

THE SUBSTITUTABILITY OF CIGARETTES AND FOOD: A BEHAVIORAL ECONOMIC APPROACH

By

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(Under the Direction of James MacKillop)

ABSTRACT

More preventable deaths are attributed to obesity and cigarettes smoking in the United States than any other causes. Smoking and eating behaviors appear to influence each other in various ways. Behavioral economics can help understand the consumption of commodities. The price of one commodity can affect the consumption of another including functioning as substitutes when consumption of one item increases as the price of another increases. Despite speculation that smokers may substitute food and cigarettes, no study has directly examined this. The current study evaluated the effects of rising food prices on cigarette consumption and the effects of rising cigarette prices on food consumption. The extent to which these relationships were symmetrical and were associated with Body Mass Index (BMI) and other variables related to smoking and eating behaviors was also examined. Cigarette smokers ($N = 86$) completed a two-part hypothetical task in which they could allocate money to purchase cigarettes and fast food-style reinforcers (e.g., burgers, sandwiches, soft drinks, ice cream) as the prices of the commodities varied. Cross-price elasticity coefficients indicated that neither food nor cigarettes were substitutes for one another. Food purchases were independent of cigarette price, whereas cigarette purchases decreased as food price rose. Individuals'

confidence in their ability to effectively control their weight, appetite, and eating without smoking was significantly associated with cross-price elasticities, but BMI and other facets of eating and smoking behavior were not. For cigarette smokers, greater taxation of food items like those used in the substitutability task may have the potential to reduce consumption of these foods as well as cigarettes, given the decrease in purchases of both observed as a function of food price. Heavy taxation of cigarettes, on the contrary, would be expected to have minimal impact on purchasing of high-calorie convenience foods. Perceived ability to manage one's weight and eating without cigarettes may influence who uses food as a substitute for cigarettes after smoking cessation.

INDEX WORDS: Smoking, Weight, Obesity, Behavioral economics, Substitution, Cross-price elasticity of demand, Smoking cessation

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DEDICATION

To J. Acker – To different minds the same world is a hell and a heaven...may you always have the courage to follow your heart and intuition.

To the PPC – No road is long with good company. Thank you for countless hours of love, support, inspiration, encouragement, and laughter.

To my parents, with grateful thanks for believing in me, always.

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CHAPTER 1

INTRODUCTION

Cigarette smoking and excess body weight are both substantially associated with increased risk of morbidity and mortality (Centers for Disease Control and Prevention, 2012; National Heart, Lung, and Blood Institute, 1998). Indeed, tobacco and poor diet/physical inactivity represent the two leading causes of preventable death in the United States (Mokdad, Marks, Stroup, & Gerberding, 2004). Smoking and obesity share many characteristics including starting early in life, involving heavily marketed commodities, being highly prevalent, being major risk factors for chronic disease, and being difficult to treat (Schroeder, 2007). While excess weight and tobacco use, individually, lead to higher rates of disease, disability, and death, when an individual has both risk factors, the consequences are serious and multiplicative. Indeed, relative risk of cardiovascular disease mortality is up to five times greater in smokers who are obese or overweight compared to normal weight individuals who have never been smokers (Freedman et al., 2006). Related, the life expectancy of obese smokers is estimated to be approximately seven years less than that of normal weight smokers and 13 years less than that of normal weight nonsmokers (Peeters et al., 2003). Reducing these risks may be challenging, in part, due to the interactive way in which eating and smoking may influence each other.

Relationship between Weight and Smoking Initiation and Maintenance

There has been a long-recognized relationship between cigarette smoking and body weight, with high tobacco consumption causing lower body weight among current

smokers (Winslow, Rode, & Nordestgaard, 2015) and smokers tending to weigh less and to have lower rates of obesity than nonsmokers (for review on smoking and body weight see Klesges, Meyers, Klesges, & La Vasque, 1989). The effects of cigarettes on body weight have been shown to encourage the initiation and maintenance of smoking, particularly for women, individuals with weight concerns, and those who diet (Pomerleau et al., 1993; Camp, Klesges, & Relyea, 1993; French, Perry, Leon, & Fulkerson, 1994; Austin & Gortmaker, 2001; Pomerleau, Zucker, & Stewart, 2001; Levine, Perkins, & Marcus, 2001; Potter, Pederson, Chan, Aubut, & Koval, 2004). Research showing that women who report smoking as a means of weight control are more likely to endorse disinhibited overeating and consume more food when abstaining from cigarettes supports the notion that smoking may curb problematic eating behaviors and/or hyperphagia which then may reemerge once smoking ceases (Pomerleau et al., 1993).

Obese and overweight smokers may be particularly likely to experience the phenomenon of problematic eating being masked by smoking and unmasked by abstinence. Disinhibited eating behavior has long been associated with obesity (Stunkard & Messick, 1985) and genetic and pathophysiological research has suggested that expression of the hormones involved in appetite regulation may predispose individuals to obesity (Cummings & Schwartz, 2003). Overweight and obese smokers endorse more disinhibited eating than normal weight smokers, more concern about post-cessation weight gain, and less confidence in their ability to maintain their weight without smoking (Pomerleau & Saules, 2007; Levine, Bush, Magnusson, Cheng, & Chen, 2013). This may be because one of the factors contributing to them starting smoking was, in fact, weight control. In adolescents, objective and subjective measures of weight

are important determinants of smoking initiation (Cawley, Markowitz, & Tauras, 2004) with the relationship between smoking and BMI strengthening over the teenage years (Seo, Jiang, & Kolbe, 2009). In a recent study, obese smokers reported that their eating habits changed once they began smoking, including having reduced appetite, replacing eating with smoking, and wanting a cigarette when hungry (Bush, Hsu, Levine, Magnusson, & Miles, 2014a). Over time, a tendency for uncontrolled eating may be reduced via smoking, with a greater reliance on nicotine resulting. This is supported by research suggesting that, among smokers, the average number of cigarettes smoked daily tends to be positively associated with measures of adiposity including BMI and waist-to-hip ratio (Bamia, Trichopoulou, Lenas, & Trichopoulos, 2004). Similarly, the odds of being obese are much higher in heavy smokers than light or moderate smokers, even after controlling for diet, activity, and relevant demographic variables (Chiolero, Jacot-Sadowski, Faeh, Paccaud, & Cornuz, 2007). Taken together, overweight and obese individuals appear to have more problematic eating and smoking habits which act to influence each other. Dissatisfaction with weight may trigger smoking initiation in overweight or obese youth as a means of weight control. The appetite suppressing effects of smoking may help overweight or obese smokers feel better equipped to manage uncontrolled eating with the insidious consequence of increased nicotine dependence and anxiety about controlling weight without cigarettes.

Smoking Cessation-Related Weight Gain and Associated Concerns

Weight gain is a well-known consequence of smoking cessation and, to date, there are no behavioral or pharmacological treatments that have been shown to reduce post-cessation weight gain in the long-term (Farley, Hajek, Lycett, & Aveyard, 2012). A recent meta-analytic review of weight changes during smoking cessation concluded that

average weight gain 12 months after smoking cessation was approximately 10lbs and the amount gained was comparable in those particularly concerned about weight gain and those who were not (Aubin, Farley, Lycett, Lahmek, & Aveyard, 2012). A considerable number of both men and women express concern regarding expected post-cessation weight gain (Clark et al., 2006). These concerns are associated with lower readiness and motivation to quit smoking (Pomerleau et al., 2001; Clark et al., 2004). Nonetheless, research has suggested that post-cessation weight concerns neither predict the likelihood of actually making a quit attempt (Fidler & West, 2009) nor contribute to a significant difference in abstinence rates when quitting (Clark et al., 2006). Similarly, actual weight gain has been found to be unassociated with failure to quit smoking (Hutter, Moshammer, & Neuberger, 2006), or associated only among participants who did not receive follow-up sessions individually tailored to their needs (Copeland et al., 2006). Thus, cessation-related weight concerns seem to be related to readiness to quit, but they do not seem to affect the likelihood of actually making a quit attempt, the amount of weight gained, or the outcome of smoking cessation.

While many factors are likely to contribute to post-cessation weight gain, increased caloric intake is one mechanism (Klesges et al., 1989; Perkins, 1993; Vander Weg, Klesges, Clemens, Meyers, & Pascale, 2001; Filozof, Fernandez Pinilla, & Fernandez-Cruz, 2004). It has been theorized that, because smokers often describe a craving for a cigarette as a physical gut sensation much like hunger, over time, the sensations that arise from neural pathways associated with hunger are interpreted by smokers as either cigarette craving or hunger based on the situational context or environmental cues (West, 2001). Logically, the physical sensation of hunger is relieved by eating and the physical sensation of an urge to smoke is relieved by smoking. Since the two sensations

appear to be comparable, a cigarette may be able to mitigate the discomfort of hunger pangs and food may be able to reduce cigarette cravings. When an individual is quitting smoking, however, cigarettes are no longer viable for these purposes. This could result in an overreliance on food in response to either situation. Indeed, there is evidence that giving abstaining smokers food or simply glucose can reduce the urge to smoke and satisfy cravings for both food and nicotine (Ogden, 1994; West, 2001). Individuals may also use food to satisfy cravings for cigarettes as part of the tendency to substitute “indulgences” in addictive behavior (Marlatt & Gordon, 1985, p. 63). As it happens, best practice behavioral approaches to smoking cessation treatment give the recommendation of finding substitutes such as candy to use as a replacement for a cigarette in high-risk situations likely to trigger smoking (Brown, 2003).

Obese and overweight individuals may be particularly susceptible to becoming overly reliant on food during smoking cessation. Research on changes in weight showed that, over an eight year period, the weight of overweight and obese continuing smokers remained fairly stable, whereas the weight of overweight and obese individuals who quit smoking during the same period increased, on average, by the equivalent of 22lbs and 43lbs, respectively (Lycett, Munafò, Johnstone, Murphy, & Aveyard, 2011). Likely because those who gain weight while quitting have successfully replaced cigarettes with food, Hall, Ginsberg, & Jones (1986) found that greater initial weight gain during smoking cessation predicted sustained abstinence rather than relapse, with weight gain positively associated with maximum body weight reached in one’s lifetime. In another study, overweight smokers gained more weight than normal weight smokers, which corresponded to better rates of quitting, although this pattern was not observed in the smokers who were obese (Bush et al., 2014b). The above findings suggest that past

vulnerabilities may resurface when the appetite suppressing effects of nicotine are removed in overweight and obese individuals.

Beyond the effects of hunger and satiety on obesity, the neural circuits related to food's rewarding effects also seem likely to contribute to obesity (Volkow, Wang, Fowler, & Telang, 2008; Volkow, Wang, & Baler, 2011). A theorized model characterizing obesity parallels that of drug addiction and implicates four contributing neural circuits: (i) reward–saliency; (ii) motivation–drive; (iii) learning–conditioning; and (iv) inhibitory control/emotional regulation/executive function. These circuits, when disrupted, have the potential to enhance the value of a reinforcer (i.e., high-density food for the obese individual and cigarettes for the nicotine dependent individual) via conditioned learning and resetting of the reward thresholds that occur due to repeated consumption of cigarettes and/or high-density foods (Volkow et al., 2008). Thus, obese individuals may have greater learned associations and conditioned responses to food and food cues, which parallels the response to drugs and drug cues in addicted individuals. Food may be more rewarding and valued, and obese individuals may be less able to inhibit urges to consume highly palatable or appetizing foods much like those addicted to nicotine and other substances experience cravings to use that are difficult to resist.

Using Behavioral Economics to Understand Substitution of Goods

Consuming more calories as a function of consuming fewer cigarettes suggests that eating and smoking may be interchangeable for some individuals. When two commodities are highly interchangeable, behavioral economic (BE) theory refers to them as substitutes (Bickel, DeGrandpre, & Higgins, 1995a). The study of BE integrates economic principles of consumer behavior with psychological theories of judgment and decision making with the goal of understanding how people decide to allocate resources

among available alternatives (MacKillop, Amlung, Murphy, Acker, & Ray, 2013).

Specifically, BE is the “study of the allocation of behavior within a system of constraint” (Bickel, Green, Vuchinich, 1995b, p. 258). These constraints include both constraints on access (e.g., price) to the reinforcer and to concurrently available alternative reinforcers (Bickel, Madden, Petry, 1998).

The type of alternative reinforcers available is important, because reinforcers can interact in various way that affect consumption. When an individual must choose between two alternatives, the cost and value of each alternative is considered. According to BE theory, commodities can be either substitutes, complements, or unrelated (Bickel et al., 1995a). Substitutes are alternative reinforcers that compete with/take the place of the reinforcer (e.g., coffee and tea) whereas complements generally go together/are used in conjunction with the reinforcer (e.g., cookies and milk). Two items (e.g., goods, commodities, reinforcers) are perfect substitutes when they are equally preferred and interchangeable. The relationship between alternative reinforcers is tested by varying the constraints (e.g., price) on access to one of the reinforcers while keeping the constraints on access (e.g., price) to the other reinforcer constant.

Creating a system in which two goods are available and individuals must decide how to allocate resources between them under varying conditions of constraint, allows for a direct measure of the substitutability of the two. Previous work has compared the substitutability of illicit substances by calculating cross-price elasticity (Petry & Bickel, 1998; Petry, 2000). Generally speaking, elasticity of demand measures the extent to which a change in price for a commodity results in an equivalent change in consumption (i.e., reducing purchases for it in equal, greater, or lesser proportion to the increase in price). Cross-price elasticity adds a second reinforcer to the equation in order to assess

how increasing the constraints on access (i.e., raising the cost) for one good will affect demand for another reinforcer. In this context, there are three possibilities: purchases of the second item will increase (i.e., a substitute), decrease (i.e., a complement), or will be unaffected (i.e., independent). For example, if the price of chocolate chip cookies increases sharply, but the price of oatmeal cookies remains unchanged, individuals may be inclined to buy fewer chocolate chip cookies and more oatmeal cookies, substituting the latter for the former. Higher cross-price elasticity, or a small price increase for one good (e.g., raising the price of chocolate cookies by \$.10) producing a notable change in demand for the second good (e.g., buying twice as many oatmeal cookies), is a good indicator that there is equality between alternatives and one can readily be substituted for the other. Notably, cross-price elasticity is not always symmetrical (i.e., proportionately identical) between two commodities. In other words, an increase in the price of oatmeal cookies may have a larger impact on how many chocolate chip cookies are purchased than raising the price of chocolate chip cookies would have on the number of oatmeal cookies purchased.

Within the context of food and cigarettes, an individual may report being able to reduce an urge for a high-density food successfully by smoking a cigarette, but, perhaps, report that eating a piece of cake is not a viable substitute when craving a cigarette. This would reflect asymmetry in that the individual reports cigarettes can substitute for food given constraints (e.g., dieting) but food cannot substitute for cigarettes given constraints (e.g., quitting smoking). Of course, asymmetry in the opposite direction is also possible (i.e., food can be a substitute for cigarettes but cigarettes cannot be a substitute for food).

Given that the nicotine-dependent individual has a strong drive to smoke, difficulty inhibiting urges to smoke, has been conditioned to smoke in response to various cues, and finds smoking very rewarding, it may be that very few viable alternative substitutes exist. However, this may not be the case for overweight or obese smokers. Research has suggested that food is a powerful reinforcer for overweight/obese individuals and the greater the severity of obesity, the more food becomes a substitute for alternative reinforcers (Epstein, Salvy, Carr, Dearing, & Bickel, 2010). Participants in a study of obese smokers indicated that smoking becomes an integral part of eating rituals, as a way to signal to themselves that the meal is over and they are done eating (Bush et al., 2014a). Yet, participants also reported substituting the two commodities: “I know when I don’t eat, I’ll want something to eat, and rather than eat, I say, ‘Ah, I’ll smoke a cigarette’. Now, when I say, ‘I’m not going to smoke, I’m not going to smoke’ then I go to look for something to snack on” (Bush et al., 2014a, pg. 1234). Therefore, for many overweight or obese smokers, who have had longstanding, problematic, patterns of use of both cigarettes and food, it may be the case that both commodities serve as similarly powerful reinforcers, facilitating greater ease of substitution between the two.

