Working to Reduce Food Waste: Investigating Determinants of Food Waste amongst Taiwanese Workers in Factory Cafeteria Settings

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Abstract: Food waste is a critical issue affecting the world, and more research is needed to find ways to reduce it. Much of the existing research has examined supply chain inefficiencies and plate waste in restaurants and homes, while few researchers have studied the food waste which occurs in factory cafeterias. As many factories are in Asia, examining factory cafeteria food waste behavior in an Asian context is a good starting point. With this in mind, the authors research drivers that influence Taiwanese factory workers’ behavioral intentions toward food waste reduction. To do so, a conceptual framework model is constructed using the Theory of Planned Behavior and extended using the Norm action model and Proenvironmental factors, as well as additional factors including habit, cafeteria-service quality and situational factors. A pencil-and-paper survey was conducted with 156 participants, and collected data were evaluated using a partial least squares structural equation modeling (PLS-SEM) analysis. Results reveal that climate change awareness, injunctive norms and habit are strong motivating factors towards Taiwanese factory workers’ intention to reduce food waste. When combined with cafeteria-service quality and situational factors, intention to reduce food waste is also shown to have a significant explanatory effect on food waste behavior.

Keywords: climate change awareness; factory cafeteria; factory workers; food waste; Taiwan; theory of Planned Behavior

1. Introduction

Food waste is generally defined by the United Nations (UN) as a type of food loss, and includes any high-quality food that is suitable for human consumption which is produced and enters the supply chain, but does not get consumed either due to spoilage or expiration [1]. It is commonly cited that nearly 30% of all the food produced globally is wasted [2]. However, according to a recent study this number may be much higher than originally estimated [3]. Regardless of the actual number, this is a major issue for multiple reasons. Most visibly is the associated hunger and starvation that affects roughly 820 million people worldwide [4]. Another less known issue is the resources consumed to produce all food waste represents a total carbon footprint of nearly 3.3 billion tons of carbon dioxide [5].

While food waste is a global issue, it can be looked at and studied on a microlevel. As an example, Taiwan generates approximately 2.2 million tons of food waste annually [6]. Furthermore, the Taipei Environmental Protection Agency has shown that of the roughly 6100 tons of food waste Taiwan produces daily, 33% is recycled while the remainder is disposed of as waste [7]. Of the approximate 2000 tons of food waste that Taiwan recycles daily, Taipei contributes roughly 170 tons, for which around 93% is composted and 7% is used as hog feed [7]. Unfortunately, due to the African Swine
Flu, some counties in Taiwan have banned the use of recycled food waste to substitute for hog feed, starting with Yunlin county in late 2018 [8]. This has somewhat dented the demand for recycled food waste, though as of January 2020, there were still some 750 hog farms operating in Taiwan certified to reuse treated food waste as hog feed [9]. Taiwan is also recycling a small amount of food waste in several small-scale bio-refinery pilot projects [10]. Bio-refining is a form of food waste valorization where bacteria is used to convert food waste into energy [11]. Although there are now a number of large-scale global food waste valorization projects [12], and research in the field is growing [13], it is still a relatively underutilized technology in Taiwan [10].

Taiwan’s food waste is mainly generated by agricultural wholesale markets, the hotel industry and the restaurant industry, and domestic food waste produced by households also contributes a large percentage to the total [7]. Much of the food waste that occurs in markets, restaurants, hotels and households involves raw food ingredients and products that spoil or expire prior to being cooked or prepared into dishes, however another type of food waste called plate waste also occurs. Plate waste refers to any edible portions of food that are discarded after a meal [14]. While plate waste occurs in many places, like homes and restaurants, it can also occur in the workplace. Office workers in Taiwan’s major cities discard uneaten portions of rice boxes, known as pien tang [15]. Others create plate waste at myriad restaurants and food stalls nearby their offices during lunch and dinner breaks.

Taiwanese factory workers create plate waste by discarding uneaten leftovers from meals prepared in central factory kitchens. Considering there are over 80,000 factories throughout Taiwan, of which more than 4000 factories employ over 100 workers [16], the amount of plate waste generated in Taiwan’s factories is immense. It is therefore important to ask what factors influence factory workers’ intention to reduce food waste. Equally important is to understand what underlying factors can be identified to help motivate workers to reduce food waste. Given the limited amount of research on this subject, particularly in relation to factory cafeterias, there is a clear need of academic research concerning the factors that explain Taiwanese factory workers’ behavioral intentions toward food waste reduction.

It should be noted that few researchers have performed empirical research into the factors that influence food waste intention and behavior in workplace cafeterias [17,18]. The majority of previous research on consumer food waste is concentrated on household waste [19–21], and despite a few empirical studies [17,18,22–24], the relationship of underlying factors affecting consumer food waste in a nonhousehold context has received inadequate attention, especially in East Asia. Additionally, most of the previous pertinent research is limited to restaurants [25]. Therefore, exploring factors affecting nonhousehold food waste behavior, especially in the context of Asian factory cafeterias, is a worthwhile research question to investigate.

In light of the above arguments, the first and primary objective of this proposed research is to determine factors affecting food waste behavior in Taiwan’s factory cafeterias. In doing so, the current research attempts to explore factors from various perspectives such as psycho-social, habitual, situational and cafeteria-service. Earlier research shows that food waste behavior is not only an interesting topic but also an area that is largely valued in the field of sustainability [22]. Therefore, the second objective of this research is to investigate how or whether sustainability factors such as climate change awareness shape and influence Taiwan factory workers’ intention toward food waste.

To answer the aforementioned objectives, this study draws a robust research framework on the basis of the Theory of planned behavior (TPB), Proenvironmental theory and Norm activation model (NAM), and extends it by incorporating habitual factors, situational factors and cafeteria-service quality factors. Acknowledging the importance of sustainable consumption in relation to food-related behaviors, this study is also designed to explore whether proenvironmental factors such as climate change awareness shape intention not to waste food.

The next section presents a brief overview of food waste related literature and the theoretical model. This is followed by a detailed methodology review and results analysis. We then present our discussions, implications and limitations, after which we offer suggestions for future research and close with our conclusions.
2. Literature review

In general, abundant literature on food waste exists. Previous research has explored food waste occurring at various stages of the food supply chain such as production [26,27], processing [28], logistics [29], wholesale [30], retail [31], consumption [17–21,23] and food waste valorization [11–13]. Researchers have also investigated food waste from various other perspectives such as supply chains [32,33], its economics [34,35], food loss quantification [27,36], food waste policy [37], food sharing [38,39] and corporate social responsibility [40].

While food waste is present at all levels of the food supply chain, waste at the consumption stage is both sizable and meaningful [32]. Extensive research on food waste at the consumption level [19–21] has been conducted. Despite significant growth of nonhousehold food waste research in recent years, extant relevant research is not only scarce but is also limited to specific contexts such as restaurants [23–25], university dining [41] and Western workplace cafeterias [17,18].

Many of the studies mentioned above have employed theories based explanations of food waste. A theory that is often integrated into behavioral studies associated with food waste is the theory of planned behavior (TPB), in which attitudes, subjective norms and perceived behavioral control are used to accurately predict behavioral intention [42]. Conceptual frameworks based on extended TPB have been used in prior food waste studies to identify predictors and motivators that drive behavioral intention towards food waste reduction [17–20,22,23].

