (0.033)	−0.003 (0.034)	0.073 *** (0.027)	0.034 (0.039)
Household asset holding (asset score)	0.000 *** (0.000)	0.000 *** (0.000)	0.000 *** (0.000)	0.000 (0.000)	0.000 ** (0.000)
Household resides in Ilolo village	0.048 (0.055)	−0.073 (0.066)	0.014 (0.069)	−0.086 (0.057)	0.081 (0.079)
Household resides in Ndebwe village	0.055 (0.035)	−0.016 (0.042)	0.061 (0.042)	0.007 (0.035)	0.046 (0.046)
Constant	1.286 *** (0.136)	1.489 *** (0.160)	1.407 *** (0.163)	1.785 *** (0.129)	1.933 *** (0.181)
ln(alpha)					−3.447 (0.308)
Alpha					0.823 (0.075)
Observations Wald chi2 Probability > chi2 Pseudo R2	449 139.84 0.00 0.027	449 162.66 0.00 0.038	449 135.11 0.00 0.031	449 86.41 0.00 0.017	449 107.96 0.00 0.044

Table A3. Determinants of food consumption diversity in Kilosa (Production diversity indicator used: crop-livestock count).

	HDDS	HDDS (Planting)	HDDS (Pre-Harvest)	HDDS (Post-Harvest)	FVS
Crop-livestock count	0.001 (0.007)	0.016 ** (0.005)	0.008 (0.005)	0.006 (0.005)	0.008 (0.008)
Age of HH head (years)	−0.002 ** (0.001)	−0.001 (0.001)	−0.000 (0.001)	−0.000 (0.001)	−0.002 ** (0.001)
Gender of HH head (Male = 1)	0.008 (0.032)	0.007 (0.029)	−0.001 (0.028)	−0.023 (0.024)	0.015 (0.039)
Education of HH head (School years)	0.003 (0.004)	0.002 (0.003)	0.004 (0.003)	0.004 (0.003)	0.001 (0.005)
Land size owned (ha.)	0.008 (0.007)	0.014 *** (0.005)	0.010 ** (0.005)	0.012 *** (0.004)	0.007 (0.008)
Livestock owned (TLU)	−0.002 (0.001)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	−0.004 ** (0.002)

Table A3. *Cont.*

	HDDS	HDDS (Planting)	HDDS (Pre-Harvest)	HDDS (Post-Harvest)	FVS
Labor (Worker equivalents)	0.007 (0.009)	−0.001 (0.008)	0.005 (0.006)	0.006 (0.005)	0.012 (0.011)
Per capita per month: Low-middle	0.051 (0.042)	−0.041 (0.035)	−0.025 (0.037)	−0.019 (0.030)	0.092 * (0.053)
Per capita per month: Middle	0.097 ** (0.039)	0.020 (0.030)	0.057 * (0.030)	0.036 (0.026)	0.135 *** (0.051)
Per capita per month: High-middle	0.117 *** (0.038)	−0.010 (0.030)	0.028 (0.029)	0.016 (0.025)	0.167 *** (0.049)
Per capita per month: High	0.154 *** (0.034)	0.040 (0.028)	0.053 ** (0.027)	0.038 * (0.022)	0.192 *** (0.044)
Share of home consumption	−0.036 (0.031)	−0.036 (0.026)	−0.028 (0.027)	−0.034 (0.023)	−0.048 (0.039)
Access to market information (Yes = 1)	0.063 ** (0.027)	0.039 * (0.023)	0.024 (0.023)	0.038 * (0.021)	0.071 ** (0.033)
Distance to nearest paved road	−0.033 *** (0.007)	−0.015 ** (0.006)	−0.009 (0.006)	−0.013 ** (0.005)	−0.042 *** (0.009)
Access to off-farm employment (Yes = 1)	−0.065 ** (0.029)	−0.051 ** (0.024)	−0.029 (0.024)	0.017 (0.018)	−0.102 *** (0.036)
Access to non-farm self-employment (Yes = 1)	0.051 * (0.026)	0.027 (0.021)	0.044 ** (0.019)	0.039 ** (0.017)	0.075 ** (0.034)
Household asset holding (asset score)	−0.000 (0.000)	−0.000 (0.000)	−0.000 (0.000)	−0.000 (0.000)	−0.000 (0.000)
Household resides in Ilakala village	−0.013 (0.028)	0.004 (0.024)	0.010 (0.024)	−0.012 (0.022)	−0.018 (0.033)
Household resides in Nyali village	0.007 (0.030)	0.064 *** (0.025)	0.049 ** (0.025)	0.040 * (0.023)	0.036 (0.037)
Constant	1.970 *** (0.077)	1.983 *** (0.072)	1.951 *** (0.069)	2.010 *** (0.063)	2.335 *** (0.099)
Observations Wald chi2 Probability > chi2 Pseudo R2	450 119.35 0.00 0.021	450 56.28 0.00 0.009	450 45.14 0.00 0.006	450 48.03 0.00 0.005	450 119.33 0.00 0.039

Table A4. Determinants of food consumption diversity in Kilosa (Production diversity indicator used: Number of food groups produced).

	HDDS	HDDS (Planting)	HDDS (Pre-Harvest)	HDDS (Post-Harvest)	FVS
Number of food groups produced	0.009 (0.009)	0.014 (0.010)	0.006 (0.010)	0.004 (0.009)	0.015 (0.011)
Age of HH head (years)	−0.002 ** (0.001)	−0.001 (0.001)	−0.001 (0.001)	−0.000 (0.001)	−0.002 ** (0.001)
Gender of HH head (Male = 1)	0.012 (0.035)	0.021 (0.036)	0.003 (0.035)	−0.028 (0.031)	0.013 (0.040)
Education of HH head (School years)	0.003 (0.004)	0.003 (0.004)	0.006 (0.004)	0.005 (0.004)	0.001 (0.005)
Land size owned (ha.)	0.009 (0.008)	0.018 ** (0.007)	0.013 * (0.007)	0.016 *** (0.006)	0.008 (0.010)
Livestock owned (TLU)	−0.002 * (0.001)	0.002 ** (0.001)	0.001 * (0.001)	0.001 ** (0.001)	−0.003 (0.003)
Labor (Worker equivalents)	0.000 (0.010)	−0.007 (0.011)	0.001 (0.009)	0.001 (0.008)	0.012 (0.011)
Per capita per month: Low-middle	0.084 * (0.046)	−0.035 (0.045)	−0.003 (0.046)	−0.003 (0.040)	0.091 * (0.053)
Per capita per month: Middle	0.120 *** (0.044)	0.037 (0.041)	0.088 ** (0.041)	0.056 (0.036)	0.135 *** (0.050)
Per capita per month: High-middle	0.147 *** (0.045)	−0.024 (0.043)	0.030 (0.040)	0.015 (0.037)	0.167 *** (0.050)
Per capita per month: High	0.172 *** (0.040)	0.049 (0.040)	0.064 * (0.038)	0.040 (0.034)	0.192 *** (0.048)

Table A4. *Cont.*

	HDDS	HDDS (Planting)	HDDS (Pre-Harvest)	HDDS (Post-Harvest)	FVS
Share of home consumption	−0.025 (0.034)	−0.071 ** (0.036)	−0.053 (0.035)	−0.065 ** (0.031)	−0.053 (0.039)
Access to market information (Yes = 1)	0.047 (0.030)	0.048 (0.031)	0.034 (0.030)	0.050 * (0.028)	0.074 ** (0.034)
Distance to nearest paved road	−0.029 *** (0.009)	−0.021 ** (0.008)	−0.014 * (0.008)	−0.020 *** (0.007)	−0.043 *** (0.010)
Access to off-farm employment (Yes = 1)	−0.082 ** (0.034)	−0.082 ** (0.032)	−0.038 (0.032)	0.014 (0.026)	−0.102 *** (0.039)
Access to non-farm self-employment (Yes = 1)	0.041 (0.029)	0.038 (0.030)	0.061 ** (0.029)	0.067 *** (0.026)	0.072 * (0.040)
Household asset holding (asset score)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	−0.000 (0.000)	−0.000 (0.000)
Household resides in Ilakala village	−0.035 (0.031)	−0.007 (0.033)	0.004 (0.032)	−0.026 (0.029)	−0.018 (0.037)
Household resides in Nyali village	−0.041 (0.034)	0.079 ** (0.034)	0.063 * (0.035)	0.047 (0.032)	0.040 (0.041)
Constant	1.638 *** (0.084)	1.793 *** (0.093)	1.757 *** (0.090)	1.826 *** (0.082)	2.321 *** (0.096)
Observations	450	450	450	450	450
Wald chi2	104.02	59.67	48.72	56.58	93.54
Probability > chi2	0.00	0.00	0.00	0.00	0.00
Pseudo R2	0.019	0.013	0.009	0.009	0.040

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Quantifying Postharvest Loss and the Implication of Market-Based Decisions: A Case Study of Two Commercial Domestic Tomato Supply Chains in Queensland, Australia

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Abstract: Using a multi-disciplinary approach, this study quantifies horticultural postharvest losses of two medium-sized (annual pack volume 4500 t) commercial, domestic, tomato supply chains. Quantification of loss was based on weight or volume, consistent with direct measurement methods of the *Food Loss and Waste Accounting and Reporting Standard 2016* and qualitative techniques were used to identify the drivers of the loss and contextualise the findings. Postharvest loss was found to be between 40.3% (55.34 t) and 55.9% (29.61 t) of the total harvestable product. It was determined that between 68.6% and 86.7% of undamaged, edible, harvested tomatoes were rejected as outgrades and consequently discarded due to product specifications. Between 71.2% and 84.1% of produced tomatoes were left in the field and not harvested. This study highlights significant factors contributing to high levels of food loss and waste. Edible products are being removed from the commercial food supply chain, rejected as outgrades deemed cosmetically defective due to market-based decisions. With only 44.1% and 59.7% of the harvestable crop reaching the consumers of the two supply chains, respectively, it is perhaps more appropriate to describe a food "waste" chain as opposed to a food "supply" chain.

Keywords: food security; horticulture; tomato; postharvest loss; food loss and waste; private food policy and standards; destination of loss

1. Introduction

Feeding a global population of 9.5 billion by 2050 is anticipated to become one of the greatest challenges of our time [1–3]. Rapid population growth [1,3–7], decreasing agricultural productivity [8–10], climate change [3,10,11], natural resource scarcity [3,12], and biofuel production [3,13–18] collectively undermine the current and future capacity of global food production systems. The risk of food insecurity is no longer a challenge exclusive to lesser-developed countries. In Australia, one in six Australians reported having experienced food insecurity in 2016 [10], with an estimated 2 million people having sought food relief [19,20].

While there have been considerable effort to identify strategies to enhance and diversify current food production systems [4,5,9], of equal importance is an increasing realisation of significant inefficiencies in the global food system due to food loss and waste (FLW) [6,21–25]. Global FLW has been estimated to represent 27% to 50% of total agricultural production [26–31]. Annually, there is around 4 Mt or AUD8 billion worth of FLW in Australia, 33% of which is horticultural product [19,32,33]. Due to their relative perishability, horticultural products are considered particularly vulnerable to elevated losses. Until recently, reliable and systematic estimations of global FLW have been difficult to

determine, due to an absence of a universal and consistent quantification methodology for reporting and managing food removed from the food supply chain [31,34–36]. In response, the Food Loss and Waste Protocol was established in 2013, with the first international *FLW Accounting and Reporting Standard* ratified in June 2016 during the Global Green Growth Forum (3GF) in Copenhagen.

FLW within commercial food supply chains is shaped by multifarious contributors, including various types of production system inefficiencies and consumer behaviour [21,23,24,27,28]. Of increasing concern and importance is the discourse between the food marketing and consumer purchasing behaviour that is perpetuating FLW throughout the food supply chain [3,6,22,25,31,37,38]. Supermarkets showcase only premium and unblemished product, fabricating unrealistic expectations of how fruits and vegetables should appear. Accordingly, consumers often equate food safety and freshness with elevated cosmetic standards. In combination, these factors have created intrinsically wasteful food systems [1,3,19,22,24,25,27,29,31,35,39]. Private food policy and standards aligned with marketing campaigns often reinforce high levels of FLW via cosmetic product specifications and use-by-dates, driving losses up-stream within the food supply chain [3,19,37].

In seeking to address FLW, potential remediation strategies are predominantly directed at the consumer-end of the food supply chain, in part due to difficulties in quantifying loss at the primary production stages [6]. Highlighting this fact, a newly established protocol for quantification of FLW [40] specifically quantifies postharvest losses, deliberately excluding pre-harvest losses and consumer waste. There is a premise that commercial farms, operating highly mechanised and technology-centric agricultural production systems have achieved an optimum level of FLW minimisation [31,41]. While it is intuitive to presume low levels of FLW within technology-dense horticultural supply chains, there is increasing evidence to the contrary [21,22,25,27,28,42] proposing that such production systems may in fact be more wasteful given the stringent adherence to private food policy and standards.

This study sought to quantify horticultural postharvest losses associated with a highly mechanised commercial tomato enterprise with access to appropriate and effective postharvest handling equipment and infrastructure. The aim of this study was to document accumulative and overall postharvest losses, and to better understand the impacts of technology (e.g., packing shed mechanisation and grading/sorting automation), supply chain length (distance, time, and biophysical conditions), and private food policy and standards (i.e., supermarket standards and product specification) on FLW. To do so, a multi-disciplinary approach was undertaken, based on quantitative documentation of postharvest losses and handling conditions, and qualitative techniques to identify the drivers of the loss and contextualise the findings within the food supply chain.

2. Materials and Methods

2.1. Experimental Design

Two medium-sized (annual pack volume 4500 t) commercial domestic tomato supply chains, with product sourced from the same farm but with divergent market destinations and associated transport distance were assessed. Harvesting and handling practices and biophysical conditions were documented, postharvest loss along the food supply chain was quantified by weight, and interviews were conducted to evaluate how supply chain actors influenced postharvest losses in their decision-making. This study was collectively undertaken in November to December 2014. FLW calculations included postharvest and destination of loss, but did not include pre-harvest losses and consumer waste. However, an opportunistic and independent assessment of pre-harvest losses was undertaken and documented here, but losses were not included with the total postharvest loss for the supply chains assessed. Terminology used in this paper is based on the *FLW Accounting and Reporting Standard 2016*, with destination of loss referring to the end use or destination of product removed from the commercial food supply. Pre-harvest loss, such as weather or pest-related damage is about maximising potential, as opposed to addressing losses of material ready for harvest or in subsequent stages of the food supply chain [40].

2.2. Study Location and Production System

The farm selected for this study was located in Queensland's Bundaberg region, one of Australia's largest tomato production regions, with an annual farm-gate value of AUD500 million [43]. The selection of the farm was undertaken in consultation with the Bundaberg Fruit and Vegetable Growers Association to ensure production; postharvest handling and transport practices were typical for the region. The farm, located in Elliot Heads (Figure 1), was supplying tomatoes (*var. Lava)* to domestic markets in either Brisbane or Bundaberg. Product for the two trials was sourced from separate harvests in the spring/summer season of 2014. Both supply chains were based on tomatoes being trellis-grown in an open field with a rain-fed production system, and incorporated mechanized harvesting, modern and efficient packaging and grading equipment, and access to cool storage infrastructure.

Figure 1. Map of study area, Bundaberg, Queensland.

2.3. Supply Chains Assessed

The first supply chain (SC1) involved product sourced during the mid-season harvest (11–18 November) using a mechanical harvest aid, transportation to a commercial packing shed for sorting, grading, packing, and refrigerated storage, then transportation by a fully-enclosed, refrigerated semi-trailer truck to the Rocklea Wholesale Fruit and Vegetable Market, Brisbane, and further transportation by a fully-enclosed, unrefrigerated light truck to a retail outlet in Morningside, Brisbane.

The second supply chain (SC2) involved the same commercial farm and associated harvesting and pre-distribution practices, however, product was sourced from a harvest one month later (10–13 December) at the end of season and was instead transported by a small, fully-enclosed, unrefrigerated truck to a small local wholesale/retail outlet in Bundaberg.

2.4. Quantification of Loss

2.4.1. Field and Packing Shed Horticultural Postharvest Losses

Quantification of loss was based on weight or volume, consistent with direct measurement methods of the *FLW Accounting and Reporting Standard* [40]. Field losses were determined by counting the number of individual pieces of fruit of commercial maturity (one-quarter to full-colour fruit) that remained in-field immediately following a completed harvesting cycle, based on a sub-sample of 608.18 kg, within a transect of 1311.80 m^2. Field losses were then calculated relative to a total harvested area of 8.5 and 12.14 ha respectively for SC1 and SC2. Field loss was defined as mature fruit left on the vine or product on the ground left by the harvest aid and/or bucket pickers, or discarded from the harvest aid where preliminary discarding of product was performed. The primary destination of all field loss was via 'land application'. 'Land application' is the term used to describe the destination whereby losses are discarded through spreading, spraying, injecting, or incorporating organic material onto or below the surface of the land to enhance soil quality [40].

