Master's Thesis of Environmental Management

# Impact of perceived food accessibility on household food waste behavior

## 인식된 음식 접근성이 가구의 식품폐기행동에 미치는 영향

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# Abstract

Food waste is a global issue that is currently gaining attention in light of food security problems and related environmental issues. Studies related to household food waste have looked at socio demography and consumer behavior in attempting to explain household food waste behaviors. However, there are also other factors stemming from material infrastructure such as food accessibility that can also indirectly impact household food waste behaviors. This paper therefore looks at food accessibility, measured in terms of time and effort levels, and its impact on household food waste. A conceptual model was formed from the literature review and data obtained from questionnaires distributed at two locations in the Klang Valley, Malaysia. The collected data was then analyzed using PLS-SEM. Three significant paths were found in the model connecting food waste with effort levels, environmental concern and price importance.

**Keyword :** food accessibility, household food waste behavior, food access, food waste

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# Chapter 1. Introduction

According to the Food and Agriculture Organization of the United Nations (FAO), 1.3 billion tons of global edible food produced for human consumption is wasted annually (Food and Agriculture Organization of the United Nations, 2011). Food waste, as opposed to food loss, can be defined as "food that is of good quality and fit for human consumption but that does not get consumed because it is discarded either before or after the food spoils"(Lipinski et al., 2013).

Food waste is a global issue that is currently gaining attention in light of food security problems and related environmental issues. It is also a waste of labor, energy, water and land that is used in the production of food. Saving only a quarter of food lost globally would feed 800 million people suffering from food insecurity (Roca, Roca, & Roca, 2017) while managing food waste sustainably has the potential to reduce 518 million tons of greenhouse gas emissions – the equivalent of all cars off the road in the European Union (The World Biogas Associaton, 2018).

The trends for food waste differ by income category as lower income countries were found to waste food in the production to processing stages of the food supply chain while middle income and high-income countries reportedly waste food at the final household consumption stage (Food and Agriculture Organization of the United Nations, 2011). This is backed by studies that have shown that a rising middle class and increasing income can cause food waste quantities to increase simply because they can now afford to waste food

(Aschemann-Witzel, Giménez, & Ares, 2018; Hebrok & Boks, 2017).

As higher income households converge in urban areas this will therefore have an impact on generation of food waste in these areas. With a predicted 70% of the global population living in cities by 2050, it is therefore important to understand drivers of urban food waste in order for policy makers to enact effective solutions to curb this problem (The World Biogas Associaton, 2018).

Among factors driving food waste behavior, several socio-demographic factors have been shown to play a part in household food waste generation. Studies have found that older households tend to waste less food (Hebrok & Boks, 2017; Visschers, Wickli, & Siegrist, 2016) while single households have been shown to produce the most food waste per capita (Hebrok & Boks, 2017). However, on a per household basis, larger households appear to waste more food especially those with children as it is difficult to predict the amount of food consumed (Visschers et al., 2016).

Studies on consumer behavior have also been used to explain household food waste behavior. Behaviors such as diet importance(Visschers et al., 2016), price orientation(Aschemann-Witzel et al., 2018), planning behavior (Diaz-Ruiz, Costa-Font, & Gil, 2018; Hebrok & Boks, 2017; Stancu, Haugaard, & Lahteenmaki, 2016), preventive and recycling behaviors(Diaz-Ruiz et al., 2018; Hebrok & Boks, 2017; Stancu et al., 2016) and consumer values such as environmental awareness(Diaz-Ruiz et al., 2018; Hebrok & Boks, 2017; Stancu et al., 2016) and cultural background (Visschers et al., 2016) have been shown to influence

household food waste generation.

While the relationship between household food waste generation and consumer behavior has been widely studied, other factors indirectly influencing consumer behavior have also been shown to impact household food waste behaviors (Hebrok & Boks, 2017; Ilyuk, 2018). These factors include material infrastructure such as living situations and geographical access to stores and transportation which influence daily routines and hence household food waste behavior (Hebrok & Boks, 2017).

Access to food, in particular, has been drawn on in recent studies attempting to understand drivers of household food waste from a material infrastructure perspective (Hebrok & Boks, 2017; Ilyuk, 2018; Lee, 2018). A study by Lee (2018) used time as a measure of food access to assess the influence of food accessibility of different retail formats on household food waste. It was found that in the case of hypermarkets, food waste was higher with lower purchasing frequency and longer travel times. Over-purchasing was also found to be positively correlated with travel time (Lee, 2018). In addition, transportation modes was found to influence over-purchase as those who walked indicated less over-purchase than those who did not (Lee, 2018).

Other studies also show that consumers often go for large shopping trips once a week with an addition of one or two visits to top up supply (Farr-Wharton, Foth, & Choi, 2014). This strategy allows for the stocking of food as having food available saves time from having to purchase food again but may also cause food

waste as consumption is unpredictable (Farr-Wharton et al., 2014; Hebrok & Boks, 2017). Lee (2018) found that among the reasons for food waste caused by over purchase at hypermarkets and supermarkets were that participants simply "forgot about the food" and "didn't have the time to eat/cook it" (Lee, 2018).

As seen from the studies above, factors such as food access may also influence household waste behavior as it has been shown that households tend to purchase more at a less accessible food source (i.e. longer time taken to access). Over-purchase may then lead to food waste as products may expire before consumption. However, only using time as a measure of food access may not include other temporal dimensions such as transportation mode that also have an influence on food accessibility. As such, this study will attempt to look at food accessibility in terms of time as well as effort and its impact on urban household food waste behaviors.

# Chapter 2. Literature Review

## 2.1. Food access and household food waste

Pechansky and Thomas were one of the first to explore the definition of access, albeit in the context of access to the public health system. It was defined as the degree of fit between clients (i.e. the patients) and the healthcare system. Pechansky and Thomas identified five dimensions of access namely availability, accessibility, accommodation, affordability and acceptability (Pechansky & Thomas, 1981).

The accessibility dimension (i.e. geographic access) of this concept has been heavily drawn upon by other researchers exploring the food environment – diet relationship in the context of public health. This dimension, as opposed to the broader concept of access, is geographical and relates to the relationship between the location of supply and consumers, taking into consideration transportation resources and travel time, distance, cost and effort on use (Caspi et al., 2012).

These subjective measurements of accessibility (i.e. perceived accessibility) differs from the objective measurement of accessibility as it does not equate with actual distance (Wang, Brown, & Liu, 2015). Perceived accessibility, rather than objective accessibility, has been found to have more influence on frequency of facility use and hence more important to understand human behaviors (Kruger, Carlson, & Kohl, 2007; Wang et al., 2015). This is especially so as the subjective and objective variables of accessibility vary between each individual. It was found in a study by Wang et al. (2015) assessing accessibility of parks using

both subjective and objective accessibility, that subjective variables such as safety and pleasant walking options have an influence on park use and visits(Wang et al., 2015). From these studies it can be seen that a better measure of accessibility can be achieved by including these subjective considerations.

Food access has been widely researched in connection to healthy dietary habits (Walker, Keane, & Burke, 2010), obesity (Ghosh-Dastidar et al., 2014), food desserts and food security (Caspi et al., 2012) as well as food consumption (Maas et al., 2012). However, a consequence of food consumption, food waste, has not been widely researched in literature. As fluctuations in food consumption have a direct impact on food waste, it is therefore important to also consider the influence that food accessibility may have on household food waste.

Food consumption and waste are components of practices that comprise a consumers' daily life and hence in order to address unsustainable food consumption and waste, how these practices emerge and evolve needs to be understood. Quested et al. noted that "the generation of food waste is not a behavior in itself, but results from the interaction of multiple behaviors relating to planning, shopping, storage, preparation and consumption of food" (Parizeau, von Massow, & Martin, 2015). Lee (2018) posits that an important influence on these practices relate to infrastructure systems such as transportation systems, food retailers' opening hours as well as physical accessibility that can influence households' grocery shopping practices and transportation mode. For example, tight schedules and lengthy grocery shopping trips may raise the opportunity cost of not buying the necessities

and hence contribute to over-purchase and food waste (Lee, 2018).

Moreover, there appear to be differences in household food waste behavior with different food access levels. A study by Ilyuk (2018), for example, found that waste likelihood is higher when purchases are made online compared to physical purchases at stores (Ilyuk, 2018). Online purchases are deemed more accessible to the consumer compared to physical purchases as it requires less time (a common measure of accessibility) (Widener & Shannon, 2014)) and effort for the consumer to purchase the food. In contrast, a study by Lee (2018) found that high avoidable food waste is significantly correlated with lower buying frequency and longer travel times as well as over-purchasing as a result of bulk buying and marketing promotions (Lee, 2018). The major difference between these two studies is the type of food source involved. Ilyuk (2018) looked at online grocery purchases while Lee (2018) studied physical grocery stores and hence this may be the reason for the difference in findings. To compliment these findings, further research may therefore be required.

As seen above, generation of food waste is driven by the interaction of multiple behaviors that are influenced by the infrastructure system. Therefore, access to food, as a manifestation of the infrastructure system, may also impact food waste behaviors by influencing households' shopping trip frequency and subsequently purchasing behavior. Studies have used time as a measure of food accessibility, but this measure excludes effort levels which can also be seen as a cost and provides disutility during product acquisition (Ilyuk, 2018).

## 2.2. Time and effort

Food access has been traditionally analyzed from a static geographic perspective. However, research has found contradicting evidence of a relationship between the static food environment, and food availability and consumption with many cases finding no evidence thereof (Shannon & Christian, 2016). Furthermore, studies have shown that consumers do not use the store with the closest proximity to their homes for various reasons (Widener & Shannon, 2014) as their daily activities would also involve areas other than their homes such as offices, schools, social activity spaces such as public parks and shopping malls. This high mobility would therefore affect their exposure to food sources. Furthermore, mobility varies by individual as factors shaping their mobility differs by work travel, visits to friends and family and trip chaining which is the act of combining several different activities together (Widener & Shannon, 2014).

Individual mobility is not only influenced by their social activity but also by their transport mode of choice. The urban transportation network's changing conditions and efficiencies shape mobility through the frequency of service, reliability and spatial extent of the public transportation system. This will greatly impact the amount of time a transport rider needs to get to a food source. Moreover, private transportation is also affected by road networks and traffic congestion while walking and bicycling have their own factors such as safety and weather conditions to consider. For example, a person who owns a car would have different food retail opportunities than one who relies on public transport or walking. All of these

factors impose a time cost on grocery shopping (Widener & Shannon, 2014).

In addition, the change in the makeup of food retailers in recent times have given rise to a temporal food environment. From local markets to the rise of the supermarket in the 20th century and lately with the introduction of convenient stores and online food purchasing, how consumers interact and purchase food has changed(Widener & Shannon, 2014). This is because of the change in food source opening hours that was traditionally limited in the case of traditional markets and supermarkets, to 24 hours in the case of convenient stores and online food purchasing. Changes in location, such as in the case of food trucks and markets, adds to the temporal characteristic of the modern food environment. Online food purchase websites add to this as individuals can now purchase food wherever internet is available.

The factors above create a temporal dimension to spatial food accessibility. Research incorporating this temporal dimension have widely used time as a measure of accessibility (Järv, Tenkanen, Salonen, Ahas, & Toivonen, 2018; Shannon & Christian, 2016; Widener & Shannon, 2014).

While time enables some incorporation of the temporal dimension in measuring accessibility, it is not able to provide a proper reflection of this as it does not incorporate the difficulty levels of access of different transport modes and other factors such as opening hours of food source. For example, a 10-minute drive would cover a further distance than a 10-minute walk and hence enable drivers with access to larger food source opportunities than those without cars. To

incorporate this difference, effort measurement should also be introduced in measurements of accessibility.

Standard economic theory posits that effort is a cost and provides disutility during product acquisition (Ilyuk, 2018). In the context of access, it can be seen as an opportunity cost of non-purchase. In other words, the opportunity cost of not buying a product is higher at a place where more effort is taken to access (Lee, 2018). For example, a 10-minute walk in the mid-day sun to the local food store may require more effort than a similar 10-minute drive to a store located further away at the same time. To reduce the opportunity cost of non-purchase, consumers would therefore tend to over purchase at places that require more effort to access (Lee, 2018). Over-purchase due to bulk purchasing and marketing promotions have also been found to contribute to higher food waste (Lee, 2018) but the direct link between effort to access food sources and food waste has yet to be studied.

With dynamic urban mobility and consumer activity, the traditional static spatial measurement may therefore not be an appropriate measure of food accessibility. Consumer perception of time and effort, on the other hand, may provide a more useful means of capturing how people experience the food landscape around them as the perceived food environment implicitly accounts for temporal factors (Widener, 2018). This study will therefore use both time and effort levels and explore the relationships of these food accessibility measures with household food waste behaviors.

## 2.3. The conceptual model

Based on the literature review above, a conceptual model exploring the relationship between household food waste likelihood and perceived food accessibility was developed. Perceived accessibility is represented by two factors, time and effort, and is the variable that is the focus of this paper. The other three components; food related habits, waste management and values were included based on existing findings in literature and serve as control variables.

### 2.3.1. Perceived accessibility

This variable is included to measure the accessibility of food source to the consumer from the viewpoint of the consumer in terms of perceived time and effort. Time was chosen as a measure of perceived accessibility as it is able to reflect different individual mobilities which are influenced by their social activities and transport mode of choice (Järv et al., 2018; Shannon & Christian, 2016; Widener & Shannon, 2014).

This component is also measured in terms of perceived effort to a certain food source. Effort is related to accessibility as studies have found that food source placed at a distance require effortful action from an individual and hence will affect possibility of consumption (Maas, de Ridder, de Vet, & de Wit, 2012). Furthermore, food source that requires more effort to access has been shown to influence over purchase due to bulk buying by the consumer. This is because the opportunity cost of non-purchase is high at a food source that requires more effort to access (Lee, 2018).