The TPB framework has been expanded to predict a number of household food waste behaviors [18–20]. Examples of these studies range from investigating food waste sorting behaviors in Swiss-German households [21], to comparing Danish household routines, skills and psycho-social factors associated with household food waste behavior [19], to avoiding food waste in the context of Romanian households’ planning and shopping routines [20].

While households have often been the focal point of many food waste studies, others have approached the subject of consumer food waste behavior by utilizing extended TPB frameworks in the context of cafeterias and restaurants. These include a study addressing the underlying factors causing food waste behavior in Swedish buffet restaurants [23], as well as an investigation of beliefs and psychological factors used to predict food waste behavior in French factory cafeterias [17,18].

For the present study we aim to use an extended TPB framework to examine food waste reduction intentions within the context of Taiwan factory cafeterias, and examine factors that influence Taiwan factory workers to reduce food waste. More specifically, we extend the TPB framework by adding psycho-social factors such as habitual factors as well as proenvironmental factors related to environmental attitudes and climate change awareness to better understand and determine what role they play in influencing workers’ intentions to reduce food waste.

Past food waste related studies have often extended the attitude construct incorporated within the TPB framework by examining moral attitudes [20,21], general attitudes towards waste reduction [20,22] and environmental attitudes [19,23]. A number of researchers have found moral attitudes to play a significant role in helping to explain food waste behavior.

Moral attitudes reflected in past studies have focused on the attitudes that individuals express when food waste occurs, such as feelings of guilt towards people who are starving or feelings of distress when food waste is observed [21]. According to Stefan et al. [20], moral attitudes have been used in past research to predict intentions to purchase organic foods, consume ready-to-eat meals and to predict food waste intentions. Additionally, as noted in previous findings, moral attitudes had significant explanatory effects on the generation of consumer food waste when using planning and shopping routines as mediators [20].

While moral attitudes have been shown to have a significant direct relationship with food waste behavior, general attitudes have also been shown to have explanatory power over behaviors and intentions concerning food waste. For example, Kim and Hall [22] pointed out that among other factors, attitudes have been used to help explain tourists’ waste reduction intentions as well as consumer
takeaway food waste separation behaviors in workplaces. Their research has also shown that general attitudes on waste reduction have a significant impact on behavioral intentions to reduce waste.

In contrast to moral and general attitudes, attitudes associated with environmental concerns and awareness have been shown in prior studies to have mixed results in explaining intentions to reduce food waste and general food waste reduction behaviors. For example, Stancu et al. [19] referenced prior literature that determined consumers failed to link food waste with environmental concerns like greenhouse gas emissions. Visschers et al. [21] also cited prior research that found environmental concerns were less important than financial concerns with regards to wasting food, and they were regarded as having little influence on food waste behavior in general. Furthermore, Stefan et al. [20] found that consumers participating in their study were generally unaware of environmental consequences caused by food waste. On the contrary, prior research conducted by Williams and Walton [43] concerning hospital food waste found that individuals with higher environmental awareness tended to produce less food waste.

Based on the prior research and findings it is strongly believed that Taiwanese factory workers’ moral and general attitudes likely have a positive effect on their intention to reduce food waste, but what about environmental attitudes? Climate change and global warming were shown to be the most serious environmental and ecological problems in a survey of Taiwanese respondents [44]. Indeed, in terms of measuring progress towards combatting climate change, Taiwan ranked 40th out of 180 countries in the 2020 Environmental Performance Index [45]. Further, considering that global food loss and waste is responsible for 8% of total greenhouse gas emissions resulting from human activity [46], we intend to test whether environmental attitudes have an effect on intentions to reduce waste food, and therefore hypothesize that workers’ environmental attitudes should have a positive effect on their behavioral intention to reduce food waste.

Past research has extended the TPB by adding measures of moral norms which have been shown to significantly influence and predict behavioral intention towards reducing food waste [17]. Likewise, Visschers et al. [21] demonstrated that personal moral norms have the ability to predict food waste behavior. This was shown by respondents reporting feelings of guilt and unease when food waste occurred. Furthermore, Lavén [23] showed that in addition to several other predictors of food waste behavior, personal moral norms proved to be a reliable predictor as well. The personal moral norms expressed in these studies are rooted in the norm activation model (NAM) proposed by Schwartz [47], and have been widely used in the context of altruistic and environmentally friendly behavior to study individual prosocial behavior. Prosocial behavior is defined as behavior that benefits others, examples being helping others, sharing, and ecofriendly behavior [48].

While an individual’s personal moral norms have been shown to predict intended behaviors [47–49], subjective norms or the societal views shared by people closest to the individual have also been shown to have a noticeable influence on intended behavior [42,49]. It should be noted that when applied to behavioral studies focused on food waste reduction, subjective norms have provided mixed results. Some studies were unable to show a significant relationship between subjective norms and reported food waste [17,20,21,23], while in other studies, subjective norms were found to have a significant contribution and were able to successfully predict intentions to reduce food waste [22].

In addition to subjective norms, another set of norms that are related to social influence and have been used to extend the theory of planned behavior are injunctive norms [19]. Similar to subjective norms, injunctive norms are considered to be the shared belief system overseeing what is approved or disapproved in a given society. These can be thought of as norms dictating how a person ought to behave, which is why they are also sometimes referred to as “ought” norms [19]. For the present study, in lieu of subjective norms, we have decided to apply injunctive norms to measure social influence. In line with previous food waste related studies, particularly, [19,21,23] we have included prosocial norms in the proposed framework, and hypothesize that prosocial norms, expressed as injunctive norms, will have a significant positive effect on intention.
As with other factors taken from the theory of planned behavior, perceived behavioral control is an important factor used in studying intention to reduce food waste. Perceived behavioral control has been shown to support food waste reduction intentions through indirect variables such as food planning and shopping activities [20]. Lavén [23] also found strong correlation between perceived behavioral control and intention to reduce food waste, and reported that both intention and behavioral control were related to concrete reductions in food waste.

On the contrary, while [19] found that perceived behavioral control had a strong effect on overall food waste behavior, their findings did not indicate higher levels of correlation when compared to intentions to reduce food waste. It should also be noted that perceived behavioral control differs when comparing household food waste and waste that occurs in workplace cafeterias. This is primarily due to the fact that in household situations, the individual has greater control over what type of food as well as what quantities of food are purchased, while in cafeteria or catered meal settings, consumers may face limited food choices and restricted portion sizes thus there is less perceived control [17].

As the main context of this study centers on factory cafeterias, and given the variance of past research outcomes, it is questionable whether Taiwanese workers’ perceived behavioral control will have a significant effect. It is therefore hypothesized that perceived behavioral control will not have a significant effect on behavioral intention to reduce food waste in the context of this study.

The central factor of the theory of planned behavior used in this study is the intention to avoid food waste. It is through this intention that we explore the effects of an extended theory of planned behavior. In this case, environmental attitudes, perceived behavioral control, injunctive norms extended with habitual factors and climate change awareness are used to predict intention which in turn is used to predict food waste behavior, as it has been shown that intention to reduce food waste has a direct relationship with actual food waste reduction [20]. In several related studies, intention to avoid or reduce food waste was shown to have a positive relationship between attitudes towards reducing food waste and food waste reduction [17,21]. Sebbane and Costa [18] further suggest that in public places, such as workplace cafeterias, intention to reduce waste has a significant impact on food waste behavior. Given this prior research, it is hypothesized that intention to reduce food waste will have a negative effect on food waste behavior.