During the harvest of SC1, a sub-sample of 100 fruits was taken to determine the mean weight of a single tomato at the field and packing shed stages of the supply chain. During the harvest of SC2, three random sub-samples of discarded field and shed product were utilised to determine the causal factors of out-grading. Product that left the supply chain was deemed unsalable based on product specification (i.e., physical blemishes/abrasions, size and shape), colour and maturity, or physical damage (punctures or pathogenic deterioration).

Postharvest loss in the on-farm packaging shed was calculated based on the volume of product removed during sorting and grading, proportional to total volume of product initially arriving at the shed. Packing shed volumes were based on a count of harvest bins with a mean net weight of 330 kg, entering and leaving the packing shed during a complete harvesting cycle. Saleable product was packaged in 10-kg cardboard cartons, and pre-cooled prior to transportation to market within 24 h. The destinations of packing shed losses were partially quantified; they were used for 'land application' and 'animal feed'. 'Animal feed' refers to destination of loss by diverting material from the food supply chain (directly or after processing) to animals [40]. Truck transport for the discarded product was empty at the commencement and cessation of the sampling period. To further validate loss at this stage, packing shed losses were recorded for a further two days consecutive to the SC2 trial period using the same method.

As SC2 represented a late seasonal harvest and was immediately followed by an abrupt cessation of seasonal harvesting due to depreciation of the market, we were also able to determine pre-harvest loss and destination of loss, independent of the SC1 and SC2 postharvest loss trials. Pre-harvest loss included unharvested product from the commercial harvesting cycle, being mature residual product remaining in-field on or off the vine, at the cessation of the commercial harvesting season. On completion of seasonal harvesting a field of 3.64 ha was defoliated in preparation for the next seasons planting. An assessment of pre-harvest loss was undertaken to determine percentage loss relative to the volume of the entire seasonal harvest for the field. Twenty-six trellises were randomly selected within the field of 8400 trellises. The number of individual fruits remaining on each vine was counted and recorded for each trellis and later extrapolated across the field's entire seasonal harvest based on carton volume leaving the farm.

2.4.2. Wholesale and Retail Horticultural Postharvest Losses

Wholesale and retail losses were determined by individually counting the number of unsaleable fruit based on a sub-sample of 3 × 10.80-kg cartons at the wholesale stage, and a subsequent 1 × 10.80-kg carton at the retail stage. Wholesale losses of the sub-sample were determined on point of arrival at market. Retail losses of the sub-sample were determined at the end of the retail period, when the last of the sub-samples was sold to consumers. For SC1, this was done using simulated conditions following a period of refrigerated storage with the retailer. The sub-sample was collected from the retailer to be

held under ambient conditions for 24 h simulating the display period prior to consumer purchase in the retail store. For SC2, the wholesale and retail enterprises were combined, located within the same outlet. Wholesale losses were determined as in SC1. Retail losses were determined by the retailer using a logbook to document daily losses, consistent with the *FLW Accounting and Reporting Standard 2016* [40].

2.5. Bio-Physical Postharvest Conditions

Temperature management along the supply chain was assessed to determine whether storage conditions were a potential contributor to observed postharvest losses. Postharvest storage conditions were assessed based on continuous sub-sampling of mean fruit core temperature from point-of-harvest to retail point-of-sale using an EcoScan Temp 5 with thermistor probe (Eutech Netherlands). In SC2, the storage and transport temperature was also continuously recorded every 2 min using a Tiny Tag Tansit-2 temperature logger (Gemini Data loggers, West Sussex, UK). Temperature loggers were located centrally within the product load during harvest, storage and transport.

Truck routes were concurrently recorded every 2 s, using a Super Trackstick® (Telespial Systems Inc., Burbank, CA, USA) with global positioning system (GPS) referencing uploaded onto Google Earth™. All loggers and GPS devices were time-synchronised to allow spatial and temporal cross-referencing of truck speed and product temperature.

2.6. Informal and Semi-Structured Interviews

Nineteen informal interviews (Table 1) along both supply chains were undertaken to understand the decision-making of supply chain actors and how these factors influenced postharvest losses. Interviews were conducted on-farm concurrent to the quantitative assessment, as farm workers went about their daily duties, with each interview lasting up to 20 min. Following the supply chain assessments, five semi-structured interviews (Table 2) with key supply chain actors and industry specialists were undertaken to reflect on findings and investigate the drivers and impacts of FLW, specifically drawing on the role of technology, supply chain length, and private food policy and standards. With participant consent, all interviews were audio-recorded and transcribed verbatim. Standard thematic analysis techniques were used, supported by NVivo qualitative data analysis Software (QSR International Pty Ltd., version 11.4.0). All subjects gave their informed consent for inclusion prior to participation in the study. The study was conducted in accordance with the Declaration of Helsinki, and the protocol was approved by the Ethics Committee of the University of the Sunshine Coast (HREC S/14/691).

Table 1. Informal interviews—list of supply chain actors interviewed.

Reference	Interview Location	Number of Interviewees
Labour contractor	Field	1
Fruit picker	Field	1
Field supervisors	Field	3
Fruit sorters	Packing shed	4
Fruit packer	Packing shed	1
Growers	Office shed	2
Packing shed supervisor	Packing shed	1
Farm forklift and truck operator	Packing shed	1
Ex-wholesale agent	Packing shed dispatch	1
Wholesale agent	Brisbane Market	1
Retailers	Brisbane Market and Retail Outlet	2
Retail manager	Bundaberg Wholesale Outlet	1
Total		19

Table 2. Semi-structured interviews—list of industry specialists interviewed.

Reference	Industry Experience (year)	Location/Duration
Extension officer 1	35	Telephone, 34 min
Extension officer 2	30	Telephone, 47 min
Grower 1	42	In person, 24 min
Grower 2	40	In person, 19 min
Academic, emeritus professor of rural sociology	40	Telephone, 1 h 11 min

No statistical analysis was undertaken in this case study as data was based on overall actual loss at each point along the chain, rather than replicated mean sub-sampling. This approach is consistent with recent FLW studies [44–46] and reflects an emphasis on comparative loss along the chain rather than specific loss.

3. Results

3.1. Quantification and Destination of Horticultural Postharvest Loss

3.1.1. Quantification of Loss

Supply chain one involved a total 137.41 t of harvestable product. Between the point-of-harvest and the retail point-of-sale, 55.34 t or 40.3% of harvestable product was removed from the commercial supply chain (Table 3). A total of 28.7% (39.4 t) of harvestable product was discarded in-field. Packing shed losses were 10.8% (10.56 t), based on the total volume of product entering the shed of 98.01 t (Table 3). Following grading, sorting and packing, a consignment of 4128 cartons was transported 392 km from the farm to the Rocklea Market, Brisbane. On arrival at the market, 7 h 20 min after leaving the farm, the consignment was moved into refrigerated storage, with no observed postharvest losses on arrival (Table 3). At 28 h, product was moved to the market floor where it was held at an ambient temperature for 3 h before being transported to the Morningside retail outlet, 14.2 km from the Rocklea Market. At 5 days of retail storage and display, 5.4% (5.38 t) of the product was deemed unsaleable by the retailer, with 100% of the loss going to landfill (Table 4).

Supply chain two involved a total 52.96 t of harvestable product. Between the point-of-production and the retail point-of-sale, 29.61 t or 55.9% of harvestable product was removed from the commercial supply chain (Table 3). A total of 47% (24.9 t) of harvestable product was discarded in-field. Packing shed losses were 14.1% (3.96 t), based on the total volume of product entering the shed of 28.05 t (Table 3). When averaged with two consecutive days', mean packing shed losses were 14.6%, based on the total volume of product entering the shed. A consignment of 300 cartons was transported 19.1 km from farm to a local wholesale/retail market in Bundaberg. On arrival at the market, 1.5 h after leaving the farm, the consignment was moved into refrigerated storage, with no observed postharvest losses on arrival (Table 3). At 17 h product was moved to a refrigerated display where it remained until it was sold, 12 h later. At 2.5 days of retail storage and display, the retailer deemed 2.4% (0.74 t) of the product unsaleable, with 100% of the loss going to landfill (Table 4).

Despite a lower total at-harvest yield, SC2 had proportionally higher postharvest losses in the field and packing shed when compared to SC1 (Table 3). The reason for this variability is thought to be due to differences in out-grading. Supply chain two did not include a third-grade product and harvesting cycles were more frequent, every one to two days, with less fruit on the vine. Supply chain one involved picking and packing all sizes and colours, with less frequent harvesting cycles, every third day, with more fruit on the vine. Differences in transport distance between SC1 (392 km) and SC2 (19 km) had no tangible impact, with no determined wholesale loss in either chain.

Table 3. Percent of actual and cumulative losses by location within the supply chain where postharvest loss was determined, and calculation of the percentage of harvested product made available to the consumer.

Location of Loss (Postharvest Stage)	Supply Chain One (SC1)			Supply Chain Two (SC2)		
	Actual Loss [a] (%)	Loss as a % of Potential Harvest [b]	Loss as a % of Overall Loss [c]	Actual Loss [a] (%)	Loss as a % of Potential Harvest [b]	Loss as a % of Overall Loss [c]
Field	28.7	28.7	71.2	47.0	47.0	84.1
Packing shed	10.8	7.7	19.1	14.1	7.5	13.4
Wholesale	0	0	0	0	0	0
Retail	5.4	3.9	9.7	2.4	1.4	2.52
Total		40.3	100		55.9	100
Percentage available for consumption		59.7			44.1	

[a] Percent actual loss is the amount of loss specific to a defined point along the supply chain. [b] Percent accumulative loss is the actual loss at each point along the supply chain relative to the total potential harvest (i.e., to include point-of-harvest field loss). [c] Percent loss at each point along the supply chain relative to overall loss.

Table 4. Destination of loss.

Destination of Loss	Supply Chain One (SC1) Percentage Loss	Supply Chain Two (SC2) Percentage Loss
Not harvested [a]	71.2	84.1
Land application [b]	17.2	12.0
Landfill [c]	9.7	2.5
Animal feed [d]	1.9	1.3

[a] Product (tomato) not harvested and left in the field or tilled back into the soil; [b] Product that was used as organic material on or below the surface of the land to enhance soil quality; [c] Product removed from the farm to an area of land or an excavated site specifically designed and built to receive wastes; [d] Diverting material from the food supply chain (directly or after processing) to animals.

3.1.2. Destination of Losses

In SC1, of the total loss, 71.2% (39.4 t) of harvestable product was left in the field and not harvested, 17.2% (9.5 t) was disposed of via land application, 9.7% (5.39 t) became landfill, and 1.9% (1.05 t) was used as animal feed on an adjacent property (Table 4). For SC2, 84.1% (24.9 t) of harvestable product was left in the field, 12% (3.56 t) was disposed of via land application, 2.5% (0.75 t) became landfill, and 1.3% (0.4 t) was used as animal feed (Table 4). Based on the cumulative destination of loss for SC1 and SC2, the volume of product available for consumption was 59.7% and 44.1% respectively (Table 3).

3.2. Drivers of Loss

3.2.1. Biophysical Conditions

During harvest in SC1, internal fruit core temperature did not exceed 28.4 °C (Figure 2). Following packaging, the fruit was cooled to 13.2 °C prior to transport. Transport temperature was from 10.2 °C to 12 °C. When moved to the market floor, core temperature increased, peaking at 18 °C. Product was then stored by the retailer between 13.8 °C and 17 °C. Once moved from refrigerated storage to display, the core temperature slowly increased to a peak of 25 °C. While there was minor difference in terms of specific temperature, the overall temperature storage conditions recorded in SC2 were consistent with those of SC1.

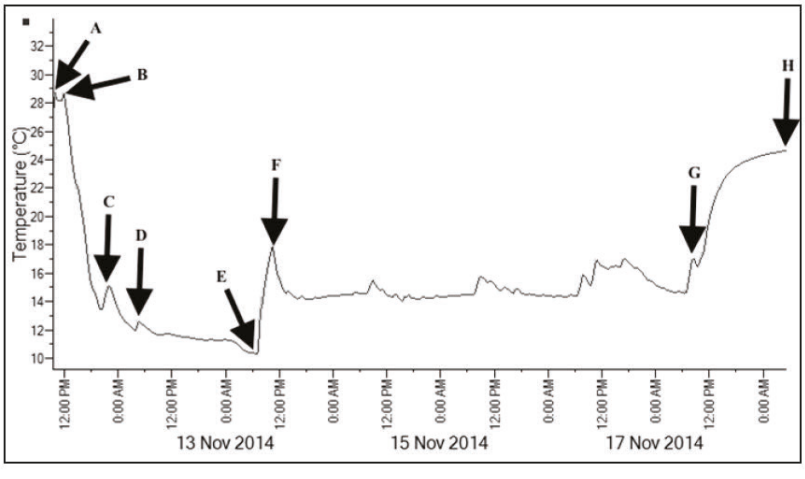

Figure 2. SC1 internal fruit core temperature of sub-sample from point-of-harvest to retail point-of-sale. (**A**) Product harvested; (**B**) Product packed into carton, moved to on-farm cold room; (**C**) Consignment collected by transport company from farm; (**D**) Truck arrives at Rocklea Market, Brisbane; (**E**) Consignment moved from wholesale cold room to market floor; (**F**) Consignment collected by retailer, transported to retail outlet, stored in cold room; (**G**) Moved to ambient display (**H**) Sold, probe removed.

3.2.2. Market Price

In SC2, 390.76 t of residual product was not harvested due an abrupt end to the season. These losses represent 94% of the entire season's harvest volume for the field. Grower 1, grower 2 and extension officer 2 identified the wholesale market price as a key driver of this loss. A grower is unable to recover operational costs of harvest when the farm-gate value of a carton (10.80 kg) falls below AUD7.50–8.00—a dollar value equal to the operational cost to harvest, pack and transport product to market. At this point, the farmer suffers production losses of AUD7.50 per carton based on combined production and operation costs of AUD15–15.50 per carton (Table 5). Grower 1 commented that *"The supply [was] far superior to . . . demand. We're getting towards the end of the line with our crop, so our quality is going to start dropping back. It's still quite good . . . in the box, but [we've] got to work harder at it. If [we] haven't got the right sizes [that is, product specified for orders] to get the better return, because the market is low, [we're] going to lose a lot of money so therefore [we] have to make the decision whether to cut [our] losses or continue."*

Table 5. Actual, calculated full day's postharvest losses (kg) and estimated economic loss and potential market value along the supply chain.

Location of Loss (Postharvest Stage)	Supply Chain One (SC1)			Supply Chain Two (SC2)		
	Actual Loss [a] (kg)	Calculated Loss of Entire Harvest (kg)	Financial LOSS [b] (AUD)	Actual Loss [a] (kg)	Calculated Loss of Entire Harvest (kg)	Financial Loss [b] (AUD)
Field	608.2	39,400	$29,550 ($39,400) [c]	269.1	24,906	$1880 ($24,906)
Packing shed	10,560	10,560	$7920.00 ($10,560)	3960	3960	$2970.00 ($3960)
Wholesale	0	0	$0.00 ($0)	0	0	$0.00 ($0)
Retail	0.6	5381	$4035.92 ($5381)	0.3	747	$560.43 ($747)
Total		55,341	$41,506 ($55,341)		29,613	$22,210 ($29,613)

[a] Actual loss is the amount of the loss sampled specific to a specific point along the supply chain. [b] Estimated production cost based on $7.50 per 10 kg carton (i.e., immediate loss to grower). Values are shown in AUD. [c] Estimated farm-gate value based on $10 per 10 kg carton.