Relative reinforcing value (RRV) is also commonly used in BE to understand preference between alternatives. Using this methodology, schedules of reinforcement that use effortful behavior (e.g., button presses) or other forms of response cost are typically employed, with constraint resulting from increasingly larger output of effort required in order to obtain one of the two reinforcers rather than increasing its price (e.g., 20 presses, 40 presses, 60 presses instead of \$2, \$4, \$6). A limited number of research studies have been used RRV in the area of smoking and eating behavior. The findings of these studies suggest that female smokers who are high in dietary restraint

have a greater RRV for snack foods (compared to fruits and vegetables) and a greater RRV for food (compared to money) when they have not recently eaten or smoked (Perkins, Epstein, Fonte, Mitchell, & Grobe, 1995; Goldfield, Epstein, Davidson, & Saad, 2005). The amount of food consumed during an ad libitum consumption period in treatment-seeking smokers was significantly predicted by RRV of snack food (Epstein et al., 2004). Finally, the findings from a study in which participants were willing to work harder to receive preferred snacks and consumed more of these snacks if they had been deprived of nicotine, led the authors to conclude that food and nicotine appear to be substitutable rewards (Spring, Pagoto, McChargue, Hedeker, & Werth, 2003). If the two are substitutable, individuals may eat more when smoking less and/or smoke more when they are eating less (i.e., deprivation of food increases the reinforcing value of cigarettes). The latter is consistent with research showing that obese smokers in a weight loss program had increases in their cotinine levels as they lost weight (Niaura, Raciti, Pera, & Abrams, 1992). Interestingly, substitution of cigarettes for food has also been suggested on a population level, as decreases in cigarette smoking have seemed to correspond with increases in the prevalence of overweight and obesity (Chou, Grossman, & Saffer, 2004; Flegal, Troiano, Pamuk, Kuczmarski, & Campbell, 1995).

Thus, there has been speculation and anecdotal evidence of possible substitution of cigarettes and food, and some research exploring the relationship between food and cigarettes using RRV, but no studies to date have directly examined the substitutability of the two commodities, nor have any studies examined the extent to which substitution varies as a function of adiposity. Ultimately, examination of the substitutability of cigarettes and food may help understand the overconsumption of both commodities and could potentially lead to the development of more comprehensive and effective

interventions. In behavioral treatment of smoking cessation, for example, understanding the extent to which an individual finds smoking and eating similarly reinforcing, coupled with willingness to gain weight, and assessment of potential harm resulting from weight gain may be incredibly useful information to have when deciding whether or not to recommend the use of food as a cigarette substitute. Similarly, in the area of multiple behavioral change for obesity (Epstein et al., 2010), if cigarettes and food are truly substitutable for many individuals, helping an overweight smoker increase engagement with an alternate reinforcer and/or a healthy behavior that is a substitute for both may result in complementary reductions in two unhealthy behaviors simultaneously rather than one. In addition to clinical applications, knowing the substitutability of cigarettes and food could be beneficial on a public policy level as it may allow for better predictions about consequences of food and tobacco taxation policies.

Aims

The goal of the current study was to characterize concurrent preferences for food and cigarettes systematically using cross-price elasticity to quantify substitutability. The study had three primary aims: 1) To examine the cross-price elasticity of cigarettes at escalating food prices (i.e., the substitutability of cigarettes for food). 2) To examine the cross-price elasticity of food at escalating cigarette prices (i.e., the substitutability of food for cigarettes). 3) To determine whether or not there was an asymmetrical substitution effect between the two. In addition to the primary aims, a secondary aim was 4) To evaluate the extent to which substitutability was associated with BMI, nicotine dependence, smoking, and/or other individual difference variables of note in the eating and smoking realm. To that end, the relationships between substitutability, gender,

smoking-related weight concerns, weight efficacy after quitting smoking, and eating behavior were explored.

CHAPTER 2

METHOD

Participants

Participants ($N = 86$) were recruited from the community as part of two concurrent research studies. Advertisements were for a treatment research study using neuroimaging to predict treatment success during smoking cessation (Study #1; $n = 46$) and for a research study of the relationship between cigarette smoking and eating (Study #2; $n = 40$). Study #1 involved a telephone screen, an in-person screen, a functional magnetic resonance imaging (fMRI) assessment, and smoking cessation counseling; the data in the current study pertain to only the in-person screening assessment prior to imaging and treatment sessions. Study #2 involved a telephone screen and an in-person assessment session that paralleled the in-person screening session of Study #1. Inclusion criteria included being 18-65 years old, currently smoking ≥ 5 cigarettes/day, $\geq 8^{\text{th}}$ grade education, and no regular (i.e., weekly or more frequent) use of illicit substances in the past three months. Study #1 had additional criteria of self-reported motivation to quit smoking (i.e., reporting desire to quit ≥ 5 on a scale from 1-10), not having been involved with smoking cessation treatment during the past 90 days, not being treated for mental health issues during the past three months, not having any MRI contraindications (e.g., metal implants, pacemaker), and not having a history of diagnosed neurological disorder (e.g., traumatic brain injury, epilepsy) or another serious medical condition that could affect fMRI results (e.g., endocrine disorders, HIV, heart failure).

Procedures

Eligible participants completed an in-person individual assessment. Upon arrival, study procedures were reviewed in detail with the participants and informed consent was obtained. Information was collected via self-report measures and semi-structured interviews with trained research staff. Participants were compensated for their time (approximately 2-3 hours).

Assessments

Food and Cigarette Substitutability Task (FCST). Substitutability of food and cigarettes was assessed using a two-part, hypothetical purchasing task adapted from the cigarette purchase task (Jacobs & Bickel, 1999; MacKillop et al., 2008) and the food purchasing questionnaire task (Epstein, Dearing, & Roba, 2010). Food and cigarettes were assigned reference prices at 100% of local market value including \$1.00 per food item and \$0.25 per cigarette. In order to equate prices across a variety of foods, the food items selected were all comparably priced offerings (mode = \$1.00; range = \$0.99 to \$1.99) at local fast food restaurant chains. As cigarette and food prices were based on market value, the price of a single food item and a single cigarette were not equivalent; assigning both the same price would result in greater artificiality due to the large discrepancy from market value that would be required for one of the commodities in all price conditions. This would be likely to result in responses that reflected a desire to maximize on a sale or deal (e.g., ability to buy a hamburger for \$.25) rather than true preferences between alternative reinforcers. Food items were selected for the FCST menu (Appendix A) in order to give participants an adequate variety of breakfast (e.g., fruit and maple oatmeal), lunch (e.g., chicken Caesar wrap), dinner (e.g., cheeseburger

deluxe), and snack items (e.g., soft baked chocolate chip cookies) with similar energy densities (mean calories/item = 289) to mimic eating over the course of a day.

The FCST had eight trials in total: four in which the price of cigarettes was held constant while the price of food items increased to 200%, 300%, and 400% of the reference price and four trials in which the price of food was held constant while the price of cigarettes increased by the same percentages. Similar paradigms have been used in the past to examine preference for and/or substitutability of drugs of abuse (Petry & Bickel, 1998) and healthy and unhealthy foods (Epstein et al., 2006). Participants were given the following instructions *“Imagine a typical day during which you are smoking and eating the amounts you usually do. Assume you have a \$16 “tab” to spend but no cigarettes or food for the day. [Participants given \$16 in experimental cash]. Imagine that the foods on this menu are the ones that are available for you to purchase and that the cigarettes available for purchase are your preferred brand (i.e., the brand that you usually smoke). Assume that you have access to water but NO ACCESS to any other foods than those offered on the menu at these prices. Assume you have NO ACCESS to any cigarettes or nicotine products other than those offered at these prices. Therefore, assume you have no snacks or cigarettes stashed away and that you cannot get food or cigarettes through any other source. Also, assume that the cigarettes and food you are about to purchase are for your consumption only. In other words, you can’t sell them or give them to anyone else. You also can’t save or stockpile food or cigarettes for another day. Everything you buy is, therefore, for your own personal consumption within a 24-hr period. I will ask you to indicate the NUMBER OF CIGARETTES AND THE NUMBER OF FOOD ITEMS you would purchase at various prices. Be sure to consider each price increment carefully and respond to the questions honestly.*

Remember, the total amount you spend for your daily food and cigarettes cannot exceed \$16.”

Before beginning the task, the participants completed a modified practice version of the task to ensure understanding. Similarly, before being shown the items on the food menu (Appendix A), they completed a brief questionnaire asking about the recency of smoking and eating (i.e., *“When did you last smoke a cigarette? When did you have your last meal or snack?”*), their current level of cigarette craving and hunger (Food: *“Please rate your current level of hunger using the scale below:”* 0 (not hungry at all) – 10 (extremely hungry); Cigarettes: *“Please circle the number that best describes how you are feeling right now:”* I crave a cigarette right now: 0 (not at all) – 10 (the strongest feeling possible)), and frequency of eating fast food (*“On average, how many days in a typical 30 day period do you consume a meal or snack from a fast food restaurant?”*). They were given a few minutes to familiarize themselves with the menu and were asked to rate how much they liked the menu items (*“Overall, how much do you like the food items on this menu?”* 0 (extreme dislike) – 10 (like extremely), and how appetizing they were (*“Overall, how pleasant or appetizing do you find the food items on this menu?”* 0 (not at all pleasant) – 10 (extremely pleasant), and to identify the food items that they would be most and least interested in purchasing and consuming.

Fagerström Test of Nicotine Dependence (FTND; Heatherton, Kozlowski, Frecker, & Fagerstrom, 1991). The FTND is a 6-item measure of nicotine dependence that evaluates quantity of cigarette consumption, urges to smoke, and level of physical dependence. Scores range from 0-10 with 10 indicating a very high

level of dependence. It has been shown to be both reliable and valid (Pomerleau, Carton, Lutzke, Flessland, & Pomerleau, 1994).

Body Mass Index (BMI). Participants' height and weight were measured and recorded by the research staff. BMI was calculated using the standard formula which divides weight in pounds by height in inches squared and multiplies by a conversion factor of 703 to account for differences from the metric system.

Three Factor Eating Questionnaire (TFEQ-R21; Stunkard & Messick, 1985; Tholin, Rasmussen, Tynelius, & Karlsson, 2005). The TFEQ originally had 51-items which measured three traits underlying eating behavior: cognitive restraint, disinhibition, and hunger. It was later revised to an 18-item (Karlsson, Persson, Sjöström, & Sullivan, 2000) and subsequently a 21-item measure (TFEQ-R21). The TFEQ-R21 has demonstrated a stable factor structure and evidence of construct validity (Tholin et al., 2005). The revised factors included three eating behavior domains: cognitive restraint (i.e., a tendency to consciously restrict and control one's food intake instead of using physiological cues in order to control weight and/or shape), uncontrolled eating (i.e., a tendency to overeat and/or lose control of eating when around food stimuli or feeling hungry) and emotional eating (i.e., tendency to overeat as a way to cope with negative mood states such as loneliness, depression, and anxiety). Items responses are given 1-4 points using Likert-scale responses (e.g., *definitely true* to *definitely false*) with higher scores on each factor reflecting higher levels of the trait.

Smoking-related weight concerns and weight self-efficacy after quitting (Perkins, Conklin, & Levine, 2008). A composite assessment tool consisting of 16 items used in previous research to assess weight concerns related to smoking cessation, including concerns about post-cessation weight gain and self-

efficacy for preventing post-cessation weight gain/weight-efficacy after quitting (WEAQ; Borrelli & Mermelstein, 1998). These domain are scored from 1 (not at all) to 10 (very), with higher scores of weight-concerns reflecting greater levels of concern over post-cessation weight gain and higher levels of weight-efficacy indicating greater confidence in one's ability to control appetite and eating post-cessation. In addition, three questions were administered about anticipated weight gain during a quit attempt, concern over gaining any weight, and concern over gaining 10lbs in the year following smoking cessation both scored from 0 (not at all) to 100 (extremely) (Perkins et al., 2001).

Demographics assessment. Individuals provided self-report data via a questionnaire evaluating standard demographic information such as race, ethnicity, age, and gender.

Data Analysis

Primary analyses. Ecross (i.e., cross-price elasticity) values were calculated as food and cigarette prices rose using the following equation (Allison, 1983; Petry & Bickel, 1998) which quantifies changes in consumption of an unmanipulated commodity as a function of the price of a manipulated commodity:

$$\text{Ecross} = [\log (\text{QA2}) - \log (\text{QA1})] / [\log (\text{PB2}) - \log (\text{PB1})]$$

In the above equation, QA2 = the quantity (Q) consumed of commodity A at the second of two successive prices of commodity B, QA1 = the quantity consumed of commodity A at the first of two successive prices of commodity B, PB2 = the price (P) of commodity B at the second of two successive prices, and PB1 = the price of commodity B at the first of two successive prices. Therefore, when cigarette prices rose, Ecross values reflected the change in food items purchased divided by the change in cigarette price and when food prices rose, Ecross values reflected the change in cigarette purchases divided by the

change in food price. Logs were used so that when price and consumption data were plotted on log-log coordinates, the Ecross value was equivalent to the slope of the line between the two price points. Ecross values of ≥ 0.2 , ≤ -0.2 , and between -0.2 and 0.2 were defined as substitutes, complements, and independents, respectively, reflecting increases, decreases, and no change in the purchases of commodity A as a function of the price of commodity B (Bickel et al., 1995a; Petry, 2001). Slopes ≥ 0.20 detected for Ecross of cigarettes at escalating food prices (EcrossCig) indicate that cigarettes are a substitute for food (Aim #1). Slopes ≥ 0.20 detected for Ecross of food at escalating cigarette prices (EcrossFood) indicate that food is a substitute for cigarettes (Aim #2).

To determine demand for food and cigarettes as prices for these commodities rose, own-price elasticity (Eown) was calculated with the following equation (Allison, 1983; Petry & Bickel, 1998):

$$E_{own} = [\log(QA_2) - \log(QA_1)] / [\log(PA_2) - \log(PA_1)]$$

In this equation, Q is the quantity of reinforcer A (e.g., food) purchased at two different prices for it (P1 and P2). When price and consumption data are plotted on log-log coordinates, the slope between any two adjacent points represents Eown. If the slope is < -1 , demand is said to be elastic, and an increase in price quickly results in a decrease in consumption. Alternatively, if the slope is between -1 and 0 , demand is said to be inelastic, and any decrease in consumption is proportionately smaller than was the increases in price. In other words, if raising the price of cigarettes from \$5.00 to \$7.50 per pack, a 50% price increase, decreases a pack-a-day smoker's cigarette consumption by 10 or more cigarettes (50%+), cigarette demand would be considered elastic (i.e., relatively sensitive to change in price). If consumption does not decrease or changes by a proportionately smaller amount (e.g., a 50% increase in price leads to a 10% decrease in

consumption), demand is considered to be inelastic (i.e., relatively insensitive to price changes).

Elasticities were calculated for each successive increase in cigarette or food price. Thus, three cross-price elasticities for cigarettes were calculated as food prices increased in \$1 increments from \$1 to \$4 (EcrossCig) and three cross-price elasticities for food were calculated as cigarette prices increased in \$0.25 increments from \$0.25 to \$1 (EcrossFood). The slopes of the best-fitting lines reflecting consumption over all four cigarette or food prices were also determined as a measure of overall cross-price or own-price elasticity of demand. Analyses were conducted for each participant so that all participants had their own, individual-level, measure of cross-price elasticity for food and for cigarettes. When calculating slopes for individual participants, a value of 0.3 was added to all purchases so that data points of 0 could be included in analyses (DeGrandpre et al., 1993; Petry, 2000). Analyses were repeated utilizing other units (e.g. 0.01) with similar results obtained. In addition to individual-level data, the mean number of cigarettes and food items purchased at each price was used to calculate the slopes of the best-fitting lines which reflected trends in cross-price elasticities for the sample as a whole.

Repeated measures ANOVAs were conducted to measure whether changes in purchases of the commodities were statistically significant across price conditions. Significant results of repeated measures ANOVAs were followed with post hoc tests to compare differences between means at the various prices. The extent to which substitution of the two commodities was symmetrical or asymmetrical (Aim #3) was determined by comparing the slopes of the overall best-fitting cross-price elasticity of demand lines for mean number of cigarettes purchased over increasing food prices and

mean number of food items purchased over increasing cigarette prices. Symmetry was indicated if the slopes of both lines were ≥ 0.20 (similarly substitutable), if the slopes of both lines were ≤ 0.20 (similarly complementary), or if the slopes of both lines were between -0.2 and 0.2 (both independent of one another). Asymmetry was indicated if none of the above conditions were met, reflecting different relationships between the commodities as a function of which reinforcer price was manipulated. Finally, the degree to which individual difference variables were related to substitutability (Aim #4) was explored using Pearson's r for all variables except gender, for which Spearman's rho was calculated.

CHAPTER 3

RESULTS

Participant Characteristics

Participant characteristics are displayed in Table 1. Participants in sample #1 differed from those in sample #2 in that they were slightly older $t(84) = -2.35, p = .03$, smoked more cigarettes per day $t(83) = -3.07, p < .01$, and reported having commensurately higher levels of nicotine dependence $t(83) = -2.24, p = .03$. Participants, on average, were overweight and smoked approximately a pack of cigarettes a day. Mean FTND scores suggested a low to moderate level of nicotine dependence.