### 2.3.2. Food related habits

i) Diet importance

It is found in existing literature that diet influences food waste behaviors. Those on a healthy diet showed a negative relationship with food waste. However, there are also those who throw away more food when more criteria were used to judge between edible and non-edible foods (Visschers et al., 2016). This control variable is therefore included to measure the dietary inclination of the respondent.

ii) Price importance

Deals and price offers may result in greater household food waste as there have been suggestions, as well as implementation in some countries, that it is a major instrument in dealing with in-store food waste. Findings note that price-oriented consumers are influenced by these efforts and hence potentially reduce food waste (Aschemann-Witzel et al., 2018). Customers looking for the optimal price-quality balance is also found to be a leading factor in food purchase. Hence potential over purchase in reaction to changes in prices such as volume discounts and price gradients can be seen to be made by price-oriented customers (Aschemann-Witzel, de Hooge, Amani, Bech-Larsen, & Oostindjer, 2015).

This control variable measures the importance of price on purchasing behavior as consumers who have been found to favor cheaper priced goods are found to have a higher waste likelihood. This control variable is included to measure the consumer's price orientation when making purchasing decisions and its consequent impact on household food waste.

iii) Purchase discipline

It was found that households with fewer shopping trips per week produced more food waste compared to households that visit grocery stores more often as it may be difficult to plan meals over a longer period (Visschers et al., 2016). In addition, bulk purchases encouraged by marketing and promotions have also seen to result in higher food waste (Diaz-Ruiz et al., 2018). Those who make lesser shopping trips per week may also need to buy in bulk to stock up on food resulting in over stocking and overpreparation of food. While having food available may save time, without a meal plan, it is unpredictable when the food can be consumed (Hebrok & Boks, 2017)

As such, having planning routines, such as advance meal planning and inventory checks, can help households lower food waste as it decreases the likelihood of inventory underestimation and purchase of leftover stock as well as contribute to better reuse routines (Stancu et al., 2016; Visschers et al., 2016).

As mentioned above, consumers without shopping routines tend to purchase in bulk which is found to have a positive impact on food waste likelihood. This control variable is included to measure whether consumers have a shopping routine and whether there is an inclination towards bulk purchases.

### 2.3.3. Waste management

Studies have suggested that waste prevention has a negative correlation with recycling which may decrease the effort to reduce waste (Diaz-Ruiz et al., 2018). Changing leftover waste routines were seen in studies to have the largest

effects on food waste, even though shopping routines may also play a part (Stancu et al., 2016). However, how leftovers are being dealt with differ by the different material and social-cultural aspects of food consumption (Hebrok & Boks, 2017).

The two components of waste management; recycling behavior and preventive behavior, were included in the model as control variables.

### 2.3.4. Values: Environmental concern

Studies have contradictory findings on the influence of environmental values on waste minimization (Diaz-Ruiz et al., 2018; Hebrok & Boks, 2017; Stancu et al., 2016; Visschers et al., 2016). While a study by Diaz-Ruiz et al found an indirect link between environmental awareness and waste minimization (Diaz-Ruiz et al., 2018), Stancu et al found that consumers made little connection between environmental awareness and food waste (Stancu et al., 2016). Instead, financial concerns were found to have a stronger negative connotation with food waste. This is backed by Australian, UK and US studies which show that consumers were more motivated financially rather than protecting the environment where food waste is concerned (Hebrok & Boks, 2017).

This control variable measures the respondent's level of concern towards the environment resulting from their food waste as well as impact of their food waste on worldwide resource distribution.

The conceptual model was then developed incorporating all the variables above as illustrated below:

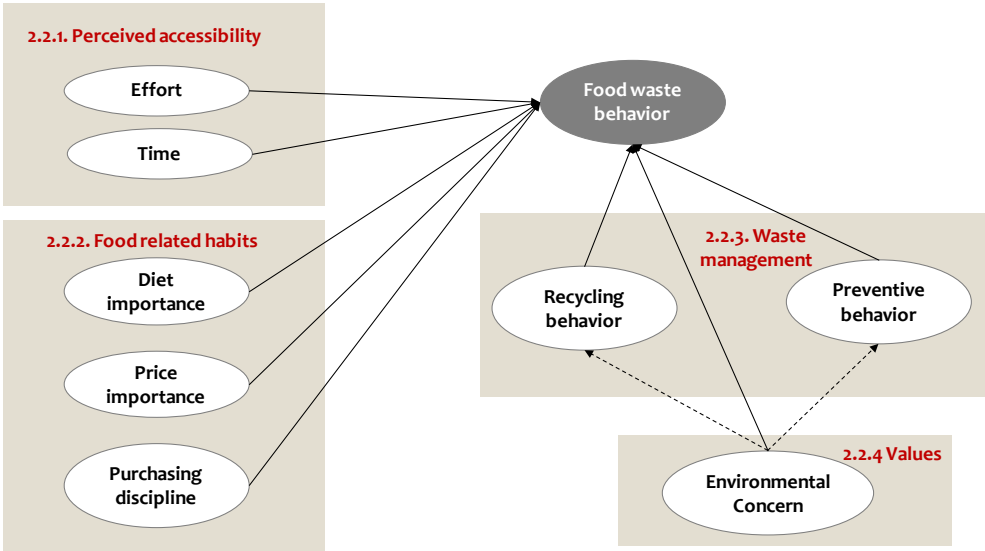



Figure 1: Conceptual model depicting the relationship between perceived accessibility to food source and food waste likelihood (Diaz-Ruiz et al., 2018; Ilyuk, 2018; Roodhuyzen, Luning, Fogliano, & Steenbekkers, 2017)

# Chapter 3. Research Methodology

## 3.1. Research Objective and Scope

This research aims to look at the impact of food accessibility on household food waste. This paper will use two temporal dimensions, time and effort, in assessing food accessibility.

The first dimension, time, has been suggested in recent literature as an appropriate temporal measure of accessibility. Time taken to access a food source has been linked to over purchasing by consumers (Lee, 2018). This is because, to avoid frequent visits to a food source that takes longer to access to, consumers tend to over purchase products in order to maintain food availability which may not be fully consumed before it expires (Shannon & Christian, 2016). There is, however, also the possibility that longer time taken to access a food source may reduce food consumption (Maas et al., 2012) instead and hence with reduced consumption, lower food waste. However, in the context of urban households with the means to afford food, it is more likely that the food requirements remain the same. Hence with lower frequency of purchase, the amount of food bought at each purchase time may increase which subsequently leads to wastage if not consumed within the best before period. To test this, the following hypothesis was derived:

H1: Households who take more time to access a food source are expected to waste more food

Time by itself, however, may not fully reflect the full picture of food accessibility as it may not fully represent the effort taken to access a food source. Effort can also be seen as a cost of acquiring food and research has found that over purchase tends to occur with higher opportunity cost of non-purchase which may also lead to food waste generation. The second hypothesis, therefore, is as follows:

H2: Households who take more effort to access a food source are expected to waste more food

The paper will focus on respondents located in Klang Valley which is an area centered around Kuala Lumpur, the capital of Malaysia, with adjoining cities and towns in the state of Selangor:

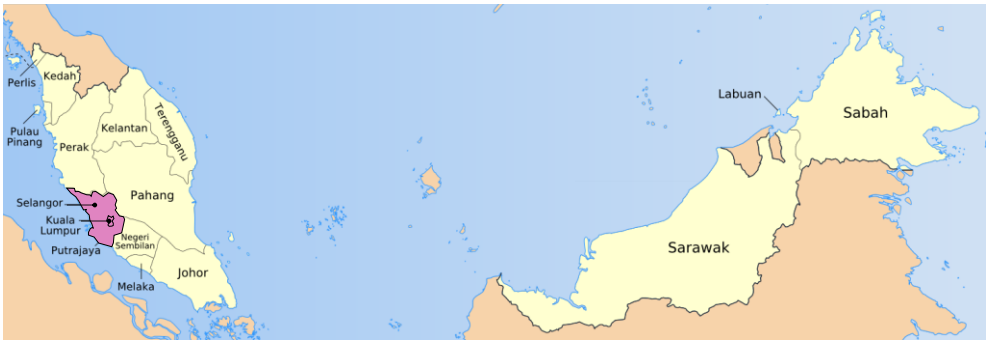



Figure 2: Map of Malaysia and location of Klang Valley (Selangor and Kuala Lumpur) (Image sourced from Google Images)

Malaysia has a population of 32.5 million with approximately 8.3 million (25.5% of total population) living in the Klang Valley[①](Department of

① Statistics as per 3rd quarter 2018

Statistics Malaysia, 2018a). The Klang Valley contributed 38% of Malaysia's Gross Domestic Product (GDP) of RM1.1 trillion (approximately USD264 billion[②]) in 2016(Department of Statistics Malaysia, 2016). The GDP per capita for Selangor (RM44,616; approximately USD 10,648) and Kuala Lumpur (RM101,420; approximately USD24,205) is higher than the Malaysian average GDP per capita of RM38,887 (approximately USD 9,280) indicating that residents in these areas on average have higher incomes than the rest of the country.

## 3.2. Research Methodology

### 3.2.1. Data collection methodology: Measuring food accessibility and household food waste

i) Measuring food accessibility

There are a few methods of measuring food accessibility in literature. The most common measurement is through the Geographic Information System (GIS)(Apparicio, Cloutier, & Shearmur, 2007; Caspi, Sorensen, Subramanian, & Kawachi, 2012; Walker, Keane, & Burke, 2010) by geocoding the food source (i.e. supermarkets, grocery stores, fast food outlets etc), and thereafter measuring store density (using buffer distances) and proximity to food source(Caspi et al., 2012).

Store audits, also known as ground truthing, are an alternative to the GIS analysis of food environments. This method involves the physical visit to stores in an area to determine its features (e.g. shelf space, food variety, density) (Caspi et al., 2012; Sharkey, 2009). This method is not as popular as GIS analysis as it is

② USD 1.00 = RM 4.19 as per Google results on 29 November 2018

more time consuming. However, it provides better details of each food source in the food environment, allowing for other subjective measures such as food variety data which cannot be analyzed using GIS.

Respondent based measures such as questionnaires and surveys have also been used to capture perceived accessibility in the food environment. However, this is not as common compared to GIS-based methods (Caspi et al., 2012).

The three methods above are the most common methods for measuring food access. There are also other type of measurements such as focus groups, food use inventories, interviews, business lists/directors etc but these are uncommon methodologies (Walker et al., 2010).

Two of the more common methods of measuring food accessibility relate to static spatial accessibility and is therefore not able to capture the temporal characteristics of accessibility. Respondent based measures, however, are more appropriate for the purpose of measuring the perceptions of time and effort to access food.

ii) Measuring household food waste

Presentation of food waste in existing literature has been done in absolute numbers as well as in relative figures (Roodhuyzen et al., 2017). The difference between measurement methods depends on the design of the study and demarcation, calculation method and metrics used. Most measurements for waste use mass (i.e. weight) but other indicators have also been noted to be used for its size or impact. These include measurements in terms of calories, percentage of the

weight of food purchased, weight of domestic waste or in monetary value (Jörissen, Priefer, & Bräutigam, 2015).

Secondary data such as calculations from databases, reports or earlier studies have been used to study waste generation at the population level (Roodhuyzen et al., 2017) but are not common in studies looking at household level food waste. The most valid assessment of household food waste would be the collection of all solids and fluids leaving the household, but this is rarely performed due to high cost (Visschers et al., 2016). More common methods are self-reporting procedures such as surveys, the keeping of kitchen diaries by respondents, interviews, and waste composition analyses (Hebrok & Boks, 2017; Stefan, van Herpen, Tudoran, & Lähteenmäki, 2013; Visschers et al., 2016).

Self-reporting procedures are known to be underreported but is still relied upon by most food waste studies (Hebrok & Boks, 2017) as official data on food waste at the household level is still scarce, especially in developing countries. While responses may reveal little to no waste, more detailed questions will provide a better view on waste streams such as inedible foods, fresh produce etc. Assessments will also be easier to quantify if the question asks food wasted relative to the amount purchased or grown. Time should also be presented as an average week (Visschers et al., 2016).

Based on the common data collection methods reviewed in previous studies, a respondent-based measure, through the use of questionnaires, would be the appropriate method to measure perceived food accessibility as well as household

waste behaviors. This is more so as food waste data at household level in Malaysia is not publicly available. As such, questionnaires were distributed and household food waste as well as perceived accessibility is self-reported by respondents.

### 3.2.2. The sample

Data was collected through offline surveys distributed at two locations within the Klang Valley, namely, at Café D'Workshop at Seri Kembangan and The Prep Room in Sri Hartamas. One hundred questionnaires were given to each café for distribution at the start of the survey period on the 15th of August 2018. At collection on the 5th of October 2018, Café D'Workshop received 61 responses while The Prep Room received 44 responses for a total of 105 responses.

The survey was targeted at patrons of each café in order to increase the response rate and the number of considered responses from those customers waiting for friends or family or those just leisurely spending time at the cafe. Both areas were chosen due to differences in the availability of food source within the area.

The Seri Kembangan café is located within an area where major hypermarkets are within a 15-minute driving distance with a wet market within a 5-minute driving distance. There are many restaurants (including 24 -hour eateries) within 5-minutes driving distance. However, local cafes and eateries are not within walking distance.

Sri Hartamas, on the other hand, do not have major hypermarkets within a 15-minute driving distance and no wet market within 5 to 10 minutes driving distance.

As with Seri Kembangan, there are many restaurants within a 5- minute driving distance. However, there are many local cafes and eateries within walking distance in Sri Hartamas.

### 3.2.3. Data analysis

Descriptive statistics was analyzed using Excel. To test the model, Partial Least Squares-Structural Equation Modelling (PLS-SEM) using SmartPLS 3 was used.