3.2.3. Product Specification

The standards by which product is removed from the supply chain was variable and market dependent. It was determined that between 68.6% and 86.7% of undamaged, edible field and shed products were rejected as outgrades, and consequently discarded due to product specifications (Table 6). Interviews with supply chain actors involved in harvesting (Table 1), revealed that on any day specific instructions from field supervisors were critical in determining harvestable product. Field Supervisor 1 commented *"The size we pick depends on the days' price . . . if the price is a little bit high, the market wants the small tomatoes as well. Otherwise, if the price is low, . . . we do not pick the small stuff."* Interviews with sorters (Table 1) affirmed that high field and packing shed losses were mostly due to cosmetic appearance, with edible product being discarded. A sorter commented *"Sometimes [they're] too small . . . , too big . . . , too odd shaped—plus the markings [so we throw them out]"*. When there is an over-supply of volume, secondary lines are out-graded due to buyers tightening the specification in favour of premium product. However, standards are not only a reflection of supply and demand, but also a reduced market share, with increased competition from newer varieties coming onto the market, placing upward pressure on standards. Grower 1 explained *"it has changed dramatically in the last 10 or 15 years but particularly in the last 4 years. our market share has diminished a lot...when I first started, there was only round [tomatoes], there was nothing else. there wasn't even romas . . . [now] 42 years later . . . a decent retail shop . . . could have 15 lines of tomatoes. A housewife . . . might pick a few gourmets, a couple of romas, a few cherries, and couple of teardrop, maybe a truss, whatever suits."* due to a reduced market share and in the absence of new market opportunities, it is likely that levels of postharvest losses at the primary production stage will increase in subsequent years. Private supermarket policy and standards were mentioned by most supply chain actors and industry specialists as a driver of postharvest losses via stringent specifications and the ability to reject product, by the pallet, based on a single blemish. The practice of supermarkets over-ordering and then having a pick of premium product was highlighted by

extension officer 1 *"they pick and choose and they control the market"*. Another example of an asymmetric supermarket practice likely to elevate postharvest loss is the re-negotiation on price due to subjective quality standards. Extension officer 1 revealed that *" . . . you'll lock in a price . . . two weeks ahead, which is what you have to do . . . and if there is a change in market, you can bet your bottom dollar that [your product is] going to be rejected [in part or full] . . . because [the supermarkets] will go and buy if off the [market] floor at a cheaper price."*

Table 6. Identified reasons for product being removed from the commercial supply chain, expressed as a percent of total losses in the field or in the packing shed.

Postharvest Descriptor			Loss (%)
During harvesting [a]			
	Undamaged, edible product		86.7
		Field blemish	60.2
		Size	8.9
		Irregular shape	17.7
	Damaged product		11.5
		Physically damaged	0.9
		Insect damage	0.9
		Overripe	5.3
		Diseased	4.4
	Other		1.8
		Harvesting error [c]	1.8
Packing shed [b]			
	Undamaged, edible product		68.6
		Field blemish	37.3
		Size	16.7
		Irregular shape	14.7
	Damaged product		30.4
		Physically damaged	3.9
		Overripe	11.8
		Diseased	14.7
	Other		1.0
		Harvesting error	1.0

[a] Includes losses collected off the ground, walking behind harvest aid during harvest, and losses thrown away by sorters on harvest aid in field. Sample number (harvesting) = 113. [b] Collected off waste conveyer from the first sorting point in packing shed. Sample number (packaging shed) = 102 [c] Mistakenly harvested, likely due to being knocked from bush during harvest.

Discussion with industry specialists (Table 2) focused on the wider consumer purchasing and behaviour elements that underpin private food standards. Extension officer 1 stated that *"perfect fruit [was] the crux of the whole matter"*, commenting that *"as an agricultural society we have not done enough work in educating the consumer"* about produce, particularly produce appearance and the purpose of used-by-dates. In support of this view, extension officer 2 likened the supermarket standards to expecting produce to *"conform like a packet of Arnott's biscuits!"*. The academic summarised that *"Supermarkets have gained a lot of power, and with that power they are imposing their own rules and standards,"* they *"demand from their wholesalers and primary suppliers exactly [what they] want."* He continues, *"this is*

important because [supermarkets] have been imposing more stringent standards and . . . the growers . . . have got to abide by very, very, particular standards." He finishes stating that *"the rigid regime . . . probably does lead to food waste in the field."*

3.2.4. Technology and Supply Chain Length

Counterintuitively, extension officer 2 and the ex-wholesale agent both viewed technology as a driver of postharvest loss, specifically packing shed mechanisation. Technologies such as laser colour graders have enabled growers to consistently produce uniform product that conforms with stringent specifications escalating volumes of out-graded product. While transport distance was not considered a contributor to postharvest loss, behavioural practices of supply chain actors were, with retailer 1 commenting, *"You could have two people in the chain, and if one of them doesn't care about how he handles the fruit, you're going to have [postharvest loss]"*.

4. Discussion

Postharvest loss in the two commercial tomato supply chains assessed in this case study was between 40.3% (55.34 t) and 55.9% (29.61 t). The highest incidence of postharvest loss occurred at the harvesting and grading stages of the supply chains, including field and packing shed losses, accounting for between 90.3% and 97.5% of overall losses. The lowest incidence of postharvest loss occurred after the farm-gate, accounting for between 2.5% and 9.7% of overall losses. Retail losses were 2.4% and 5.4%, with the highest incidence in SC1, which was the longer (by distance and time) of the two supply chains. Destination of loss was predominantly to land application, due to the high incidence of point-of-harvest field loss. It is difficult to contextualise these findings due to few comparable horticultural FLW studies of technology-dense supply chains, with no previous FLW assessment of tomato supply chains in developed counties identified in the literature. In an older study Parfitt et al. [31] reported postharvest losses in tomatoes of 18% to 43% in Egypt. Underhill and Kumar [45], in an assessment of smallholder farmer tomato supply chains in Fiji, found destination losses of 60.8%, whereas a Cambodian study found losses between 22.5% and 23% in a comparative study between traditional and modern supply chains [47]. None of these studies assessed in-field point-of-harvest losses, so it is difficult to draw a meaningful conclusion as to relative postharvest losses observed in the two supply chains. Given the importance of global tomato production [48], the apparent dearth of previous FLW tomato studies, especially pertaining to developed countries, is interesting. In comparison to global FLW loss, where it is widely accepted that one-third of total agricultural production is lost or wasted along current food supply chains [27], the level of FLW within the two Bundaberg tomato chains appears to be comparatively high.

The finding that loss was concentrated at the primary production end of the chain is consistent with a study [27] of FLW in North America and Oceania, where 26% of FLW was attributed to the primary production level and 12% to the distribution and retail stages [27]. However, the present results are inconsistent with Lipinski et al. [24] who reported 24% of total production was lost at the point of production, and another 24% during transport and storage, and Griffin et al. [42] who found losses of 20% at primary production, 1% during processing and 19% during distribution. An American report described losses of 15% to 35% at the production stage and 27% at the retail level [30]. While much of the current literature advocates equal losses between the retail and primary production ends of the supply chain, the omission or limited inclusion of point-of-harvest loss would appear to have resulted in proportionally higher losses elsewhere along the chain. Results in this study were consistent with the consensus that horticultural commodities experience comparatively higher FLW than most other commodities, with FLW at around 50% of total production [28,36,39,49]. Postharvest losses in our study exceeded findings of a synthesis report [49] indicating horticultural postharvest losses in a developed country between 2% and 23% at the production end, dependent on horticultural commodity. However, our study was more consistent with an Iranian study [50] finding postharvest losses in strawberries of 35% to 40% and a study from the United Kingdom [39] stating that characteristic

losses for fresh vegetables could be as high as 50% in the primary production stages of a fresh food supply chain.

Few studies of FLW have sought to quantify and segregate destination of losses [28,29,39,42]. Noting the exclusion of in-field point-of-harvest losses in quantifying FLW in those studies, it is not surprising that landfill, rather than land application, is the predominant destination of loss.

High levels of FLW are immanent to horticultural production systems of developed countries, driven by fierce competition and financial incentives that have crafted the current 'business model' that favours wasteful practices [2,28,35,39]. Edible products are being removed from the commercial food supply chain as outgrades deemed cosmetically defective [31]. Private standards, prescribing 'perfect' product ensure high levels of FLW, inducing consumer intolerance of 'substandard' product and impacting purchasing behaviour [3,22,28,37]. Extension officer 2 broached the subject of consumer demand and the implications of those at the primary production level. Among consumers in developed countries, there was limited understanding around the implications and prevention of waste, [3,6,22,25,31,37,38] perpetuated by supermarkets who showcase only premium, unblemished product fabricating unrealistic expectations of how fruit and vegetables should appear.

The quantification of FLW in the context of high-technology production systems in developed countries has received relatively little attention. The premise that developed countries operate highly efficient agricultural systems optimising FLW minimisation [31,41], may in part explain this situation. Central to this view is a pre-occupation with consumer waste [6] in affluent populations as the largest and most visible portion of FLW [31,35] and that, given the inherent difficulty in changing human behaviour [24], no significant or further FLW reductions can be achieved [51]. In this study, to the contrary, the highest postharvest losses occurred at the primary production end of the chain. Discussions with industry experts revealed the potential role of technology, particularly packing shed mechanisation, in driving high levels of FLW due to uniformity of product in the sorting and grading processes. Contributing factors of FLW observed in the two tomato chains in the study were not due to poor postharvest or storage practices, or transport distance, but rather a series of commercial decisions. The most apparent driver was the cost-benefit of harvesting, based on market price, supply volume, and perceptions of retailer and consumer purchasing behaviour, which effectively made high levels of loss an economically acceptable outcome. The supply chain actors were both aware of the extent of loss and had strong and consistent views as to these key contributors. With only 44.1% and 59.7% of harvestable crop reaching the consumers of the two supply chains assessed, perhaps there should be discussion of a food "waste" chain as opposed to a food "supply" chain.

5. Conclusions

This study sought to quantify postharvest losses associated with a highly-mechanised enterprise to determine drivers of FLW independent of postharvest handling practices. The storage conditions observed for the packaged and ripening fruit along both chains were unlikely to have had any adverse effect on product shelf life or have been a contributor to postharvest loss [52,53]. In the context of the supply chains assessed, this study has demonstrated that postharvest loss is due to the deliberate and informed actions of supply chain actors, dictated predominantly by private food standards and market value rather than a lack of access to appropriate postharvest handling infrastructure. Stringent product specifications enforced via private food standards due to the combination of asymmetric supermarket business practices and consumer purchasing behaviour are considered by the supply chain actors to be the fundamental cause of high FLW. Given the notable lack of research on food loss and waste in developed countries, the results of this paper necessitate a greater research effort, particularly at the production end of the food supply chain.

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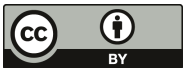

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Horticultural Loss Generated by Wholesalers: A Case Study of the Canning Vale Fruit and Vegetable Markets in Western Australia

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Abstract: In today's economic climate, businesses need to efficiently manage their finite resources to maintain long-term sustainable growth, productivity, and profits. However, food loss produces large unacceptable economic losses, environmental degradation, and impacts on humanity globally. Its cost in Australia is estimated to be around AUS$8 billion each year, but knowledge of its extent within the food value chain from farm to fork is very limited. The present study examines food loss by wholesalers. A survey questionnaire was prepared and distributed; 35 wholesalers and processors replied and their responses to 10 targeted questions on produce volumes, amounts handled, reasons for food loss, and innovations applied or being considered to reduce and utilize food loss were analyzed. Reported food loss was estimated to be 180 kg per week per primary wholesaler and 30 kg per secondary wholesaler, or around 286 tonnes per year. Participants ranked "over supply" and "no market demand" as the main causes for food loss. The study found that improving grading guidelines has the potential to significantly reduce food loss levels and improve profit margins.

Keywords: food loss; sustainability; food supply chain; food security; loss management; productivity

1. Introduction

Food loss is a serious global problem that needs immediate action [1]. The loss begins at the farm and continues throughout the food supply chain [2,3]. Fruits and vegetables are delicate products that are subjected to a number of natural and physical sources of deterioration during the marketing process that leads to food loss [4–10]. The high loss levels reported (typically ~35%) are serious threats to food security and the long-term economic sustainability of the food supply chain for present and future generations [1,11–13]. In addition, fruit and vegetable shortages resulting from loss can also contribute to commodity price increases [14–16]. Furthermore, food loss has a negative environmental impact on land usage, water resources, and the use of non-renewable resources such as fertilizer and energy that are utilized to produce, process, handle, and transport the food [17]. Because of the impact of food loss, government, industry, and community groups need to collaboratively work together to achieve policy and cultural change towards the prevention of loss at all levels in the food supply chain [18].

Food supply chains are complex networks consisting of several stages that begin at the farm and end on the proverbial plate of the consumer. Research into the various stages of a food supply chain concerned with fruit and vegetable loss have focused on producers [5,13,16,19–21], retailers [22–27], and consumers [19,28–31]. An often overlooked and rarely studied stage in the food supply chain is the wholesale sector and, as a result, very little reliable data is available. According to Cadilhon et al. [32], wholesale markets can be defined as physical places where supply chain actors (such as producers, processors, retailers, grocers, caterers) come together to buy and sell products to other professionals. Recently, Stenmarck et al. [33] discussed both retail and wholesale trade loss produced in several Nordic countries (Denmark, Finland, Norway, and Sweden). However, their study was based on a review of currently available literature and produced no new data quantifying the amounts of fruit and vegetable loss in the respective Nordic countries. The study did indicate that food loss amounts tended to vary depending on the individual characteristics of the respective retail and wholesale sectors in each country. The study also highlighted the need for further research into establishing the levels of loss in both the retail and wholesale sectors in the respective Nordic countries.

Like many other countries, the fruit and vegetable sector is an important component of the Australian economy. In 2015, Australia's fruit and vegetable production was estimated to be 5.77 million tonnes and valued at AUS $10.59 billion [34]. Most large Australian cities have wholesale markets to distribute fresh fruits and vegetables to a variety of retailers who will in turn supply smaller retail outlets in the surrounding regions [2]. The wholesale market investigated in the present study is located at Canning Vale (south of the states' capital, Perth, as shown in Figure 1) and plays an important role in the Western Australian economy. The present study, for the first time, identifies causes for and extent of food loss at the wholesaler stage for a major food value chain in the state of Western Australia. An innovation of the study is its examination of several approaches that can be applied to reduce and utilize food loss by wholesalers. Among the wholesalers, 53% were primary wholesalers (buy produce directly from growers) and 47% were secondary wholesalers (buy produce in bulk from primary wholesalers and supply to the local retail market, caterers, and customers with specific requirements). The study consisted of a ten-question survey that was distributed to all wholesalers, and their responses were recorded. The questions were designed to: (1) determine quantity of produce (fruits and vegetables) received and supplied; (2) estimate the level of fruit and vegetable loss; (3) quantify the ratio between supply and loss; (4) identify the key reasons for loss generation; and (5) identify loss reduction and innovations currently being applied or under consideration for future food loss reduction and utilization strategies.

2. Materials and Methods

2.1. Survey Methods and Questionnaires

The study collected primary data via a structured questionnaire aimed at businesses that receive and sell fresh fruits and vegetables at Market City Canning Vale, Perth, Western Australia. The market facility consisted of refrigerated warehouses throughout, including packaging and a number of open display areas, as seen in Figure 1b,c. Produce handled was largely domestically sourced (94%), with a small volume of imported crops (6%). Research in this field has shown that estimating the levels of fruit and vegetable loss is often difficult and in many cases not reliable. Historically, two main approaches have been used to measure food loss. The first approach actually measures what has been lost, but this implies knowledge of what was present at the outset and this is usually not the case [35]. The second approach uses an Investigative Survey Research Approach (ISRA) to elicit loss estimates from those involved in the food supply chain [36]. In the second approach, a structured questionnaire enables the collection of various information from respondents [37]. The questionnaire used in this study considered: (1) produce sold; (2) the amount of received produce in a week; and (3) the amount of produce loss per week. In addition, to assist wholesalers, all questions had multiple answer choices based on an extensive background literature review. Respondents were asked to choose the "most" or

"least" preferred answer choice. In this survey, loss was defined as the portion of fruits and vegetables that do not reach their natural destination. In this case, human consumption and losses result from spoilage, decay, or any other kind of deterioration. Furthermore, participants were not requested to provide information regarding any qualitative fruit and vegetable losses, but were asked their reasons for not selling and their opinions on future loss reduction and utilization methods. The reason behind this approach stems from previous studies that showed qualitative losses were much more difficult to determine than quantitative losses [16,38]. Importantly, poor produce quality attracts little consumer interest since factors such as appearance, taste, texture, and nutritional value are expected for premium quality fruits and vegetables [39]. Consumer dissatisfaction with quality results in lower market values and higher levels of produce loss [40,41]. However, in developed countries, quality management of fruits and vegetables is rigorously maintained, since consumer choice is the key to successful retail business outcomes. Thus, retailers have to know their customers' quality preferences and operate their quality practices accordingly to maintain optimum profitability. The present questionnaire focused on assessing reported fruit and vegetable loss at the wholesale stage, since very little data is currently available. In addition, all participants were provided with an information letter fully explaining the nature of the survey and questionnaire, as required by the human ethics and confidentiality procedures promoted by Murdoch University.

Figure 1. (**a**) Aerial view of Market City Canning Vale, Perth, Western Australia; (**b**) wholesalers at work in the market; (**c**) typical examples of fresh produce sold at the market; and (**d**) a representative view of food loss in a bin.