In addition to utilizing the theory of planned behavior in studies concentrated on food waste behavior, it is also important to apply other psycho-social factors such as habitual factors, as it has been shown to help in understanding food consumption-related behaviors [50]. Through their research on seafood consumption, Honkanen et al. [50] suggests that in addition to the TPB, habitual factors play an important role in explaining repetitive behavior such as food consumption. They further demonstrate that both habits as well as past behavior were positively related to intention, and through their study they showed that these factors had strong relationships to attitudes when it comes to consuming seafood. Moreover, habit tends to be linked to past behavior which has also been looked at in food waste studies. One notable study looked at households’ past behavior in terms of shopping and planning and subsequent food waste behavior [20]. In this study it is also believed habitual factors have a strong influence on the intention to reduce food waste. As such, we hypothesize that Taiwanese factory workers’ habits have a positive effect on their intention to reduce food waste.

Food waste has been shown to be a significant contributor to climate change [46]. When food is wasted, resources such as energy and water used to produce and transport the food are also wasted. Moreover, when uneaten food ends up in landfills, the rotting material produces methane, a known greenhouse gas [51]. The UN reports that food waste generation has serious negative effects on the environment and the food sector in general accounts for as much as 8% of all human generated greenhouse gas emissions [46]. The UN includes sustainable production and consumption as the 12th Sustainable Development Goal for the planet [52]. Furthermore, the UN has set a target date of 2030 to reduce food losses along production and supply chains and halve per capita global food waste at the retail and consumer levels [52].
Past food waste studies have used proenvironmental factors to extend the TPB model. Examples include environmental knowledge [53] and lack of concern [20]. In this latter study, lack of concern is used as a measure of general attitude to examine its impact on the intention to not waste food. Stefan et al. [20] reported a negative relationship between lack of concern and intention to not waste food. Interestingly, awareness of climate change causes and effects have also been shown to influence food waste reduction, and in their study, Kim and Hall [22] showed the significant impact climate change awareness has had on influencing attitudes and behavioral intention related to food waste reduction.

Other proenvironmental factors, such as the concept of sustainability, have also been used to develop extended TPB frameworks. Bauer et al. [54] noted that prior research showed weakness in linking the influence knowledge has over proenvironmental or sustainable behavior. They contend that one possible explanation for this is the way the knowledge construct has been developed in prior studies. As such, in a 2018 extended TPB model proposal, a dual knowledge approach was offered by separating problem-based and solution-based knowledge aspects while adapting knowledge constructs related to sustainability [54].

For this paper we focus on the problem-based knowledge aspect operationalized as climate change awareness, and adopt intermediate and longer-term cause and effect items in regard to greenhouse gas emissions and their effect on climate change. As demonstrated in the study conducted by Kim and Hall [22], we too hypothesize that climate change awareness will have a significant positive influence on the intention to reduce food waste.

In addition to the factors examined above, cafeteria-related factors should also undergo intensive review when trying to understand workers’ intentions to not waste food as well as actual food waste behavior. Cafeteria related factors that we review in closer focus center around cafeteria-service quality. Prior literature has expanded the meaning of service quality to include factors such as speed and efficiency of service staff, friendliness of service staff, location and convenience of the meal service, i.e., the cafeteria, as well as variety of food choices [55]. It is believed better service quality and friendly staff will give workers a better impression of the food. Faster service means meals will be hotter and fresher, which in turn will make it more appealing to the workers. A convenient location will result in the workers being able to get in and out of the cafeteria more quickly so they will not be rushed to finish their meal. That said, we hypothesize that a higher perception of service quality will in turn have a negative effect on food waste behavior. In other words, the better the service quality, the less food waste workers are likely to produce.

In the context of food waste, perceived behavioral control and situational factors are regarded as having an influence on behavioral intention [23]. Situational factors can be divided into external and internal factors, where external factors in the context of cafeteria food can include factors such as food appearance, taste and flavor. Internal factors are related to appetite, i.e. feelings of hunger or fullness, as well as personal taste and preferences which can influence whether a worker finishes their food or not [56]. Time constraints where one may or may not have enough time to finish a meal is also an example of a situational factor that can have a direct impact on whether food waste is generated or not [23]. It is thought that situational factors, for example lack of appetite or a feeling of being rushed, will cause workers to be less likely to finish their meals and thus they will produce more food waste. The proposed research model can be seen in Figure 1.

In light of above arguments, we propose the following hypotheses:

**Hypothesis 1 (H1):** Factory workers’ environmental attitudes have a positive effect on their intention to not waste food.

**Hypothesis 2 (H2):** Factory workers’ injunctive norms have a positive effect on their intention to not waste food.

**Hypothesis 3 (H3):** Factory workers’ perceived behavioral control have a positive effect on their intention to not waste food.
Hypothesis 4 (H4): Factory workers’ habit have a positive effect on their intention to not waste food.

Hypothesis 5 (H5): Factory workers’ climate change awareness has a positive effect on their intention not to waste food.

Hypothesis 6 (H6): Cafeteria-service quality has a negative effect on food waste.

Hypothesis 7 (H7): Situational factors have a positive effect on food waste.

Hypothesis 8 (H8): Factory workers’ intention not to waste food has a negative effect on food waste.

3. Methodology

In order to address the aforementioned research questions, a TPB research model was proposed and extended within a factory cafeteria food waste context. Further, a pool of survey items was developed through semistructured interviews and literature review. The initial version of the developed survey was reviewed by experts in the field and the survey was improved according to their suggestions. Thereafter, the survey was translated into Mandarin Chinese and back-translated into English to maintain translational equivocality. Both Mandarin Chinese and English versions of the survey were presented to academic experts in the field and refinements were carried out. A pretest was then carried out with 30 factory workers to check if the questions proposed were clear, understandable, and sensible. After making slight modifications, the final version of the questionnaire was distributed to various factories in Taiwan. Appendix A briefly portrays overall scale development and testing procedure.

The final survey, containing 39 items, was distributed in March 2020 in the form of a self-administered paper-and-pencil questionnaire used to collect data from Taiwanese factory workers who regularly patronize factory cafeterias. A total of 189 participants took part in the survey. Of the 189 questionnaires collected, a total of 156 were deemed usable and valid for hypotheses testing. A total of 33 surveys were excluded due to some participants failing to complete the entire questionnaire, while others completed the questionnaire using patterned responses (e.g., checking the same Likert scale number for all items.)