Structural equation modelling (SEM) is a second-generation type of modelling and may be used to test unobserved variables (i.e. latent variables) such as behavior that is measured indirectly by indicator variables. It is used in many social science fields such as behavioral sciences, marketing, organization, management information system and business strategy (Wong, 2013). There are a few approaches to SEM; covariance-based SEM (CB-SEM) which is used to confirm or reject theories, partial least squares SEM (PLS-SEM) which is used to develop theories in exploratory research(Hair, Hult, Ringle, & Starstedt, 2017), Generalized Structured Component Analysis which is a component-based SEM and Nonlinear Universal Structural Relational Modelling (NEUSREL)(Wong, 2013).

The PLS-SEM method is chosen as it can work well with small sample sizes and complex models (Diaz-Ruiz et al., 2018; Hair, Sarstedt, Hopkins, & Kuppelwieser, 2014). Furthermore, PLS-SEM has no distributional assumptions and hence can deal with non-normal data distributions which is the nature of the data collected for this research compared with CB-SEM which requires data that is

normally distributed (Hair et al., 2017). Other research studying household food waste has also used PLS-SEM in exploring the relationships between variables which enables result comparison with other studies using the same methodology (Abdelradi, 2018; Diaz-Ruiz et al., 2018; Russell, Young, Unsworth, & Robinson, 2017; Stefan et al., 2013). In addition, Hair et al. (2017) recommends the use of PLS-SEM when the goal is to identify key driver constructs which fits the purpose of this study.

# Chapter 4. The Questionnaire

To collect data from households on household food waste behaviors and food accessibility, a questionnaire was developed based upon the conceptual model. Each variable was assigned with several questions to assess its relationship with household food waste. Feedback from early respondents was for the questionnaire to be translated into Chinese as the Sri Kembangan area had predominantly Malaysian-Chinese respondents. As such, the questionnaire was distributed with both Chinese and English translations.

The questionnaire included 53 questions that covers all four components to build the hypothesized model. Socio demography questions were added to provide a basic overview of respondent demography.

For the socio demography questions, the respondent was asked to manually input their answers for questions on age, household size, no. of children below 18 in the household, household income and postcode. Choices were given to the respondent for questions on gender, education level and occupation (Aschemann-Witzel et al., 2018; Diaz-Ruiz et al., 2018; Stancu et al., 2016). The questions were given as follows:

1. Gender/性别 ☐ Male/男 ☐ Female/女

2. Age/年龄 _____

3. Education level (Please indicate your last formal education level)
教育程度（请选择您接受的最高教育程度）
☐ Primary/ / 小学 ☐ Secondary/ 高中 ☐ Bachelors/ 本科 ☐ Masters/ 硕士
☐ Doctorate, Professional etc/ 博士，专业人士

4. Occupation / 工作
☐ Employee / / 雇员 ☐ Self-employed/ 自营
☐ Unemployed, pensioner, housewife etc/ 失业，退休，家庭主妇 ☐ Student / 学生

5. No of people in household / 家庭成员数量
_____

6. No of children below 18 years old in the household/ 家庭成员里 18 岁以下的数量
_____

7. Total household income (RM per month) / 每月家庭总收入 （RM）
_____

8. Home postcode / 家庭住址邮编
_____

Figure 3: Questionnaire – Socio demographics section

The following section deals with measurement of household food waste of the respondent's household and is divided into two sections. The first asks the respondent to self-report in percentage form the amount of food thrown away in a regular week (Diaz-Ruiz et al., 2018; Stancu et al., 2016). The second part provides a Likert scale from 1 (none) to 7 (a lot) that asks the respondent to describe the amount of each type of food thrown in a regular week (Neff, Spiker, & Truant, 2015; Stefan et al., 2013). If the household does not consume the item, they are required to select 0. A summary question in the food waste section asks the respondent to report the percentage of all food that is thrown away in a regular week in their household. An illustration of the questions are as follows:

9. In a regular week, how much food have you thrown away in your household that has….
在一个星期里，您家里有多少食物会被扔掉．．．

*Please indicate the estimated % thrown out of the original amount bought in the box below*/ 在以下表格中请估算写出您扔掉的食物所占原来购买食物数量的百分比

| | |
|---|---|
| Passed the best before date/ 超过了保质期…… | % |
| Were ingredients that has gone bad/ 变质了…… | % |
| Leftover from a meal but still edible/仍可食用的剩饭菜…… | % |
| Leftover from a meal and has gone bad/变质的剩饭菜…… | % |
| Leftover from cooking because the ingredients were overprepared/由于食材过量准备导致的剩饭菜 | % |
| Not eaten because I don't like it / 不喜欢吃的食物…… | % |
| Leftover from a meal or meal preparation that cannot be eaten (e.g bones etc) /不可食用的剩饭菜（如骨头等） | % |
| A result of unsuccessful cooking (e.g. mushy cakes, too salty soup etc)/失败的烹饪 （如烤糊的蛋糕，太咸的粥等等） | % |

10. On a scale of 1 (none) to 7 (a lot) describe the amount of each type of food below that your household throws away in a regular week. (If your household does not consume the item, please indicate 0)
用 1（完全没有）到 7 （很多）来描述 在一个星期内您家庭里弃置的每类食物的数量。如果有您家庭没吃的食物请写 0 号）

| | |
|---|---|
| Package food stored outside the fridge 存放在冰箱外面的食物 | □0 □1 □2 □3 □4 □5 □6 □7 |
| Milk and dairy products/ 牛奶和其他乳制品 | □0 □1 □2 □3 □4 □5 □6 □7 |
| Fresh fruits and vegetables/ 新鲜水果和蔬菜 | □0 □1 □2 □3 □4 □5 □6 □7 |
| Meat and fish /肉和鱼 | □0 □1 □2 □3 □4 □5 □6 □7 |
| Bread and other bakery products 面包和其他烘焙食品 | □0 □1 □2 □3 □4 □5 □6 □7 |
| Rice/米饭 | □0 □1 □2 □3 □4 □5 □6 □7 |
| Inedible food waste (e.g. peelings, bones) 不能吃的食物（壳、骨头等等） | □0 □1 □2 □3 □4 □5 □6 □7 |
| Leftovers from a meal /吃剩的饭菜 | □0 □1 □2 □3 □4 □5 □6 □7 |

11. About how many percent of all the food that comes into your household is later thrown away in a regular week?
大约有多少百分比的食物进入您的家庭后会在一周内被扔掉？
_____ (% of all food bought in a week/ 占一周买的食物的%)

Figure 4: Questionnaire - Household food waste section

The third section in the questionnaire measures perceived accessibility. A mixture of question types was provided to respondents to assess their perceived accessibility to food source. Two food sources were identified, namely groceries and take-away foods. The same questions were developed targeting both types of food source and measures the time taken to purchase, effort level (Caldwell,

Kobayashi, DuBow, & Wytinck, 2009), mode of transport, frequency of purchase in a week (Visschers et al., 2016) and whether the respondent has made purchases online (Ilyuk, 2018). An illustration of the survey questions is as follows:

15. What is your mode of transport when buying groceries?
您怎么去买杂货？
☐ I walk/cycle/走路 ☐Drive a vehicle/开车 ☐Get it delivered/外卖 ☐Take public transport/用公共交通

16. How long does it usually take for you to travel to take away food?
平均而言，您需要花费多久去买食物？
_____(minutes/分钟)

17. How often do you take away food in a week?
您在一周内有几次会带走食物？
_____(times/分钟)

18. On a scale of 1 (least troublesome) to 7 (very troublesome), how troublesome is it for you to take away food?
用 1（很方便）到 7（很麻烦）来描述你带走食物有多麻烦？
☐1 ☐2 ☐3 ☐4 ☐5 ☐6 ☐7

19. What is your mode of transport when taking away food?
您怎么去带走食物？
☐ I walk/cycle/走路 ☐Drive a vehicle/开车 ☐Get it delivered/外卖 ☐Take public transport/用公共交通

20. Have you purchased groceries or ready-made food online?
您有没有在网上买杂货或食物？
☐Yes/有 ☐No/没有 (go straight to question 21/直接去往问题 21)

a. If yes, on average, how many times do you purchase meals online in a week?
有的话， 平均而言您一周内几次在网上买食物？
_____(times/回)

b. If yes, on average, how many times do you purchase groceries online in a week?
有的话， 平均而言您一周内几次在网上买杂货？
_____(times/回)

12. On average, how long does it take for you to travel to purchase groceries?
平均而言，您购买杂货需要多长时间？
_____(minutes/分钟)

13. How often do you buy groceries in a week?
您在一周内买几次杂货？
_____(times/回)

14. On a scale of 1 (least troublesome) to 7 (very troublesome), how troublesome is it for you to buy groceries?
用 1（很方便）到 7（很麻烦）来描述你买杂货的麻烦程度？
☐1 ☐2 ☐3 ☐4 ☐5 ☐6 ☐7

Figure 5: Questionnaire - Food Accessibility section

For questions pertaining to diet importance (Diaz-Ruiz et al., 2018), price importance (Diaz-Ruiz et al., 2018; Porpino, Parente, & Wansink, 2015), purchasing discipline (Diaz-Ruiz et al., 2018; Razak, 2017; Stancu et al., 2016),

recycling (Diaz-Ruiz et al., 2018; Porpino et al., 2015) and waste prevention behaviors (Roodhuyzen et al., 2017), a Likert scale of 1 (never) to 7 (always) was provided for respondents to choose from. The questions were as follows:

21. On a scale of 1 (Never) to 7 (Always), please rate the statements below:
用 1（完全没有）到 7（经常），来评价以下陈述：

| | |
|---|---|
| I eat food rich in vitamins that is good for me<br>我吃的富含维生素的食物对我有好处 | □1 □2 □3 □4 □5 □6 □7 |
| I eat low fat/calorie foods/ 我吃低卡路里的食物 | □1 □2 □3 □4 □5 □6 □7 |
| I eat organic food free of potential hazardous ingredients such as pesticides<br>我吃有机食品，没有农药等潜在的危险成分 | □1 □2 □3 □4 □5 □6 □7 |

| | |
|---|---|
| I only purchase products that are on sale<br>我只购买正在减价的产品 | □1 □2 □3 □4 □5 □6 □7 |
| I purchase products that are on sale even if I don't need it/即使我不需要，我也会购买正在减价的产品 | □1 □2 □3 □4 □5 □6 □7 |
| I only purchase cheap products/我只买便宜的产品 | □1 □2 □3 □4 □5 □6 □7 |
| I buy more than I need (e.g. bulk purchases)<br>我买的比我需要的多 （批量采购等等） | □1 □2 □3 □4 □5 □6 □7 |
| I only buy things that are on my shopping list<br>我只买我购物清单上的东西 | □1 □2 □3 □4 □5 □6 □7 |
| I use leftovers from my meal as compost<br>我用我的饭剩菜作为堆肥 | □1 □2 □3 □4 □5 □6 □7 |
| I use leftovers from my meal as ingredients for the next meal/我用我的饭剩菜作为下一餐的食材 | □1 □2 □3 □4 □5 □6 □7 |
| I use leftovers from my meal to feed animals (pets, strays etc)/ 我用我的饭剩菜来喂养动物 | □1 □2 □3 □4 □5 □6 □7 |
| I only buy the amount that I will use to cook or eat<br>我只买我用来做饭或吃的量 | □1 □2 □3 □4 □5 □6 □7 |

Figure 6: Questionnaire – Food related habits and waste management section

Lastly, for questions on consumer values such as environmental concern (Aschemann-Witzel et al., 2018; Visschers et al., 2016), respondents were asked to rate statements on a Likert scale of 1(totally disagree) to 7(totally agree) with 4(neutral). The questions are as follows:

22. On a scale of 1 (Totally disagree) to 7 (Totally Agree), with 4 (Neutral), please rate the statements below:
用 1（完全不同意）到 7（完全同意），4（中立）来评价以下陈述：

| | |
|---|---|
| It is in my culture to prepare more food than necessary/在我的文化中准备比必要的更多的食物 | □1 □2 □3 □4 □5 □6 □7 |
| People who are important to me find my attempts to reduce the amount of food wasted unnecessary<br>对我很重要的人认为我减少食物浪费量的行为是不必要的。 | □1 □2 □3 □4 □5 □6 □7 |
| I do not really worry about the environmental impact of the food that I throw away<br>我不担心我扔掉的食物对环境的影响 | □1 □2 □3 □4 □5 □6 □7 |
| I do not really worry about the amount of food that I throw away/我并不担心我扔掉的食物的数量 | □1 □2 □3 □4 □5 □6 □7 |
| I do not really worry about the impact of my food waste on the distribution of resources in the world<br>我并不担心我的食物浪费对世界资源分配会产生影响 | □1 □2 □3 □4 □5 □6 □7 |

Figure 7: Questionnaire - Consumer values section

# Chapter 5. Results

## 5.1 Sample Description

### 5.1.1. Socio Demographics

A total of 105 responses were received from the two areas of distribution, Sri Kembangan and Sri Hartamas, in the Klang Valley. A higher number of females (62%) responded to the survey compared to males (38%). Feedback from respondents was that the female members of the family were largely in charge of food management in the household and as such had a better idea of food waste. Other food waste studies have also received a similar gender ratio result (Aschemann-Witzel et al., 2018; Diaz-Ruiz et al., 2018; Stancu et al., 2016). The age distribution of respondents in the sample is similar to the age distribution of the Klang Valley population (18-34 years old 43.5%, 35-49 years old 30.0%, 50-64 years old 18.4% and above 65 years old 8.1%) (Department of Statistics Malaysia, 2018b).