2.2. Administration and Data Analysis

The survey questionnaire was circulated to all 55 fruit and vegetable wholesalers, secondary wholesalers, and processors operating in Market City Canning Vale, Western Australia. Both a walk-in hand-out approach and online survey were carried out to obtain maximum participation. Also provided was an information letter detailing the objectives of the questionnaire and the nature of the survey. Once a week, business owners were contacted either by face-to-face meetings or by email to assist and check their progress in completing the questionnaire. After a 12-week period, which started in mid-June 2015, a total of 35 questionnaires were returned from the various wholesale businesses. Data collected in the questionnaires was classified into meaningful categories and captured using a specially designed excel spreadsheet template before applying descriptive statistics of frequency and percentage [42]. The Social Sciences (SPSS) statistical software version 21.0 (IBM Corp, Armonk, NY, USA, 2012) was then used to analyze the data [43]. Analysis revealed three distinct key themes: (1) fruits and vegetables received and reasons for loss generation; (2) loss reduction strategies; and (3) food loss utilization preferences. During the analysis, emergent patterns and relationships amongst the key questions were identified through a process of reduction and rearranging of the data into more manageable and comprehensible forms. Furthermore, qualitative text analysis software program Nvivo (QSR

International Pty Ltd., Doncaster, Victoria, Australia, 2012) was used to analyze open-ended question answers [44]. Participants were also requested to add their own thoughts regarding the reasons behind loss generation, loss reduction, and loss utilization approaches in the 'other section' of the questionnaire. Text analysis was also used to analyze the 'other section' of the questionnaire.

3. Results

The various outcomes of the questionnaire are presented in the following four sections. Section 3.1 presents percentage distribution of participation by the various wholesalers and processors contacted. The weekly tonnages of supplied fresh fruits and vegetables and respective loss levels are also reported in this section. The following section examines the relationship between received fresh produce and the amount of loss with respect to each business type. Section 3.3 examines the causes of loss generation, while the final section lists the various comments received from participants regarding loss reduction and loss utilization strategies.

3.1. Wholesaler and Processor Participation, Received Fruits and Vegetables, and Loss Levels

A total of 55 businesses were contacted and invited to take part in the present survey questionnaire. Figure 2 presents a percentage breakdown of participation from the various businesses (primary wholesaler, secondary wholesaler, and processor) located at Market City Canning Vale, Western Australia, as seen in Figure 1a. There were a total of 35 respondents to the survey questionnaire. Of the 35 participants, 18 were primary wholesalers (51.43%), 13 were secondary wholesalers (37.14%), and the remaining 4 were processors (11.43%). The remaining businesses declined to participate in the survey, citing business confidentiality. Those businesses that responded were found to be sincere and genuinely interested in reporting, since they could see the value of identifying loss and developing loss utilization strategies.

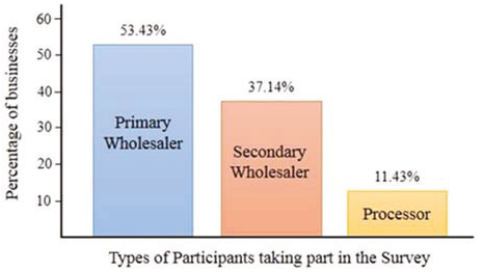

Figure 2. Percentage participation of wholesalers and processors located at Market City Canning Vale, Perth, Western Australia.

Figure 3 reports the weekly tonnage of supplied fresh fruits and vegetables and respective loss levels reported by each respective participant. Figure 3a presents the percentage breakdown of fresh fruits and vegetables received by each participant business each week. Around 31.43% of participants receive between 41 to 100 tonnes of fresh produce each week, while another 25.71% of participants receive between 1 to 20 tonnes each week. This was followed by 23% of participants receiving more than 100 tonnes of fresh produces each week. Figure 3b presents the weekly breakdown of food loss produced by the respective participants, with 31.4% of participants reporting loss levels exceeding 180 kg each week. Surprisingly, 25.71% of participants reported no loss during the week.

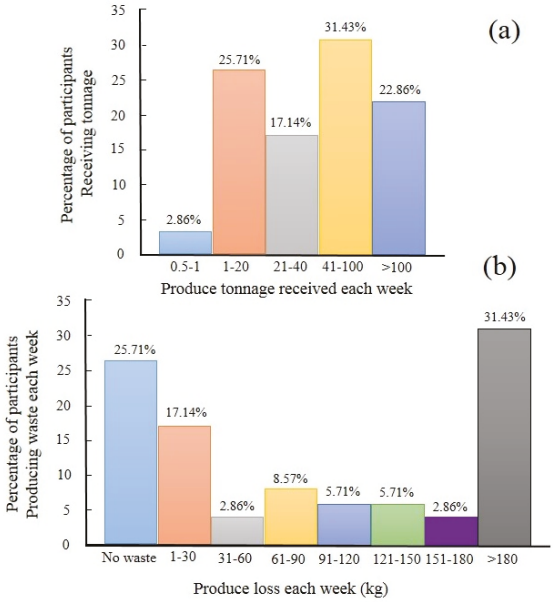

Figure 3. (**a**) Percentage breakdown of weekly tonnage of supplied fresh fruits and vegetables; and (**b**) percentage breakdown of respective loss levels reported by each respective participant.

3.2. Relationship between Received Produce and Loss Level with Respect to Business Type

Three main business categories were considered in this study, namely primary wholesaler, secondary wholesaler, and processor. The reported tonnages indicated that around 75% of primary wholesalers (six) received more than 100 tonnes of fresh produce each week. This was followed by 36.36% of primary wholesalers (four) receiving from 41 to 100 tonnes, and eight primary wholesalers handling between 1 and 40 tonnes of fresh produce. In the case of secondary wholesalers, 25% (two) received more than 100 tonnes and four reported receiving between 41 and 100 tonnes of produce each week. The four processors received between 1 and 100 tonnes of fresh fruits and vegetables each week. Losses were also reported by each of the respective businesses. For primary wholesalers, six businesses (54.55%) reported a weekly loss greater than 180 kg, while eight businesses reported losses between 1 and 180 kg each week. The remaining four primary wholesalers reported "nothing lost" each week. For secondary wholesalers, four businesses (36.36%) reported generating more than 180 kg of food loss each week, four businesses reported losses ranging from 1 to 180 kg, and five businesses (55.56%) reported "nothing lost" each week. For processors, three businesses reported losses between 1 and 180 kg and one business (9%) reported a loss above 180 kg. Further analysis of loss reporting was carried out using a log-linear model that used the "Processors" as the reference level. The model was also used to verify the significance of loss levels by each respective business in the three categories surveyed. The modelling revealed no statistically significant differences in loss levels between the processors and the secondary wholesalers (p-value = 0.81) and between the processors and primary wholesalers (p-value = 0.56).

Table 1 characterizes the association between received fresh produce and levels of loss generated each week by the various businesses surveyed. Only one business (2.86% of total participants) received between 501 and 1000 kg of fresh produce each week and reported no loss. For businesses receiving between 1 and 20 tonnes of fresh produce each week (nine in total, or 25.71% of total participants surveyed), three (33.33% of the nine businesses) produced no loss, while two (22.22% of the nine businesses) reported generating loss levels greater than 180 kg each week. Among businesses

receiving between 21 and 40 tonnes of fresh produce each week (six in total, or 17.14% of total participants surveyed), three (50.00% of the six businesses) generated no loss, while one (16.67% of the six businesses) reported loss levels greater than 180 kg each week. Among businesses receiving between 41 and 100 tonnes of fresh produce each week (11 in total, or 31.43% of total participants surveyed), two (18.18% of the 11 businesses) generated no loss, while four businesses (36.36% of the 11 businesses) reported loss levels greater than 180 kg each week. For businesses receiving more than 100 tonnes of fresh produce each week (eight in total, or 22.86% of total participants surveyed), four (50.00% of the eight businesses) generated loss levels greater than 180 kg each week (Table 1). Furthermore, the log-linear modelling used also examined the association between the dependent variable loss levels and the independent variables of business type and weekly reported amounts of produce received and showed that there were no statistically significant associations between the reported loss levels and the independent variables at $p = 0.05$. Overall, from the information reported by the 35 participants, it was possible to estimate average loss levels for primary and secondary wholesalers. Average fruit and vegetable loss for primary wholesalers was estimated to be around 180 kg per week and 30 kg per week for secondary wholesalers. Based on the reported fruit and vegetable losses, the annual loss was estimated to be around 286 tonnes.

Table 1. Relationship between received fresh fruits and vegetables and weekly loss levels reported by participants at the Canning Vale Wholesale Market, Perth Western Australia.

Produce Received	Fruits and Vegetables Removed Due to Loss (kg)								Total
	No Loss	1–30	31–60	61–90	91–120	121–150	151–180	>180	
501–1000 kg	1 (100.00%) [z]	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	1 (2.86%)
1–20 tonnes	3 (33.33%)	2 (22.22%)	0 (0.00%)	1 (11.11%)	1 (11.11%)	0 (0.00%)	0 (0.00%)	2 (22.22%)	9 (25.71%)
21–40 tonnes	3 (50.00%)	1 (16.67%)	0 (0.00%)	1 (16.67%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	1 (16.67%)	6 (17.14%)
41–100 tonnes	2 (18.18%)	2 (18.18%)	1 (9.09%)	1 (9.09%)	0 (0.00%)	1 (9.09%)	0 (0.00%)	4 (36.36%)	11 (31.43%)
>100 tonnes	0 (0.00%)	1 (12.50%)	0 (0.00%)	0 (0.00%)	1 (12.50%)	1 (12.50%)	1 (12.50%)	4 (50.00%)	8 (22.86%)
Participants	9	6	1	3	2	2	1	11	35

[z] Values in parentheses are % of total received.

3.3. Causes of Food Loss

Participants were asked to rank "reasons for loss" from four loss categories, with the most applicable (rank 1) to least applicable (rank 5). The four categories included: (1) low market price; (2) no market demand; (3) over supply; and (4) high/low temperature damage. Participants reported "over supply" (rank 1.56) and "low market price" (rank 2.65) as the most and least applicable reasons, respectively, for fruit and vegetable loss each week (Figure 4). Comments made in an "other" box for this section in the questionnaire indicated participants thought poor product quality was the main factor influencing the level of loss.

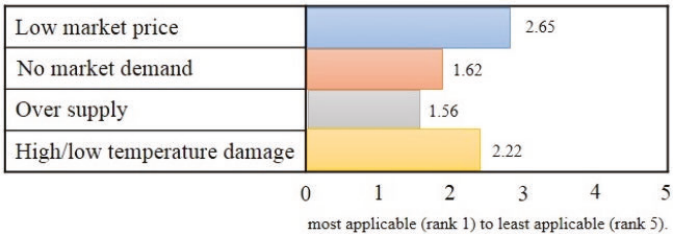

Figure 4. Food loss generation categories and mean rankings produced from participant responses.

3.4. Participant Perspectives of Food Loss Reduction and Loss Utilization

There are two parts to this section. In the first part participants were asked to rank five methods for loss reduction, and then comment on loss reduction strategies. The categories of methods for loss reduction were: (1) Revising visual appearance standards for fruits and vegetables at supermarket; (2) Improving storage facilities, technology, and infrastructure to better connect wholesalers to the market; (3) Engaging trained workers in wholesale to handle fresh produce; (4) Promoting more grower markets to sell produce directly to the consumers; and (5) Changing government policy to promote subsidies for wholesalers and processors. The businesses reported "Improving storage facilities, technology, and infrastructure" more important than either "Revising visual appearance standards" or "Promoting more grower markets" as an effective method for reducing weekly loss levels (Figure 5). Interestingly, "Promoting more grower markets" and "Revising visual appearance standards" produced *p*-values of 0.021, while "Improving storage facilities, technology and infrastructure" and "Promoting more grower markets" gave *p*-values of 0.004. Participants were also asked to add their own comments on loss reduction strategies to the questionnaire in an "other" box. However, very few participants (11) responded and those that did respond reported that if all stakeholders accepted and implemented quality standards there would be much lower levels of loss at the wholesale stage.

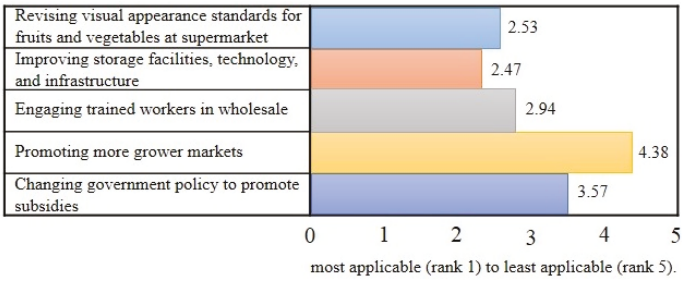

Figure 5. Food loss reduction categories and mean rankings produced from participant responses.

In the second part, participants were asked to rank methods for loss utilization and comment on loss utilization strategies. Loss utilization methods were assigned five categories: (1) Use for bio-energy production; (2) To make value-added compounds; (3) To make fish/animal food; (4) More donations to food bank and increasing tax deduction for food donations to charities; and (5) Increase revenue from selling compost made from crop scraps. The rank values determined from the reported date for the five loss utilization categories were 1.17 for "More donations to food bank and increasing tax deduction for food donations to charities", 2.58 for "To make fish/animal food", 2.94 for "Increase revenue from selling compost made from crop scraps", 3.00 for "To make value-added compounds", and 4.15 for "Use for bio-energy production" (Figure 6). Participants were also asked to add their own comments to the questionnaire in the "other" box stating their views on food loss utilization strategies. Participants expressed the view that "More donations to food bank and increasing tax deduction for food donations to charities" was the preferred food loss utilization strategy.

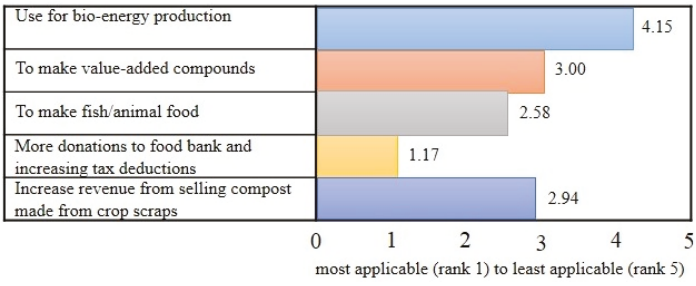

Figure 6. Food loss utilization categories and mean rankings from participant responses.

Another interesting item reported by participants was the relationship between loss levels and produce delivery frequency (daily/alternate days/twice a week or weekly). The reported data revealed that 95% of participants received produce daily, while the remaining 5% of participants received produce twice a week. Analysis of the data indicated that there was no association between produce delivery frequency and the amount of food loss generated.

4. Discussion

The volume of fruit and vegetable loss resulted from the relationship between the amounts of produce received, the quality of the produce, and market forces that influenced the amount of produce sold. Currently, there is very little data available about wholesale marketing of fresh fruits and vegetables in Australia. Although loss audits regularly take place in Australia, the respective audit sources are often inconsistent and present conflicting data [45]. This makes analysis difficult and, as a result, comparative studies are not performed. The present study has identified fruit and vegetable loss levels not previously reported for wholesale markets in Australia. Food loss levels can be derived from both qualitative and quantitative auditing at each stage in the wholesale marketing of fruits and vegetables. These types of losses within a food supply chain can be difficult to determine [16,38]. Generally, losses associated with quality are usually identified by a decrease in the market value of the produce [40,41]. For example, fruits or vegetables with some visual imperfections or that are misshapen, despite having similar taste and nutritional value, will not attract customers and will remain unsold. In the present study, loss was defined as the total amount of unsold produce going to loss each week. The survey contacted 55 businesses, but 20 declined, citing business confidentiality. The 35 businesses that participated in the survey were generally interested and were conservative in reporting loss levels.

Analysis of reported data revealed that 25.71% of participants received between 1 and 20 tonnes of fresh produce each week. Larger tonnages ranging from 21 to 40 tonnes were reported by 17.14% of participants, while 31.43% received between 41 and 100 tonnes and 22.86% received more than 100 tonnes of fresh produces each week. Interestingly, the survey also revealed that around half of the businesses (54.29%) receive more than 41 tonnes of produce each week, indicating larger and smaller wholesalers/processors were equally split in terms of business composition at the market, as seen in Figure 3a. Similarly, Table 1 summarized received fresh produce tonnages of and the weekly breakdown of loss levels produced by each respective participant. Moreover, only 31.4% of participants reported producing more than 180 kg of loss each week and, surprisingly, 25.71% of participants reported producing no food loss, as presented in Figure 3b. Estimation of average weekly loss revealed that primary wholesalers produced 180 kg and secondary wholesalers generated 30 kg. Based on the data, this would yield 286 tonnes of food loss each year by the 35 participants operating at the market.