The gender distribution of the sample population was 56.4% male and 43.6% female. The majority of the participants were between the ages of 25 and 44 (69.2%), with the next largest age group being between the 45 and 54 (17.9%). Slightly under half of the participants had a basic high school education...
or less (45.5%), while roughly a third had graduated from college (34.6%). More than half of the participants reported earning a monthly salary of between NTD 25,000 and NTD 45,000 (55.1%), and a minority of participants reported earning a monthly income of less than NTD 25,000 (9%) (1 USD ≈ 30 NTD). Most participants had work experience of over 5 years but less than 20 years (52%), with the next largest group having worked for over 20 years or more in a factory (16%). The complete demographic profile of the participants is summarized in Table 1.

| Variable Categories | Sample% | Frequency |
|---------------------|---------|-----------|
| Gender              | Male    | 56.4%     | 88        |
|                     | Female  | 43.6%     | 68        |
| Age                 | 18–24   | 3.8%      | 6         |
|                     | 25–34   | 33.3%     | 52        |
|                     | 35–44   | 35.9%     | 56        |
|                     | 44–54   | 17.9%     | 28        |
|                     | 55–64   | 7.2%      | 11        |
|                     | >64     | 1.9%      | 3         |
| Education           | High-school or less | 45.5% | 71 |
|                     | Trade school | 12.8% | 20 |
|                     | College degree | 34.6% | 54 |
|                     | Graduate degree | 7.1% | 11 |
| Income              | Up to NTD 25,000 | 8.3% | 13 |
|                     | NTD 25,000–35,000 | 32.7% | 51 |
|                     | NTD 35,001–45,000 | 22.4% | 35 |
|                     | NTD 45,001–55,000 | 18.6% | 29 |
|                     | NTD 55,001 and over | 18% | 28 |
| Work experience     | Less than 1 year | 5.8% | 9 |
|                     | 1–3 years | 13.5% | 21 |
|                     | 3–5 years | 12.8% | 20 |
|                     | 5–10 years | 21.2% | 33 |
|                     | 10–20 years | 30.8% | 48 |
|                     | Over 20 years | 16% | 25 |

Data analysis was conducted using a multistep approach. Exploratory factor analysis and Confirmatory factor analysis were employed for measurement scale purification and validation [57,58]. Exploratory factor analysis (EFA) was employed for the sake of scale purification, reduction and identification of distinct variables by group. Furthermore, we performed Kaiser Meyer Olkin (KMO) and Bartlett’s test of sphericity to ensure sampling adequacy and to confirm that the item correlation matrix was not significantly different from the respective identity matrix. The results of EFA showed that Kaiser Meyer Olkin (KMO) index = 0.85 and Bartlett’s test of sphericity = Chi square = 4203.04, p < 0.05. Overall, it indicated that the sample size was adequate to perform factor analysis.

Exploratory factor analysis on 39 items was performed using the principal component analysis (PCA) approach with Varimax rotation, while retaining factors with an eigenvalue greater than 1.0. A total of 3 items, each with (1) cross-loading above 0.4 on other factors and, (2) factor loading below 0.5 were eliminated [59]. Finally, 33 items, contributing a total variance over 70% with 9 factors, were retained. The factors, i.e., constructs represented climate change awareness, environmental attitudes, injunctive norms, habit, perceived behavioral control, cafeteria-service quality, situational factors, intention to avoid food waste and food waste behavior. The constructs were measured using a 5-point Likert scale, with higher values corresponding to higher levels of agreement.

Harman’s single factor approach was applied to test common method bias. Since only 27.23% of variance was explained by the single factor, Common method bias (CMB) was not a problem. For further confirmation of CMB, we followed Podsakoff et al. [60] and Liang et al. [61] in our study.
In doing so, all 33 items distributed among 9 principle constructs were converted into second-order indicator constructs. Structural paths were drawn connecting these second-order indicator constructs and their corresponding principle constructs as well as a newly introduced construct, method variable. Appendix B shows results of the common method bias test. The average substantive and method variance were calculated to be 0.75 and 0.002, respectively. Overall, we think CMB was unlikely to be a serious concern for this study.

A confirmatory factor analysis (CFA) was performed with regards to the measurement framework in SmartPLS (v. 3.3.2) [62]. An initial evaluation using Cronbach’s $\alpha$-value was implemented to determine scale reliability. Of the 9 constructs analyzed, all but one had a Cronbach’s $\alpha$ greater than 0.70, with Injunctive Norms just falling slightly below the cutoff at 0.68. This was still considered acceptable as the $\alpha$-value of 0.6 to 0.7 generally indicates an acceptable level of reliability [63,64]. Based on these results it was concluded that the constructs’ internal reliability is acceptable. All measurement items were found to have a factor loading greater than 0.50, as recommended by Hair et al. [65]. Internal consistency and convergent validity were assessed through the composite reliability (CR) and average variance extracted (AVE), respectively. As suggested by Fornell and Larker [66], CR and AVE values were evaluated and found to be greater than or equal to 0.70 and 0.50, respectively, with CR values ranging from 0.82 to 0.95 and AVE values ranging from 0.61 to 0.86. All factors have higher CR and AVE values than the suggested minimum thresholds, which indicates internal consistency of the measurement items included within their respective factors. Table 2 presents the detailed measurement model.

| Constructs and Items | Items | Factor Loading | Ref. |
|----------------------|-------|----------------|------|
| **Food waste (FW)** (AVE = 0.74, CR = 0.93, Cr. $\alpha$ = 0.91) [23] | How likely did you have plate leftovers the last five times at lunch? | FW1 | 0.90 |
| | How likely would you leave protein (meat, fish, tofu) on your plate? | FW2 | 0.85 |
| | How likely would you leave starch (rice, pasta, potatoes) on your plate? | FW3 | 0.87 |
| | How likely would you leave vegetables on your plate? | FW4 | 0.90 |
| | How likely would you leave soup in your bowl? | FW5 | 0.78 |
| **Intention not to waste food (INT)** (AVE = 0.81, CR = 0.95, Cr. $\alpha$ = 0.94) [17,23] | I try to eat all foods that I have taken myself | INT1 | 0.89 |
| | I try to throw away no food at all | INT2 | 0.94 |
| | I try to produce only very little food waste | INT3 | 0.95 |
| | I try to leave as little food as possible | INT4 | 0.92 |
| | In the next few weeks in the canteen, I intend not to leave edible food at the end of my meals | INT5 | 0.79 |

Scale: less than a tenth (less than 10%) (1) more than a tenth but less than a quarter (between 10% and 25%) (2) more than a quarter but less than a half (between 25% and 50%) (3) more than half but less than three quarters (between 50% and 75%) (4) more than a three quarters (more than 75%) (5)
Table 2. Cont.

| Constructs and Items                          | Items                                      | Factor Loading | Ref.   |
|----------------------------------------------|--------------------------------------------|----------------|--------|
| **Cafeteria-service quality (CSQ)** (AVE = 0.70, CR = 0.92, Cr. \( \alpha = 0.88 \)) | The cafeteria serves tasty food | CSQ1            | 0.85   |
|                                              | The cafeteria provides fresh food         | CSQ2            | 0.88   |
|                                              | The cafeteria is conveniently located in the factory | CSQ3            | 0.81   |
|                                              | There is a big variety of cafeteria food | CSQ4            | 0.89   |
|                                              | The cafeteria staff are friendly        | CSQ5            | 0.72   |
| Scale: strongly disagree (1) to strongly agree (5) |                              |                |        |
| **Situational factors (SLF)** (AVE = 0.76, CR = 0.90, Cr. \( \alpha = 0.84 \)) | If I leave food it is because I’m full   | SLF1            | 0.82   |
|                                              | If I leave food it is because the food does not taste good | SLF2            | 0.88   |
|                                              | If I leave food it is because the food does not appeal to me | SLF3            | 0.92   |
| Scale: strongly disagree (1) to strongly agree (5) |                              |                |        |
| **Environmental attitude (ENA)** (AVE = 0.80, CR = 0.88, Cr. \( \alpha = 0.75 \)) | One should not load the environment with food waste | ENA1            | 0.93   |
|                                              | Wasting food would make me guilty about the environment | ENA2            | 0.86   |
| Scale: strongly disagree (1) to strongly agree (5) |                              |                |        |
| **Habit (HBT)** (AVE = 0.86, CR = 0.92, Cr. \( \alpha = 0.83 \)) | I do not frequently leave uneaten food on my plate | HBT1            | 0.93   |
|                                              | The cafeteria provides fresh food         | HBT2            | 0.91   |
| Scale: strongly disagree (1) to strongly agree (5) |                              |                |        |
| **Injunctive norms (IVN)** (AVE = 0.61, CR = 0.82, Cr. \( \alpha = 0.68 \)) | One should never waste any food          | IVN1            | 0.80   |
|                                              | One should recycle the food waste generated (e.g. composting) | IVN2            | 0.62   |
|                                              | One should not load the environment with food waste | IVN3            | 0.90   |
| Scale: strongly disagree (1) to strongly agree (5) |                              |                |        |
| **Perceived behavioral control (PCB)** (AVE = 0.66, CR = 0.88, Cr. \( \alpha = 0.83 \)) | Not leaving edible food at the end of a meal is extremely difficult (Scale: strongly disagree (1) to strongly agree (5)) | PCB1            | 0.76   |
|                                              | In my opinion wasting food is … (Scale: extremely avoidable (1) to extremely unavoidable (5)) | PCB2            | 0.86   |
|                                              | In my opinion loading the environment with cafeteria food waste is … (Scale: extremely avoidable (1) to extremely unavoidable (5)) | PCB3            | 0.77   |
|                                              | Not to throw food away would be …         | PCB4            | 0.87   |
| All items were reversed. Scale: very easy (1) to very difficult (5) |                              |                |        |
Table 2. Cont.