| | Frequencies | Proportions (%) |
|---|---|---|
| **Gender** | | |
| Male | 40 | 38.1 |
| Female | 65 | 61.9 |
| | | |
| **Age** | | |
| 18-34 | 42 | 40.0 |
| 35-49 | 35 | 33.3 |
| 50-64 | 21 | 20.0 |
| More than 65 | 7 | 6.7 |
| | | |
| **Education** | | |
| Primary | 2 | 1.9 |
| Secondary | 22 | 21.0 |
| Bachelors | 46 | 43.8 |

| | Frequencies | Proportions (%) |
|---|---|---|
| Masters | 20 | 19.0 |
| Doctorate, Prof. etc | 15 | 14.3 |
| **Occupation** | | |
| Employee | 54 | 51.4 |
| Self-employed | 31 | 29.5 |
| Unemployed, pensioner, housewife etc | 18 | 17.1 |
| Student | 2 | 1.9 |
| **Income**③ | | |
| <RM3,000 | 11 | 11 |
| >RM3,000 to <RM6,275 | 27 | 26 |
| >RM6,276 to <RM10,000 | 40 | 38 |
| >RM10,001 to <RM15,000 | | |
| >RM15,001 | 7 | 7 |
| | 20 | 18 |
| **Household size** | | |
| 1 | 7 | 6.7 |
| 2 | 20 | 19.0 |
| 3 | 19 | 18.1 |
| 4 | 21 | 20.0 |
| 5 | 21 | 20.0 |
| 6 or more | 17 | 16.2 |
| **Children under 18 at home** | | |
| None | 69 | 65.7 |
| 1 | 16 | 15.2 |
| 2 | 11 | 10.5 |
| 3 or more | 9 | 8.6 |

Table 1: Descriptive results of survey

### 5.1.2. Household food waste

In terms of food waste, most respondents (69.5%) reported to throw up to 10% of food that comes into their household every week with most inclined to

③ USD 1.00 = RM 4.19 as per Google results on 29 November 2018

throw away leftovers from a meal. The questionnaire surveyed reasons for household food waste which required respondents to manually input the % of waste thrown due to the pre-described reasons. The means are as follows:

| **Reasons for household food waste** | **Mean (% thrown out of original amount bought)** |
|---|---|
| Passed the best before date | 12.95 |
| Were ingredients that has gone bad | 16.22 |
| Leftover from a meal but still edible | 11.30 |
| Leftover from a meal and has gone bad | 16.30 |
| Leftover from cooking because the ingredients were over prepared | 14.93 |
| Not eaten because I don't like it | 7.72 |
| Leftover from a meal or meal preparation that cannot be eaten (e.g. bones etc) | 19.10 |
| A result of unsuccessful cooking (e.g. mushy cakes, too salty soup etc) | 8.50 |
| Package food stored outside the fridge | 2.03 |

Table 2: Reasons for household food waste

Respondents noted that most waste was thrown as it was left over from a meal or from meal preparation that cannot been eaten. Most are inclined to throw leftovers away (more than 10% of total waste thrown). However, packaged food that is stored outside the fridge had a very low throw rate, with a mean of only 2.03%. This may also be because packaged foods can be kept longer than fresh foods, especially food that has already been cooked. Some respondents, with a mean of 7.72%, also threw away food because it was not to their liking.

The type of food thrown away was also surveyed among respondents and is measured on a Likert scale from 1 (a little) to 7 (a lot). Those that do not consume the food type are required to choose 0. The results were grouped into 4 levels; low throw rate from 1 to 3, medium throw rate at 4 and high throw rate from

5 to 7. Those who did not consume the items were noted at 0. The results are as follows:

| Food type | Mean | 0 | 1 to 3 | 4 | 5 to 7 |
|---|---|---|---|---|---|
| Packaged food stored outside the fridge | 2.03 | 19% | 62% | 6% | 13% |
| Milk and dairy products | 1.63 | 35% | 50% | 4% | 10% |
| Fresh fruits and vegetables | 2.20 | 15% | 64% | 8% | 13% |
| Meat and fish | 1.69 | 43% | 39% | 3% | 15% |
| Bread and other bakery products | 1.63 | 29% | 56% | 8% | 8% |
| Rice | 1.49 | 30% | 58% | 5% | 7% |
| Inedible food waste (e.g. peelings and bones) | 3.10 | 14% | 43% | 18% | 25% |
| Leftovers from a meal | 1.95 | 15% | 69% | 6% | 10% |

Table 3: Household food waste type

In general, the mean was within the low throw rate indicating that the respondents did not have a high throw rate of any product. As expected, 25% of respondents reportedly threw away a lot of inedible food waste, which is in line with the results from reasons for household food waste generation. 69% of respondents also claimed to throw very little leftovers from a meal. Of the fresh produce (i.e. milk and daily, fresh fruits and vegetables, meat and fish), 43% of respondents claim to not consume meat and fish while more than half threw very little milk and dairy products as well as fresh fruits and vegetables. In general, most respondents threw very little to moderate amounts of each food type with the exception of inedible food waste.

### 5.1.3. Access to food source

The average time taken to purchase groceries by respondents was 25.6 minutes while time taken to purchase take away food was lesser at a mean of 17.5 minutes. Compared to groceries, which only saw a mean frequency of 1.69 per

week, take away had a higher frequency at 3.18 times per week. However, although take away had lesser average time and higher frequency, there were more respondents that reported higher effort to take away food compared to groceries as shown in the table below:

| | **Groceries (n-105)** | **Take away (n-103)** |
|---|---|---|
| Mean time taken to purchase groceries | 25.6 minutes | 17.6 minutes |
| Mean frequency of purchase per week | 1.7 times per week | 3.2 times per week |
| Effort level (% of respondents) | | |
| 1 – Least troublesome | 23% | 25% |
| 2 | 24% | 26% |
| 3 | 30% | 18% |
| 4 | 14% | 17% |
| 5 | 3% | 10% |
| 6 | 6% | 2% |
| 7 – very troublesome | 1% | 1% |
| Access method | | |
| Walk/cycle | 7% | 11% |
| Drive a vehicle | 90% | 81% |
| Delivery | 0% | 6% |
| Public transport | 4% | 2% |

**2 respondents did not respond to the take away questions as they do not take away food*

Table 4: Response for food accessibility

An overwhelming majority drive a vehicle when purchasing both groceries and take away foods. No respondent bought groceries and had them delivered to their home. In terms of online purchases, 67% of respondents stated that they have never purchased groceries or pre-made food online before, proving that online food is not popular in the sample respondents.

### 5.1.4. Control variables

The control variables included in the survey relate to diet importance, price importance, purchasing discipline, recycling behaviors, preventive behaviors, and environmental values. Except for the environmental value variable, all other questions asked respondents to rate the statements according to the frequency of use from 1 (never) to 7 (always). For the environmental concern (ENV) variable, the questions asked respondents to rate their agreement with the statement provided from 1 (totally disagree) to 7 (totally agree). The results are as follows:

| **Question** | **Mean** | **SD** | **Distribution within 7-point Likert scale (%)** | | |
|---|---|---|---|---|---|
| | | | **1-3** | **4** | **5-7** |
| DIET 1: I eat food rich in vitamins that are good for me | 4.98 | 0.15 | 20.0 | 18.1 | 61.9 |
| DIET 2: I eat low fat/calorie foods | 3.97 | 0.14 | 37.1 | 36.2 | 26.7 |
| DIET 3: I eat organic food free of potential hazardous ingredients such as pesticides | 3.31 | 0.15 | 57.1 | 20.0 | 22.9 |
| PRICE 1: I only purchase products that are on sale | 3.43 | 0.14 | 49.5 | 28.6 | 21.9 |
| PRICE 2: I purchase products that are on sale even if I don't need it | 2.24 | 0.13 | 81.9 | 12.4 | 5.7 |
| PRICE 3: I only purchase cheap products | 3.10 | 0.15 | 62.9 | 21.9 | 15.2 |
| PURCHASE 1: I buy more than I need (e.g. bulk purchases) | 2.84 | 0.15 | 67.6 | 17.1 | 15.2 |
| PURCHASE 2: I only buy things that are on my shopping list | 4.24 | 0.16 | 38.1 | 15.2 | 46.7 |
| RECYCLE 1: I use | 2.24 | 0.17 | 78.1 | 6.7 | 15.2 |

| Question | Mean | SD | Distribution within 7-point Likert scale (%) | | |
|---|---|---|---|---|---|
| | | | 1-3 | 4 | 5-7 |
| leftovers from my meal as compost | | | | | |
| RECYCLE 2: I use leftovers from my meal as ingredients for the next meal | 2.77 | 0.17 | 68.6 | 11.4 | 20.0 |
| RECYCLE 3: I use leftovers from my meal to feed animals (pets, strays etc) | 2.35 | 0.19 | 75.2 | 8.6 | 16.2 |
| PREVENT 1: I only buy the amount that I will use to cook or eat | 4.45 | 0.18 | 29.5 | 22.9 | 47.6 |
| ENV 1: I do not really worry about the environmental impact of the food that I throw away | 2.42 | 0.15 | 74.3 | 12.4 | 13.3 |
| ENV 2: I do not really worry about the amount of food that I throw away | 2.30 | 0.15 | 81.0 | 7.6 | 11.4 |
| ENV 3: I do not really worry about the impact of my food waste on the distribution of resources in the word | 2.46 | 0.17 | 75.2 | 11.4 | 13.3 |

Table 5: Results from survey questions on control variables

## 5.2 Measurement model evaluation

The model consists of 26 observed variables (OV) forming 9 latent variables (LV). The measurement model is validated in three stages (Hair et al., 2014); 1) Internal consistency reliability, 2) convergent validity and 3) discriminant validity.

i) Internal consistency reliability and convergent validity

These two stages in the measurement model evaluation were analyzed concurrently as each have an impact on the other. The outer loadings of all constructs were first evaluated and those with outer loadings below 0.4(Hair et al., 2017) were eliminated from the construct as it is deemed too weak. Those above 0.4 but below 0.7 and had no impact on composite reliability when deleted were kept in the model. The remaining indicators are as follows:

| | Outer Loading | Chronbach's Alpha | Composite reliability | Average variance extracted |
|---|---|---|---|---|
| **Time (ACCESS)** | | 1.000 | 1.000 | 1.000 |
| ACCESS1 | 1.000 | | | |
| **Effort (ACCESS)** | | 0.696 | 0.863 | 0.759 |
| ACCESS3 | 0.810 | | | |
| ACCESS7 | 0.928 | | | |
| **Diet Importance (DIET)** | | 0.571 | 0.796 | 0.669 |
| DIET2 | 0.651 | | | |
| DIET3 | 0.956 | | | |
| **Environmental Concern (ENV)** | | 0.807 | 0.877 | 0.705 |
| ENV1 | 0.864 | | | |
| ENV2 | 0.885 | | | |
| ENV3 | 0.765 | | | |
| **Preventive Behavior (PREVENT)** | | 1.000 | 1.000 | 1.000 |
| PREVENT1 | 1.000 | | | |
| **Price Importance (PRICE)** | | 0.746 | 0.848 | 0.652 |
| PRICE1 | 0.727 | | | |
| PRICE2 | 0.864 | | | |
| PRICE3 | 0.825 | | | |
| **Purchasing Discipline (PURCHASE)** | | 1.000 | 1.000 | 1.000 |
| PURCHASE1 | 1.000 | | | |
| **Recycling Behavior (RECYCLE)** | | 0.338 | 0.699 | 0.568 |
| RECYCLE1 | 0.452 | | | |
| RECYCLE3 | 0.965 | | | |
| **Household Food Waste (WASTE)** | | 0.906 | 0.920 | 0.515 |
| WASTE1 | 0.632 | | | |
| WASTE3 | 0.795 | | | |
| WASTE6 | 0.775 | | | |
| WASTE9 | 0.810 | | | |
| WASTE10 | 0.786 | | | |
| WASTE11 | 0.734 | | | |
| WASTE12 | 0.697 | | | |
| WASTE13 | 0.655 | | | |
| WASTE14 | 0.648 | | | |
| WASTE16 | 0.614 | | | |
| WASTE17 | 0.713 | | | |

Figure 8: Indicator reliability

Chronbach's alpha and composite reliability indicators were used together to provide an indicator of the measures' internal consistency reliability. This is because Chronbach's alpha is deemed to be a more conservative measure and tends to underestimate internal consistency reliability as it is sensitive to the number of

measure items. Composite reliability on the other hand takes into account different outer loadings of the indicator variables and overestimates the internal consistency reliability (Hair et al., 2017). By using Chronbach's alpha as the lower bound and composite reliability as the upper bound, the measure's true reliability can be gauged (Hair et al., 2017).

Higher values generally indicate higher levels of reliability with values below 0.60 indicating a lack of internal consistency reliability (Hair et al., 2017). The constructs above all have an upper boundary that is higher than 0.60 while diet importance (0.571) and recycling behavior (0.338) have a lower boundary just below 0.60. As the upper boundary for these two constructs is above 0.60, both can therefore still be accepted.