Preliminary Analyses

Distributional properties of participant characteristic and cross-price elasticity variables were examined for assumptions of normality. Outliers defined as $Z > 3.29$ were Winsorized to one unit above the next highest value. Four participants indicated that they did not typically eat fast food monthly and were considered for possible exclusion due to the nature of the items displayed on the FCST menu. Of these four participants, all reported finding the items on the FCST menu somewhat appetizing and liking the items depicted. Accordingly, all participants were retained in analyses.

On average, participants reported liking the items on the food menu ($M = 6.19, SD = 2.54$), finding the menu items pleasant or appetizing ($M = 6.38, SD = 2.63$), and consuming meals or snack from fast food restaurant on 7.92 days ($SD = 6.96$) in a typical month. There was no relationship between participants' overall cross-price

elasticities for either commodity and how frequently they consumed fast food ($r_s = -.13-.09$, $p_s = ns$), how much they liked the types of food listed on the menu ($r_s = -.12-.13$, $p_s = ns$), or how pleasant or appetizing the items were perceived to be ($r_s = -.06-.17$, $p_s = ns$). Similarly, participants' overall cross-price elasticities for food and cigarettes were neither associated with state levels of hunger ($r_s = -.01-.15$, $p_s = ns$), nor cigarette craving ($r_s = -.07-.14$, $p_s = ns$).

Behavioral Economic Analysis of Cigarette-Food Substitutability

The left panel of Figure 1 shows food and cigarette purchases as a function of cigarette price. A repeated measures ANOVA with a Huynh-Feldt correction adjusting degrees of freedom given violation of sphericity assumptions, determined that cigarette purchases differed significantly across the four cigarette price conditions, $F(1.48, 126.04) = 127.28$, $p < .01$. Post hoc tests using the Bonferroni correction revealed that the \$.50, \$.75, and \$1 conditions differed significantly from the \$.25 reference price condition ($p_s < .01$). The average number of cigarettes purchased at the reference price (23.99 ± 12.11) was reduced by the 200% (15.87 ± 6.13), 300% (11.33 ± 5.75), and 400% (8.56 ± 4.21) price increases.

Analyses conducted for individual participants based on own-price elasticity of demand for cigarettes calculated at adjacent price points, showed that 71% of participants demonstrated elastic demand at one or more of the three cigarette price increases. Overall, however, when examining the slopes of the best-fitting lines created for each participant, only 21% of participants had price elastic demand for cigarettes across the four cigarette price conditions. Individual participant data are shown in Appendix B.

Table 2 shows own-price elasticity of demand for cigarettes based on mean units purchased in the sample. At all three cigarette price increases, demand for cigarettes was inelastic with increases in price associated with proportionately small changes in cigarette purchases. Similarly, the slope of the best-fitting line was less than -1 (Table 2), suggesting predominantly inelastic demand based on cigarette price. Demand became increasingly more elastic as cigarette prices rose.

Rising cigarette prices influenced the purchase of food items as well. The left panel of Figure 1 shows the number of food items purchased at each cigarette price. On average, as cigarette prices rose, food purchases decreased, $F(2.04, 122.21) = 11.27, p < .01$. Post hoc tests using the Bonferroni correction revealed that the number of food items purchased in the \$.50, \$.75, and \$1 cigarette price conditions differed significantly from the number purchased in the \$.25 reference price condition ($ps \leq .01$). The average number of food items purchased was reduced from 7.24 ($SD = 3.28$) to 6.41 ($SD = 2.70$) when the price of cigarettes increased from \$.25 to \$.50, and reduced further to 5.68 ($SD = 3.37$) when the price increased to \$.75 per cigarette. When the price of cigarettes increased to \$1, there was a slight increase in the average number of food items purchased (5.86 ± 3.49).

Forty-three participants (50%) substituted food for cigarettes at one of the three cigarette price increases based on cross-price elasticities calculated for each participant at successive prices. The number of participants whose E_{cross} value suggested substitution at each price increase is shown in Table 2. The number of participants substituting food for cigarettes increased as cigarette prices escalated, with nearly a third of participants substituting food for cigarettes when cigarette price rose to \$1.

When considering cross-price elasticities for the sample determined by mean number of food items purchased at each cigarette price (Table 2), the relationship between cigarette price and food purchases was categorized as marginally complementary at one of the prices increases and considered independent in the other two. At the final price increase to \$1 per cigarette, the positive cross-price elasticity coefficient (Table 2) reflects a tendency to consume more food items when the cost of cigarettes has gotten very high. The slope of the best-fitting line based on mean food items purchased (Table 2) suggests that the number of food items purchased was predominantly independent from cigarette price.

The right panel of Figure 1 shows food and cigarette purchases as a function of food price. A repeated measures ANOVA with a Huynh-Feldt correction determined that food purchases differed significantly across the four food price conditions, $F(1.40, 119.23) = 177.52, p < .01$. Post hoc tests using the Bonferroni correction revealed that the \$2, \$3, and \$4 food conditions differed significantly from the \$1 condition with regard to number of food items purchased ($ps < .01$). The number of food items purchased at the \$1 reference price (6.93 ± 3.02) was reduced by the 200% (4.35 ± 1.48), 300% (3.24 ± 1.04), and 400% (2.58 ± 0.93) price increases.

Analyses conducted for individual participants' purchases at adjacent price points indicated that 66% of participants demonstrated elastic demand for food at one or more of the three price increases. Nevertheless, overall, slopes based on the best-fitting line for each participant's responses suggested that only 6% of participants showed price elastic demand for food across the four price conditions. Individual participant data are shown in Appendix B.

Table 2 shows own-price elasticity of demand for food based on mean number of items purchased. At all three price increases, demand for food was inelastic with increases in price associated with proportionately small changes in number of food items purchases. The slope of the best-fitting line was less than 1 (Table 2), suggesting predominantly inelastic demand based on food price. Although own-price elasticity of demand for food appeared to increase somewhat as food price increased, it was remarkably consistent across all levels of food price increases (Table 2).

Examination of cross-price elasticity for cigarette purchases as food price increased suggested that, on average, as food prices rose, cigarette purchases decreased, $F(2.55, 208.95) = 26.01, p < .01$. Post hoc tests using the Bonferroni correction revealed that the \$2, \$3, and \$4 food price conditions differed significantly from the \$1 reference price condition ($ps \leq .04$). The average number of cigarettes purchased was reduced from 24.43 ($SD = 11.18$) to 21.87 ($SD = 2.70$) when the price of food increased from \$1 to \$2. The number of cigarettes purchased was reduced further to 19.38 ($SD = 10.61$) and 17.12 ($SD = 12.37$) at the \$3 and \$4 prices, respectively.

Cross-price elasticities for individual participants' purchases at adjacent price points indicated that 31% of the participants substituted cigarettes for food at one of the three food price increases. The number of participants whose E_{cross} value suggested substitution at each price increase is shown in Table 2. The number of participants substituting food for cigarettes remained fairly consistent with only 10-16% of participants making a substitution at any given food price increase.

When considering cross-price elasticity based on mean number of cigarettes purchased at the four food prices, the relationships varied somewhat across price conditions. At low food prices, the relationship between food price and cigarette

consumption was found to be independent (Table 2). However, at the subsequent price increases, cigarettes were found to be a complement to food items, with the number of cigarettes purchased decreasing along with the number of food items purchased. The slope of the best-fitting line determined by mean number of cigarettes purchased at each price, suggested that cigarettes were a complement to food rather than a substitute for it (Table 2).

Overall, the price of cigarettes significantly affected the purchase of food and the price of food significantly affected the purchase of cigarettes. As price of food increased, both cigarette and food purchases decreased significantly. Cigarettes were a complement to food, with the overall number of cigarettes purchases decreasing by 7.31 cigarettes over the course of three food price increases and an overall E_{cross} value of -0.25. In contrast, as the price of cigarettes rose, food purchases decreased only slightly, by 1.08 food items, over the course of three cigarette price increases. The overall E_{cross} value of -0.14 indicated that, as cigarette prices increased, food purchases were independent rather than substitutes or complements. Thus, there was an asymmetrical effect detected between cigarettes and food with cigarettes serving as a complement to food, but food not being a complement to cigarettes. In other words, among cigarette smokers, cigarette consumption may decrease as food becomes more expensive, but food consumption is not likely to vary considerably as the price for cigarettes increases.

Associations with Body Mass Index and Collateral Variables

Associations between BMI, nicotine dependence, cigarettes/day, and cross-price elasticity of demand at the three cigarette and food price increases are shown in Table 3. BMI was not associated with cross-price elasticity at any price increase for cigarettes or food, nor was it associated with the overall slopes of the best-fitting E_{cross} lines (Table

3). Although level of nicotine dependence and number of cigarettes smoked daily were not associated with the slopes of the best-fitting lines depicting cross-price elasticity for cigarettes and food (Table 3), there were significant associations at specific price increases. Cross-price elasticities at the \$1 to \$2 and \$2 to \$3 food price increases were associated with number of cigarettes smoked per day. Individuals who reported smoking more cigarettes per day were more likely to have lower E_{cross} values when the price of food increased from \$1 to \$2, suggesting a greater degree of decreasing their cigarette purchases as food prices rose. Subsequently, when the price increased to \$3 per food item, those who smoked fewer cigarettes per day were more likely to have lower E_{cross} values. Level of nicotine dependence was also associated with cross-price elasticity. When the price of a cigarette increased from \$.50 to \$.75, level of nicotine dependence was negatively associated with cross-price elasticity. Participants who had higher levels of nicotine dependence had less positive E_{cross} slopes (i.e., less likely to increase the number of food items purchased as the price of cigarettes rose to \$.75 each). All remaining cross-price elasticities were unassociated with number of cigarettes smoked and level of nicotine dependence. There was a large association between daily cigarette smoking and nicotine dependence (Table 3). Neither smoking variable was significantly associated with BMI.

Finally, collateral variables of interest were explored, including gender, smoking-related weight concerns, weight efficacy after quitting smoking, and eating behavior (Table 4). BMI, number of cigarettes smoked per day, and nicotine dependence were significantly associated with cognitive restraint and emotional eating. Individuals with higher BMIs reported a greater tendency to make conscious efforts to try to restrict their food intake and a greater tendency to eat to cope with negative mood states such as

loneliness and anxiety. Similarly, women were more likely to endorse these tendencies. Individuals who were more dependent on cigarettes and smoked a greater number of cigarettes per day reported less of a tendency to consciously limit their food intake in order to control their weight, but a greater tendency to eat to cope with unpleasant emotions, and a greater tendency for uncontrolled eating such as binge eating, experiencing seemingly insatiable hunger, and difficulty stopping oneself from eating when tempted. Of the three eating factors, only cognitive restraint, such as deliberately limiting portions, restricting the types of foods consumed, and avoiding stockpiling of tempting foods, was associated with cross-price elasticity of demand for food. Participants who reported a greater tendency to consciously refrain from eating certain foods had higher cross-price elasticity values when cigarette prices increased. Specifically, those reporting higher levels of cognitive restraint were more likely to substitute food for cigarettes as the cost of cigarettes increased (Table 4).

BMI was significantly associated with smoking-related weight concerns. Individuals with greater BMIs were the most likely to endorse using cigarettes to control their weight and/or to be concerned about gaining weight as a result of quitting. BMI was unassociated with confidence in one's abilities to quit smoking without eating high-calorie foods and/or gaining weight. Individuals who reported more uncontrollable or more emotional eating habits had significantly less confidence in their ability to quit smoking without becoming overly reliant on food, and reported a greater likelihood of resuming smoking if they gained too much weight after quitting smoking. Those who reported having the lowest confidence in their ability to manage their weight and appetite without cigarettes were the individuals who smoked the most heavily and were the most dependent on nicotine. Finally, weight self-efficacy after quitting smoking was

significantly associated with cross-price elasticities for both cigarettes and food (Table 4). Specifically, individuals who reported greater confidence in their ability to quit smoking without gaining weight and/or eating more than usual had higher E_{cross} values for food (i.e., more likely to increase food purchases as the cost of smoking rose) and lower E_{cross} values for cigarettes (i.e., less likely to increase cigarette purchases as the cost of food rose).

CHAPTER 4

DISCUSSION

The goal of the current study was to explore the cross-price elasticity of demand for cigarettes and food in order to determine the extent to which the two goods were substitutable for each other in a sample of regular cigarette smokers. In addition, a secondary goal was to understand the extent to which these relationships varied based on individual difference variables such as BMI, nicotine dependence, gender, concern about post-cessation weight gain, confidence in one's ability to prevent weight gain after quitting smoking, and traits underlying eating behavior.

Own-Price and Cross-Price Elasticity of Demand

The results of the study showed own-price elasticity of demand was inelastic for both food and cigarettes. Demand for necessities such as food and water are generally inelastic, or, in other words, a change in price is unlikely to result in a notable change in the quantity demanded because the commodity is essential. Elastic demand occurs when a price increase is able to cause a notable decrease in consumption and is observed more typically for non-essential items and luxuries. Many reinforcers display mixed elasticity on a demand curve where demand is inelastic (i.e., insensitive to price) at lower prices and becomes more elastic (i.e., sensitive to price) at higher prices (Bickel, Marsch, & Carroll, 2000). In the current study, demand for cigarettes tended to be more inelastic (slope > -1) at lower cigarette prices and became increasingly elastic at higher prices, consistent with previous BE research of cigarette purchase tasks (MacKillop et al., 2012) and drug substitutability (Petry & Bickel, 1998). Indeed, at the final cigarette

price increase, there was a nearly perfectly proportionate 32% decrease in consumption following a 33% increase in price. Overall, tobacco demand was found to be inelastic in this study. Estimates of elasticity of demand for tobacco in the United States suggest inelasticity with a 10% cigarette price increase resulting in only a 2.5-5% decrease in smoking (Chaloupka, Hu, Warner, Jacobs, & Yurekli, 2000). The largely inelastic nature of both cigarette and food demand suggests persistence in purchasing both commodities despite escalating costs.

Substitution of Food for Cigarettes

Because participants continued to buy cigarettes as they became increasingly more expensive, they were left with less money with which to buy food. The number of food items purchased as smoking became more expensive differed significantly from the number purchased when cigarettes cost the reference price of \$.25 each. Despite statistically significant differences, food was not determined to be a complement nor a substitute for cigarettes, overall. Participants, on average, purchased approximately six food items during the task across cigarette price conditions. On average, there were slight decreases in the number of food items purchased during the first two cigarette price increases, but following the third price increase, there was a slight increase in the number of food items purchased. It is likely that the change in the left-most digit of the cigarette price (from \$0.75 to \$1.00) may have resulted in the greater decrease in cigarette consumption relative to price increase observed, given that previous work on cigarette demand has suggested that the left-most digit of cigarette price may wield disproportionate influence on cigarette purchasing behavior (MacKillop et al., 2012). As such, the increase in food purchases seen at the \$1 cigarette price may represent a cross-over point at which a preference for food rather than cigarettes begins to emerge, in

part, due to left-digit effects, and due to demand for cigarettes shifting from inelastic to elastic. Nonetheless, since there were no further price increases on the FCST, it is impossible to determine the extent to which this initial shift towards substitution would have persisted and resulted in increasingly more food purchases at subsequent cigarette price increases and eventual substitution.

Another, related, possibility for the lack of substitution of food for cigarettes observed in the present study, is that individuals will not substitute food for cigarettes until they have reached a their breakpoint (i.e., the point at which cigarette purchases are reduced to zero). It is possible that as individuals decide that the cost of smoking is too great to purchase even one cigarette, they would elect to buy additional food items instead. Past research on substitutability has demonstrated that reducing heroin purchases to zero, as the result of the price of a bag of heroin exceeding available experimental income, increased the purchases of available alternative drugs (Petry & Bickel, 1998). As the current study did not force consumption of cigarettes to zero by design, the majority of participants did not reach their breakpoints and they continued to purchase cigarettes even when priced at \$1/each. Of the five participants who reached their individual breakpoints for smoking, 60% increased their food purchases once they were no longer buying cigarettes, while the remainder did not. It is possible that the tendency for substitution may reflect a breakpoint-specific phenomenon, but equally possible that many individuals would report purchasing approximately the same number of food items even after they have decided to forgo smoking. Due to the small proportion of individuals whose consumption was suppressed to zero, it is not possible to draw any conclusions at this time and further research is needed to explore whether

higher cigarette prices, and cigarette prices surrounding one's breakpoint would result in increased food purchased.