| Constructs and Items | Items Factor Loading | Ref. |
|----------------------|----------------------|------|
| **Climate change awareness (CCA)** (AVE = 0.77, CR = 0.93, Cr. α = 0.90) | | [22,54] |
| I am concerned about climate change | CCA1 0.92 | |
| I am alarmed about the reasons of climate change | CCA2 0.76 | |
| I am worried about the consequences of climate change | CCA3 0.93 | |
| The emission of climate-active gases contributes to global warming | CCA4 0.90 | |

Scale: strongly disagree (1) to strongly agree (5)

Additionally, the square root of the average variance extracted was calculated and shown to be higher than the correlation between each factor, which indicates sufficient discriminant validity [67,68]. Referring to Table 3, the lowest value of the square root of the AVE is 0.78 (Injunctive norms), which was higher than all correlation coefficients in the correlation matrix. Overall, we can conclude that both the reliability and validity criteria recommended by the prior research Fornell and Larker [66] was satisfied.

From the above results it was thus determined that the proposed conceptual model had both sufficient convergent and discriminant validity as well as reliability, and thus the proposed conceptual model was regarded as being satisfactory. Table 3 displays the correlation matrix.

Table 3. Correlations.

| Constructs | Mean | SD | 1    | 2    | 3    | 4    | 5    | 6    | 7    | 8    | 9    |
|------------|------|----|------|------|------|------|------|------|------|------|------|------|
| CSQ        | 3.24 | 1.08 | 1.00 |      |      |      |      |      |      |      |      |      |
| CCA        | 4.21 | 0.80 | 0.30 *** | 1.00 |      |      |      |      |      |      |      |      |
| FW         | 1.47 | 0.80 | -0.25 *** | -0.13 | 1.00 |      |      |      |      |      |      |      |
| HBT        | 4.28 | 0.76 | 0.21 * | 0.44 *** | -0.32 *** | 1.00 |      |      |      |      |      |      |
| IVN        | 4.33 | 0.75 | 0.11 | 0.49 *** | -0.17 | 0.66 *** | 1.00 |      |      |      |      |      |
| INT        | 4.26 | 0.74 | 0.20 * | 0.46 *** | -0.37 *** | 0.66 *** | 0.58 *** | 1.00 |      |      |      |      |
| ENA        | 4.10 | 0.84 | 0.16 | 0.54 *** | -0.21 * | 0.55 *** | 0.63 *** | 0.45 *** | 1.00 |      |      |      |
| PCB        | 2.65 | 1.17 | -0.17 | -0.27 ** | 0.25 ** | -0.37 *** | 0.26 * | -0.36 *** | -0.24 * | 1.00 |      |      |
| SLF        | 3.40 | 1.15 | -0.10 | -0.12 | 0.23 * | -0.21 | 0.07 | -0.14 | -0.23 * | 0.27 ** | 1.00 |      |

Note: *** p < 0.001; ** p < 0.01; * p < 0.05.

4. Results

The conceptual framework model was tested using the partial least squares structural equation modeling (PLS-SEM) method using SmartPLS (v. 3.3.2). PLS-SEM is generally preferred for smaller sample sizes and more complex models [68]. Furthermore, PLS-SEM has been shown to produce higher levels of statistical power even when sample sizes are relatively small, and as little as 100 observations can be sufficient [69]. In that regard, it has been suggested to use a minimum sample size of 10 times the maximum number of paths aiming at any construct within the research model [68]. It can be clearly seen from Figure 2 that five structural paths are pointing at the construct, with the intention not to waste food. Therefore, in the proposed research model, our sample size of 156 observations is deemed sufficient for analysis using PLS-SEM.

Verification of the proposed research model as well as factor relationships was conducted using a bootstrap re-sampling technique, where large numbers of subsample sets are produced and analyzed using observations randomly drawn (with replacement) from the original data set. Path coefficients as well as t-statistics have been assessed for the eight hypotheses by utilizing the PLS bootstrapping technique with 5000 re-samplings. Figure 2 shows the path analysis results, including the path coefficients as well as t-statistics and the variance of the dependent variables. Table 4 shows the
hypothesis relationships along with the path coefficients and t-statistics, as well as the decision on whether each hypothesis was supported or not.

![Structural path model](image)

**Figure 2.** Structural path model.

**Table 4.** Hypotheses testing results.

| Hypothesis | Relationship   | Path Coefficient | t-Statistics | Result     |
|------------|----------------|------------------|--------------|------------|
| H1         | ENA→INT        | −0.02            | 0.31         | Not supported |
| H2         | IVN→INT        | 0.20*            | 2.06         | Supported  |
| H3         | PBC→INT        | −0.12            | 1.75         | Not supported |
| H4         | HBT→INT        | 0.43***          | 4.45         | Supported  |
| H5         | CCA→INT        | 0.16*            | 2.08         | Supported  |
| H6         | CSQ→FW         | −0.17*           | 1.98         | Supported  |
| H7         | SNF→FW         | 0.16**           | 2.70         | Supported  |
| H8         | INT→FW         | −0.31***         | 3.90         | Supported  |

Note: **p < 0.001; * p < 0.05; Legend: ENA—Environmental attitude; IVN—Injunctive norm; PBC—Perceived behavioral control; HBT—Habit; CCA—Climate change awareness; CSQ—Cafeteria service quality; SNF—Situational factors; INT—Intention not to waste food; FW—Food waste.

Not surprisingly, climate change awareness was shown to have a significant positive association with intention to reduce food waste. This finding is also supported by prior research shown by Kim and Hall [22]. Contrary to previous research conducted by Lavén [23], environmental attitudes themselves were not shown to have any significant effect on intention to reduce food waste.

Injunctive norms were also shown to be significantly associated with intention to reduce food waste, resulting in a positive effect as hypothesized. This further ties in with previous findings presented by Stancu et al. [19], in which they provided evidence that injunctive norms have strong predictive power concerning intention, especially in food related behavioral studies where injunctive norms are used to operationalize the TPB’s subjective norm component. It is also interesting to point out that this finding is contrary to the work offered by Stefan et al. [20], as unlike Stancu et al. [19], they reported that consumers were generally unaware of the environmental effects of food waste and the normative construct of the TPB did not have a significant effect on intention.