Literature in the field has indicated a wide range of factors that result in loss generation, and many of these factors vary between developed countries, and between developed and developing

countries [46–48]. The present study also identified major factors contributing to food loss generation. The participants taking part in the present study were all experienced operators in the local West Australian market place and were aware of the causes behind loss generation. The questionnaire revealed that participants ranked "over supply" and "no market demand" as the main factors contributing to loss generation. Participants were also encouraged to add their own comments in the "other" section of the questionnaire and by follow-up conversations. Follow-up conversations tended to target and blame growers for not following proper growing practices and guidelines. Thus, a large proportion of produce reaching the market was not premium quality and could not be ranked as Grade 1 produce. However, from the growers' perspective, there was a need to harvest and deliver to meet prospective market demand. Thus, the need to meet potential market demand often meant immature produce may be harvested, adding to larger levels of loss. These losses resulted from immature fruit becoming moldy or decaying, leading to shorter shelf lives. For example, a number of participants commented that, if growers strictly followed grading and packaging guidelines for cherry tomatoes, loss levels could be dramatically reduced. Importantly, most participants reported that visual appearance should not be the only parameter used in grading and more importance should be given to the nutritional value of the produce.

Furthermore, although estimating loss generation by wholesalers was the aim of the study, there was a contributing factor to loss resulting from poor quality produce arriving at the market. This outcome suggests that further research is needed to fully examine the levels of immature and poor quality produce being delivered, and this contribution to food loss in the market. In terms of loss utilization, participants preferred option was "More donations to food bank and increasing tax deduction for food donations to charities" followed by "To make fish/animal food" (Figure 6). This reported preference is important for policy makers and the private sector, since it indicated that increasing tax deductions for donations to food bank was the preferred option of wholesalers. Alternative strategies that involve further processing of food loss were not well-received by wholesalers, as they did not believe "To make value-added compounds" and "Use for bio-energy production" were effective loss utilization strategies.

5. Conclusions

Average weekly fruit and vegetable losses reported by primary wholesalers was estimated to be 180 kg, with 30 kg of loss generated by secondary wholesalers/processers. This equated to around 286 tonnes of fruit and vegetable loss annually by the participants. Causes for food loss generation were identified, and preferred options for loss utilization strategies recommended by participants were examined and discussed. Wholesalers reported a number of important issues affecting loss that included: (1) Over supply and poor market demand; (2) Lack of adherence to proper growing practices and guidelines for producing high quality produce, with a tendency to harvest regardless of market demand by growers; (3) The need to improve infrastructure and promote better business practices to reduce loss levels; and (4) Revising visual appearance standards for produce and highlighting the importance of nutritional value to increase sales. From the grower's perspective, being able to deliver the right crop with high quality, in the right quantity at the right time to meet prevailing market demand, is difficult. Moreover, forecasting future demand is influenced by many factors, and market volatility exacerbates the difficulty. Thus, balancing supply and market demand will have an impact on food loss levels. The current imbalance could be alleviated by more effective on-line based market information being made available to all stakeholders. Furthermore, an increased supply of higher quality produce resulting from improved grading guidelines has the potential to significantly reduce food loss levels and improve profit margins. However, the size of the sampling pool used in this study was small and only enlisted 64% of wholesale businesses operating at the market. The number of non-participating wholesalers (36%) does influence the statistical significance of the findings. Nonetheless, considering the highly competitive nature of wholesalers and their general reluctance to reveal any businesses related information, the 64% participation was considered

a good outcome. Thus, by addressing the reported food loss and possible loss utilization strategies discussed in this study, it should be possible to reduce loss levels and promote a more profitable business environment for all stakeholders.

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Author Contributions: Purabi Ghosh and Shashi Sharma planned and designed the survey; Purabi Ghosh coordinated with Market City wholesalers, implemented the survey and collected data, traveled to conduct interviews with all stakeholders, and transcribed interviews. Purabi Ghosh, Derek Fawcett, and Devindri Perera worked on analysis; while Gerrard Poinern coordinated project activities and developed the framework for the paper. All authors substantially contributed to writing the paper.

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

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Economic Cost-Analysis of the Impact of Container Size on Transplanted Tree Value

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Abstract: The benefits and costs of varying container sizes have yet to be fully evaluated to determine which container size affords the most advantageous opportunity for consumers. To determine value of the tree following transplant, clonal replicates of *Vitex agnus-castus* L. [Chaste Tree], *Acer rubrum* L. var. *drummondii* (Hook. & Arn. *ex* Nutt.) Sarg. [Drummond Red Maple], and *Taxodium distichum* (L.) Rich. [Baldcypress] were grown under common conditions in each of five container sizes 3.5, 11.7, 23.3, 97.8 or 175.0 L, respectively (#1, 3, 7, 25 or 45). In June 2013, six trees of each container size and species were transplanted to a sandy clay loam field in College Station, Texas. To determine the increase in value over a two-year post-transplant period, height and caliper measurements were taken at the end of nursery production and again at the end of the second growing season in the field, October 2014. Utilizing industry standards, initial costs of materials and labor were then compared with the size of trees after two years. Replacement cost analysis after two growing seasons indicated a greater increase in value for 11.7 and 23.3 L trees compared to losses in value for some 175.0 L trees. In comparison with trees from larger containers, trees from smaller size containers experienced shorter establishment times and increased growth rates, thus creating a quicker return on investment for trees transplanted from the smaller container sizes.

Keywords: *Acer rubrum*; *Taxodium distichum*; *Vitex agnus-castus*; gain; loss; landscape establishment; tree establishment

1. Introduction

Nurseries over the years have produced trees in increasingly larger container sizes [1,2]. Retail garden centers and even large box stores, such as Walmart®, Lowe's®, and Home Depot®, now sell trees in up to 378.5 L (#100) containers. While debate continues over the relative merits of different container sizes [2], this could in part be due to the appreciation that commercial and residential customers have for the instant impact large trees can provide, such as greater aesthetic value of larger trees [3,4], greater biomass present to withstand environmental anomalies [5], less potential for accidental or malicious mechanical damage [6], instant shade [3,4], and increase in property value [7]. However, these larger trees cost more to grow and occupy a greater amount of nursery space per tree over longer time frames than smaller trees resulting in higher costs of production for growers and higher prices for consumers [6]. Smaller container sizes are ultimately less expensive for consumers as nurseries expend less materials, maintenance costs, and allocate less square footage to produce smaller trees. Also, smaller container sizes, once transplanted to the field, have been reported to experience reduced transplant shock [2], are in a phase of growth more closely aligned with the exponential growth rate of young seedlings [8], have been in containers for shorter times and transplanted to larger container sizes fewer times potentially reducing the chances of circling root development [9], and their smaller size makes for easier handling and staking [6]. The economic benefits and costs of varying container

sizes have yet to be fully evaluated to determine which container size affords the most advantageous opportunity for consumers.

The value of a tree, defined as its monetary worth, is based on people's perception of the tree [10]. Arborists use several methods to develop a fair and reasonable estimate of the value of individual trees [11,12]. The cost approach is widely used today and assumes that value equals the cost of production [13]. It assumes that benefits inherent in a tree can be reproduced by replacing the tree and, therefore, replacement cost is an indication of value [10]. Replacement cost is depreciated to reflect differences in the benefits that flow from an "idealized" replacement compared with an older and imperfectly appraised tree. The depreciated replacement cost method uses tree size, species, condition, and location factors to determine tree value [14].

The income approach measures value as the future use of a tree such as in fruit or nut production [15]. In the absence of such products, the income approach could be based on the monetary benefits of the future economic, environmental, and health well-being value of the tree [11]. For example, benefits have been shown to improve the value of the tree, including energy savings [16], atmospheric carbon dioxide reductions [17], storm water runoff reductions [18], and aesthetics [19]. Quantifying and totaling these benefits (ecosystems services) over time can provide an idea of a tree's projected value, but require data outside the scope of this project, thus a derivation of the replacement cost method was utilized within this study.

The objective of the current research was to determine the initial cost and replacement cost value of five different container sizes in three tree species at transplant and after two growing seasons in the landscape.

2. Materials and Methods

In analyzing the impact container size has on the value of the tree, the establishment cost of the tree was calculated and then compared to the replacement price of the tree after two growing seasons. Using the difference, it was then possible to see the net change in value for each container size tree over time. For the purposes of this study, price is the selling price paid by the customer buying the product, cost is the cost of care incurred by the homeowner in maintaining the product, and value is the bundle of attributes important to a homeowner in determining the product's overall worth. The three taxa utilized were selected to represent different niches of the landscape industry. Selections of *Vitex agnus-castus* L. (Chaste Tree), *Acer rubrum* L. var. *drummondii* (Hook. & Arn. *ex* Nutt.) Sarg. (Drummond Red Maple), and *Taxodium distichum* (L.) Rich. (Baldcypress) were chosen due to their widespread use in the southern USA nursery trade and their representation of a variety of classes of landscape trees. Additionally, five container sizes, 3.5 L (#1), 11.7 L (#3), 23.3 L (#7), 97.8 L (#25), and 175.0 L (#45), were selected as demonstrative of a range of typical container sizes purchased in the landscape trade. Clonal selections of these trees grown using as similar inputs as possible [20,21] were transplanted and monitored over the course of two growing seasons in a sandy clay loam (66% sand, 8% silt, 26% clay, 6.0 pH) field in College Station, TX (lat. 30°37'45" N, long. 96°20'3" W) beginning June 2013. All replicates of the 3.5 L *Acer rubrum var. drummondii* died within the first season due to deer grazing and pathogens and, therefore, are excluded from the cost analysis. Trunk diameters of all three species were within ANSI (American National Standards Institute) Z60.1-2004 specifications [22] for their respective container sizes [20].

2.1. Initial Costs

In order to analyze the value of the various sizes of the containerized trees, data were collected from 185 different nurseries located across 21 states. Nurseries were contacted and requested to provide wholesale prices of all container sizes available in *Acer rubrum* "Summer Red" or "Red Sunset", *Taxodium distichum*, and *Vitex agnus-castus* "Shoals Creek". Although not all nurseries carried all sizes of each species, data from a minimum of twelve nurseries were acquired for each species and container size combination.

Labor and installation costs are included in analyzing the initial value of a tree. RSMeans is the industry standard source for accurate and expert information on materials, labor, and construction costs [23]. Thus, labor and materials costs were determined utilizing this information. Labor and installation costs, both by hand and using machinery, were compiled for each container size from the RSMeans data. Additionally, twelve companies that produced each container size were contacted and asked to contribute their installation costs to corroborate the data from RSMeans benchmarks.

Finally, maintenance costs were determined by using maintenance records during the two growing seasons for each container size and species. These records were then compared to RSMeans for projected maintenance costs per container size over time. Maintenance included such practices as fertilizing, weeding, pest control, pruning and watering.

2.2. Equivalent Costs

To determine the equivalent value for replacement of the planted trees at the end of two growing seasons, data were collected from the locally-grown trees. Final height and trunk diameter of the trees in the field in October 2014 were utilized to determine ANSIZ60.1 [22] container size approximations. Utilizing these ending container size equivalents, prices were designated according to the mean prices obtained from wholesale growers. Additionally, costs of installation and maintenance were derived for the ending container size of each tree. By subtracting the ending container size costs from the beginning container size costs, the net gain or loss in value over the two post-transplant growing seasons were calculated for each tree.

Data were analyzed using analysis of variance (ANOVA) with JMP 2009 and SAS 9.3 (SAS Institute Inc., Cary, NC, USA) to determine the significance of interactions and main effects for each variable. The overall model was 3 species × 5 sizes with 6 replicates (observations) per treatment combination (Table 1). Means for container size, wholesale cost, installation, maintenance, and total value for each tree were analyzed as the change between the beginning and end of the experiment. Where interactions were significant, Student's *t*-test (Fisher's Least Significant Difference) was used to compare means among the treatment combinations. When significant main effects were found, a paired *t*-test comparison was used to indicate values that are significantly different ($p \leq 0.05$).

Table 1. Means and Analysis of Variance of the effects of tree species and initial container size on changes in size, price, costs, and value of trees after transplanting to the landscape and growing for two seasons.

Species	Initial Container Size (L)	Change in Container Size (L)	Change in Wholesale Price ($)	Change in Installation Cost ($)	Change in Maintenance Cost ($)	Gain/Loss in Value ($)
Acer rubrum	11.7	46.5 ± 12.1 ^{a,b}	45.2 ± 9.2 ^{a,x,y}	52.4 ± 4.6 ^{a}	3.8 ± 1.4 ^{a}	121.4 ± 15.3 ^{a}
	23.3	49.2 ± 8.3 ^{a}	38.5 ± 7.2 ^{a}	20.2 ± 3.9 ^{b}	5.6 ± 1.2 ^{a}	94.0 ± 12.4 ^{a,b}
	97.8	12.4 ± 12.4 ^{b}	10.1 ± 10.1 ^{b}	4.9 ± 4.9 ^{c}	2.0 ± 2.0 ^{a}	17.1 ± 17.1 ^{b}
	175	12.4 ± 12.4 ^{b}	18.0 ± 18.0 ^{a,b}	4.8 ± 4.8 ^{c}	9.7 ± 9.7 ^{a}	0.0 ± 32.5 ^{b}
Taxodium distichum	3.5	1.8 ± 1.8 ^{c}	2.0 ± 1.3 ^{c}	6.9 ± 5.0 ^{c}	0.2 ± 0.1 ^{b}	−38.4 ± 6.5 ^{b}
	11.7	29.5 ± 5.6 ^{b}	26.0 ± 4.9 ^{b}	42.5 ± 6.0 ^{a}	1.8 ± 0.3 ^{b}	67.3 ± 11.0 ^{a}
	23.3	55.2 ± 7.9 ^{a}	46.2 ± 6.6 ^{a}	23.1 ± 3.6 ^{b}	6.6 ± 1.2 ^{a}	68.0 ± 11.5 ^{a}
	97.8	12.4 ± 12.4 ^{b,c}	11.5 ± 11.5 ^{b,c}	4.9 ± 4.9 ^{c}	2.0 ± 2.0 ^{b}	−6.6 ± 18.4 ^{a,b}
	175	0.0 ± 0.0 ^{c}	0.0 ± 0.0 ^{c}	0.0 ± 0.0 ^{c}	0.0 ± 0.0 ^{b}	−45.0 ± 0.0 ^{b}
Vitex agnus-castus	3.5	65.4 ± 11.3 ^{b}	53.8 ± 10.0 ^{b}	74.4 ± 3.9 ^{a}	6.1 ± 1.3 ^{a}	132.9 ± 15.2 ^{b}
	11.7	127.1 ± 20.4 ^{a}	138.5 ± 27.0 ^{a}	82.7 ± 8.3 ^{a}	15.5 ± 3.2 ^{a}	235.8 ± 38.6 ^{a}
	23.3	80.6 ± 12.4 ^{a,b}	77.1 ± 18.4 ^{a,b}	33.9 ± 4.9 ^{b}	10.5 ± 2.0 ^{a}	120.3 ± 25.4 ^{b}
	97.8	50.3 ± 15.8 ^{b}	73.8 ± 23.3 ^{a,b}	19.6 ± 6.2 ^{b}	8.1 ± 2.5 ^{a}	101.6 ± 32.1 ^{b}
	175	14.0 ± 14.0 ^{c}	12.4 ± 12.4 ^{c}	4.8 ± 4.8 ^{c}	9.7 ± 9.7 ^{a}	−22.6 ± 28.5 ^{c}
Species		***	*** ^{z}	***	***	***
Container Size		***	***	***	***	***
Species * Container Size		*	n.s.	*	n.s.	*

^{x} Standard errors, with different letters (^{a,b,c}) indicate significant differences using Students t-test at $p \leq 0.05$ within each species; ^{y} Values within a column represent the mean of six observations ± standard errors; ^{z} *, *** Indicate significance of the main effect or interaction at $p \leq 0.05$, 0.001, respectively, or not significant (n.s.).

3. Results and Discussion

3.1. Initial Costs

Prices for a range of sizes of commercial container stock were obtained. Similar price trends existed for all three species (Figure 1). They were lowest for the 3.5 L trees and then slowly increased in price until the 56.8 L trees. Trees greater than 56.8 L tree stage were increasingly expensive compared to the smaller trees. While *V. agnus-castus* was slightly less expensive in the smaller container-grown trees, it became much more expensive in the larger container-grown trees than with the other two species. Higher prices associated with trees greater than 56.8 L would indicate the price point at which nursery growers must increase the prices to a higher rate to offset extra supplies, labor, and inventory carrying costs required to maintain larger container sizes.

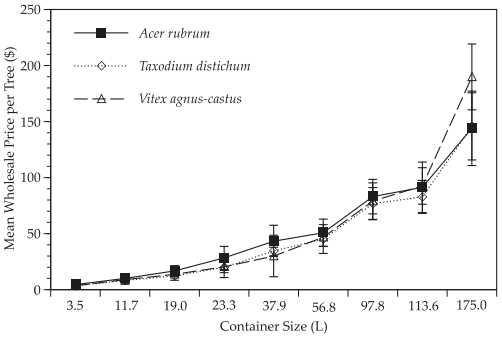

Figure 1. Mean (±standard error) wholesale price [US$] by container size for three tree species (*A. rubrum*, *T. distichum*, and *V. agnus-castus*) in 2013 where n ≥ 12.