Convergent validity is the extent a positive correlation is evident between a measure and alternative measures of the same construct (Hair et al., 2017). All LVs have an average variance extracted (AVE) of more than 0.5 which indicates that the construct explains more than half of the variance of its indicators and satisfies the criteria of convergent validity (Diaz-Ruiz et al., 2018; Hair et al., 2014).

ii) Discriminant validity

Discriminant validity measures the extent to which the construct is distinct from others and hence by satisfying this, it implies that the construct is able to capture phenomena that is not represented by other constructs in the model (Hair et al., 2017). Using the Fornell-Larcker Criterion, it was found that the discriminant

validity was satisfied. The square root of the AVE values (bold diagonal numbers) were higher than other correlation values among the latent variables as shown below:

| | DIET | EFFORT | ENV | WASTE | PREVENT | PRICE | PURCHASE | RECYCLE | TIME |
|---|---|---|---|---|---|---|---|---|---|
| **DIET** | **0.818** | | | | | | | | |
| **EFFORT** | -0.094 | **0.871** | | | | | | | |
| **ENV** | 0.105 | 0.105 | **0.839** | | | | | | |
| **WASTE** | 0.116 | 0.325 | 0.299 | **0.718** | | | | | |
| **PREVENT** | 0.162 | 0.123 | 0.018 | -0.031 | **1.000** | | | | |
| **PRICE** | 0.037 | 0.147 | 0.243 | 0.377 | -0.063 | **0.807** | | | |
| **PURCHASE** | 0.142 | 0.166 | 0.196 | 0.282 | -0.104 | 0.399 | **1** | | |
| **RECYCLE** | 0.049 | 0.104 | 0.000 | 0.218 | -0.023 | 0.168 | 0.107 | **0.754** | |
| **TIME** | 0.03 | 0.069 | 0.011 | 0.087 | -0.162 | 0.042 | 0.078 | -0.039 | **1** |

Table 6: Discriminant validity

## 5.3 Modification process

Based on the reliable and valid constructs identified, the variables forming the initial conceptual model were modified to form other possible logical relationships in order to test the best model fit. A summary of the other modified models is as follows (The final empirical model is included for reference):

| Model no. | SRMR | $R^2$ | No of OV | No of LV | No. of paths (no. of significant paths) |
|---|---|---|---|---|---|
| 1 | 0.09 | 30.8% | 21 | 7 | 9 (3) |
| 2 | 0.09 | 30.9% | 26 | 9 | 8 (3) |
| 3 | 0.09 | 30.8% | 26 | 9 | 10 (3) |
| 4 | 0.085 | 29.4% | 23 | 8 | 7(3) |
| 5 | 0.092 | 27.9% | 23 | 8 | 7 (2) |
| 6 | 0.087 | 25.5% | 20 | 7 | 6 (2) |
| 7 | 0.089 | 28.5% | 24 | 9 | 8(3) |
| 8 | 0.081 | 25.3% | 18 | 7 | 6(3) |
| 9 | 0.088 | 30.7% | 24 | 9 | 8(3) |
| 10 | 0.098 | 35.3% | 28 | 9 | 8(4) |
| 11 | 0.084 | 29.1% | 21 | 7 | 6(3) |
| 12 | 0.072 | 31.0% | 18 | 9 | 8(3) |
| 13 | 0.084 | 29.6% | 27 | 9 | 8(3) |
| 14 | 0.084 | 29.6% | 26 | 9 | 13(3) |

| | | | | | |
|---|---|---|---|---|---|
| 15 (empirical model) | 0.084 | 29.6% | 26 | 9 | 10(3) |

Table 7 : Summary of other modified models

Please refer to the appendix for an illustration and further explanation of the modification process of all the models.

It was found that the model with the best SRMR (0.072) is model 12, however the number of OVs that make up the model are too little, especially as 5 out of the 9 LVs had only 1 OV. Models 11 and 13 to 15 have the next best model fit. Models 13 and 14 were closest to the initial conceptual model while model 15 is based on the initial conceptual model. As variances to the initial conceptual model did not improve SRMR, $R^2$ and number of significant path coefficients, the initial conceptual model was therefore used (i.e. model 15).

## 5.4 Structural model evaluation

After establishing the reliability and validity of the constructs, the structural model was then assessed on significance of the path coefficients and the level of $R^2$ values (Diaz-Ruiz et al., 2018; Hair et al., 2017). However, before these assessments are made, the structural model needs to be examined for collinearity.

Collinearity can be assessed through the Variance Inflation Factors (VIF). All measures have a VIF of below 5(Hair et al., 2017) indicating no presence of co-linearity in the model as follows:

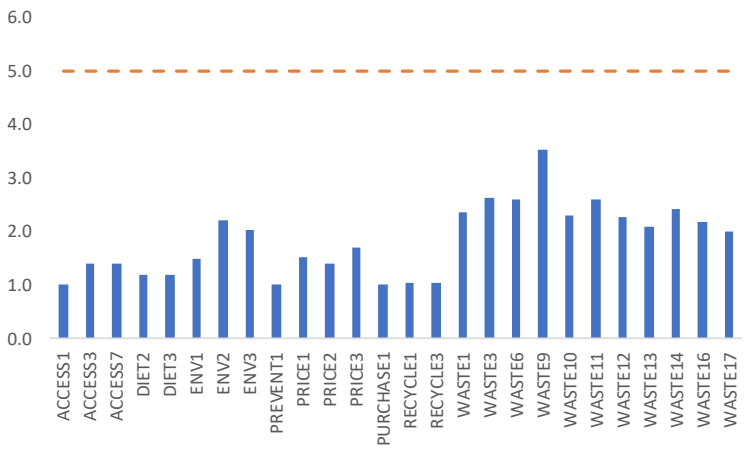



Figure 9: Outer VIF

| Inner VIF | Household food waste |
|---|---|
| Diet importance | 1.095 |
| Effort | 1.107 |
| Environmental concern | 1.093 |
| Preventive behavior | 1.112 |
| Price importance | 1.265 |
| Purchasing discipline | 1.271 |
| Recycling behavior | 1.048 |
| Time | 1.046 |

Figure 10: Inner VIF

To determine significance of path coefficient, the bootstrapping procedure was applied using 5000 sub-samples to compute the empirical t-values of the model's relationships with a two-tailed significance test. It was found that out of 8 paths, only 3 were significant based on a significance level of 10% (1.65) which is assumed when the study is exploratory in nature (Hair et al., 2017):

| | Path Coefficient | T-statistics | p- values |
|---|---|---|---|
| Diet Importance -> Household food waste | 0.101 | 0.912 | 0.362 |
| Effort -> Household food waste | 0.257 | 2.644 | 0.008 |
| Environmental Concern -> Household food waste | 0.191 | 2.153 | 0.031 |
| Environmental Concern -> Preventive Behavior | 0.018 | 0.161 | 0.872 |
| Environmental Concern -> Recycling behavior | 0 | 0.001 | 0.999 |
| Preventive Behavior -> Household food waste | -0.049 | 0.61 | 0.542 |
| Price Importance -> Household food waste | 0.232 | 2.671 | 0.008 |
| Purchasing discipline -> Household food waste | 0.071 | 0.779 | 0.436 |
| Recycling behavior -> Household food waste | 0.14 | 1.065 | 0.287 |
| Time -> Household food waste | 0.046 | 0.585 | 0.559 |

Table 8: Significance analysis of the structural model

Only the second hypothesis (H2) is supported with effort showing a positive and significant association with household food waste (path coeff. = 0.257, t-value = 2.644). The results for the first hypothesis (H1) for a direct and positive relationship between time and household food waste proved to be non-significant and hence H1 cannot be supported. Other control variables that showed a significant result is the relationship between environmental concern and household food waste (path coeff. = 0.191, t-value = 2.153) and price importance and household food waste (path coeff. = 0.232, t-value = 2.701).

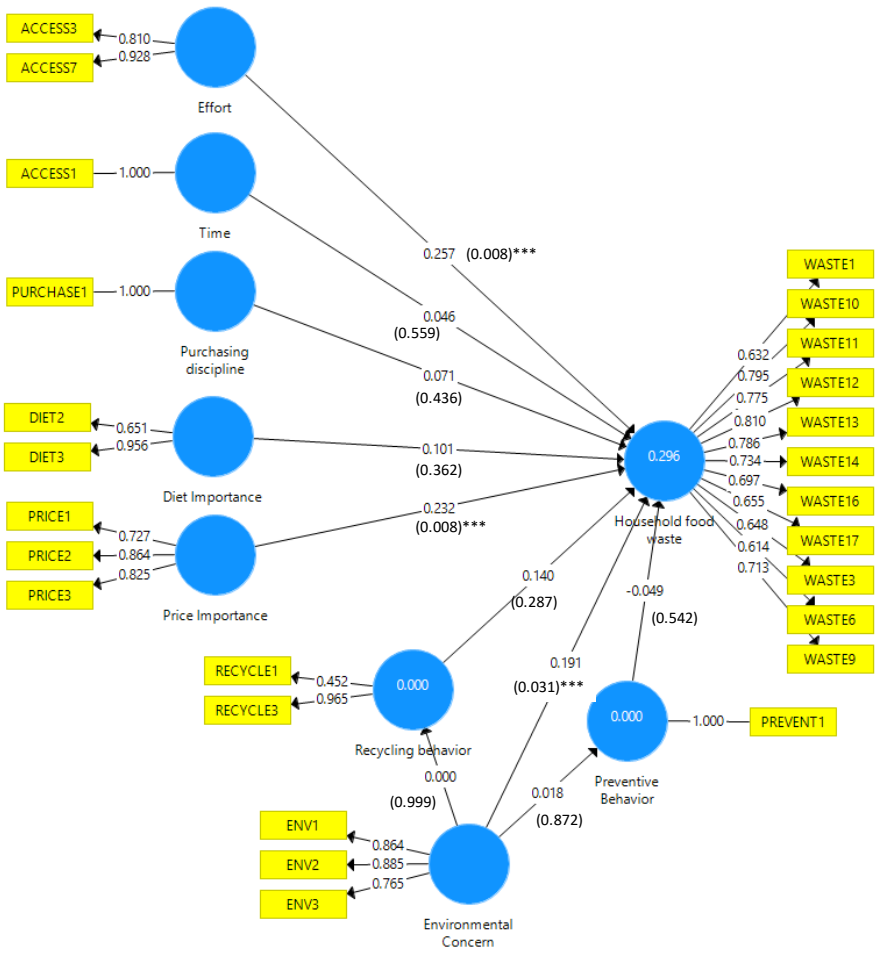
There seems to be almost no relationship between environmental concern and recycling behavior (path coeff. = 0, t-value = 0.001) as well as environmental concern and preventive behavior (path coeff. = 0.018, t-value = 0.161) as both relationships are not significant. This shows that waste recycling and prevention behavior among respondents are not driven by environmental concerns.

Looking at the p-value, which is the probability of erroneously rejecting a true null hypothesis, for a significance level of 10%, it can be seen that the p-value

for H2 is significantly below 0.1 which implies that this relationship is significant.

To look at model fit, the standardized root mean square residual (SRMR) can be used as an approximate measure with a value of less than 0.10 considered a good fit (Hair et al., 2017). The SRMR for this model is 0.084, which is less than 0.10 and can therefore be considered a good fit.

The $R^2$ value measures the model's predictive power with higher levels (closer to 1) indicating higher levels of predictive accuracy. The model under study has a $R^2$ of 29.6% which is within the range of other household food waste studies of between 19% to 65%(Diaz-Ruiz et al., 2018; Russell et al., 2017; Stancu et al., 2016; Stefan et al., 2013). The final model is illustrated as per Figure 11.




**Note: Numbers in brackets () denote p-values while the numbers outside of the brackets denote path coefficients. *** denotes significant paths.*

Figure 11: Empirical model to predict household food waste behavior

# Chapter 6. Discussion

There are many studies that conclude that household food waste behavior needs to be understood in order to reduce household food waste due to the amount of waste generated. Thus far, the literature is abundant with studies on household attitudes and food behavior that attempt to explain from the viewpoint of consumer behavior. More recent literature has, however, started to look at reasons other than consumer behavior such as infrastructure systems in explaining household food waste. This research attempts to provide a new angle to understanding household food waste generation by using factors traditionally used in public health and urban studies. A model was then developed that combines food access and traditional consumer waste related behaviors to explain household food waste.

PLS-SEM was employed to provide analysis as this study is exploratory in nature rather than a confirmatory one. The results were able to support one hypothesis (H2) relating to effort and household food waste. This indicates that the higher level of effort taken to secure food, more food waste is generated at the household level. This may be due to over purchase to avoid the opportunity cost of non-purchase (Hebrok & Boks, 2017; Lee, 2018). The respondents have indicated a tendency to only purchase sale items but also reported to only purchase necessary and planned food items. Hence over purchase due to market promotions and price (Lee, 2018) may not be a cause for over purchase in this study. Price importance also has a significant and positive relationship with household food waste which is supportive of existing findings considering that the less important price is to the

consumer, the more food they waste.

Environmental values were also seen to have a positive and significant relationship with household food waste which indicates that the amount of household food waste generation is not influenced by high environmental values. This may seem to be true as studies have previously shown that household food waste generation is more influenced by financial means rather than environmental values (Hebrok & Boks, 2017; Stancu et al., 2016). The relationship between environmental values and recycling and preventive behaviors, is however unclear as the results are not significant. Path coefficients are also almost zero implying that environmental values have almost no impact on recycling and preventive behaviors.

In addition, it cannot be assured that the rest of the variables, diet importance, time, purchasing discipline, recycling behavior and preventive behavior has an influence on waste behavior as their results are not significant.

The findings may have an impact on waste policies in Malaysia. As effort has been shown to have a direct link to waste, reducing household food purchase effort by improving access to food sources may need to be considered by policy makers. Policymakers may hence want to look beyond the individual household decision making and consider developments in physical food retails, how this influences the consumer's lifestyle and whether it compounds the food waste problem. Urban planners may therefore want to factor this in when making town plans, especially developing countries where there is still potential to build more sustainable cities.

In addition, online food websites development may also be a potential opportunity to improve food accessibility as this can be seen as lesser effort exerted to access food compared to purchase at physical stores. Furthermore, the online food industry is still in its infancy in Malaysia and many other developing countries.

Another important finding is the lack of influence that environmental values have on waste generation. Correspondingly, price importance was found to have an influence on household waste generation which supports findings by other studies. Waste policy makers may therefore need to focus on food price controls rather than promoting environmental awareness when formulating household waste targeted policies.

It can be noted that many countries provide subsidies to control prices of their goods, including Malaysia who spent RM2 billion on subsidies to control the price of basic goods such as sugar, flour, cooking oil etc (Ministry of Domestic Trade and Consumer Affairs, 2018). Prices of these goods are therefore below market price which encourages increased consumption and promotes wastage. Removing these subsidies would not only allow for national savings but also reduce food wastage and over consumption by households.