Keeping with the TPB, the t-statistic for perceived behavioral control was found to be insignificant in relation to intention to reduce food waste. This is contrary to prior research conducted by Sebbane [17] and Stancu et al. [19], which both showed that perceived behavioral control has strong significant
predictive power on intention. It is believed that a larger sample size can elevate perceived behavioral control, and should be considered for future research.

Lastly, habit was shown to have the strongest significant positive effect on intention to reduce food waste. This finding aligns with a previous study conducted by Honkanen et al. [50], where habit, in addition to past behavior, was found to explain differences in intention. Overall, explained variance for intention to reduce food waste is 51%.

Supporting prior research by Sebbane [17] and Lavén [23], our research results similarly indicate that intention to reduce food waste has a significant negative impact on food waste behavior, where higher levels of intention to reduce food waste correspond with lower levels of food waste behavior. Furthermore, service quality was also shown to have a significant negative relationship to food waste behavior. This aligns with prior research concerning food waste in a Portuguese cafeteria setting where it was noted that high or persistent levels of food waste may indicate service failure or inefficiency [70].

Situational factors had a significant positive association with food waste behavior. This finding is in line with Sebbane [17]. Measures of Cronbach’s α indicate that taste and appeal represent the strongest indicators of situational factors, which is partially supported by prior research [56] and in line with comments made by a cafeteria manager during a subsequent interview. He noted that he perceived factory floor laborers to prefer meat dishes and were more inclined to throw out vegetables, while factory office staff would generally demonstrate the opposite behavior, preferring vegetables and throwing away more meat dishes. Future studies should consider including descriptive questions to better separate factory laborers and office or administrative staff to determine if these demographic variables influence proposed frameworks. The combined model explained 20% of the variance in food waste behavior.

Overall, none of the control variables including gender, education, age, experience and income were found to have significant relationship with food waste. This may be due to the uniformity in the cultural and societal values among Taiwanese people, which are perhaps linked with the Chinese cultural tradition of food preservation practices [71]. Another possible reason is the successful implementation of government initiatives such as waste management and recycling over the last decade which might have contributed to building uniform moral values among the population [72]. For in-depth assessment, a multi-group analysis was performed to understand differences between the groups with respect to all relationships in the research model. The gender group was split between male and female, and for the other control variables we dichotomized the data. Respondents with high school and trade school backgrounds were treated as the lower education group, while respondents with college and graduate degrees were placed in the higher education group. People aged 34 years or younger were separated into a young group, while the remaining participants were placed in the middle-aged group. In order to separate work experience and income, 10 years of work experience and a reported monthly income of NTD 35,000 were set as break points for dividing these two control variables.

The results indicate there are no significant differences between groups when it comes to gender, work experience and income levels. However, the results do indicate significant differences in certain relationships within lower and higher education groups as well as young and middle-aged groups. This finding is parallel with previous food waste related research [73]. As shown in Table 5, we found statistically significant differences in lower and higher education groups while assessing the relationships between situational factors, cafeteria-service quality and intention not to waste food and food waste behavior. In the case of intention, both groups exhibited a negative correlation however higher educated workers had a stronger path coefficient. Concerning cafeteria-service quality, it was noted the relationship with food waste was positively significant in the case of highly educated workers while it was negatively significant in the lower educated worker group. Finally, the relationship between situational factors and food waste was insignificant for highly educated workers, but positively significant for workers with lower education levels. This finding was against
our expectations, and likely indicates workers with higher education levels can handle situational factors better than those with less education.

Table 5. Higher vs. lower education.

| Relationships   | High Education (Sig) (C) | Low Education (Sig) (D) | Difference (C-D) | t-Value (|C vs. D|) | Parametric p Value (C vs. D) |
|-----------------|---------------------------|-------------------------|------------------|-----------------|-----------------------------|
| 1. CCA→INT     | −0.06                     | 0.31                    | −0.37            | 1.70            | 0.07                        |
| 2. ENA→INT     | −0.05                     | −0.11                   | 0.06             | 0.28            | 0.78                        |
| 3. HBT→INT     | 0.63                      | 0.35                    | 0.28             | 1.42            | 0.16                        |
| 4. IVN→INT     | 0.17                      | 0.27                    | −0.10            | 0.53            | 0.59                        |
| 5. INT→FW      | −0.60                     | −0.16                   | −0.44            | 3.70            | 0.001 ***                   |
| 7. CSQ→FW      | 0.23                      | −0.29                   | 0.52             | 2.3             | 0.03 *                      |
| 8. SLF→FW      | −0.08                     | 0.24                    | −0.32            | 2.5             | 0.01 *                      |

Note: *** p < 0.001; * p < 0.05.

Table 6 shows the relationship between perceived behavioral control and intention not to waste food is negatively significant in younger workers while insignificant in middle-aged workers. This difference is statistically significant, and likely indicates that middle-aged workers feel that they have stronger volitional control to not waste food.

Table 6. Young vs. middle-aged.

| Relationships   | Young (Sig) (C) | Middle-Aged (Sig) (D) | Difference (C-D) | t-Value (|C vs. D|) | Parametric p Value (C vs. D) |
|-----------------|----------------|------------------------|------------------|-----------------|-----------------------------|
| 1. CCA→INT     | 0.18           | 0.20                   | −0.02            | 0.17            | 0.87                        |
| 2. ENA→INT     | 0.01           | −0.21                  | 0.22             | 1.34            | 0.18                        |
| 3. HBT→INT     | 0.29           | 0.63                   | −0.34            | 1.74            | 0.08                        |
| 4. IVN→INT     | 0.25           | 0.27                   | −0.02            | 0.44            | 0.96                        |
| 5. INT→FW      | −0.37          | −0.21                  | −0.16            | 1.30            | 0.19                        |
| 6. PBC→INT     | −0.23          | 0.04                   | −0.27            | 2.39            | 0.02 *                      |
| 7. CSQ→FW      | −0.29          | −0.09                  | −0.20            | 0.02            | 0.98                        |
| 8. SLF→FW      | 0.12           | 0.14                   | −0.02            | 0.01            | 0.99                        |

Note: * p < 0.05.

5. Discussion

The aim of the study was to measure the effects of an extended theory of planned behavior (TPB) on the intention of Taiwanese factory workers to reduce food waste and subsequent food waste behavior in a factory cafeteria context. The study further examined factors associated with the norm activation theory and proenvironmental factors that influence workers’ intention to reduce food waste and food waste behavior through a conceptual model.

For this study, the attitudes construct of the TPB was operationalized as environmental attitudes. Interestingly, the effect of environmental attitudes on intention was extremely weak in this study. It is thus reasoned that the workers’ participating in this study do not associate negative environmental impact with food waste. This could be explained by the fact that many Taiwanese generally believe that food waste has beneficial uses, for example its use in commercial composting or as pig feed in Taiwan’s robust pork industry [74].