Similar trends were observed with the costs to transplant each container-grown tree (Figure 2). The cost to transplant increased gradually with each container size. The 56.8 L container size trees indicated another break point as the cost to transplant by hand was more cost-efficient than by machinery until this point. With 97.8 L and 175.0 L trees, machinery would be necessary to efficiently transplant these trees. Additionally, the 175.0 L trees were eight times more expensive to transplant than 3.5 L trees.

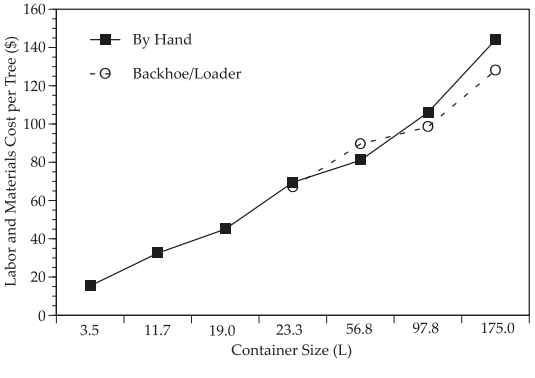

Figure 2. Labor and materials cost [US$] per tree for transplant by hand or machinery of various container size trees in 2013 (excluding wholesale cost of tree) as determined from RSMeans [23].

The maintenance costs for each container size were determined using general practices tree owners would implement during a typical year. This included fertilization, pest control, weeding, pruning, and watering. Cost of fertilization, pest control, and weeding remained nearly constant across all container size trees (Figure 3). However, the cost of pruning increased beginning at container sizes greater than 56.8 L with trees from 175.0 L containers requiring the most pruning labor. Finally, watering costs were relatively similar across all container sizes; however, a slight increase was found for the watering costs of larger container sizes. Despite more water being applied to larger container-grown trees, the current low cost of water mitigates the impact of this differential input. If in future years the cost of water increases, more substantial differences in cost of watering different container-grown trees could become apparent. Regional variation in water costs may also impact this estimate.

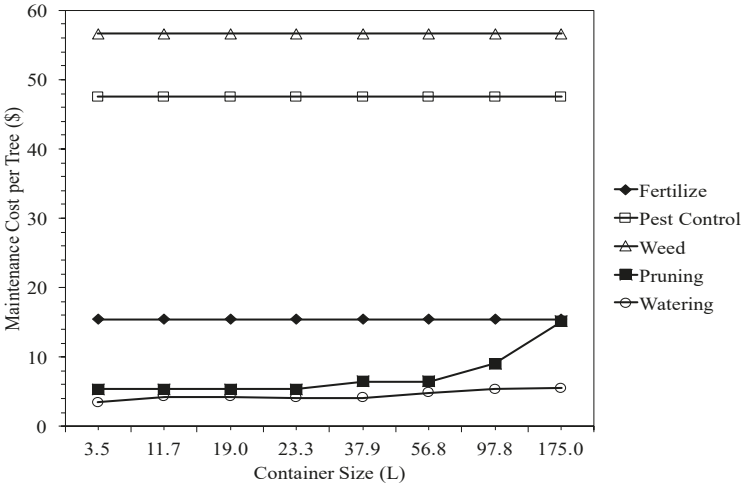

Figure 3. Maintenance costs [US$] per tree for fertilization, pest control, weeding, pruning, and watering of various container sizes summed over a two-year period of growth as determined by RSMeans [23].

3.2. Equivalent Costs

In order to predict the future value of each tree, height and trunk diameter at the end of the second growing season were compared to ANSIZ60.1 [22] to determine equivalent size container-grown trees. Given the different growth rates of the three species of tested trees, the value varies depending on species [20]. Growth and value may also differ among planting sites; however, data from first-year establishment of these species in contrasting environments in Texas and Mississippi indicated similar growth trends [21].

The main effects of species and container size were highly significant for all variables and the interaction between species and container size was significant for changes in installation costs, changes in container sizes, and net gain/loss (Table 1). Therefore, results are presented by species.

The greatest container size changes for *A. rubrum* occurred with the 11.7 L and 23.3 L trees which ended the second growing season at mean sizes of 56.8 L and 75.7 L, respectively (Figure 4A; Table 1). In contrast, 97.8 L and 175.0 L trees ended with very little change from their initial container sizes. Both 97.8 L and 175.0 L *A. rubrum* ended the second season with only one of the six replications increasing their equivalent container size (data not shown).

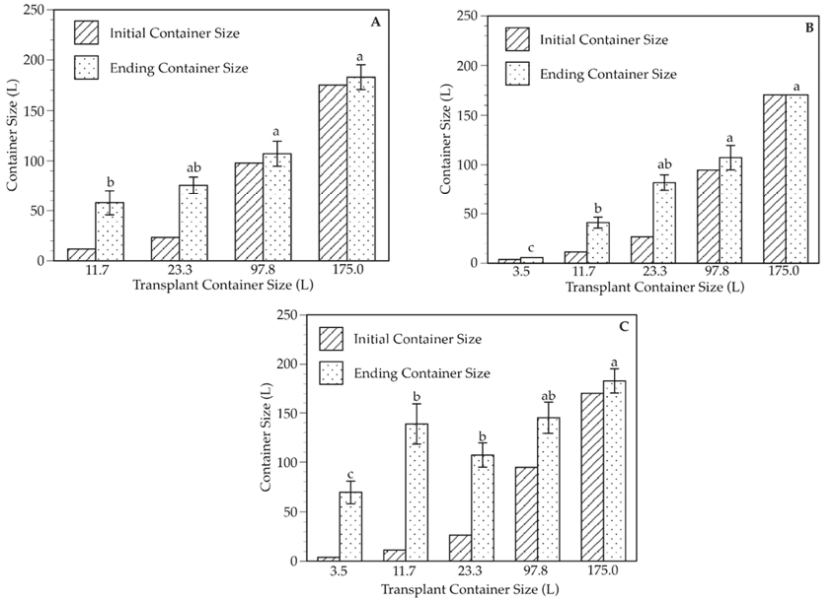

Figure 4. Mean (±standard error) of initial and ending container size of *Acer rubrum* (**A**); *Taxodium distichum* (**B**); or *Vitex agnus-castus* (**C**) trees from transplant (diagonal hatching) to the end of the second growing season (stippled hatching). Initial sizes were 3.6, 11.7, 23.3, 97.8 and 175.0 L; n = 6 or *T. distichum* and *V. agnus-castus* and 11.7, 23.3, 97.8 and 175.0 L; n = 6 for *A. rubrum*. Means of ending container sizes with the same letter are not significantly different at $p \leq 0.05$ using Student's *t*-test.

To predict the gain or loss in value over two growing seasons, the wholesale price of the tree at planting is shown with the wholesale price equivalent of the tree at the end of the second growing season (Figure 5A). The 11.7 L and 23.3 L trees had the greatest increase in replacement price, while the 97.8 L and 175.0 L barely increased (Table 1). Analyzing the cost to install the initial container size versus the cost to install the ending container size after two growing seasons also indicated that costs were lower for 11.7 L and 23.3 L container sizes, but with the greatest increase in installation costs of equivalent trees after two seasons (Figure 5B). Finally, maintenance costs remained steady for the two growing seasons with no differences between container size trees (Figure 5C).

This information allowed analysis of the overall value of the tree. The value of the tree increased the most for the 11.7 L trees of *A. rubrum*, yet the ending value was still not equal to the value of the 175.0 L trees (Figure 5D; Table 1). Therefore, while overall gains were largest for 11.7 L and 23.3 L trees (Figure 5E), 175.0 L trees still maintained the greatest overall value after two growing seasons (Figure 5D). Trends over longer time frames are unknown but suggest trees from smaller sizes may catch up to those from larger size containers if the same growth trends continue.

The stress and initial growth rates of *A. rubrum* greatly influenced final container sizes at the end of the two growing seasons of this study. The increased container sizes ultimately increased the wholesale cost of the equivalent tree, the cost of labor, and the cost of maintenance. Therefore, overall value of the tree was increased, although the final value of the smaller container sizes did not catch up to or surpass that of the larger container sizes for *A. rubrum* during the first two growing seasons. However, the gain or loss estimates for trees from each container size helps to present the overall trends. Smaller container-grown *A. rubrum* produced a greater gain for homeowners over the two growing seasons after transplanting to the landscape than did trees from larger container sizes (Figure 5E; Table 1).

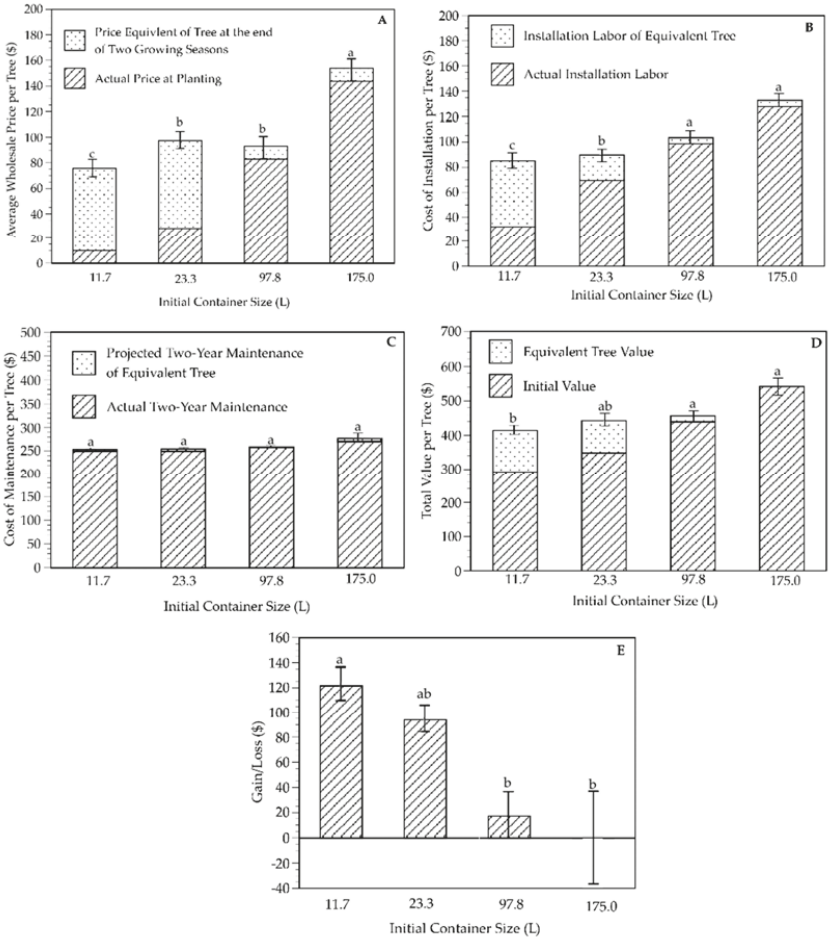

Figure 5. Mean (±standard error) wholesale cost (**A**), installation (**B**), maintenance cost (**C**), value (**D**), and gain or loss in dollars [US$] (**E**) of *Acer rubrum* trees from transplant (diagonal hatching) to the end of the second growing season (stippled hatching) for initial container sizes of 11.7, 23.3, 97.8 and 175.0 L trees. Means of final values after two growing seasons for initial container sizes with the same letter are not significantly different at $p \leq 0.05$ using Student's *t*-test.

For *T. distichum*, the greatest container size change occurred with the 23.3 L trees which ended the second growing season at a mean equivalent size of 83.3 L (Figure 4B). In contrast, the 11.7 L and 97.8 L trees changed less and the 3.5 L and 175.0 L *T. distichum* trees ended with very little change from their initial container sizes. The 97.8 L *T. distichum* trees ended the second season with only one of the six replicates increasing its equivalent container size and 175.0 L trees did not have any increase in container size equivalents (data not shown). One of the six 3.5 L trees died during the two years, which was calculated as a 0.0 L container tree, thus decreasing the mean equivalent of the remaining container sizes. Mortality was greater in the 3.5 L trees most likely due to their small size, which exposed them to more drift of salinity in the irrigation water from the mini-spray-stakes used during irrigation, greater predation by white-tailed deer (*Odocoileus virginianus*) and provided a small biomass with which to withstand environmental variation.

The wholesale price of the tree at planting was compared to the wholesale price equivalent of the tree at the end of the second growing season. The 23.3 L trees had the greatest increase in wholesale price, followed by the 11.7 L and 97.8 L trees, while the 3.5 L trees barely increased and 175.0 L trees had no increase above the actual price at planting (Figure 6A; Table 1). The 175.0 L trees were the costliest to purchase initially, but retained the greatest wholesale price equivalent at the end of the two growing seasons despite no increase in size equivalent. Analyzing the cost to install the initial container size versus the cost to install the ending container size after two growing seasons also indicated that while the costs were low for the smaller container sizes, it was also more cost-efficient to plant the smaller container sizes as greatest savings on transplant costs occurred with the 11.7 L and 23.3 L trees (Figure 6B; Table 1). Maintenance costs remained steady for the two growing seasons with no differences between container size trees (Figure 6C).

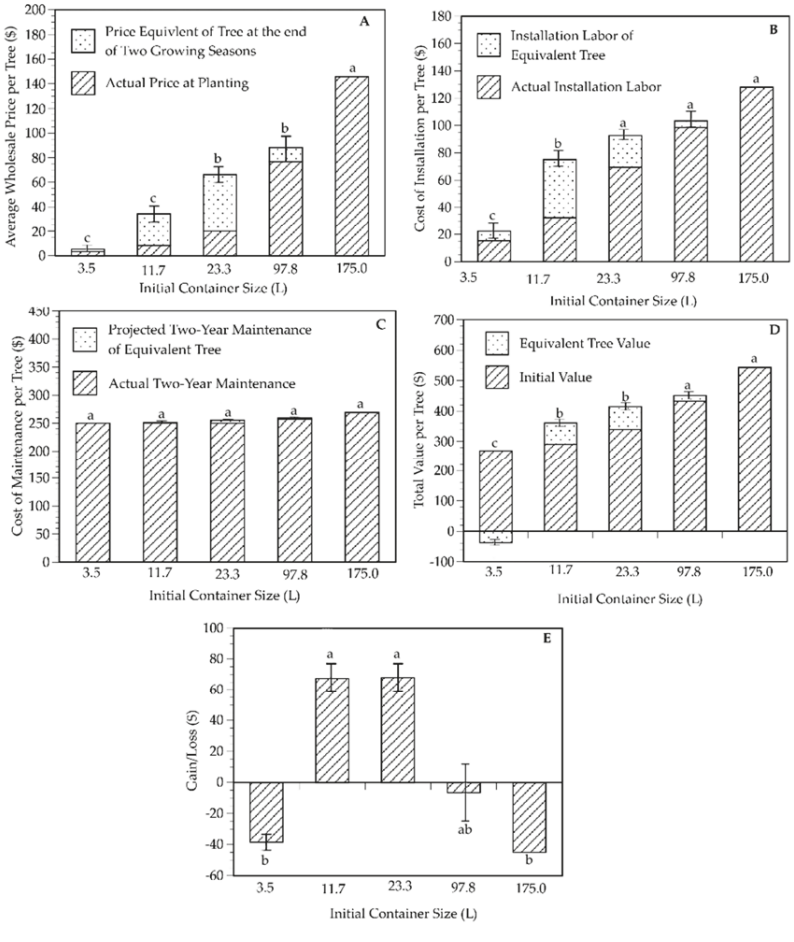

Figure 6. Mean (±standard error) wholesale cost (**A**), installation (**B**), maintenance cost (**C**), value (**D**), and gain or loss in dollars [US$] (**E**) of *Taxodium distichum* trees from transplant (diagonal hatching) to the end of the second growing season (stippled hatching) for initial container sizes of 3.5, 11.7, 23.3, 97.8 and 175.0 L trees. Means of final values after two growing seasons for initial container sizes with the same letter are not significantly different at $p \leq 0.05$ using Student's *t*-test.

The summation of this information allowed analysis of the overall value of the tree. The value of the tree increased the most for 11.7 L and 23.3 L container sizes for *T. distichum* (Figure 6D,E). However, the ending value of both sizes was still not equal to the value of the larger trees transplanted from 175.0 L containers. Therefore, while overall gains were largest in *T. distichum* from 11.7 L and 23.3 L containers (Table 1; Figure 6E), initially transplanted 175.0 L trees still maintained the greatest overall value after two growing seasons (Figure 6D). However, because the 175.0 L trees did not increase in size, money put into maintenance over the two years was considered a loss, as it did not generate an output in increased growth (Figure 6E). Losses were also seen with the 3.5 L and 97.8 L trees (Table 1; Figure 6E).

Slow growth ultimately impacted the economic cost analysis for *T. distichum*. Ending container size equivalents of *T. distichum* were similar to initial size for all container sizes, except 11.7 L and 23.3 L containers (Figure 4B). While the greatest changes occurred with 11.7 L and 23.3 L trees, only the 23.3 L trees increased enough in size so as to not statistically differ from the 97.8 L or 175.0 L trees after two growing seasons (Figure 4B). As a result, the total value and the gain in value were the greatest for 11.7 L and 23.3 L trees, and losses in net value occurred for the remaining container sizes (Figure 6D,E; Table 1).