Substitution of Cigarettes for Food

Overall, participants did not increase their cigarette smoking as food became more expensive. There was a statistically significant decrease in cigarette purchases as food prices rose. Overall, cigarette consumption fell by more than 40% as food prices increased. The majority of participants continued to buy menu items despite high costs and the increased cost of food suppressed consumption to zero for only one participant. The rising food price decreased cigarette consumption in a complementary fashion. Interestingly, rather than increasing their smoking as an alternative to eating or to curb their appetite, participants decreased their cigarette purchases considerably. In fact, at the final price of \$4/menu item, 14 participants elected to spend their entire tab on food with the consequence of cigarette consumption being reduced to zero. This is thought-provoking because, although demand for both cigarettes and food was largely inelastic, it suggests that over a 24-hour period, in which there are limited resources to allocate to food and cigarettes, smokers may be more inclined to satisfy their hunger and food cravings rather than their cravings for cigarettes. Results of past experimental research suggested that individuals who were deprived of both nicotine and food for many hours were more likely to smoke during a self-administration period in a laboratory than were individuals who had been deprived of nicotine alone (Leeman, O'Malley, White, & McKee, 2010). In this study, participants were given the choice to smoke or to receive monetary reinforcement rather than the choice to smoke or eat. In another study involving overnight abstinence from food and smoking or from food alone, participants were given the choice of working to earn food or monetary reinforcers rather than food

or cigarettes alternatives (Perkins et al., 1995). To our knowledge, no study has used a laboratory paradigm in which participants must choose between smoking and eating directly. Therefore, it is unknown the extent to which state dependent variables in acute tobacco withdrawal or food deprivation would change these preferences. In the present study, self-reported hunger and cigarette craving were not associated with performance on the FCST.

Moderating Variables and Cigarette-Food Substitutability

The possibility of substitutability being affected by secondary variables and the interrelationships among these variables was explored including associations with weight/eating variables (i.e., BMI, restrained eating, emotional eating, and uncontrolled eating), smoking variables (i.e., cigarettes smoked daily and nicotine dependence), smoking cessation-related weight gain variables (i.e., concerns about post-cessation weight gain and self-efficacy for preventing post-cessation weight gain), and a demographic variable (i.e., gender).

Weight/eating variables. Contrary to prediction, BMI was not significantly associated with cross-price elasticities. Overweight and obese individuals' performance on the FCST did not differ significantly from that of normal weight individuals. Although research has indicated that overweight and obese smokers gain much more weight than average upon quitting smoking (Lycett, Munafò, Johnstone, Murphy, & Aveyard, 2011), results of the current study do not support the substitution of food for cigarettes as contributing to this weight gain. Instead, it may be that a cluster of unhealthy behaviors and problematic traits are exacerbated by the quitting process such as emotional eating. Research has suggested that BMI is positively correlated with cognitive restraint and emotional eating mostly due to common underlying genetic

factors (Keskitalo et al., 2008) and the association between emotional eating and liking of sweet and fatty foods is also heavily based on heritability. Thus, some individuals may be more liable to experience cravings for sweet foods during periods of emotional stress, such as quitting smoking, due to genetic influences. In turn, this may contribute to increased consumption of sucrose and calories after quitting smoking (Hall, McGee, Tunstall, Duffy, & Benowitz, 1989). Although BMI is often associated with smoking more cigarettes per day, other research has also indicated that level of adiposity was not related to baseline cigarette smoking or nicotine dependence (Pomerleau & Saules, 2007). Additionally, it is possible that exclusion criteria in Study #1 related to serious medical conditions may have resulted in a somewhat healthier, and potentially less typical sample of obese and overweight smokers, which may have contributed to lack of associations with BMI found herein.

Individuals with higher BMIs reported a greater level of concern about post-cessation weight gain including endorsing a greater likelihood of going back to smoking after quitting if they gained too much weight, as has been reported previously (Pomerleau & Sales, 2007; Levine, Bush, Magnusson, Cheng, & Chen, 2013).

Given that the excess weight gain typically experienced by overweight and obese smokers can reduce the health benefits gained from smoking cessation (Chinn et al., 2005), strategies to assist this population are crucial. Surprisingly, despite heavier individuals reporting more problematic eating behavior and concern about managing weight without cigarettes, there was no association between BMI and weight self-efficacy after quitting. Since it appears that many overweight and obese individuals do, in fact, have greater difficulty managing their weight after quitting smoking, helping keep confidence high and working with individuals to combat weight gain directly is

likely to be beneficial. Augmentation of smoking cessation treatment with combined pharmacotherapy such as naltrexone plus bupropion shown to have some promising effects on weight loss in the overweight and obese (Greenway et al., 2010) and to decrease nicotine use without significant weight gain during smoking cessation in overweight and obese individuals (Wilcox et al., 2010) may be beneficial. More research is needed, including RCTs, to determine short-term and long-term effects on both smoking and weight in overweight and obese smokers with and without weight concerns.

Smoking variables. Although the slopes of the best-fitting lines showing cross-price elasticity were not associated with baseline number of cigarette smoked daily, associations were found at two different food price increases. Those smoking a greater number of cigarettes per day were apt to reduce their smoking more considerably than those smoking fewer cigarettes per day, on average, when the cost of food increased from \$1 to \$2. Individuals who smoked fewer cigarettes per day may not have yet been significantly constrained at the \$2 food price. Therefore, it is possible they were still able to purchase their desired number of cigarettes and food items despite the rising cost of food. For example, when food items were \$2 each, someone who smokes 8 cigarettes daily could purchase 7 food items while still having enough cash left to buy 8 cigarettes, and no reason to change their smoking in any way. If a heavier smoker wanted to buy an identical number of food items, however, he would no longer be able to afford his desired number of cigarettes. Thus, he would be forced to reduce the number of cigarettes he purchased. This pattern (i.e., heavier smokers forced to make a larger change in their smoking than lighter smokers) occurring repeatedly would result in the observed significant association between cigarettes/day and cross-price elasticity of food

as price increased from \$1 to \$2 per food item. By contrast, when the price of food increased the second time, those who smoked fewer cigarettes per day may have been faced with a level of constraint comparable to that experienced by the heavier smokers at the previous price, forcing them then to decrease their smoking more considerably than was required at the previous food price. In other words, when food prices rose from \$2 to \$3, even if the 8 cigarette/day smoker reduced his food purchases from 7 down to 5, due to his inelastic demand for food and the constraint of limited income, he would now be forced to reduce the number of cigarettes he purchased. Thus, it appears that the first food price increase was more likely to impact those who smoked more cigarettes and the second price increase had a greater impact on lighter smokers who may not have modified their smoking when the price of food increased to \$2.

Despite the slope of the best-fitting lines showing cross-price elasticity being unassociated with nicotine dependence overall, there was an association between nicotine dependence and cross-price elasticity at a specific price increase. Those who were more dependent on nicotine had lower E_{cross} values as the price of cigarettes rose to \$.75 each. In other words, as the price of cigarettes increased to \$.75/cigarette (\$15/pack), those who were more dependent on cigarettes had a greater decrease in food purchases than did those who were less dependent on nicotine. Consequently, it appears that those more addicted to nicotine were likely defending some minimal level of tobacco consumption due to their greater dependence. Continuing to buy cigarettes despite high costs resulted in less money with which to buy food, causing a greater decline in food purchases.

Smoking cessation-related weight gain variables. Weight efficacy after quitting (WEAQ) smoking was associated with a multitude of other study variables

including smoking and nicotine dependence, traits underlying eating behavior, and overall cross-price elasticity of demand for both cigarettes and food. First, it is notable that those who tended to smoke more cigarettes and who were more dependent on nicotine had lower scores of WEAQ, although they did not report being more concerned about weight gain per se. One possibility for this, is that those who are more dependent on cigarettes have greater difficulty quitting smoking, and are more likely to believe that they will need to use food as crutch to do so. As a result, they are not very confident they could quit smoking without eating more and gaining weight. Lower WEAQ was also associated with uncontrolled and emotional eating habits. Accordingly, people who tends to find it difficult to control their eating and who use food as a way to cope with negative emotions, may be acutely aware of the difficulties they would face in avoiding high-calorie foods and trying to control their appetite without cigarettes. When considered together, those who have higher levels of emotional eating may have learned to use cigarettes as an alternative to eating to manage negative emotions; those with higher levels of uncontrolled eating may have learned to use cigarettes to suppress their appetite or prolong satiety. This would be expected to increase smoking and nicotine dependence over time, and, once smoking was discontinued, make it much more challenging to quit smoking without a spike in one's eating and weight. The positive associations between emotional and uncontrolled eating habits and smoking behavior, along with the fact that all of these variables were negatively associated WEAQ, all support this explanation. Another possibility is that heavier smokers who are more dependent on nicotine have greater insight into the likelihood of gaining weight after quitting, possibly due to knowledge of others within their social network who

experienced smoking-cessation related weight gain and/or as a result of their own past attempts to quit smoking.

WEAQ was also shown to be associated with elasticity on the FCST. As cigarette prices increased during the task, those who were more confident in their ability to control their weight without cigarettes showed more elastic own-price elasticity of demand for cigarettes (i.e., had a steeper decline in cigarette smoking relative to price) than those who were less confident in their ability to control their weight after quitting smoking. Those with higher WEAQ also had higher cross-price elasticity of demand as cigarette prices rose (e.g., more likely to substitute food) compared to those with lower WEAQ. Naturally, if individuals feel confident that they will be able to manage their weight, there may be little to no barrier to substituting food when the cost of smoking becomes too great. In contrast, individuals with less confidence in their ability to manage their weight without cigarettes may be hesitant to substitute food, for fear of weight gain. Finally, individuals with less confidence in their ability to effectively manage their weight, appetite, and eating without cigarettes, were more likely to increase their cigarette purchases as the cost of food rose during the FCST. Logically, if individuals are not confident that they could control their appetites or eating without cigarettes, and faced with a situation in which highly appetizing foods are available, more cigarettes would be needed in order to do so.

Interrelationships among collateral variables of interest. Associations between relevant smoking, eating, and weight variables also revealed several statistically significant relationships. First, female gender was associated with a higher BMI, more emotional eating, and more dietary cognitive restraint than was male gender. Baseline FTND scores and cigarettes/day were associated with all three problematic eating

tendencies. Uncontrolled eating traits are heavily based on hunger including feeling hungry enough to eat at any time, experiencing hunger nearly constantly, and feeling so hungry that the stomach feels like a bottomless pit. Since hunger may increase urges to smoke in smokers, it is not surprising that those with uncontrolled eating traits are heavier smokers (Cheskin, Hess, Henningfield, & Gorelick, 2005). Similarly, laboratory studies have shown increased urges to smoke and decreased ability to resist smoking during periods of food restriction (Cheskin et al., 2005, Leeman, O'Malley, White, & McKee, 2010). Therefore, it may be those with high-levels of cognitive restraint who are making conscious efforts to restrict their food consumption by eating less than they would like or avoiding certain foods, smoke more cigarettes as a result. Despite the seemingly good intentions of individuals high in dietary restraint to try to limit their food intake, research has paradoxically suggested that restrained eaters do not actually consume less energy than unrestrained eaters (Stice, Sysko, Roberto, & Allison, 2010). Likely because efforts to restrict caloric intake are difficult to maintain in the long-term, many restrained eaters unexpectedly gain weight. In the present study, the tendency for those higher in cognitive restraint to be more likely to substitute food for cigarettes may be, in part, due to this phenomenon. Finally, the association between higher rates of smoking and dependence and emotional eating is likely the manifestation of individuals tending to use both food and cigarettes due to affectively-charged motivation influencing behaviors such as eating calorie-dense foods or smoking as a way to produce immediate positive shifts in affect (for review see Williams and Evans, 2014).

Theoretical and Public Policy Implications

The lack of substitution observed in the current study was somewhat surprising given the well-establish phenomenon of post-cessation weight gain (Klesges et al.,

1989). It may be that the hypothetical nature of task and its completion in a pre-cessation context resulted in responses that differed from actual behavior, which should be considered a limitation of the current study. Similarly, it may have been difficult for individuals to speculate about their behavior due to the artificiality of various aspects of the FCST such as the need to purchase all meals from a limited menu of food options and the ability to purchase cigarettes individually rather than by the pack. Another possibility for the lack of substitution observed, is that the tendency for increased food consumption while quitting smoking is predominantly a function of other factors that motivate the acquisition and consumption of substances (e.g., craving, emotion) and that may be more influential on behavior during smoking cessation than are BE factors. Finally, the lack of substitution of cigarettes for food may have been influenced by motivation to quit smoking, as motivation to quit was part of study inclusion criteria for more than half of the sample. As this study was the first to directly assess cross-price elasticities of food and cigarettes, testing the reliability of these findings in other populations of smokers (e.g., adolescent, smokers with mental illnesses or substance use disorders) and assessing the extent to which hypothetical and actual performance are associated are important next steps.

The finding that cigarettes tended to be a complement to food may be an important discovery given the relative harm caused by both smoking and poor diet. Research has suggested that poor diet and physical inactivity may soon overtake tobacco as the leading cause of preventable death in the United States (Mokdad et al., 2004). As a result, there has been a call to use methods shown to be beneficial in reducing smoking in the United States, such as taxation, to reduce escalating rates of national overweight and obesity (Garson & Engelhard, 2007). The rationale for taxation on soft drinks, snack

foods, and/or fast food is based on a variety of factors including the economic costs of obesity to society, evidence linking the consumption of these foods to the obesity epidemic, and studies on price elasticity of snack foods suggesting the tax could raise a considerable amount of funds for obesity prevention programs (Kim & Kawachi, 2006). Nonetheless, the possibility that “the direct health benefits from reduced consumption of junk foods though taxes might be offset by the substitution of these foods with... harmful non–dietary health behaviors, such as smoking” has also been suggested (Kim & Kawachi, 2006, pg. 434). The current study did not support this potential consequence. In fact, there was a 42% decrease in cigarette consumption reported, on average, when comparing the number of cigarettes purchases when food was \$1 to when it was \$4, despite the price of cigarettes remaining constant. Interestingly, more participants discontinued smoking completely when food was priced at \$4/item than when cigarettes cost \$1/each, 14 vs. 5, respectively. Thus, while additional research on the economic feasibility and cost-to-benefit ratio of potential of taxation policy on unhealthy foods is needed before implementation, the results of the present study suggest that such a tax may result in additional benefits that extend beyond the impact on consumption of unhealthy foods, and have the potential to reduce other unhealthy behaviors such as cigarette smoking as well.

Table 1

Baseline Participant Characteristics: mean (SD) or percentage

	Full sample	Sample #1	Sample #2
<i>N</i>	86	46	40
Male	62%	59%	65%
Race			
White/Caucasian	62%	63%	60%
Black/African American	33%	37%	28%
Asian/Pacific Islander	1%	0%	3%
Multi-racial	2%	0%	5%
Other race	2%	0%	5%
Annual household income			
\$0-\$14,999	50%	46%	55%
\$15,000-\$29,999	29%	33%	24%
\$30,000-\$44,999	11%	11%	11%
\$45,000 +	11%	11%	11%
Age	39.2 (12.2)	41.9 (10.8)	36.1 (13.1)*
Years education	13.0 (2.1)	13.3 (2.2)	12.7 (2.0)
Cigarettes/day	18.0 (9.3)	20.8 (9.0)	14.9 (8.7)*
FTND	4.8 (2.5)	5.4 (2.5)	4.2 (2.4)*
Body Mass Index	27.6 (6.7)	26.8 (6.3)	28.4 (7.1)
Underweight (BMI < 18.5)	1%	0%	3%
Normal weight (BMI 18.5–24.9)	48%	54%	40%
Overweight (BMI 25.0–29.9)	20%	22%	18%
Obese (BMI ≥ 30)	31%	24%	40%

Note. FTND = Fagerström Test of Nicotine Dependence total score; combined percentages differ from 100% in some instances as a result of rounding; * means differed significantly by sample.

Table 2

Own-price elasticity coefficient & cross-price elasticity coefficients for mean units purchased as price increases and number of substitutions

Food Price	Cigarette Price	Own-price elasticity	Cross-price elasticity	# substitutions
\$1.00	\$0.25			
\$2.00	\$0.25	-0.67	-0.16	11
\$3.00	\$0.25	-0.72	-0.30	9
\$4.00	\$0.25	-0.79	-0.43	14
Slope of the best-fitting line		-0.71	-0.25	
\$1.00	\$0.25			
\$1.00	\$0.50	-0.60	-0.15	9
\$1.00	\$0.75	-0.83	-0.23	16
\$1.00	\$1.00	-0.97	0.10	27
Slope of the best-fitting line		-0.73	-0.14	

Table 3

Correlations between BMI, smoking indices, and cross-price elasticity of demand for cigarettes and food

	BMI	Cigarettes/Day	FTND
Ecross Cigarettes – BFL	.04	-.12	-.07
Ecross Food – BFL	.04	.10	.04
Ecross Cigarettes \$.25 to \$.50	.19	-.04	.12
Ecross Cigarettes \$.50 to \$.75	-.04	-.07	-.22
Ecross Cigarettes \$.75 to \$1.00	-.10	-.03	.14
Ecross Food \$1 to \$2	-.14	-.23	-.09
Ecross Food \$2 to \$3	-.18	.23	.09
Ecross Food \$3 to \$4	.14	.09	.05
FTND	.09	.66	-
Cigarettes/Day	.13	-	-

Notes. Ecross = Cross-price elasticity of demand; BMI = Body Mass Index; FTND = Fagerström Test of Nicotine Dependence total score; BFL = slope of best-fitting line; Bolded correlations significant $p < .05$.