Aside from attitudes about food waste, the results also suggest that the perceived behavioral control determinant of the theory of planned behavior also does not provide significant explanatory power in the case of factory workers’ intention to reduce food waste. This is possibly due to the fact that workers may feel that food waste in the factory cafeteria setting is not under their own volitional control. During a subsequent interview with a cafeteria manager, it was mentioned that workers in his
respective factory do not decide the menu, nor are they offered choices at meal time. They are not given an option concerning the portion of food they are served as all servings are prepared by the kitchen staff. The only thing that workers that dine in his cafeteria have any control over is the amount of rice they take from a communal rice bowl at the cafeteria entrance. The cafeteria manager suggested this is the only instance where workers have any control over how much or how little they consume. In this regard, the workers do have control, and if studied separately it would likely show that PBC has a strong significant association with their intention to reduce rice waste, however in the general context of factory workers’ intention to reduce overall food waste, perceived behavioral control has been shown to only be weakly significant.

The subjects sampled by Stancu et al. [19] in their study were generally unaware of the environmental impact of food waste, which they stated was in line with prior research showing that normative constructs used in the TPB are frequently shown to be weak determinants of intention, especially when applied in food studies. However, in the present study, results showed that injunctive norms exert a strong significant influence on the intention to reduce food waste. This is possibly explained due to the fact that Taiwanese factory workers have an underlying deep-seated understanding that they ought not waste food. Indeed, members of Taiwanese society are known to be both frugal and industrious [75], traits that are generally associated with being less wasteful.

In order to extend the TPB framework further, the role of habit was examined in relation to the intention to reduce food waste. Supporting our hypothesis, the habit construct was found to have a significant effect on intention to reduce food waste. This is in line with prior research [50], in which habitual factors have shown strong influence on behavioral intention to consumer seafood. As discussed by Honkanen et al. [50], attitudes have often been used as the main driver of public awareness campaigns used to change behavioral intentions and behaviors, but changing attitudes may have little impact if strong habits are already formed in the target population. As such, while old habits are generally difficult to change, it still may be more advantageous to try and encourage the formation of new favorable habits in order to obtain the desired behavior. Based on this study, it is therefore reasoned that in order to encourage factory workers’ behavioral intentions towards food waste reduction as well as changing food waste behavior, examining their habits is an important place to start.

Service quality was measured to determine if there was a direct relationship with food waste behavior, and as hypothesized, cafeteria-service quality was shown to have a significant negative effect on food waste behavior. This can be best explained considering that better overall service will result in workers’ wasting less food. Most cafeterias are located within the factory buildings, making them more convenient during meal services. This in turns means workers have more time to eat and are not rushed, which gives them sufficient time to finish their meals.

Interconnected with convenience and time limitations, situational factors were also shown to have a significant positive impact on food waste behavior, meaning increased food waste behavior is expected when situational factors are taken into consideration. For this study, situational factor measurement items focused on factors that might drive an individual to waste food, such as loss of appetite, poor taste, low appeal or not having sufficient time to finish one’s meal.

6. Research Implications

The information gathered in this study has practical implications for factory owners, managing directors and factory cafeteria managers in Taiwan. Based on the research findings it is clear that factors such as habit, injunctive norms and climate change awareness are significant drivers of workers’ intentions to reduce food waste. When food waste reduction initiatives are carried out in the planning and implementation of factory cafeteria meal services, these factors should be addressed. This could include the reinforcement of injunctive norms and climate change awareness by hanging posters in the cafeteria expressing pro-social and proenvironmental ideas related to food waste reduction. Incentivizing good food habits could also be a suitable way to encourage the reduction of food waste.
behavior. For example, cafeterias could reward workers that consume all their food and avoid plate leftover waste. Rewards might include chances to participate in lucky draws, prizes and giveaways.

Cafeteria-service quality was also shown to have significant effect on food waste behavior. As such it is recommended to ensure service quality is optimized in order to provide efficient and speedy service, which may include hiring additional servers or ensuring a wider variety of food choices are available. Situational factors were also shown to increase food waste, so it is important to mitigate their effects by allowing workers enough time to finish meals, offering foods they like, and avoiding excessive portions.

Reducing food waste, and in particular worker’s plate leftovers, translates to direct operational cost savings. Such cost savings can be obtained through a reduction in food ingredient purchases, lower labor costs and reduced scrapping costs. For example, in one factory, the cafeteria manager reported that he generally throws out up to 25 kg of plate waste daily. Assuming he provides meal service approximately 50 weeks out of the year, that equates to over 6 tons of wasted food annually. He advised that he pays approximately NTD 1000 per month to have the food waste picked up and delivered to a pig farm. The cost covers transportation fees as well as the cost of natural gas burned to heat treat (boil) the food waste during the processing of pig feed. Assuming this is an average scrapping cost and assuming scrapping costs are relatively stable throughout the year, this translates to approximately NTD 12,000 (~USD 400 based on present exchange rates) per factory per annum. If we assume the 4000 factories employing 100 or more workers have similar scrapping costs, then the collective scrapping costs of plate waste over the whole of Taiwan could reach an estimated NTD 48,000,000 (~USD $1,600,000) per year.

Aside from the financial implications, extrapolating the environmental impact should also be considered. If the average factory is disposing roughly 25 kg of plate leftovers on a daily basis, and we assume the average amount of food waste one factory throws out per year exceeds 6 tons, then the 4000 factories employing 100 or more workers are likely responsible for as much 24,000 tons of plate leftover food waste per year. Of course, this is barely 1% of the approximate 2.2 million tons of the food waste Taiwan generates annually [6], but even incremental reductions in food waste should be encouraged. As previously mentioned, wasted food equates to wasted resources used to produce and transport it, not to mention the amount of methane that food waste will produce once it ends up in a landfill.

It should be noted that not all factory cafeterias set key performance indicators to measure food waste reduction. Some factory owners as well as kitchen managers believe that larger food portions are needed to sustain factory workers that carry out strenuous labor-intensive work. For example, one factory cafeteria controlled and divided serving sizes and portions equally, so that all workers, even administrative staff, receive the same portions. In this case, admin workers with smaller appetites may not require the full portion to feel satiated and thus will dispose of the leftovers creating food waste.

Another consideration that should be addressed is the desire of some factory owners and cafeteria managers to intentionally offer more food than is needed in order to appear more generous in the eyes of workers and staff. While food costs over time can add up substantially, perceived savings on workers’ food portions can be seen as stingy, and thus have negative human resource implications concerning employee retention and recruitment. Indeed, during a follow up interview with one cafeteria manager, she mentioned she initially considered surveying factory cafeteria patrons concerning their food waste intentions and behavior to be a taboo subject, primarily due to her concern that workers would react negatively and suspiciously to being asked to fill out a food waste related survey.

7. Limitations and Future Research Scope

The current research is not free from limitations. First, a major limitation of this paper has to do with the questionnaires being distributed in March, 2020 at the height of the COVID-19 pandemic. During the pandemic, many factories in Taiwan implemented changes in the factory cafeteria seating plans, in particular by segregating workers and preventing them from sitting in groups. It is thought that this type of intervention could have an impact on the normal behavior of workers and affect
observations. For example, during a subsequent interview with a factory cafeteria manager, he felt that the plate waste volumes had increased as workers were not allowed to share nor trade foods, which he said were common behaviors prior to the pandemic. Future research should investigate impacts of COVID-19 on food waste in factory cafeterias.

Another limitation due to the COVID-19 pandemic was the subsequent refusal of many factories to participate in the study. Multiple factories were contacted, but many were unwilling to receive visitors or materials from outside sources out of fear of contagion. As a result, we were able to distribute and receive questionnaires in only a few factories in Central Taiwan. Future researchers are recommended to investigate food waste behaviors among factory workers with a larger and more diverse sample.