Results from this study illustrates that other than the usual policies of increasing environmental awareness and waste prevention campaigns, reducing food waste may instead require integrated solutions with involvement from urban planners or simply the removal or reduction of policies to discourage over purchase and consequently food waste.

# Chapter 7. Research Limitations

The results of this research can only be limited to the areas studied in this case study as it is not representative of the population due to the limited number of respondents (105) which is slightly more than the minimum recommended by Hair et al (2017) for analysis by PLS-SEM(Hair et al., 2017). Future research may want to expand the study area and improve on the number of respondents in order for the findings to be more representative of the population.

This study also only focuses on physical food access as it is relevant in the context of Malaysia. Future studies may want to also consider online food purchases and provide a comparison between online and physical food purchase to determine effort levels and whether these have an impact on household food waste.

In addition, this study combines both physical purchases of take away and groceries. Further research may be required to determine differences in waste generation from take away foods and groceries in terms of effort levels as it was found in this study that groceries and take away appear to have different perceived effort by households. How this difference impacts food waste, however, cannot be entirely deduced from this study and hence further research may be needed to provide clarity.

Households have been shown to be an important factor in food waste and understanding the various reasons for waste generation would be key to formulating policies that can effectively target and reduce household food waste.

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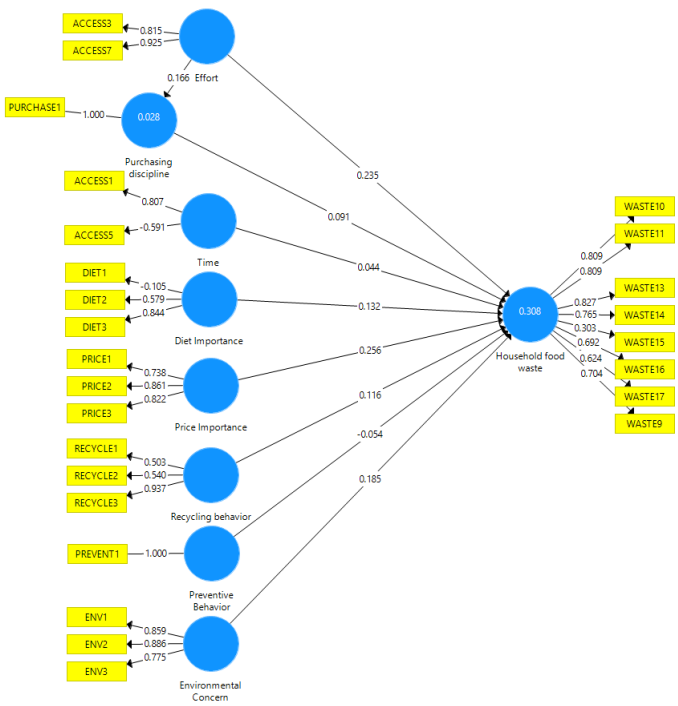
# Appendix

Modification process – model illustration

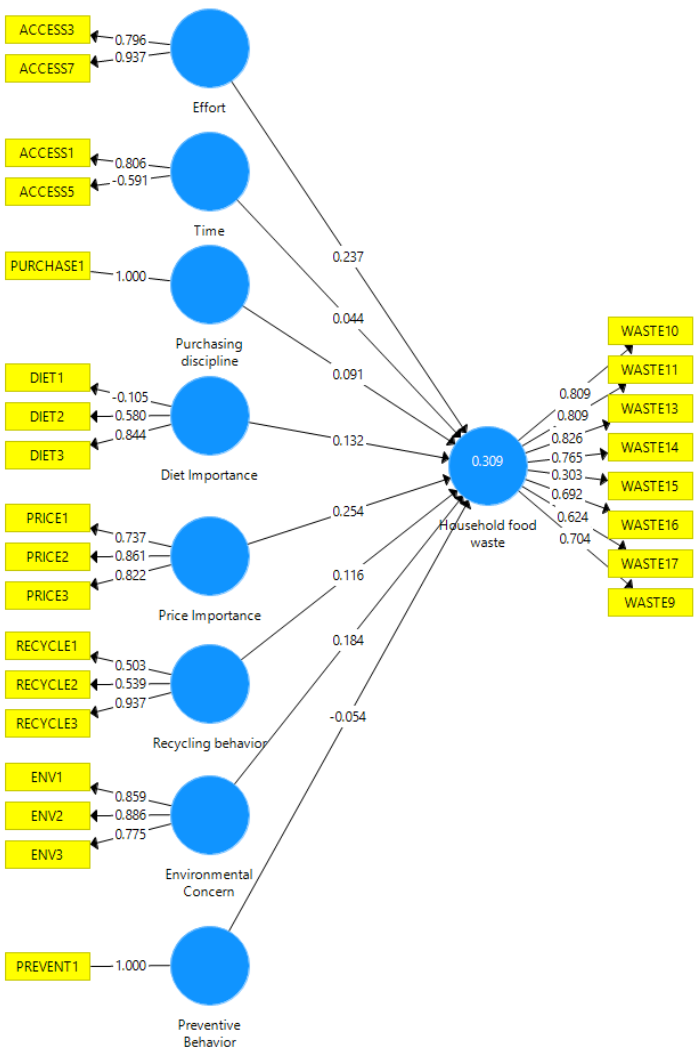
**MODEL 1**

The model was modified to include the possibility of a link between effort and purchasing discipline (i.e. over purchasing behaviors). Results shows a SRMR of 0.09 and an $R^2$ of 30.8%. However, the inclusion of both ACCESS 1 and ACCESS 5 as OVs for the time variable caused the composite reliability to drop to 0.044, way below the acceptable level of 0.7.



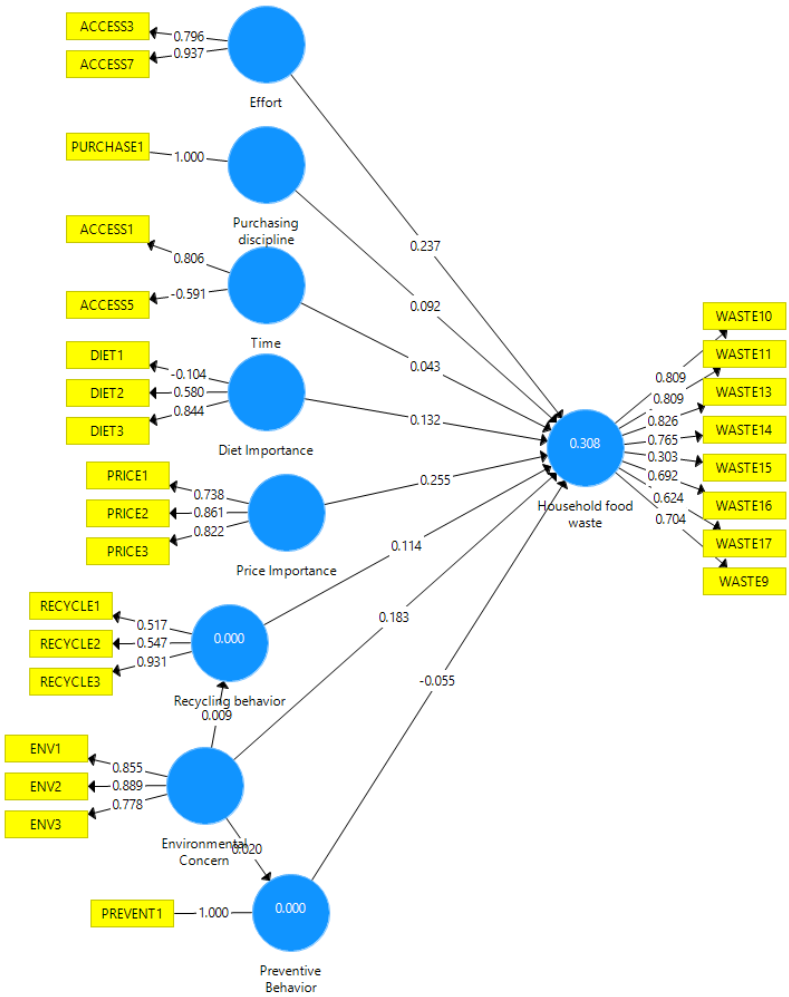
**MODEL 2**

This model is almost the same as MODEL 1 except that purchasing discipline now has no relation to effort and is only directly linked to household food waste. SRMR did not change, maintaining at 0.09 with only a slightly higher $R^2$ of 30.9%.



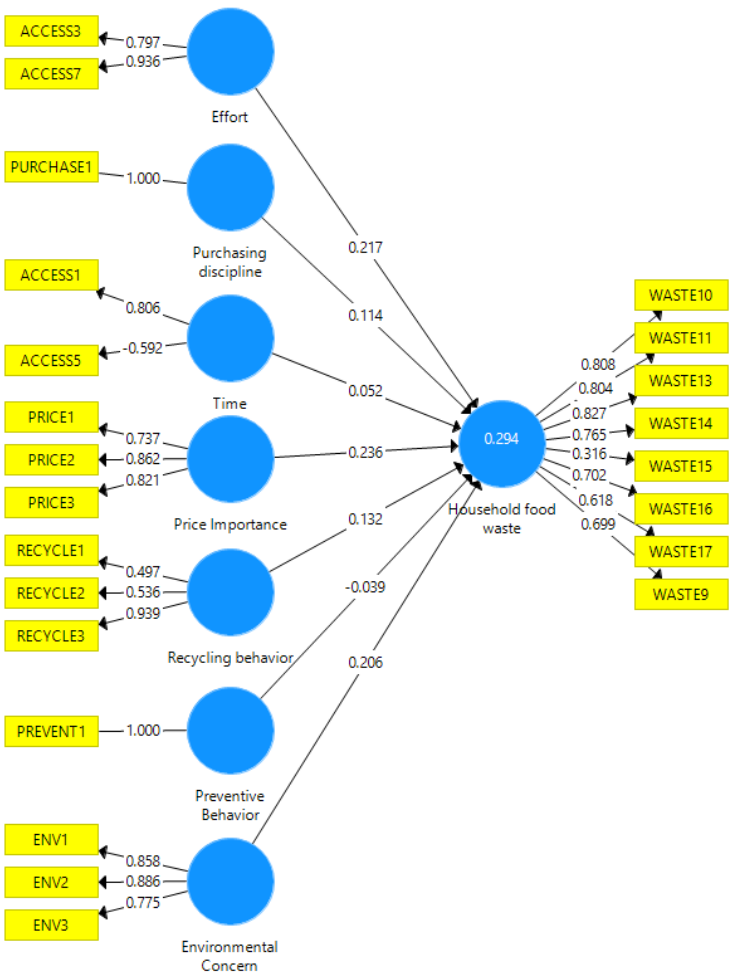
**MODEL 3**

From the previous model, this model adds the potential relationship between environmental values and waste management (recycling and preventive behaviors). The SRMR maintained at 0.09 and the $R^2$ is 30.8%, the same as model 1.



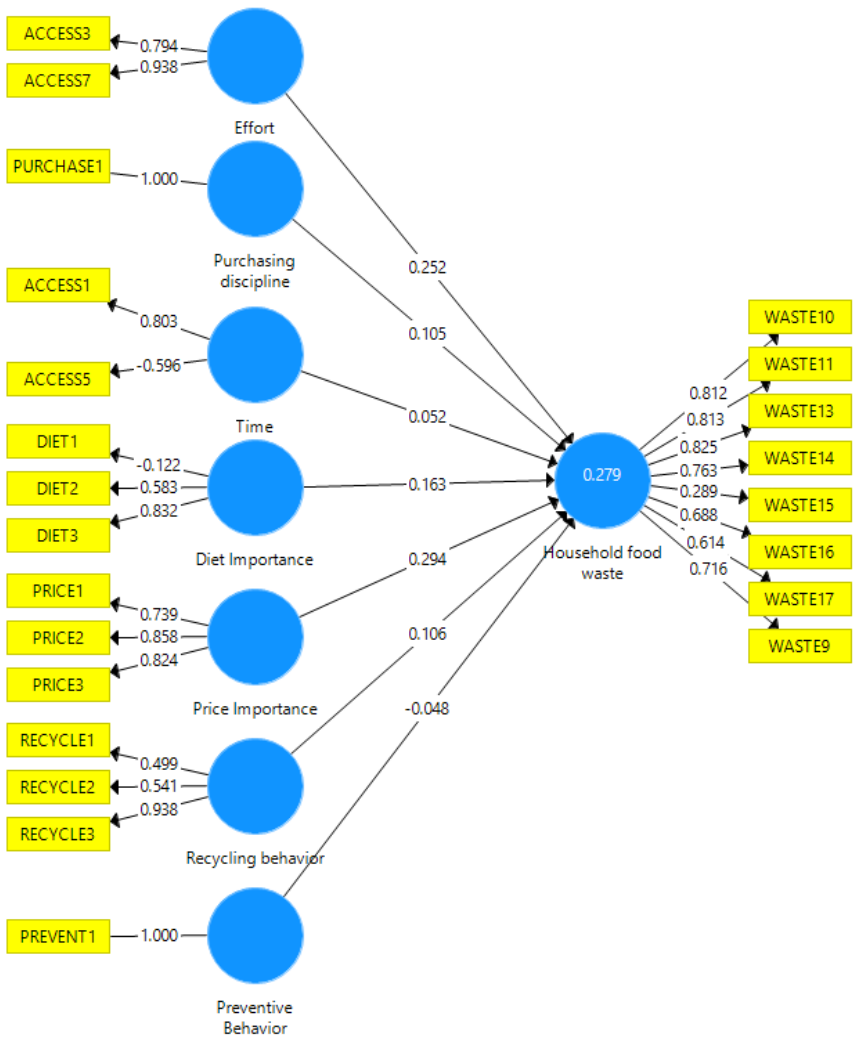
**MODEL 4**

Diet importance was removed from the model to gauge its impact. SRMR improved to 0.085 but $R^2$ reduced to 29.4%.