Table 4

Correlations between eating, smoking, and weight variables with cross-price elasticity of demand for cigarettes and food

	Gender	Restraint	Emotional	Uncontrolled	Concern	Efficacy
Ecross Food BFL	-.04	.21	.02	.08	-.05	.29
Ecross Cig BFL	-.04	.01	.09	.14	.12	-.23
BMI	.24	.34	.29	.11	.37	-.01
Cigarettes/Day	-.04	-.29	.24	.27	.18	-.44
FTND	.14	-.29	.24	.25	.17	-.33
Gender	-	.26	.30	.16	.20	.08
Restraint	-	-	.10	.03	.38	.18
Emotional	-	-	-	.74	.38	-.33
Uncontrolled	-	-	-	-	.27	-.27

Notes. Ecross = Cross-price elasticity of demand; BFL = slope of best-fitting line; BMI = Body Mass Index; FTND = Fagerström Test of Nicotine Dependence total score; Gender coded: male = 0, female = 1; Restraint = Three-Factor Eating Questionnaire Cognitive Restraint; Emotional = Three-Factor Eating Questionnaire Emotional Eating; Uncontrolled = Three-Factor Eating Questionnaire Uncontrolled Eating; Concern = Smoking-related weight concern; Efficacy = Weight control efficacy after quitting smoking; Bolded correlations significant $p < .05$.

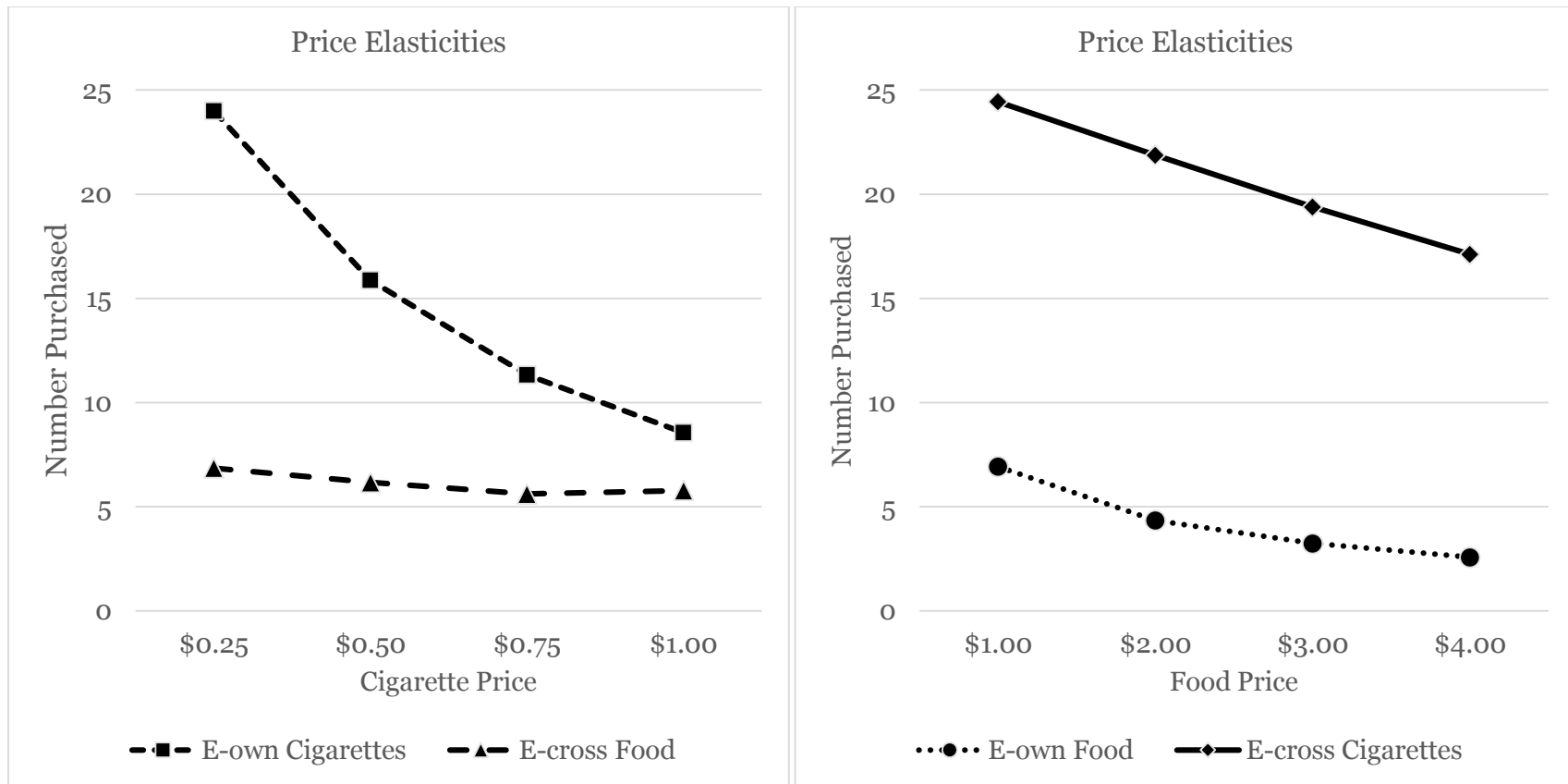


Figure 1

(Left panel) Mean units of cigarettes and food items purchased as cigarettes increase in price from \$0.25 to \$1 per cigarette. (Right panel) Mean units of cigarettes and food items purchased as food increases in price from \$1 to \$4 per food item.

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Appendix A:

Food and Cigarette Substitutability Task Menu

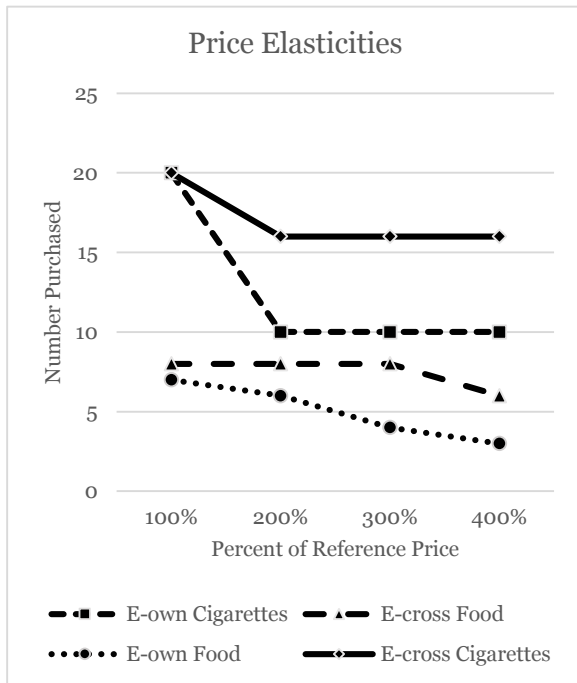
<p>A</p>  <p>SAUSAGE BISCUIT</p>	<p>B</p>  <p>FRUIT & MAPLE OATMEAL</p>	<p>C</p>  <p>SAUSAGE BURRITO</p>	<p>D</p>  <p>3 FRENCH TOAST STICKS WITH SYRUP</p>
<p>E</p>  <p>SMALL HASH BROWNS</p>	<p>F</p>  <p>JR. CHEESEBURGER DELUXE</p>	<p>G</p>  <p>JR. BACON CHEESEBURGER</p>	<p>H</p>  <p>DOUBLE CHEESEBURGER</p>
<p>I</p>  <p>CHICKEN SANDWICH</p>	<p>J</p>  <p>RANCH CRISPY CHICKEN SANDWICH</p>	<p>K</p>  <p>GRILLED CHICKEN WRAP</p>	<p>L</p>  <p>CRISPY CHICKEN CAESAR WRAP</p>

<div data-bbox="216 212 247 245">M</div>  <div data-bbox="275 553 533 574">6-PIECE CHICKEN NUGGETS</div>	<div data-bbox="625 212 657 245">N</div>  <div data-bbox="758 553 873 574">SMALL CHILI</div>	<div data-bbox="1035 212 1066 245">O</div>  <div data-bbox="1136 553 1335 574">GARDEN SIDE SALAD</div>	<div data-bbox="1465 212 1497 245">P</div>  <div data-bbox="1560 553 1755 574">CAESAR SIDE SALAD</div>
<div data-bbox="216 617 247 649">Q</div>  <div data-bbox="300 958 510 979">VALUE FRENCH FRIES</div>	<div data-bbox="625 617 657 649">R</div>  <div data-bbox="720 958 909 979">VALUE COCA-COLA®</div>	<div data-bbox="1035 617 1066 649">S</div>  <div data-bbox="1146 958 1325 979">LARGE SWEET TEA</div>	<div data-bbox="1465 617 1497 649">T</div>  <div data-bbox="1524 958 1787 979">SMALL CHOCOLATE FROSTY</div>
<div data-bbox="216 1021 247 1053">U</div>  <div data-bbox="279 1365 527 1386">FRUIT 'N YOGURT PARFAIT</div>	<div data-bbox="625 1021 657 1053">V</div>  <div data-bbox="741 1365 884 1386">VANILLA CONE</div>	<div data-bbox="1035 1021 1066 1053">W</div>  <div data-bbox="1041 1365 1430 1386">2 SOFT BAKED CHOCOLATE CHIP COOKIES</div>	<div data-bbox="1465 1021 1497 1053">X</div>  <div data-bbox="1608 1365 1703 1386">APPLE PIE</div>

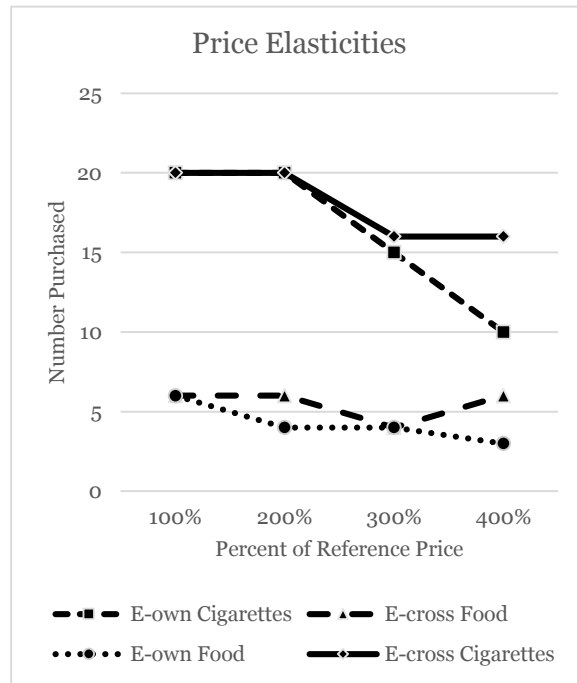
Appendix B:

Own-Price and Cross-Price Elasticity by Participant

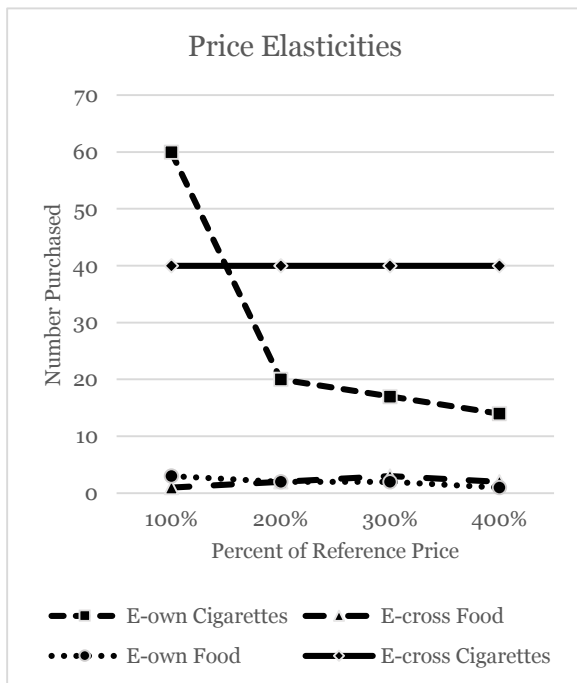
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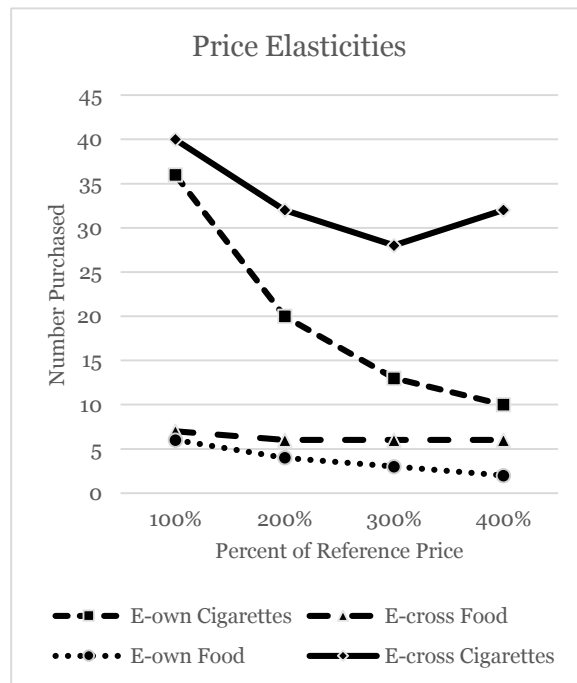
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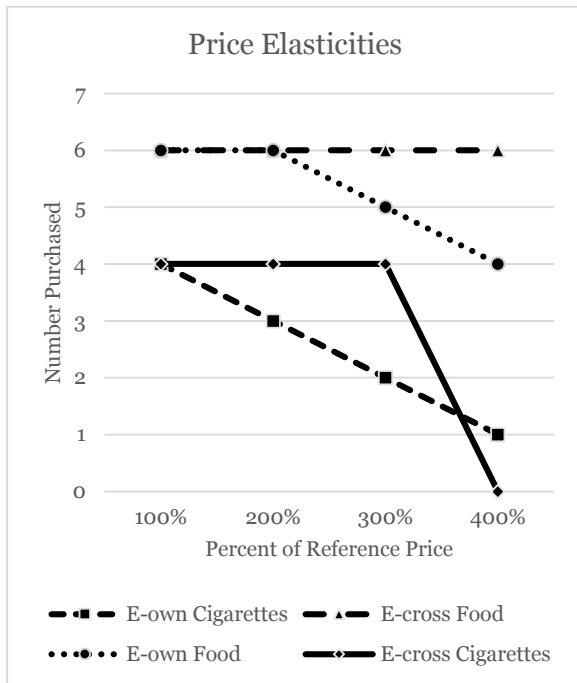
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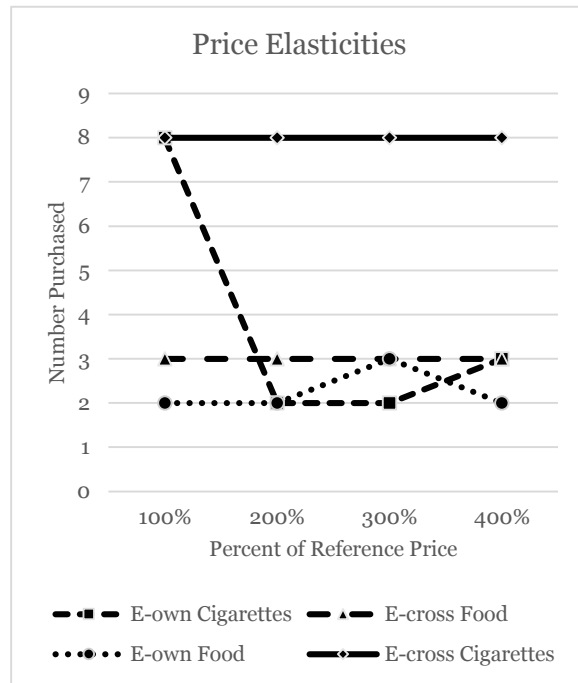
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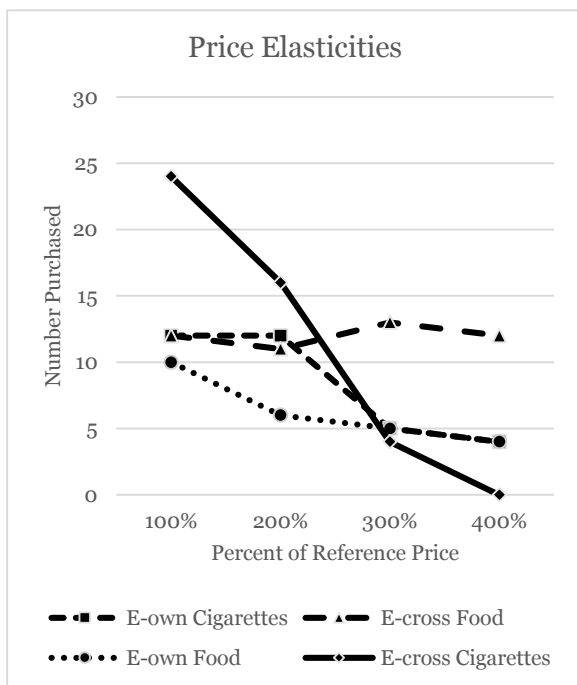
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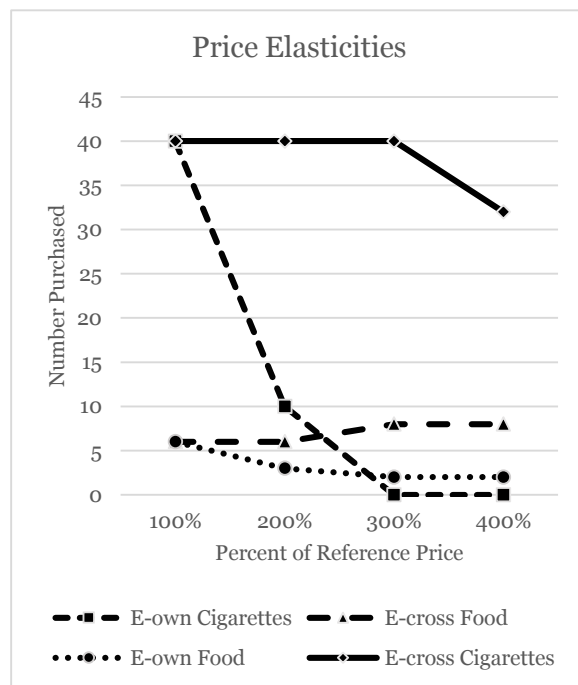
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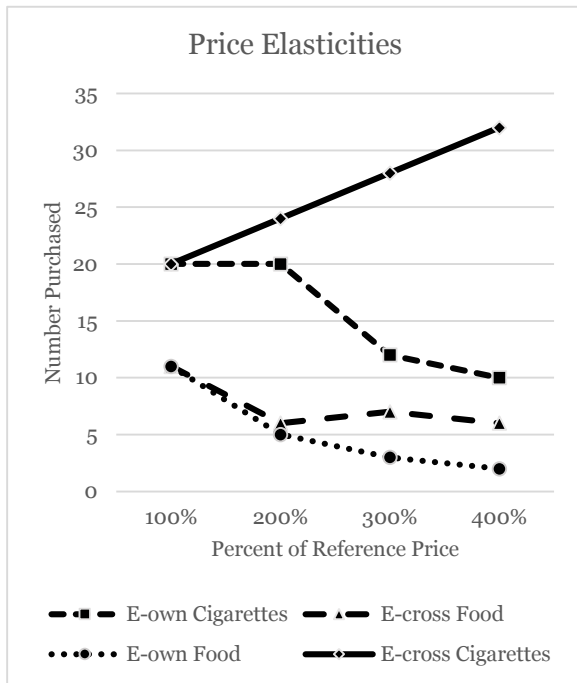
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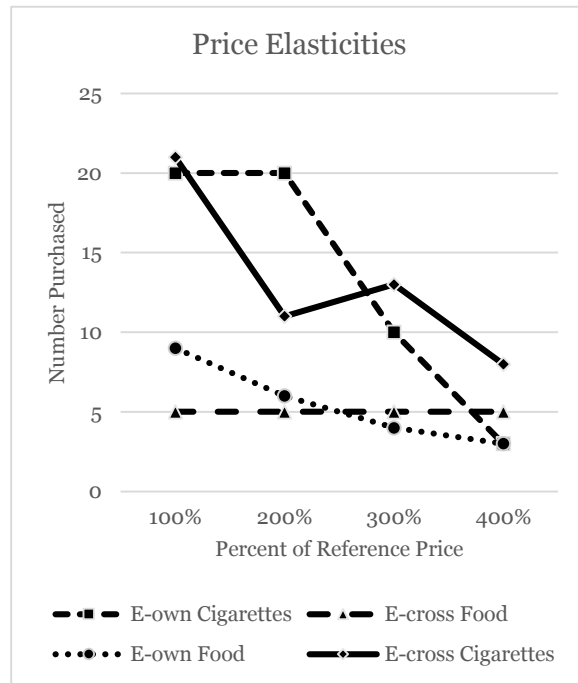
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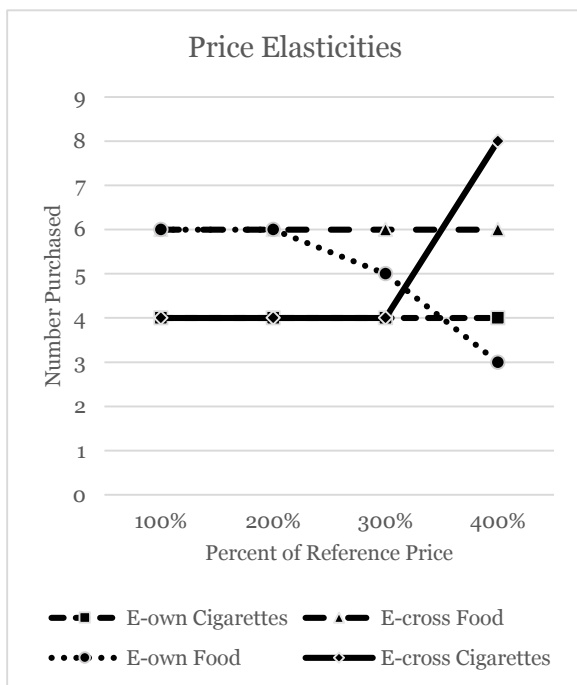
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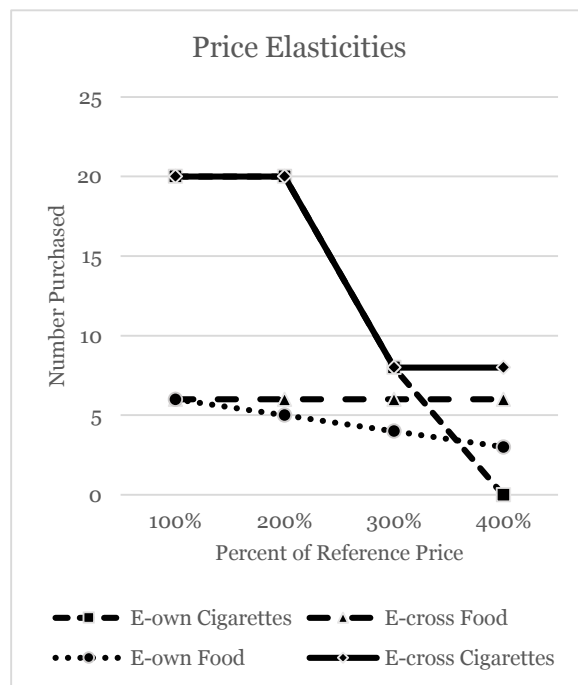
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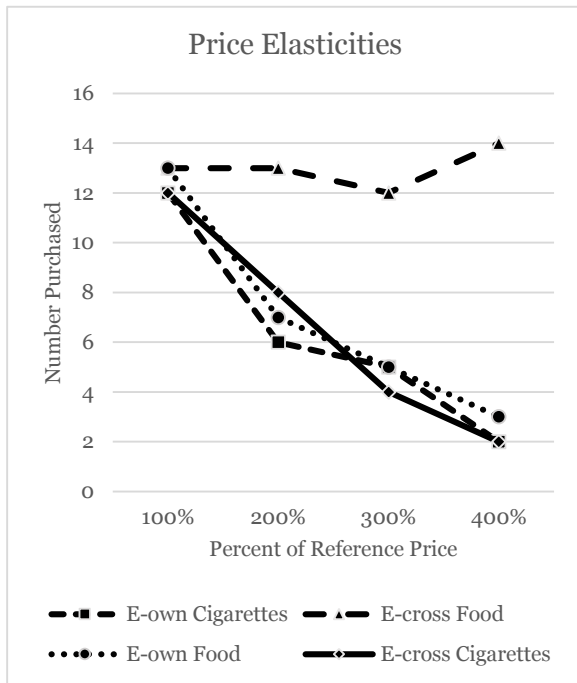
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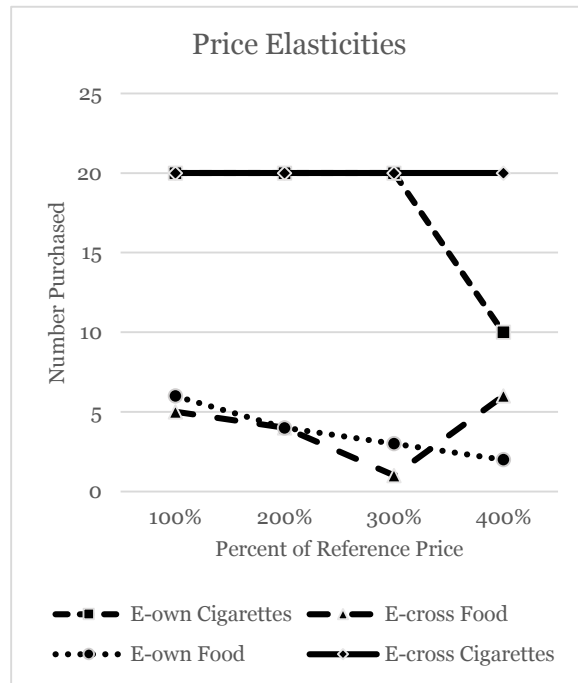
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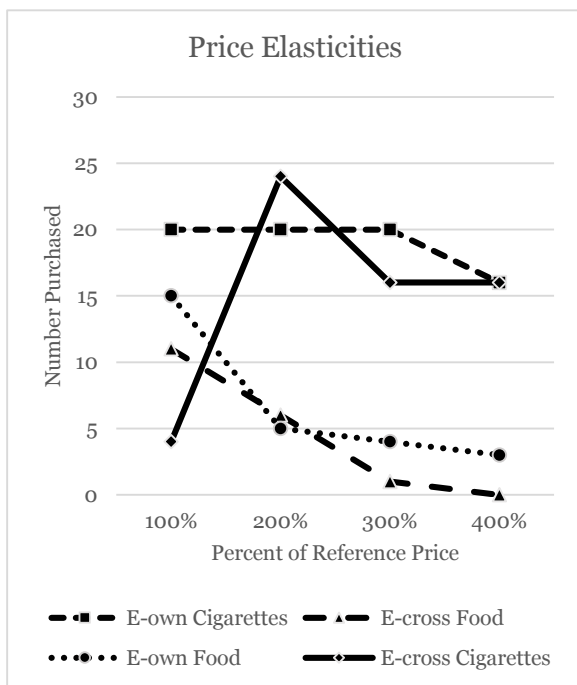
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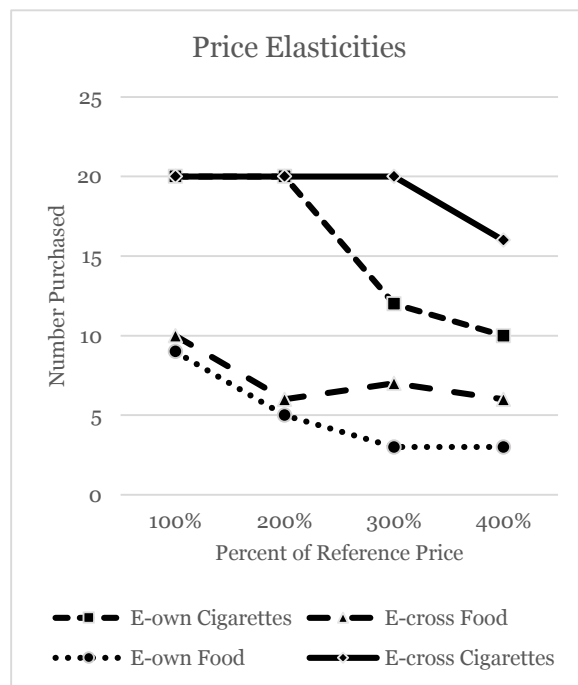
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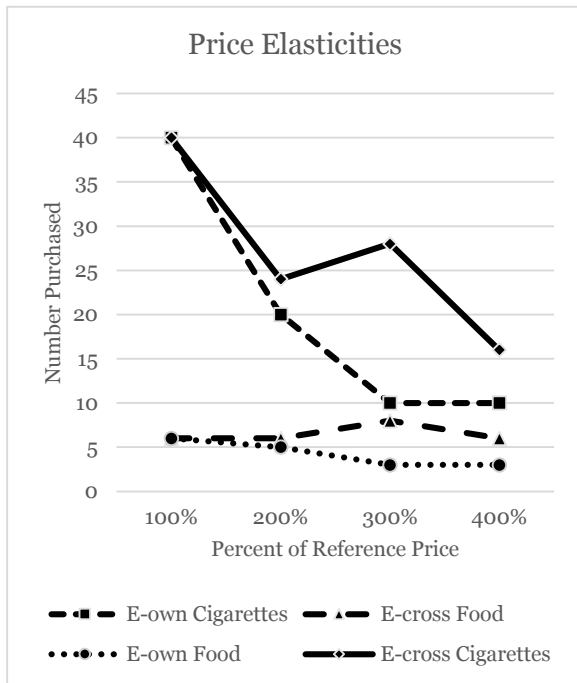