For further in-depth examination, it is recommended for future studies to also include additional demographic questions to better divide survey participants into laborers and administrative staff in order to determine if differences in motivating factors exist between these groups. It should also be noted that there is a large number of foreign migrant workers that supplement Taiwan’s factory worker population. These workers mainly come from the South East Asian nations of Vietnam, the Philippines, Thailand and Indonesia. As the survey questionnaire was developed in Chinese, many of the migrant workers were not able to participate due to language barriers, which prevented us from collecting data from them. Future researchers can consider focusing on the migrant worker groups employed in Taiwan factories to better understand their food waste reduction intentions and general food waste behavior. Lastly, as the factors examined in this study only explain 20% of the variance in food waste, future research should investigate other contributing factors related to food waste, such as psychological stress, fear of performance loss, sleep, personality traits, etc.

8. Conclusions

Food waste is a critical issue that affects the global community. Tackling the food waste problem is a major part of the UN’s sustainable development goals. Not only can reducing global food waste help to eliminate food insecurity and malnutrition, but reducing food waste, a major greenhouse gas contributor, can also help make a significant impact in slowing climate change. As such, it is critical for researchers to examine food waste behaviors and find ways to reduce food waste. Much of the existing research has been conducted in Western nations [17–21,23,24,76,77], and has focused on food waste in terms of supply chain inefficiencies as well as plate waste in restaurants and homes. While these studies represent important work in reducing food waste, there are other areas of study that require more focus and attention. As many of the world’s factories reside in Asia, it makes sense to examine factory cafeteria food waste behavior in an Asian context.

Data collected from 156 Taiwanese factory workers were analyzed using a Partial Least Squares Structural Equation Modelling (PLS-SEM) technique. Results reveal that climate change awareness, injunctive norms and habit are strong motivating factors towards Taiwan factory workers’ intention to reduce food waste. Although situational factors, cafeteria-service quality and intention to reduce food waste significantly affect food waste, these factors fail to explain a significant amount of variance. This finding was against our expectation.

This research delivers multifold contributions. First, the research addresses the key burgeoning issue of food waste in the factory cafeteria context. Given the limited academic literature associated with Asian countries and food waste problems, particularly in relation to factory cafeteria food waste, this paper examines a key unexplored food waste scenario. Second, the overall focus of this research lies at the intersection of several disciplines, such as sustainability, factory cafeteria food waste and workers’ behavioral intentions. Third, the research builds a comprehensive conceptual framework by identifying key determinants of food waste intentions and behaviors using multiple theories, which are further extended with situational and cafeteria-service quality factors. Fourth, this research contributes to the body of literature through its findings, and further highlights ways to boost intentions to reduce food waste, as well as increase food waste reduction awareness and its vital importance to global sustainable
development goals. Finally, it also helps to uncover ways factory managers can optimize meal service food management, reduce overall food waste, and contribute to a more sustainable operation.

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**Appendix A  Scale Development and Testing**

**Figure A1.** Scale development and testing procedure.

**Appendix B  Testing Common Method Bias**

**Table A1.** Common method bias analysis.

| Construct | Indicator | Substantive Factor Loading ($R_{1}$) | Method Factor Loading ($R_{2}$) | Substantive Variance ($R_{1}^{2}$) | Method Variance ($R_{2}^{2}$) |
|-----------|-----------|--------------------------------------|---------------------------------|-----------------------------------|-------------------------------|
| 1. FW     | FW1       | 0.86                                 | -0.014                          | 0.74                              | 0.0002                        |
|           | FW2       | 0.88                                 | 0.088                           | 0.77                              | 0.0077                        |
|           | FW3       | 0.87                                 | -0.085                          | 0.76                              | 0.0072                        |
|           | FW4       | 0.89                                 | 0.034                           | 0.79                              | 0.0011                        |
|           | FW5       | 0.81                                 | -0.024                          | 0.66                              | 0.0005                        |
| 2. INT    | INT1      | 0.95                                 | 0.052                           | 0.90                              | 0.0027                        |
|           | INT2      | 0.92                                 | 0.002                           | 0.85                              | 0.0000                        |
|           | INT3      | 0.95                                 | -0.004                          | 0.90                              | 0.0000                        |
|           | INT4      | 0.80                                 | -0.013                          | 0.64                              | 0.0001                        |
|           | INT5      | 0.87                                 | -0.035                          | 0.76                              | 0.0012                        |
| 3. CSQ    | CSQ1      | 0.89                                 | -0.065                          | 0.79                              | 0.0042                        |
|           | CSQ2      | 0.86                                 | 0.067                           | 0.73                              | 0.0045                        |
|           | CSQ3      | 0.71                                 | 0.001                           | 0.50                              | 0.0000                        |
|           | CSQ4      | 0.81                                 | -0.063                          | 0.65                              | 0.0040                        |
|           | CSQ5      | 0.88                                 | 0.055                           | 0.77                              | 0.0030                        |
### Table A1. Cont.

| Construct | Indicator | Substantive Factor Loading \((R_1)\) | Method Factor Loading \((R_2)\) | Substantive Variance \((R_{1^2})\) | Method Variance \((R_{2^2})\) |
|-----------|-----------|-----------------------------------|--------------------------------|--------------------------------|--------------------------------|
| 4. SLF    | SLF1      | 0.91                              | 0.008                          | 0.91                           | 0.0000                         |
|           | SLF2      | 0.81                              | 0.018                          | 0.81                           | 0.0003                         |
|           | SLF3      | 0.89                              | −0.029                         | 0.89                           | 0.0008                         |
| 5. INV    | INV1      | 0.65                              | 0.050                          | 0.42                           | 0.0025                         |
|           | INV2      | 0.89                              | −0.015                         | 0.79                           | 0.0002                         |
|           | INV3      | 0.80                              | −0.024                         | 0.64                           | 0.0006                         |
| 6. PCB    | PCB1      | 0.88                              | 0.014                          | 0.77                           | 0.0001                         |
|           | PCB2      | 0.86                              | 0.019                          | 0.74                           | 0.0004                         |
|           | PCB3      | 0.78                              | 0.021                          | 0.60                           | 0.0004                         |
|           | PCB4      | 0.74                              | 0.061                          | 0.55                           | 0.0037                         |
| 7. ENA    | ENA1      | 0.89                              | 0.027                          | 0.79                           | 0.0007                         |
|           | ENA2      | 0.90                              | −0.026                         | 0.81                           | 0.0007                         |
| 8. HBT    | HBT1      | 0.91                              | 0.038                          | 0.83                           | 0.0014                         |
|           | HBT2      | 0.93                              | −0.039                         | 0.86                           | 0.0153                         |
| 9. CCA    | CCA1      | 0.91                              | 0.003                          | 0.83                           | 0.0000                         |
|           | CCA2      | 0.93                              | 0.006                          | 0.96                           | 0.0000                         |
|           | CCA3      | 0.78                              | 0.054                          | 0.61                           | 0.0029                         |
|           | CCA4      | 0.90                              | −0.051                         | 0.81                           | 0.0026                         |
|           | Average   | 0.75                              | 0.0021                         |                                |                                |

Notes: FW—food waste; INT—intention not to waste food; CSQ—cafeteria service quality; SLF—situational factor; INV—injunctive norm; PCB—perceived behavioral control; ENA—environmental attitude; HBT—habit; CCA—climate change awareness.

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