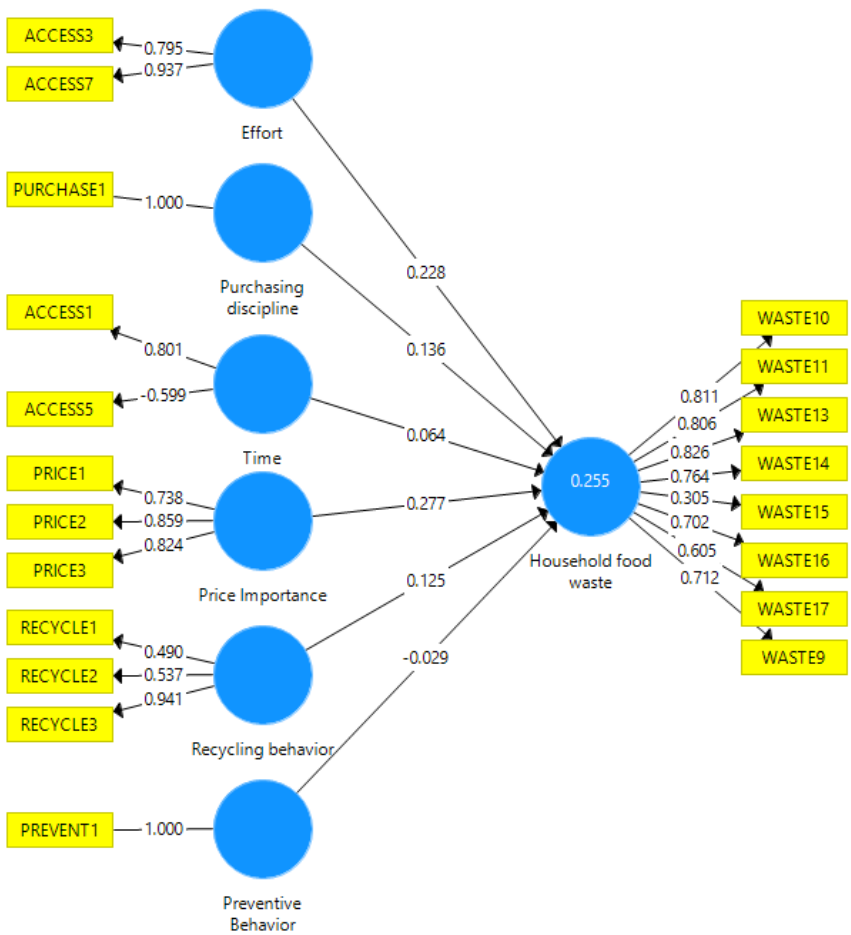
**MODEL 5**

In this model, environmental values were removed to gauge the impact on the model. SRMR increased to 0.092 while $R^2$ declined further to 27.9% implying that the removal of environmental values was a significant change.



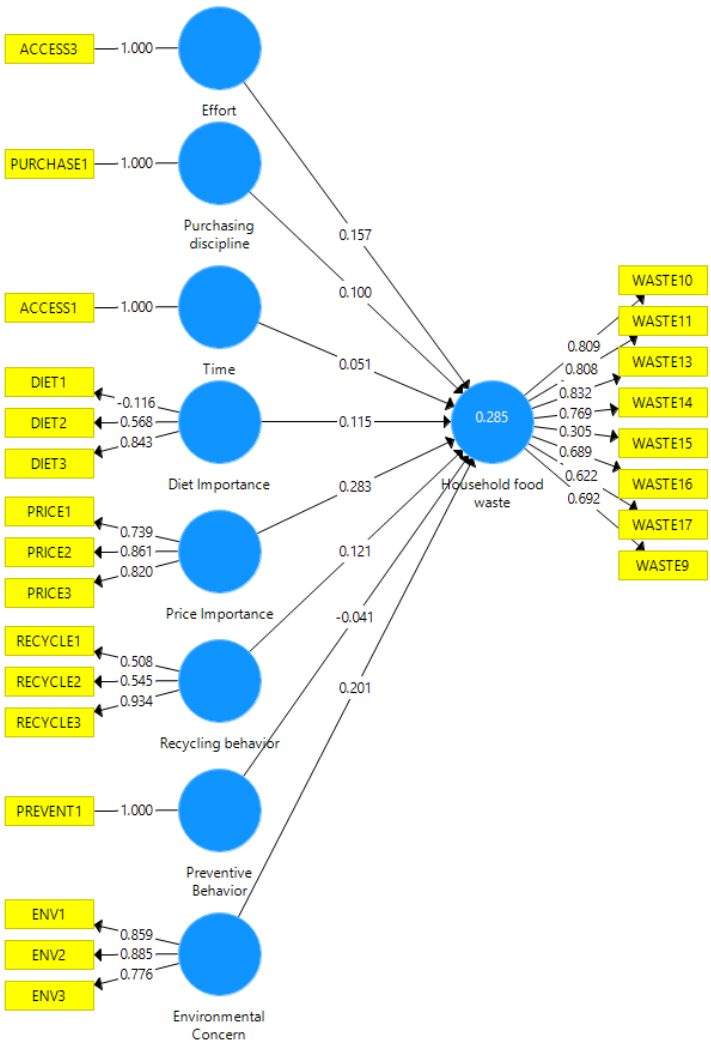
**MODEL 6**

To experiment further, diet importance as well as environmental values were removed from the model. The SRMR improved slightly to 0.09 but $R^2$ reduced further to 25.5%. This may imply that the inclusion of diet importance doesn't improve model fit.



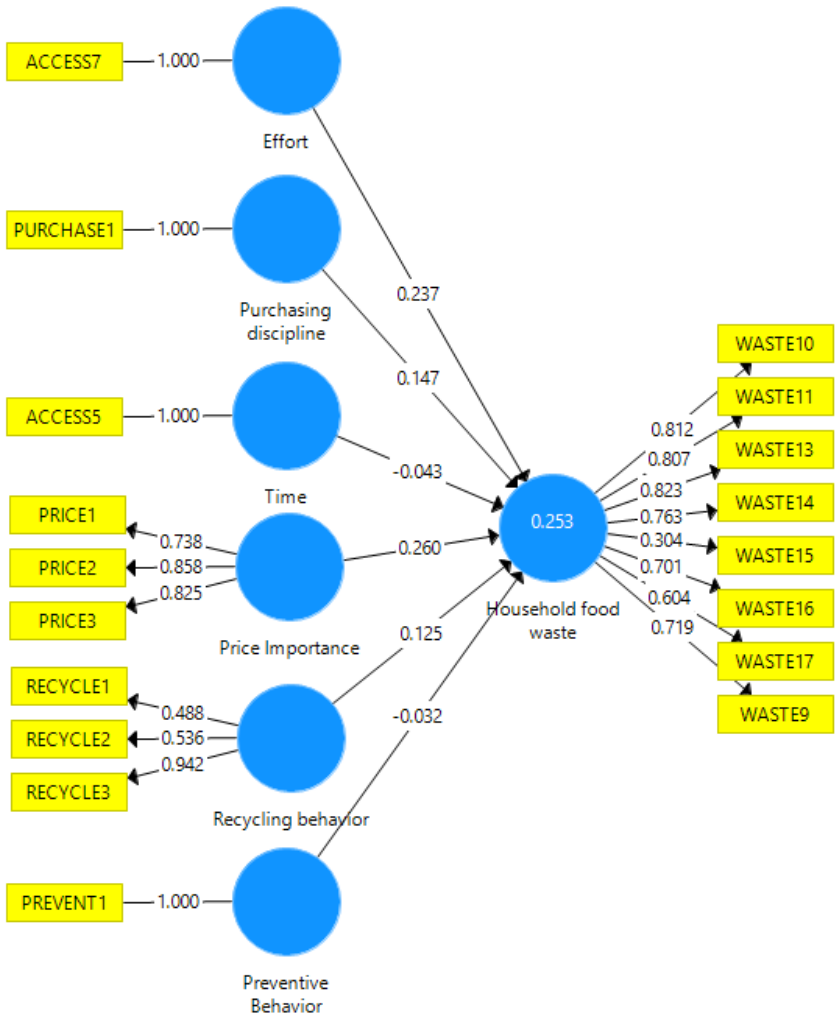
**MODEL 7**

Diet importance and environmental values were both added back to the model. Instead, the OVs for effort and time were reduced to only include one OV each that includes only grocery related OVs (excludes take away food). The SRMR improved to 0.089 and the $R^2$ also increased to 28.5%.



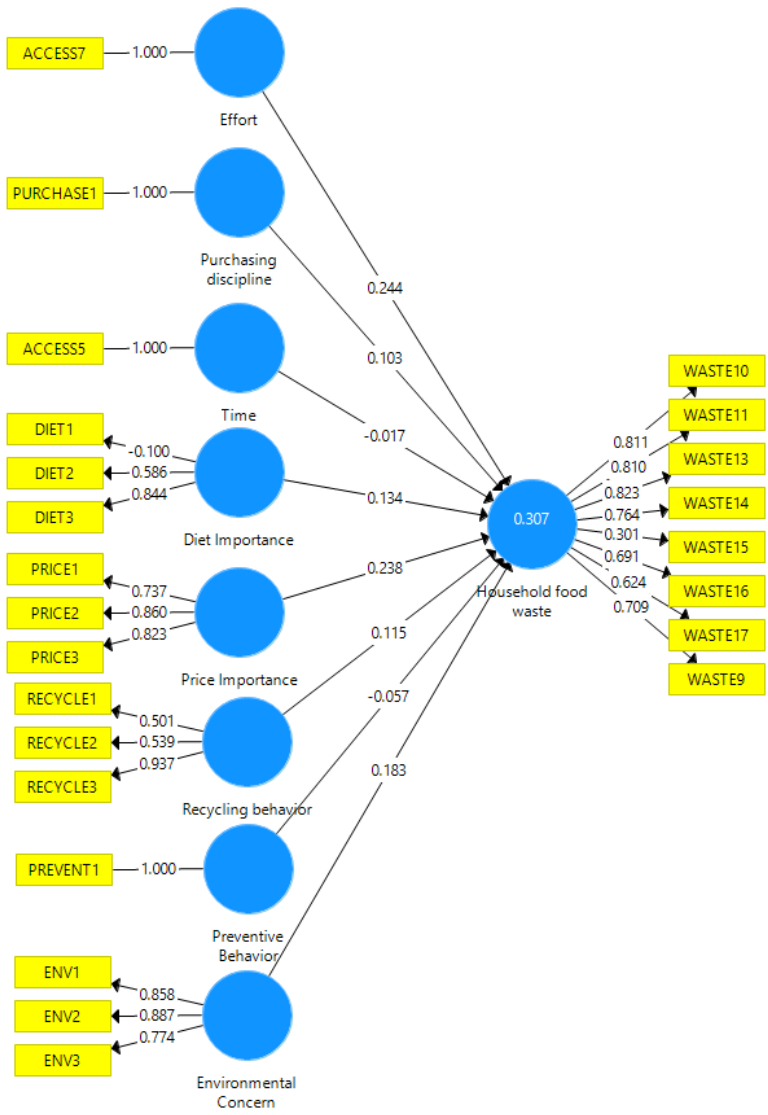
**MODEL 8**

This model then takes only the take away OVs in time and effort to as well as diet importance and environmental values. SRMR improved to 0.081 but $R^2$ decreased to 25.3%.



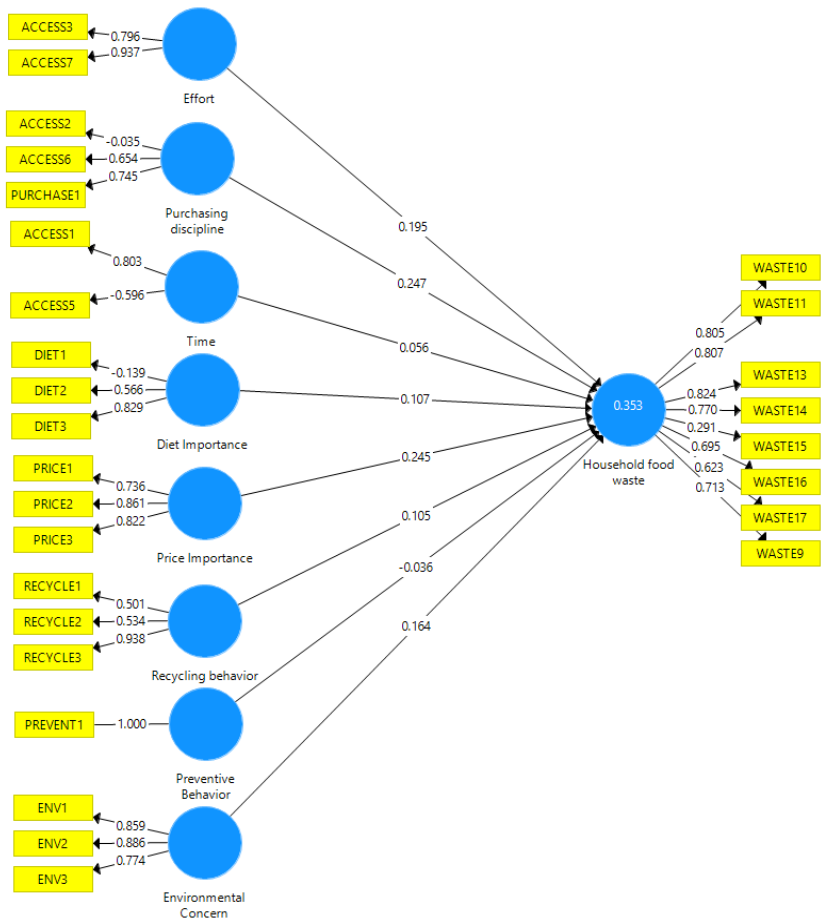
**MODEL 9**

This model then includes the diet importance and environmental values variable back into the model (from model 8). The SRMR increased to 0.088 but $R^2$ increased to 30.7%.