The greatest container size changes for *V. agnus-castus* occurred with the 11.7 L and 23.3 L trees (Figure 4C; Table 1). The initial 11.7 L and 23.3 L trees ended as 136.3 L and 106.0 L container size trees, respectively. The 3.5 L and 97.8 L container-grown trees ended with similar increases from their initial sizes, and 175.0 L trees increased the least. Ending container sizes were not significantly different among the 11.7, 23.3 and 97.8 L trees, and the 97.8 L trees did not differ from 175.0 L trees (Figure 4C).

The *V. agnus-castus* trees from 11.7 L containers had the greatest increase in wholesale price, while the 3.5, 23.3 and 97.8 L trees had similar increases to one another (Figure 7A; Table 1). The 11.7 L trees would save homeowners the most money after transplant given the higher initial purchasing and planting costs of the 97.8 L container trees. The 175.0 L trees had no increase in value. Analyzing the cost to install the initial container size versus the cost to install the ending container size after two growing seasons also indicated that while the initial installation costs of trees were low for 3.5 and 11.7 L container-grown trees, it was also more cost-efficient to plant the smaller container sizes in relation to installation costs after two seasons (Figure 7B, Table 1). Maintenance costs did not differ across container sizes for the two growing years (Figure 7C).

The overall value of the trees increased the most for the 11.7 L container sizes of *V. agnus-castus*, with an ending value equal to that of 97.8 L trees. (Figure 7D; Table 1). The total value of the 23.3 L trees exceeded that of the initial value of the 97.8 L trees. A slight decrease in total value of the 175.0 L trees occurred after two growing seasons. Gains in total value were greatest for the 11.7 L trees, were similar among the 3.5, 23.3 and 97.8 L trees, and showed a slight loss for 175.0 L trees after two growing seasons in the landscape (Table 1; Figure 7E).

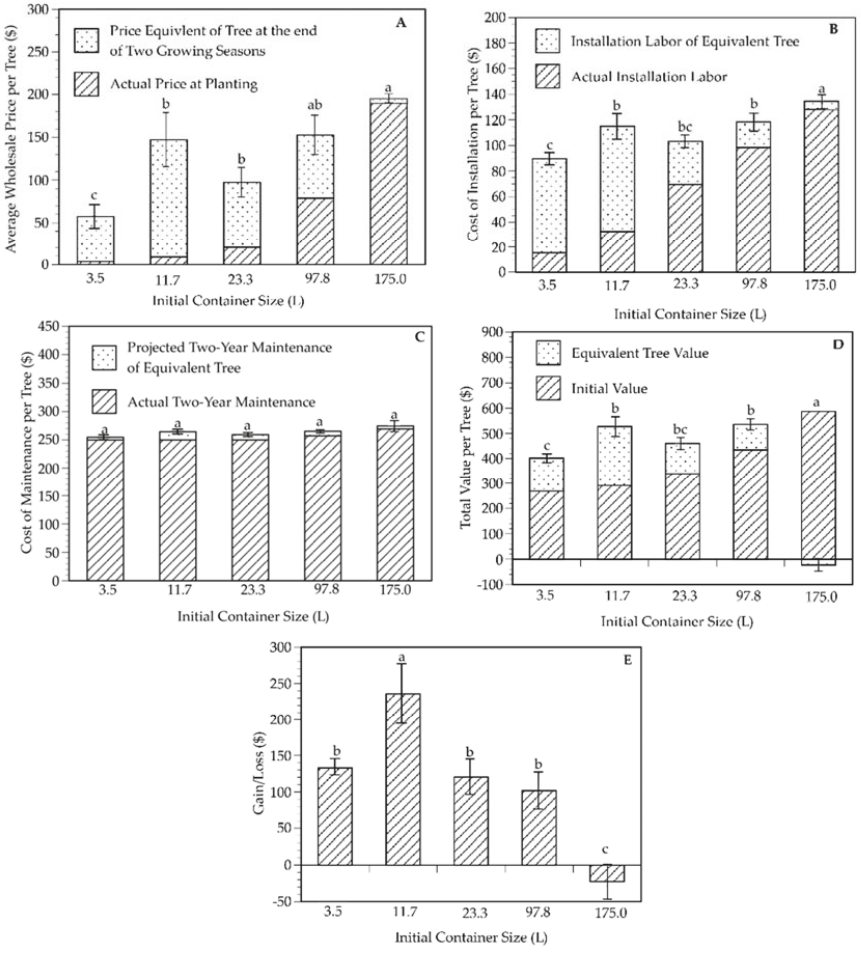

Figure 7. Mean (±standard error) wholesale cost (**A**), installation (**B**), maintenance cost (**C**), value (**D**), and gain or loss in dollars [US$] (**E**) of *Vitex agnus-castus* trees from transplant (diagonal hatching) to the end of the second growing season (stippled hatching) for initial container sizes of 3.5, 11.7, 23.3, 97.8 and 175.0 L trees. Means of container sizes topped by the same letter are not significantly different at $p \leq 0.05$ using Student's *t*-test.

4. Conclusions

Previous research has looked at assigning trees a value for real estate, insurance, production, and other uses [10,14]. However, a lack of research in the value of transplanted trees of various sizes persists. While research can be used to demonstrate that smaller or larger container-grown trees perform better in the landscape [24–26], oftentimes finances are of greater concern to the consumer. By corroborating evidence that smaller container sizes establish quicker in the landscape [8,21,24–27] with results indicating that 11.7 L and 23.3 L trees generally produce a greater profit (net value increase) than larger container-grown trees, steps are being taken to create a complete picture to present to consumers. Continued research should look at cost analysis after a 5-year, 10-year, etc. period or develop projection curves to determine if current findings persist over time. The present results were based on selected species and location (Table 1). However, experiments conducted simultaneously in a

different growing environment produced similar results [21]. Additional determination of value trends across growing environments and the time value of money during longer growing periods should be considered. Furthermore, research should analyze the impacts on growers if a shift back toward smaller container-grown trees occurred. Finally, as water shortages become a very real problem [28], future studies should monitor the impacts of irrigation costs on the overall cost of transplanting and growing trees. The current study also does not address the aesthetic value of the "instant landscape" provided by larger size stock immediately after installation, nor the potentially greater ecosystem services of larger stock sizes, which may still be justification for planting larger-sized container plants.

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Relationship Marketing: A Qualitative Case Study of New-Media Marketing Use by Kansas Garden Centers

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Abstract: A primary factor limiting the expansion of many Kansas garden centers is marketing. Most of these businesses spend the majority of advertising dollars on traditional media (newspaper, radio, etc.). However, new-media tools such as social-media can be an effective method for developing profitable relationships with customers. The purpose of this qualitative study was to explore the perceptions and experiences of garden center stakeholders as they use new-media to market their businesses. Grunig's Excellency Theory served as the theoretical framework for this study. Results indicate garden center operators prefer to use traditional media channels to market to their customers and asynchronously communicate with their target audiences. Stakeholders often have inaccurate or conflicting views of traditional media and new-media in regard to advertising and tend to approach new-media marketing from a public information or asynchronous viewpoint.

Keywords: marketing; relationship marketing; social-media marketing; new-media marketing; green industry; qualitative; garden center; nursery; landscape

1. Introduction

The green industry (garden centers, nurseries, landscaping companies, etc.) generates over $200 billion in annual revenue [1] and employs over 450,000 workers [2]. However, the retail garden center industry is highly seasonal and competes with many outside influences that can negatively affect sales, such as poor weather and competition from mass merchandisers [3]. According to Hodges et al. [4], mass merchants have acquired almost half the market share from smaller, local garden centers. Although mass merchants can offer prices that local garden centers cannot match, consumers are sometimes willing to pay higher prices for the increased selection, higher quality plants, and expert knowledge offered by small garden centers [5].

One factor limiting the expansion of garden centers and nurseries within the Great Plains region is marketing [6]. Insufficient funds for marketing is a common problem with smaller retailers who must try to find ways to generate maximum income potential with limited marketing and advertising budgets [7]. Small, family farms that have a yearly revenue not exceeding $50,000 rely heavily on marketing directly to the consumer [8]. Family-owned garden centers are no exception and have traditionally invested the majority of advertising dollars on the Yellow Pages, print media, and direct

mail [6]. Such print material most often includes newsletters and direct-mail promotional pieces that seek to educate consumers about sales or offer coupons for seasonal goods.

Although direct marketing of agricultural goods to the public has proven profitable with an association of increased sales [9], a limited marketing budget can prove detrimental to direct-mail marketing because the potential to reach the desired target audience is limited by the resource capital the business is able to allocate to the campaign [10]. Even though direct mail has limitations, such as a low response rate [11], it is still a highly popular resource [7] that can increase the volume of customers [12].

Incorporation of new-media marketing tools such as social-media has made it possible for businesses to communicate and engage directly with current and potential customers while building relationships [13–15]. Establishing a direct line of back-and-forth communication allows consumers to feel their feedback is valued and recognized, thereby increasing the probability of customers engaging in word-of-mouth (WOM) marketing via the digital sphere and physical circles [13]. Ultimately, WOM relies upon community engagement, and in today's digital age it is vital that garden centers create an interactive web presence that can be accessed across multiple platforms in order to facilitate consumer demands and promote WOM [16].

Many businesses are transitioning away from single-channel and passive marketing campaigns and have adopted more interactive strategies that encompass a wider variety of marketing channels [17]. Multiple-channel marketing (MCM) allows businesses to use specific media to market directly to a target audience [18]. Companies must recognize the wide array of channels that can influence consumers, including television, radio, magazines, and online sources. Organizations are starting to focus more on the possibilities of new-media marketing [19].

Businesses that decide to participate in MCM strategies must carefully consider the most efficient and effective channels [18]. Efficiency focuses on the cost per impression or the ability of a channel to reach consumers as economically as possible. In order to do so, marketers must have a clear and full understanding of its unique customer base. Multiple channel marketing must also be effective and yield high sales and positive brand image [18]. Modern businesses are using multiple traditional and new-media channels to market to consumers. Ultimately, the decisions on which channel to use are often the result of organizational tradition and "gut feeling" rather than statistical proof [20].

Marketing campaigns via new-media are free or low cost, and if used correctly, could lead to further promotion [21]. Properly integrating social networking tools can have a positive impact on sales, powerfully establish a company's brand, increase the salience of the business, position the company positively within the community, and reduce advertising costs [22]. However, sufficient and effective measurement practices must be implemented to determine if social-media marketing is successful and yielding a positive return on investment (ROI) [23,24]. Such measurement programs should focus on a social-media marketing campaign, and its ability to raise brand awareness, generate sales, produce customer advocacy, or encourage word-of-mouth marketing [25].

The purpose of this study was to explore the experiences of garden center stakeholders in the Great Plains region of the USA as they use social-media to market their business. Semi-structured, in-depth interviews of Kansas stakeholders explored the following research questions.

Q1: What are garden center stakeholder's perceptions and attitudes towards new-media as it relates to the marketing of their businesses?

Q2: What barriers do stakeholders encounter when using new-media to market their businesses?

This qualitative study is informed by Grunig's [26] Public Relations Theory. Grunig [26] categorizes four models of communication that businesses and public relations (PR) practitioners rely upon: (1) press agentry; (2) public information; (3) two-way asymmetrical; and (4) two-way symmetrical communication. Model one, press agentry, is the least desirable and model four, two-way symmetrical, is the most desirable form of communication. Grunig offers these models to help classify how a business or organization approaches and practices PR.

Press agentry is narrow in focus. Practitioners of this form of communication are primarily concerned with disseminating information on the company's products and increasing brand awareness [26]. Companies that practice press agentry are not bound by truth, and all communication is asymmetrical and focused on a one-way transfer of information. There is no desire for feedback or understanding the customer through strategic research. The public information model evolved from the press agentry in that it focuses on the release and distribution of truthful information [26]. However, the flow of information is still one-way from the organization to the consumer. Unlike press agentry, there is some effort given toward understanding the receiver of information through items like surveys [26].

Model three and four are considered the more desirable models of PR [27]. Model three is the two-way asymmetrical approach. While this form of PR evaluates feedback from a company's target audience, the goal of communication is strictly focused on persuasion and convincing the public to either accept a specific point of view or coerce the consumer to purchase a particular product [26].

The final model is two-way symmetrical communication, and "research shows this model is the most ethical . . . and effective approach to public relations" [26] (p. 308). Two-way symmetrical communication establishes constant communication between the business and all stakeholders to mitigate conflict. Businesses do this by understanding the needs and wants of stakeholders to "improve understanding and build relationships with publics" [26] (p. 39). Additionally, small-scale operations are more likely to use two-way communication practices [26]. In the digital sphere, two-way symmetrical communication can help organizations because listening to consumers via social-media allows a company to improve its products and more effectively target potential customers [28].

2. Materials and Methods

This case study used six in-depth interviews with participants from four garden centers. The six participants (Table 1) were two more than the minimum number needed for a qualitative study as identified by Creswell [29]. The participants at each garden center (Table 2) included the owner and/or the employee most responsible for social-media marketing content. All subjects gave their informed consent for inclusion before they participated in the study. The study was conducted in accordance with the Declaration of Helsinki, and the protocol was approved by the Committee for Research Involving Human Subjects/Institutional Review Board for Kansas State University (project #7183) on 19 May 2014.

Table 1. Characteristics of owners and employees at four garden centers in Kansas that were engaged in social-media marketing for their business.

Participant Description	Store
Employee A works at garden center A. She graduated from Kansas State University with a degree in landscape design and took a class in general business marketing. She is the sole landscape designer for the garden center and is also the marketing manager. She uses Facebook and Pinterest for her personal social-media.	A
Owner A owns garden center A. He spent the majority of his career farming. However, when faced with the difficulty of finding a way for the farm to support his children and his retirement, he decided to build a garden center. He does not use social-media in his personal life.	A
Manager B is the general manager of garden center B, and he oversees all of the marketing. Manager B does not use social-media for personal use.	B
President C is the fourth-generation manager of garden center C and received a master's degree in business administration. His current role is president of the garden center. He oversees the operations and marketing of the garden center. He uses Facebook in his personal life.	C
CEO C is the third-generation manager and is the current CEO of garden center C. He identified his primary responsibilities as helping with daily operations, preparing new-media content, and taking pictures for marketing purposes. He operates two blogs for the garden center and has a personal blog.	C
Owner D, of garden center D, works alongside her husband. Her primary responsibilities are with customer service and education. She is also the sole manager of the Facebook page and is in charge of television and radio advertisements. She uses Facebook in her personal life.	D

Table 2. Characteristics of and marketing channels used by four garden centers in Kansas.

Store	Description	New-Media	Traditional Media	Facebook Stats
A	Garden center A is located in Northwest Kansas. There are two other satellite garden center business locations in Nebraska. In addition to offering retail plant material to customers, the garden center also offers landscape design and construction services and does approximately 20% of its sales online through eBay or Amazon. The center is owned by one individual.	B,E,F,G,H,P,T	Radio Billboards Newspaper Direct mail	916 likes 0.07% engagement rate
B	Garden center B is located in Eastern Kansas, and was established in the 1950s. It has gone through several ownership changes. The primary revenue source for the garden center is in retail sales of plant material and gardening supplies such as fertilizer and weed killer.	E, F	Radio Newspaper Direct mail	818 likes 1.3% engagement rate
C	Garden center C is located in Southcentral Kansas, and is in its fourth generation of ownership. The primary focus of this garden center is in retail sales split across two locations in Wichita. In addition to retail plant supplies, the garden center also runs a gift store and a microbrewery store.	B, E, F, I, P, T	Radio Television Newspaper Direct mail	5440 likes 0.14% engagement rate
D	Garden center D is located in Western Kansas and is currently in its first generation. The store focuses on retail plant supplies while a year-round gift shop is also a significant aspect of the business.	F	Radio Television Newspaper Direct Mail	844 likes 1.09% engagement rate

Note: B = blog, E = e-newsletter, F = Facebook, G = Google Plus, H = Houzz, I = Instagram, P = Pinterest, & T = Twitter; engagement rate was calculated on 24 October 2014.

A purposively-selected list of 23 garden centers was generated by a state university Cooperative Extension horticultural specialist with expert knowledge of existing Kansas garden centers. To be included in the list, the garden centers had to be located in Kansas, have exceptional products, good business practices, great customer service, and a presence on Facebook. Since qualitative studies focus on validity and generating a large amount of data from a few participants, the original list of 23 garden centers was scaled down to four garden centers. Two garden centers were selected for a high engagement rate on Facebook and two garden centers were selected that had poor engagement rates. The level of engagement was determined by using Simply Measured's [30] engagement metric which is defined as: engagement rate = (comments + likes + shares)/total number of fans. Simply Measured's [30] engagement rate allows accurate comparisons between Facebook pages. Each of the 23 garden center's previous 60 days' worth of posts were averaged and garden centers were ranked from highest to lowest engagement rate.