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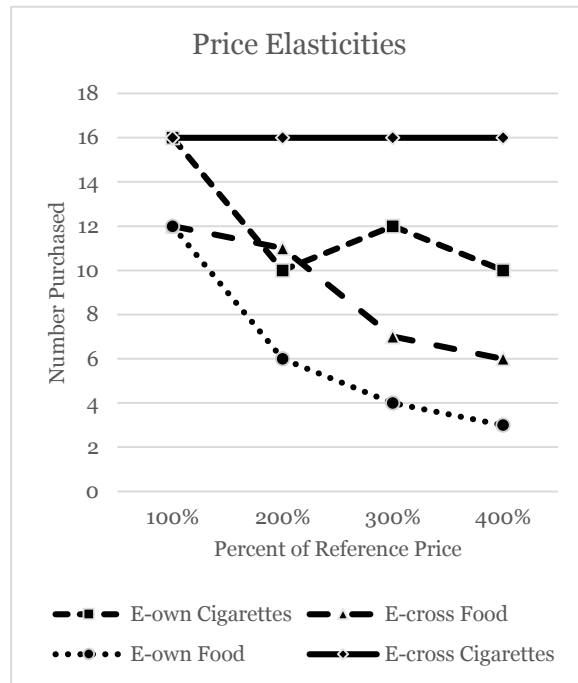
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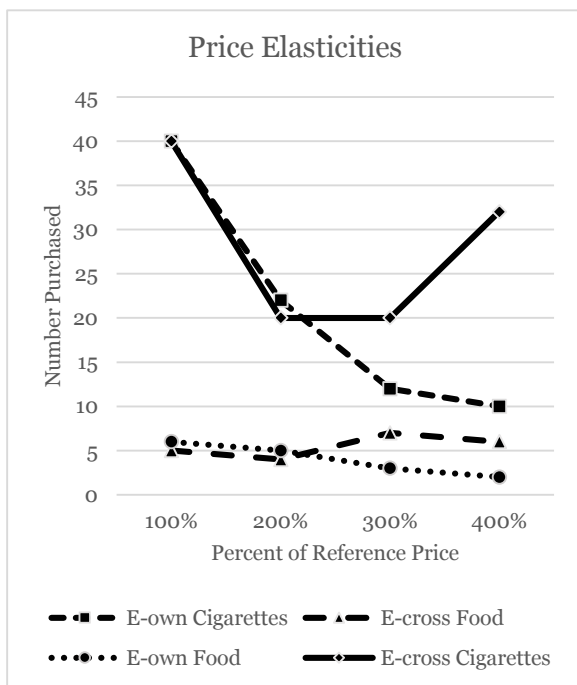
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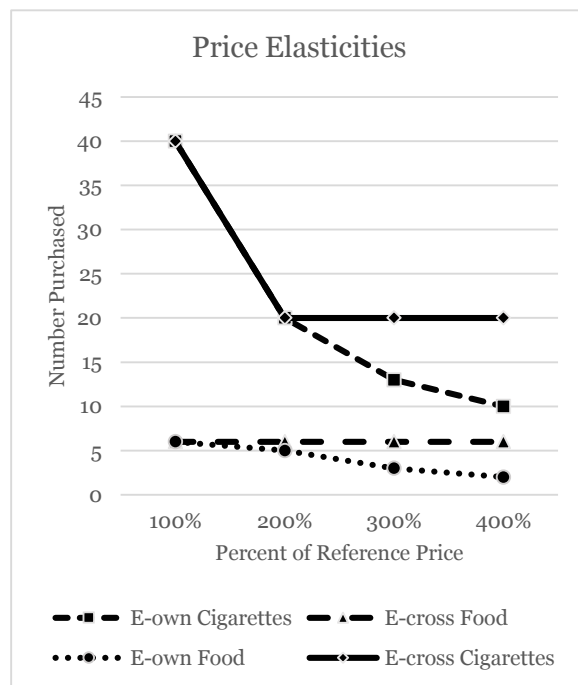
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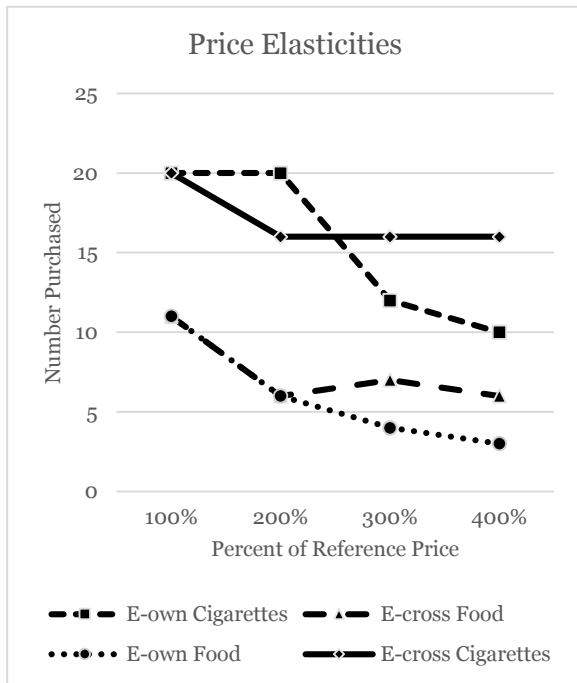
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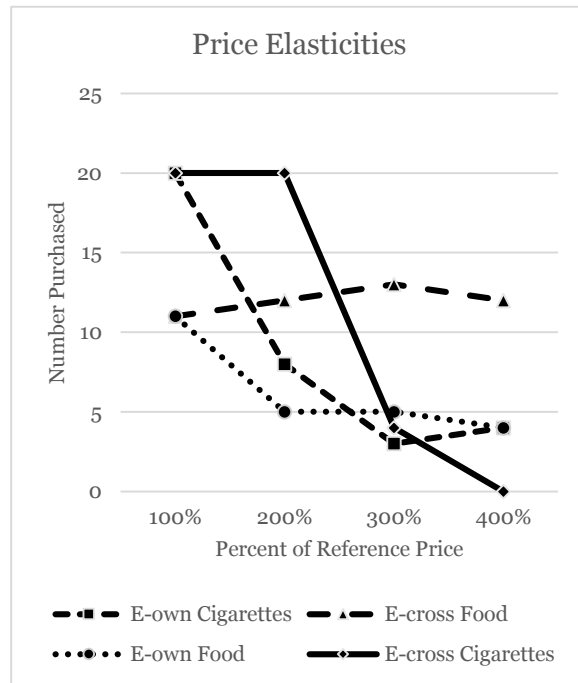
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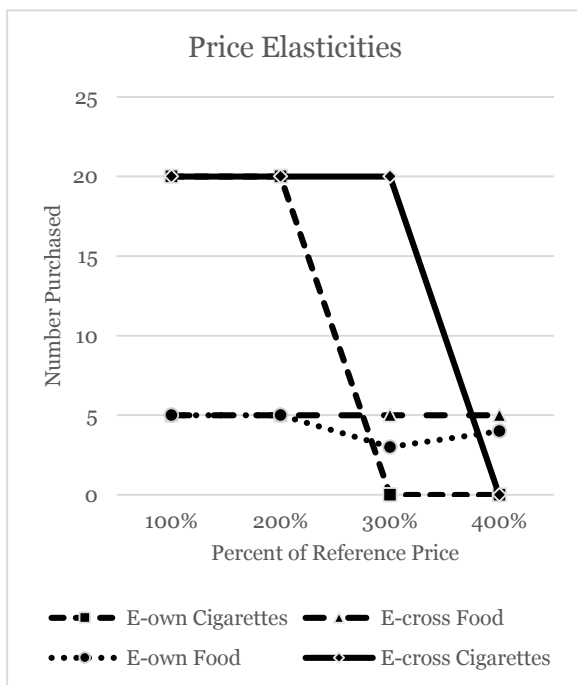
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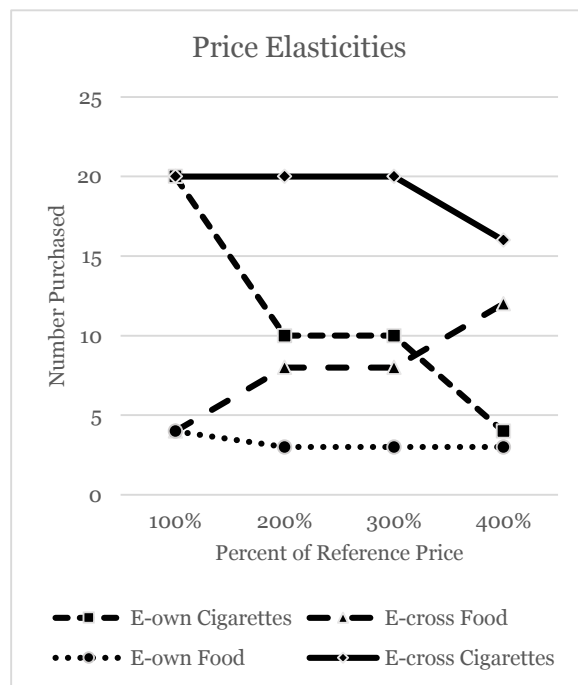
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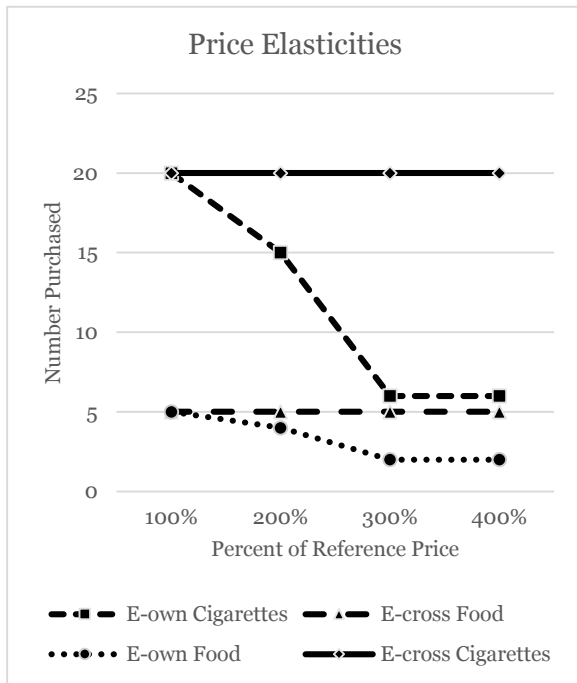
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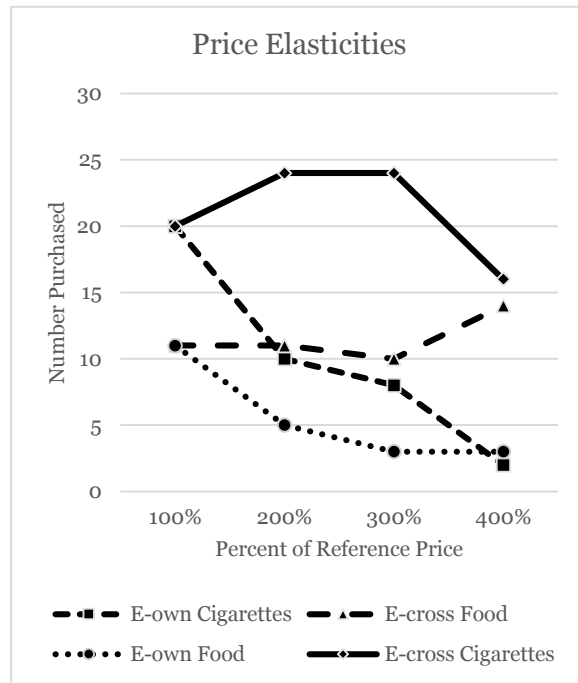
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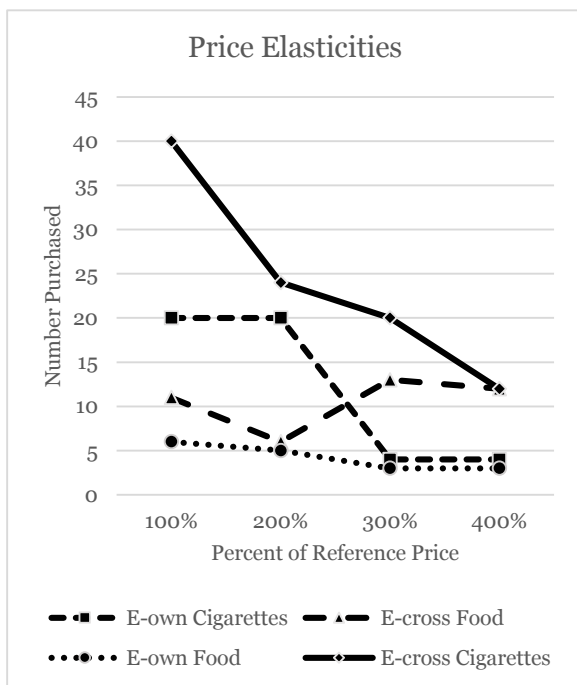
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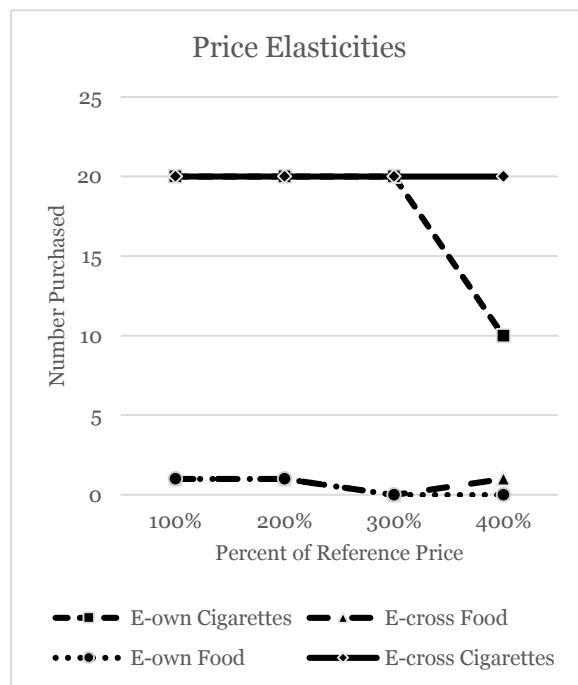
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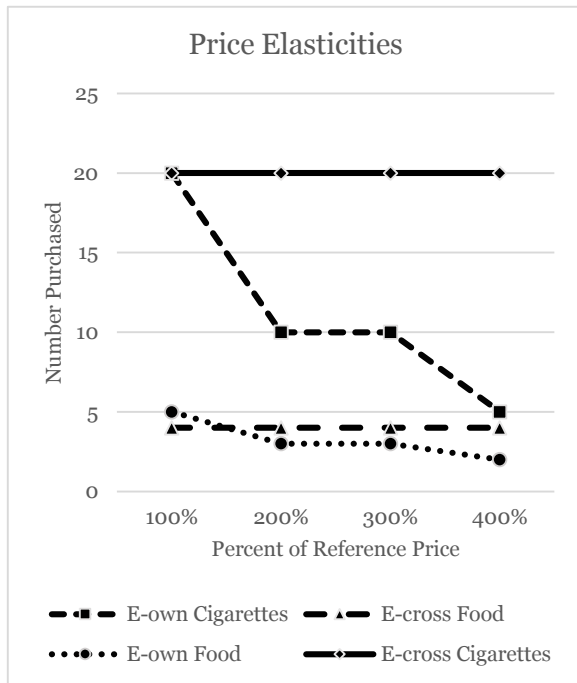
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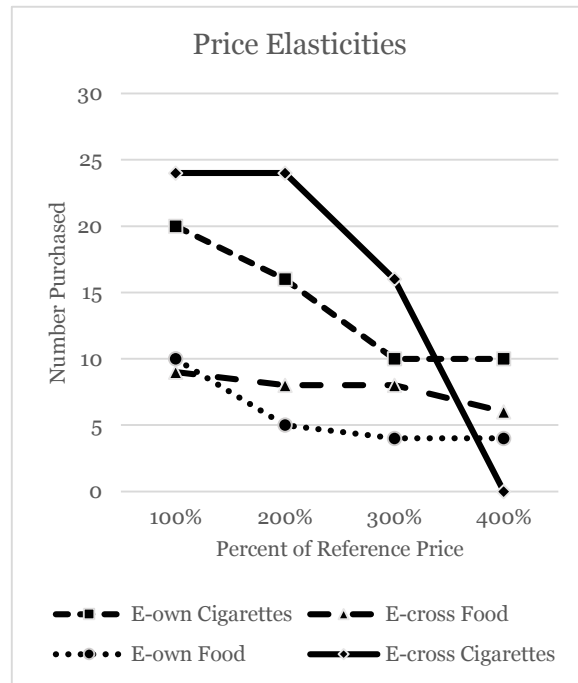
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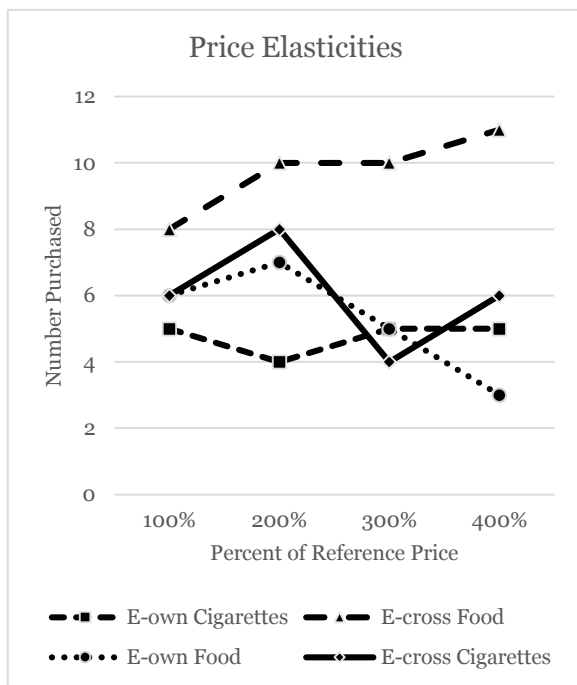