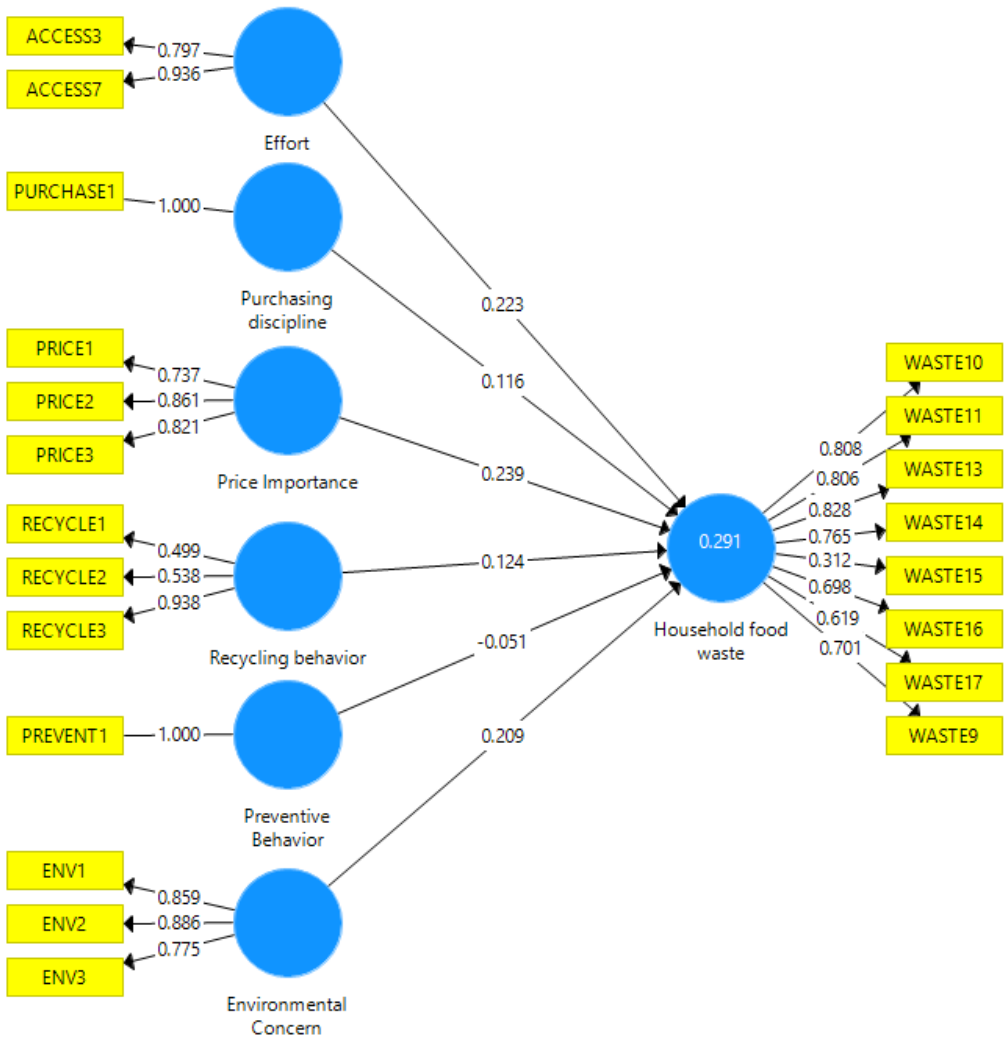
**MODEL 10**

This model now includes both groceries and take away food measures for the effort and time variables. Additional OVs were added to purchasing discipline, ACCESS 2 and ACCESS 6 which relate to frequency of purchase for groceries and take away. The SRMR increased to 0.98 indicating a lack of model fit while the $R^2$ also increased to 35.3%.



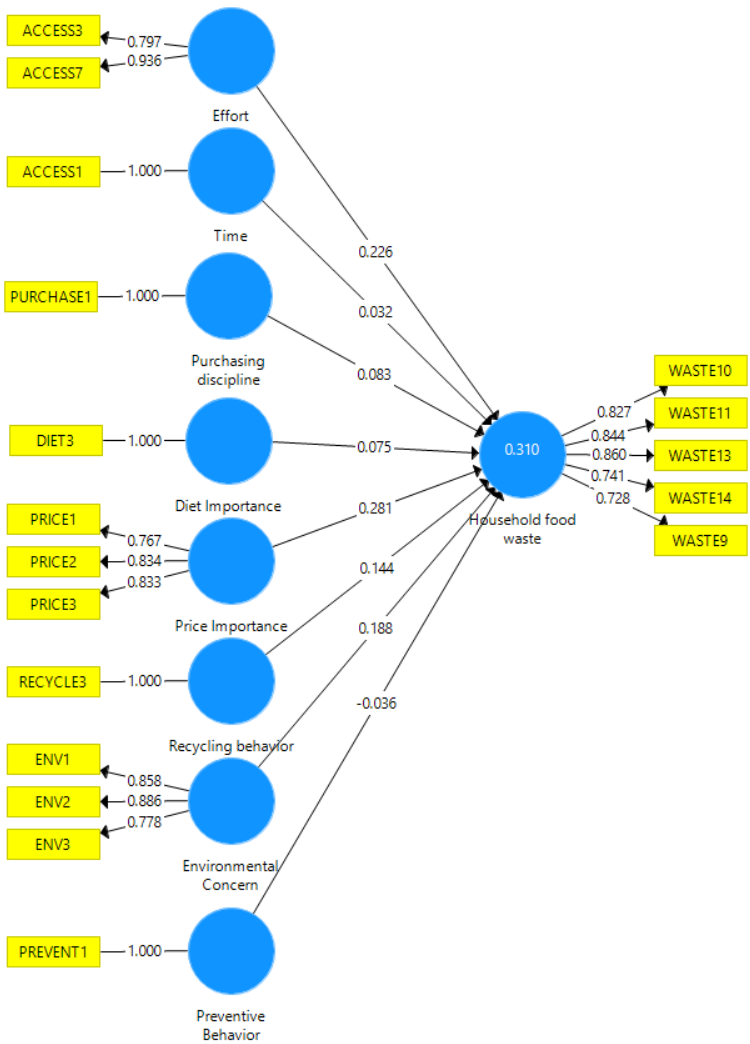
**MODEL 11**

Time and diet importance were taken out from the model to gauge the impact. SRMR improved to 0.084 but $R^2$ reduced to 0.291.



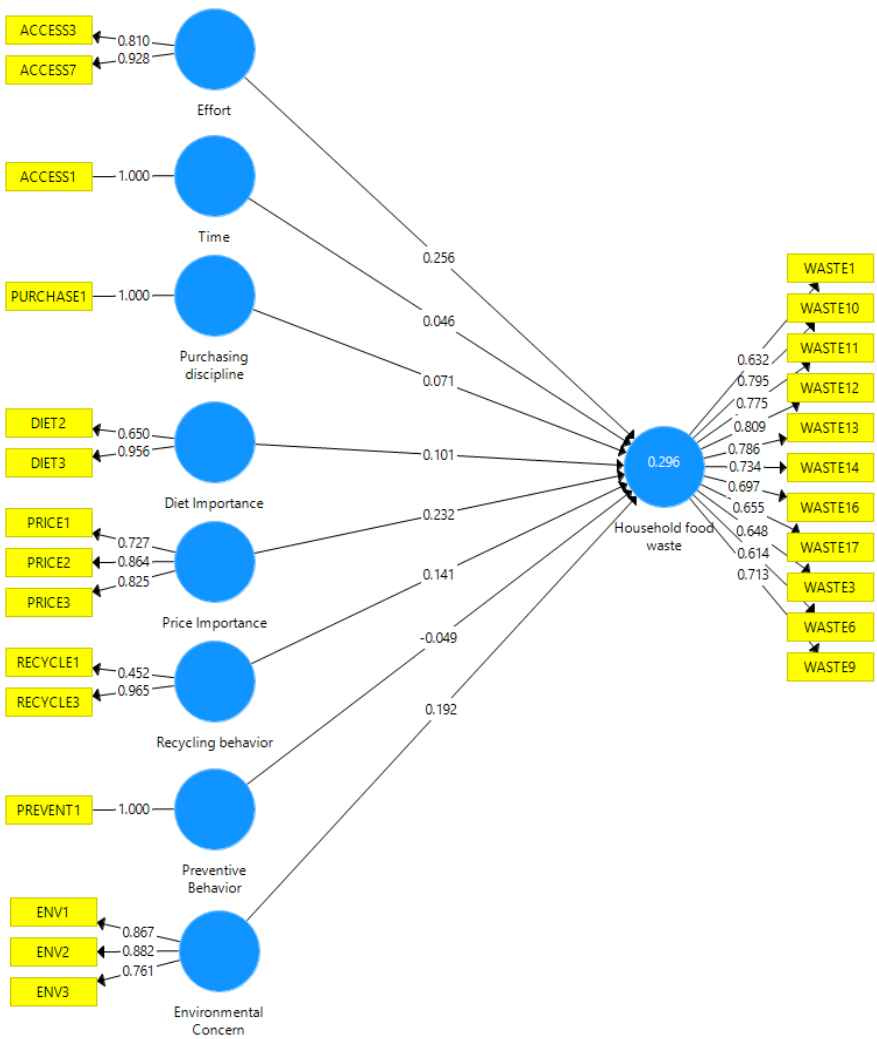
**MODEL 12**

Diet importance and environmental values were added back to the model. ACCESS 5 was excluded from the model as it severely impacted the composite reliability of the time variable. DIET 1 and DIET 2 were also removed to see the impact on the model. Model fit improved to 0.072 and $R^2$ increased to 31.0%.



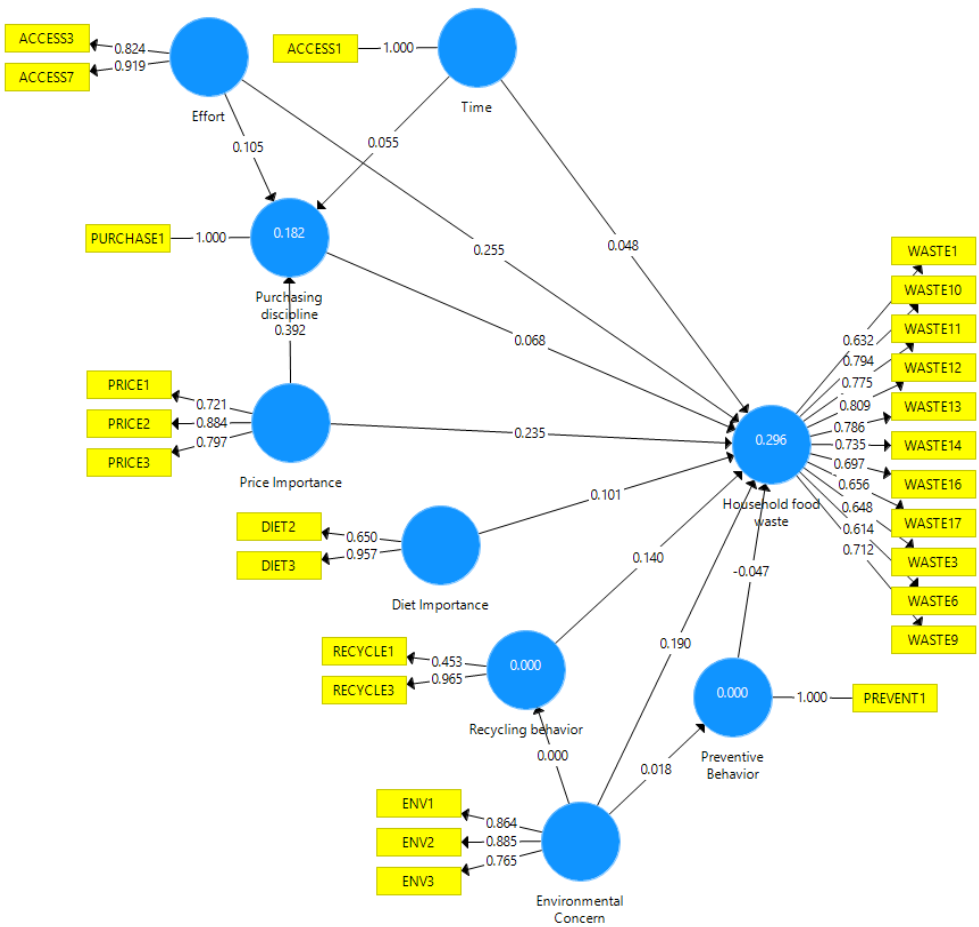
**MODEL 13**

All LVs only have one relationship in this model. DIET 2 was added back into the model to gauge impact to model fit. SRMR increased to 0.084 while $R^2$ reduced to 29.6%.



**MODEL 14**

Relationships between purchasing discipline and effort, time as well as price importance were included considering previous studies linking these variables. Environmental values were also linked to recycling and preventive behaviors. The SRMR did not change from Model 13 of 0.084 and $R^2$ also remained at 29.6%



**MODEL 15**

This model is the original conceptual model. The environmental values variable is shown with a relationship with recycling and preventive behaviors and excludes the interrelationship between purchasing discipline and effort, time and price importance. The SRMR was found to remain at 0.084 and $R^2$ at 29.6%. As modifications to the original model did not improve model fit, the conceptual model was therefore used as the final empirical model.