Participants were immediately debriefed by the researcher at the end of the interview. Interviews were transcribed by the researcher and a professor's assistant and were entered into NVivo10 (QSR International Pty Ltd., Doncaster, Victoria, Australia) for coding and analysis to determine common linkages and themes. Glaser's [31] constant comparative method assisted the researcher in categorizing participant responses into relevant major themes. Credibility, reliability, and transferability are essential components and concerns of a qualitative study, and the onus is on the researcher to demonstrate the findings result from data and not subjectivities [32]. Shenton [32] also indicates that compromising internal validity is a critical error in qualitative research. In order to mitigate any errors that could decrease credibility, all data was collected and analyzed verbatim with audio recordings and transcribed by the primary author and an assistant. Additionally, after concluding the interview sessions, all participants were debriefed by a researcher to maximize accuracy of the written data as synonymous with participant perception. The research team conducted face-validity analysis of the interview questions to increase validity of the results. External validity in qualitative research is in the eye of the beholder, and it is up to the reader to determine if the information can be generalized to his or her own socially constructed experiences [33].

Although in-depth interviews can yield rich and meaningful data in exploring the experiences of participants, caution should be used in generalizing the findings beyond the specific units of analysis

under the specific situations in which they were observed [34]. However, qualitative results may be transferable to other like businesses in similar situations.

3. Results

3.1. Q1: Stakeholder Perceptions and Attitudes towards New-Media Marketing

When asked to describe how garden centers market to the public, participant responses yielded two themes: (1) Stakeholders prefer to focus on traditional marketing strategies; (2) Although stakeholders see some positives to social-media marketing, they are skeptical of its ability to positively impact sales.

3.1.1. Stakeholders Prefer to Focus on Traditional Marketing Strategies

Garden center owners and employees indicated a preference for traditional forms of advertising which included television, radio, newspaper, and direct-mail campaigns. Owner D (Table 1), who owns garden center D (Table 2), said, "garden centers are used to being in the regular media." She continued, "[the] newspaper is timely . . . If I advertise in the newspaper I can get them in here; they will bring the coupon in. No one brings their iPhone in and says this is what I want." Manager B, general manager of garden center B, mentioned, "we do a lot of radio advertising . . . we can run radio advertisements, and I can quantify how much I've spend on it because I have the bills to show for it."

The vast majority of strategic planning for garden center marketing also focused on traditional media. President C, of garden center C, talked about his advertising calendar:

> [it has] the number, date, the Monday through Sunday, how we would run our dates, and then at the top of all these we have what we want to promote and seminars. It's really kind of like our Bible. It's got what our spot radio's gonna run. If we're going to run a newspaper that week, if direct mail needs to go out.

Manager B also discussed an in-depth level of planning for advertising:

> [I will] plan out my marketing for next year. The majority of the marketing will get planned out for next year. [It will include] when I'm going to run ads, when we're going to do this, when we're going to do that.

All participants had some form of presence on one or more social-media platforms, with the most popular being Facebook. This is most likely due to the sampling procedures used in this study that drew upon garden centers with an active Facebook page. Other networks used, although to a varying degree, were Twitter, Pinterest, Instagram, Google Plus, blogs, and Houzz.

Participants at three of the four garden centers identified the preferred method for Web 2.0 marketing was through an e-newsletter. Employee A said, "we send out a newsletter every week to all of our local customers. I like to do the newsletter Friday evening, so I can put the new blog on the newsletter." Describing his newsletter, Manager B mentioned, "the e-newsletter is something we've been doing for several years. That gets [the most] attention. We do that every two weeks year round."

President C talked about the weekly newsletter and said, "it goes out weekly and [CEO C] writes those articles . . . He's a good story teller. It's not just a here-we-are company yelling buy our stuff. He'll write a story that's interesting and maybe try to tie a product in with it. It's about a 350-word read." The newsletter has a subscription of approximately 15,000 people and is delivered through Constant Contact, Inc. (Waltham, Massachusetts), which is an e-newsletter program.

Participants varied in the degree to which they used social-media and all were skeptical regarding the ability of social-media to generate a return on investment (ROI). However, participants mentioned the ability for Facebook to facilitate WOM marketing. Discussing why his garden center uses Facebook, Owner A mentioned:

> We're too rural. We don't have enough people who could possibly drive two hours here . . . I think enough people will come here from enough distance. When they go home they're going to tell their friends about it on social-media. They'll buy from you online because they won't drive that distance . . . It's extremely important to [rural garden centers]. I feel it should be more important to us than people in the middle of the city, because we don't have enough demographics. The population isn't here to support how we want to live . . . To support that business we have to attract people from a greater distance. Social-media is one way to attract people from the urban area.

Owner D also spoke of the ability of Facebook to generate WOM marketing and offered the following unprompted response, "there's no difference between WOM, us talking, and social-media . . . It's the same thing. You're just missing the verbal and non-verbal cues." When prompted, President C also identified social-media could be viewed through the lens of WOM marketing and said, "we could do a better job of building that piece. I think if we were to do that, it would bring some value." Participants indicated a passive strategy for facilitating WOM marketing for their customers, and none of the owners or employees mentioned fostering interaction on social-media to create highly engaged customers.

3.1.2. Stakeholders Were Skeptical of New-Media Marketing Return on Investment (ROI)

Although Kansas garden centers are currently using social-media to some degree and believe it could help facilitate WOM marketing, all participants were highly skeptical of its ability to generate a ROI. When asked how her social-media presence affects the profits of the garden center, Owner D replied:

> To be able to tell you it has made me one single dime, I can't. I don't have any way to track it . . . [Facebook] has just not been the big boom that I need for me to go spend money on it . . . Social-media sometimes is not a help. It doesn't get me stuff sold because the customer is still outside my store . . . I'm spending a lot of time on [Facebook], and I cannot justify the amount of time being spent on it for the sales [that are being generated].

Other participants had similar viewpoints. When asked how social-media impacts the garden center, Employee A replied, "there's not often direct sales from [social-media]. If there are, they are really hard to track. It's just generating awareness. [The financial impact] is not much, and it is not direct." Regarding social-media being profitable to his business, Manager B mentioned if you post on "Facebook and you don't sell anymore this week than you did the week prior, then obviously it didn't strike a chord with anybody."

3.2. Q2: What Barriers Do Participants Encounter when Using New-Media to Market Their Business?

Participants were asked questions related to the challenges they face and what materials would help them improve new-media marketing of their business. Participant responses yielded the following themes: (1) Stakeholders lack time and training; (2) Stakeholders desire high-touch channels of education from experienced professionals.

3.2.1. Stakeholders Lack Time and Training

All participants identified the primary barrier to using social-media marketing was a lack of time. Specifically, stakeholders mentioned other job priorities related to the daily operations of the garden center and the large amount of time educating customers as areas that consume the most amount of time. When asked about her role in the garden center, Employee A stated:

> I'm in charge of all the marketing and the advertisements. Other than that, my main role is a landscape designer, which works more with the landscape contractor side of the business. It's all under one head, but it's two very separate branches. We all have other jobs, so

> marketing just isn't . . . it's more my job than anybody else's, but it's not my only job nor is it my most important job.

Even though Manager B identified that his role as general manager of the garden center is to oversee and supervise all advertising, he stated, "[my other responsibilities] are 110% everything [but marketing]." When asked how much time he believed social-media marketing would take, he responded, "lots of time . . . and we just don't have a lot of time with it." When prompted to give a quantitative assessment on the time required to effectively market with social-media, Manager B identified "probably five to ten minutes every day."

Participants at three out of the four garden centers felt they were hindered by the amount of time spent educating potential and existing customers. Manager B mentioned helping customers with questions through the phone or via email "sometimes makes up 10% of the day, or 20% sometimes . . . if I kept track it would probably scare me." Owner A offered similar experiences to those of Manager B. "[Educating the consumer] is what I do all day long. It's my job, my biggest role. It's full time. I do more of that than anything else."

All participants identified a feeling of being lost in an ever-changing world of social-media and felt they did not have the necessary tools or training to keep up. Employee A mentioned her confusion with Facebook advertising and posts not being seen by every follower:

> They're pushing more and more in a direction where you're going to have to pay for people to see your post . . . It seemed like it costs a lot of money, and we were confused and weren't understanding how it was being used or why we were getting charged . . . it didn't seem to correlate. It was confusing.

Owner D also identified feeling confused when it comes to Facebook updates. She mentioned, "[Getting up to speed] is the biggest problem I have with social-media. I still have a slide phone. When it comes to paid marketing, is that where I want to go?"

When asked about their desired learning method for new-media marketing training, all stakeholders mentioned a desire for hands-on, high-touch channels of education. Describing what the ideal coaching situation would look like, Employee A added: "Maybe a weekly phone call . . . First [call] would probably be a long one to discuss the overall plan and then like the weekly communication on, what have you done this week, what are you working on, and should maybe try this or that. Just someone to kind of [give you] feedback and keep accountability with." When asked to describe his ideal workshop, CEO C explained it would be a workshop where participants would, "take your laptop to the class and sit down. Actually go through the steps and build a website or whatever you're doing. The [goal would be] a finished blog or website at the end of the course".

One common characteristic participants desired with regards to learning about social-media was to seek out advice from people who, as President C mentioned, are "fighting the same fight" within the garden center industry. Manager B identified that he preferred to learn from events at trade shows or industry meetings, saying, "I attend trade shows, meetings, and hear what other garden centers do . . . If I heard something at a conference, colleagues that are doing something similar . . . I would probably connect with that more than anything" President C echoed this sentiment:

> I guess there's that sense of trust . . . it's people that are fighting the same fight that we are. That we're able to learn from what they're doing . . . I don't hold a whole lot of credence for those that call themselves a social-media expert just because it's . . . you can't quantify it. I could go out and say that I'm a social-media expert, read a couple books and probably sound like I know what I'm talking about. The people that have actually been there and done that I think to me have more credibility.

4. Discussion

Participants identified a preference and confidence for traditional marketing channels that included radio, newspaper, television, and print media. This proclivity towards older methods

of advertising is in agreement with the findings of Behe et al. [6] and Stone [35]. The preference for older forms of mass communication could demonstrate that garden center stakeholders are contrasting the recommendations of Behe et al. [16] in adopting digital marketing trends to reach the upcoming generation, and marketing strategies have remained the same for nearly 20 years. This could also lend additional support to the findings of Doctorow et al. [20], who identified that decisions for MCM campaigns are often the result of tradition.

Garden center employees and owners were also concerned about the lack of ROI in regards to the time spent marketing on social-media. However, stakeholders were measuring the success of their social-media campaigns by looking at a direct and immediate increase in sales after content was posted online. Since they do not see immediate or direct financial impacts, stakeholders indicated that they do not believe social-media can impact sales. This contrasts the recommendations of Paine [28] who states companies that are the most active on social-media are more profitable than their contemporaries which are not using social-media. Although social-media can have an impact on sales, the greatest impact results from encouraging interaction and developing meaningful and symbiotic relationships [25]. Stakeholders of this study were not focusing on, or measuring, the quality of relationships, level of interaction, or the satisfaction of customers online, which is contrary to the advice and findings of Ledingham [36]. This common perception may indicate that stakeholders are practicing PR through press agentry or public information models [26] and not the two-way symmetrical approach recommended. Since the relationship and awareness benefits can lead to profits that are not directly measurable [37], garden centers most likely are measuring the wrong forms of profit or revenue streams and becoming frustrated with the marketing efforts via new-media.

Garden center stakeholders also demonstrated a lack of understanding for traditional media and were not aware of the potential benefits and analytics of new-media marketing. For example, Owner D stated that advertising in the newspaper was "timely". Furthermore, Manager B had mentioned his preference for radio advertising because he could quantify his advertising reach by determining how much he spent on radio advertising and how it affected the sales for the week. However, new-media marketing is much more rapid in its delivery and response than newspaper, and quantifying the dollars spent on a radio campaign cannot guarantee a consumer has noticed a message. New-media marketing offers advanced analytics that extend beyond simple message reach to include multiple forms of engagement along the online consumer pathway. Furthermore, stakeholders focused on what Keller [18] defined as the efficiency of the advertising message and were not actively tracking the effectiveness of such advertising campaigns. Measurement focused specifically on the short-term sales increase and not the long-term brand awareness or relationship.

Employees and owners were also confused about how to track sales to determine advertising effectiveness. None of the participants indicated asking customers where they heard about sales or promotions or giving any type of survey to determine relevant marketing channels or WOM marketing referrals. This could be especially problematic in tracking the effectiveness and efficiency of social-media advertising and the WOM that comes with it. By not implementing such tracking measures, the participants may never know how effective their social-media marketing efforts are nor how to identify profitable marketing channels to efficiently reach market segments. Although small businesses are more apt to practice two-way symmetrical communication [26], the participants in this study believed social-media should be approached from a public information or two-way asymmetrical communication viewpoint.

The employees who had responsibilities related to social-media had, at best, a split role that involved other garden center duties. These responsibilities quickly overshadowed the marketing responsibilities of the employee. Since "success on social-media is contingent on considerable resources being allocated to the proper use and evaluation" [38] (p. 4), it is possible to conclude stakeholders are seeing little ROI on new-media because they have not fully committed the resources vital to success.

Garden centers are approaching new-media marketing from the same lens as mass communications advertising. The stakeholders identified that they were taking a "broad net" approach

to new-media marketing where they send a message out to numerous receivers and hope that results in a purchase. However, this approach of treating new-media like mass communications is in violation of Warshauer and Grimes' [39] findings, which state that social-media should be used for fostering individualized communication and interaction.

Employees and owners stated the majority of their time is spent educating customers through e-mail, phone calls, or in-person conversations. This level of personal interaction could indicate that garden center employees and owners are practicing two-way symmetrical communication offline as an organization. According to employees, customers appreciated a high level of service. However, that level of service also prevented participants from effectively marketing the store because educating customers represented a considerable portion of their time. The stakeholders within this study also had a lack of understanding regarding scheduling and publishing tools for new-media marketing. Only one participant mentioned Hootsuite (Vancouver, Canada) or the scheduled posts feature on Facebook, and she did not use these features. Participants were not actively seeking new information but were not opposed to learning about new-media marketing. If they are going to learn, they expressed a desire for high-touch channels of education from seasoned industry professionals.

5. Conclusions

This study offers several theoretical implications for Excellence in Public Relations theory and how garden centers approach PR in the digital sphere. Grunig [26] identified a two-way symmetrical model of communication as the most effective means of communication between stakeholders. Since social-media is an effective avenue for conducting research and communicating to customers [24,28], this study adds to the body of literature and theory by suggesting that engagement and interaction on social-media could diminish when businesses are not actively participating in two-way symmetrical communication online and do not understand the value it offers beyond direct sales. New-media marketing could garner additional business over time by building a loyal customer base.

Garden center owners and employees should consider implementing principles of two-way symmetrical communication in new-media marketing, and approach it not as a sales tool but, as Constandinindes and Fountain [13] describe, a medium for communicating and engaging directly with potential customers in order to build relationships. In doing so, stakeholders may harness the power of new-media to generate deep involvement with customers. Because customer interaction on social-media can be profitable [40] and WOM can reach an enhanced volume of potential customers for minimal costs [21], using new-media channels could help garden centers that are hindered by resources or geography to reach new target audiences.

Participants also identified using MCM, which included new-media, to reach their target audience. However, the bulk of their efforts focused on traditional marketing that included radio, television, newspapers, and direct mail. Although new-media marketing was used, it was often an afterthought. The popular response for why the stakeholders emphasized traditional media was a mixture of tradition and feeling like they could quantify traditional media. However, stakeholders were not using any form of analysis to determine the effectiveness or efficiency of their marketing efforts. Although stakeholders may be reaching a large number of their target audience via direct mail, radio, and television campaigns; they could be neglecting a very important demographic by ignoring the potential of new-media marketing, which is becoming more vital as traditional forms of media become increasingly segmented. Therefore, this paper recommends that garden center owners and employees implement measurement programs to determine the effectiveness and efficiency of marketing efforts and not rely on traditional or intra-organizational culture to make marketing decisions. Communicators should work to reach this market of garden centers to educate stakeholders on the value of new-media marketing.

This study recommends that future research focus on consumers' perceptions and preferences toward new-media marketing. Since educational and relevant content is paramount to consumers,

we recommend identifying content that garden center customers desire as well as which aspects of relationship marketing resonate most. Future research should also identify which new-media platforms are yielding the greatest ROI in regards to increased sales, increased reputation, and increased relationships. Lastly, studies should focus on strategies that are being implemented by garden center stakeholders, how customers perceive those strategies, and how such activities can improve customer loyalty and foster meaningful relationships.

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