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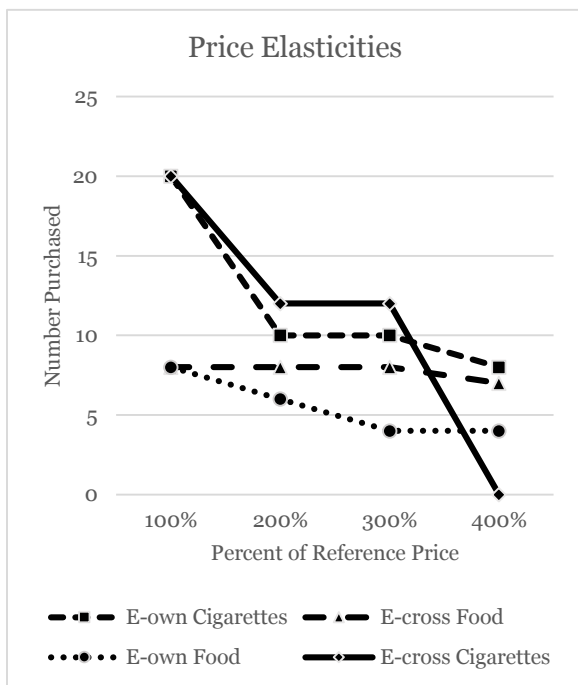
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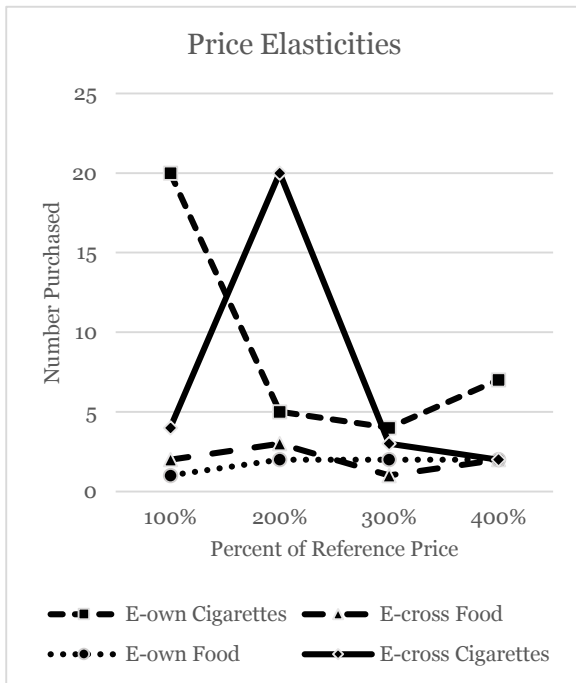
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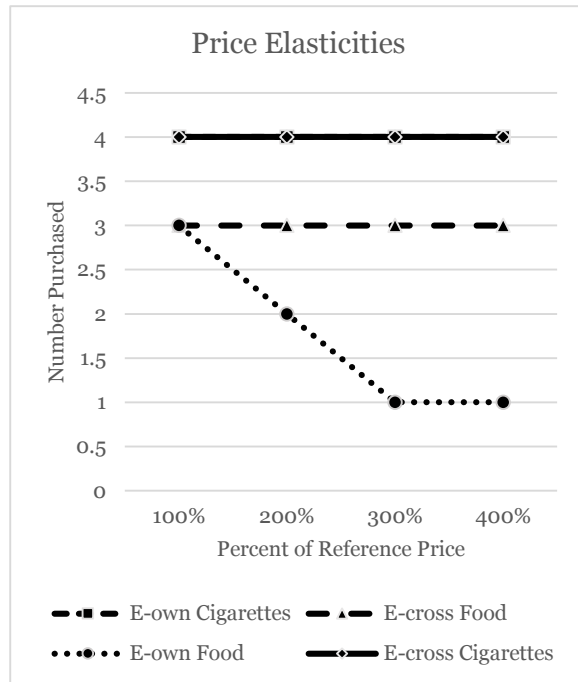
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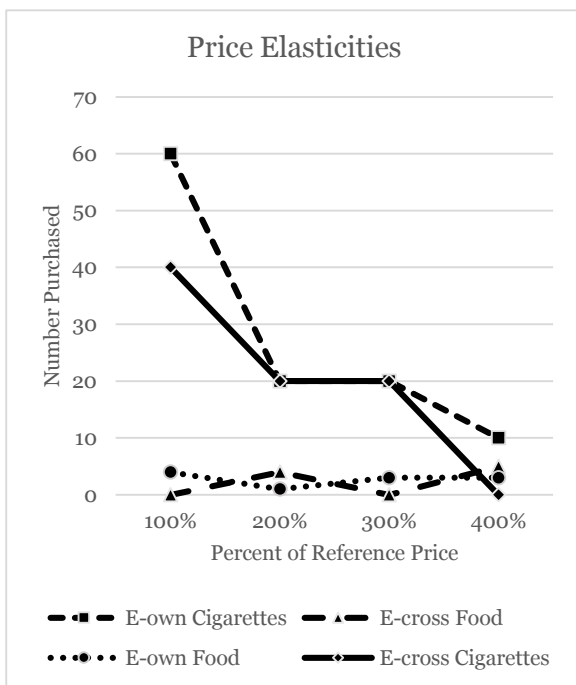
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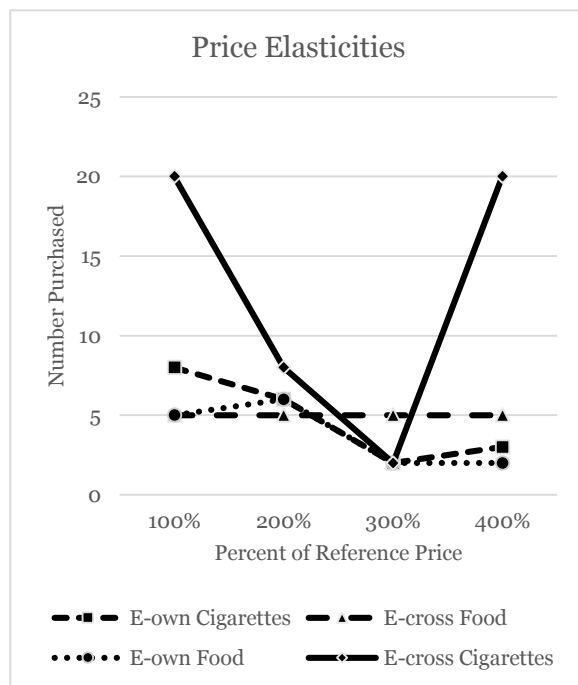
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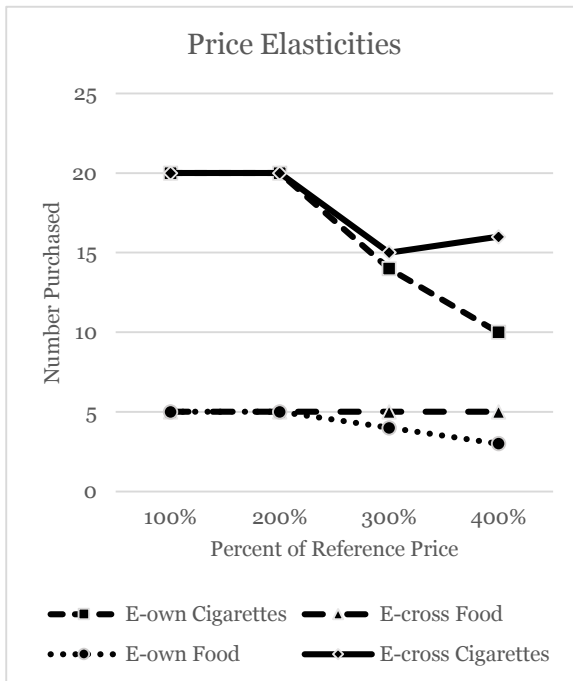
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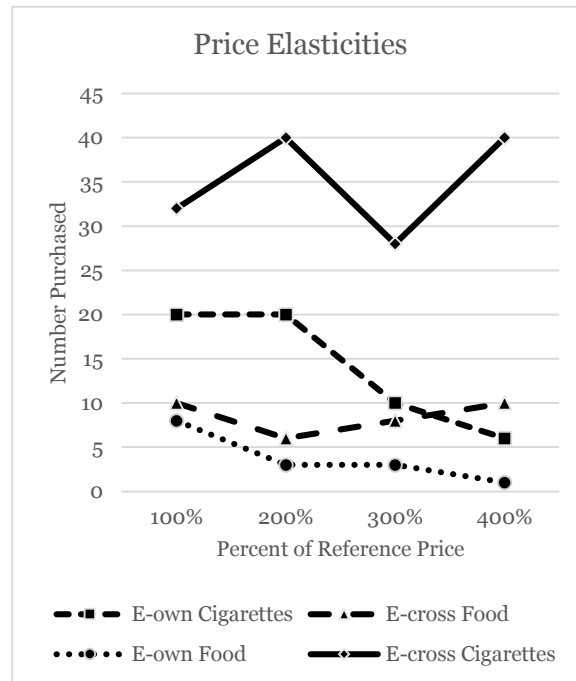
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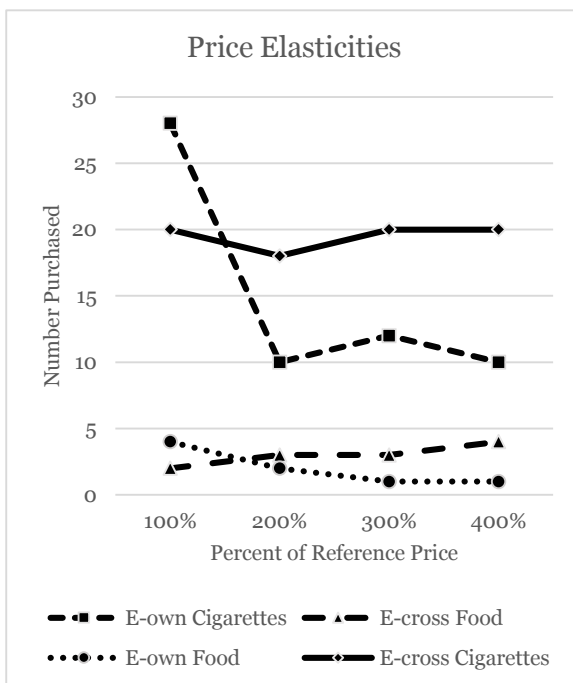
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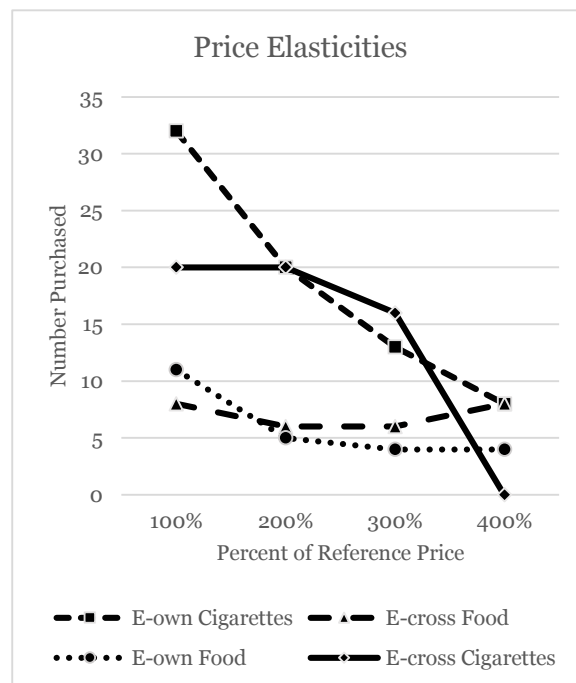
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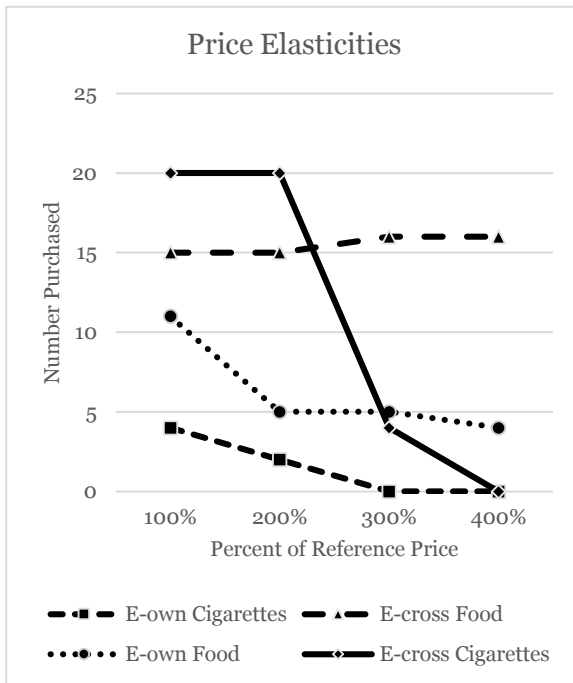
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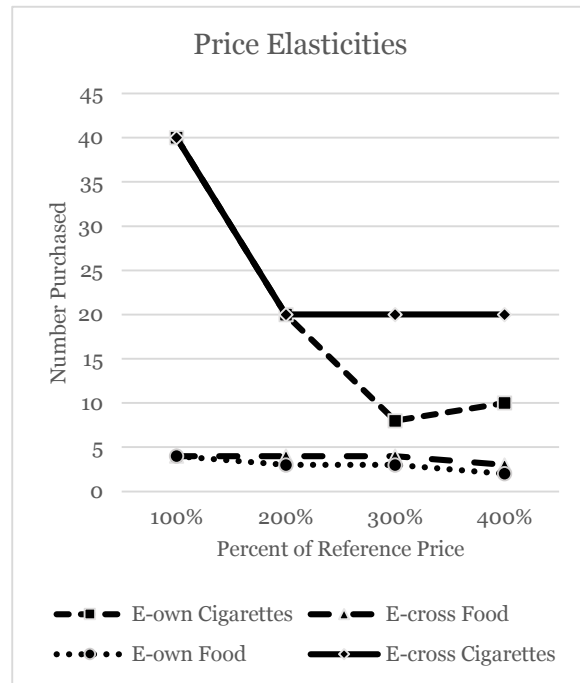
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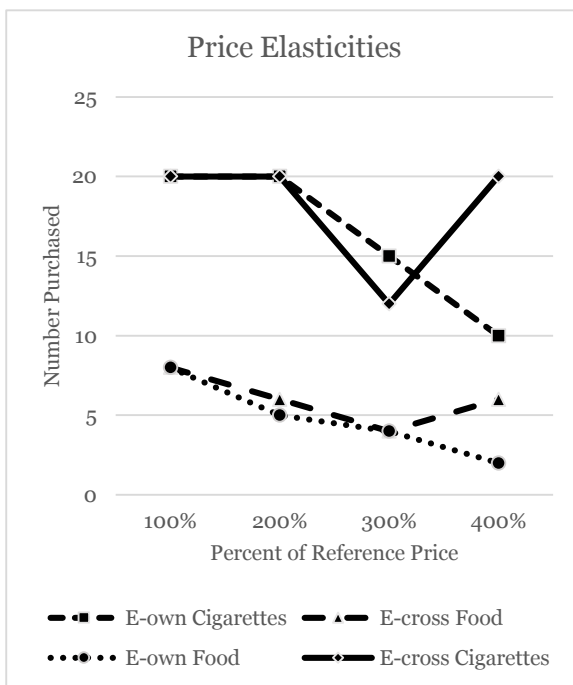
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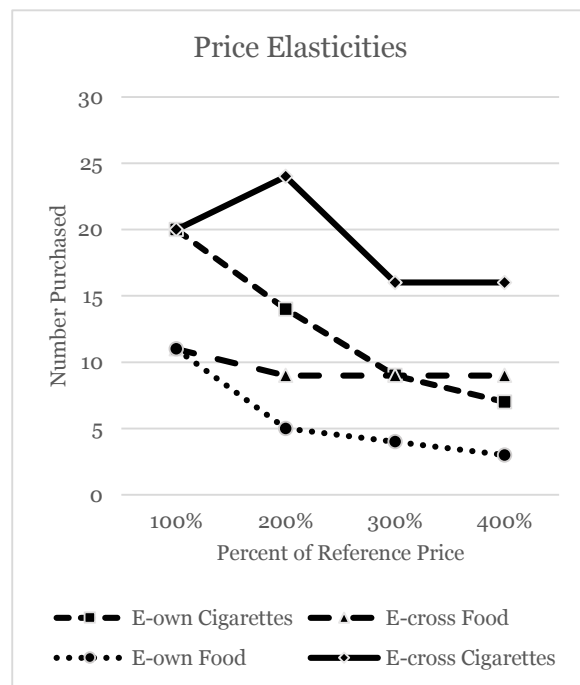
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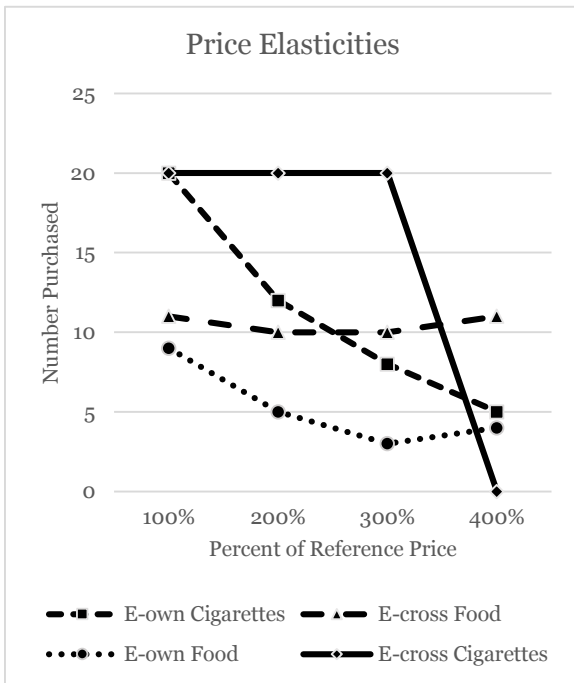
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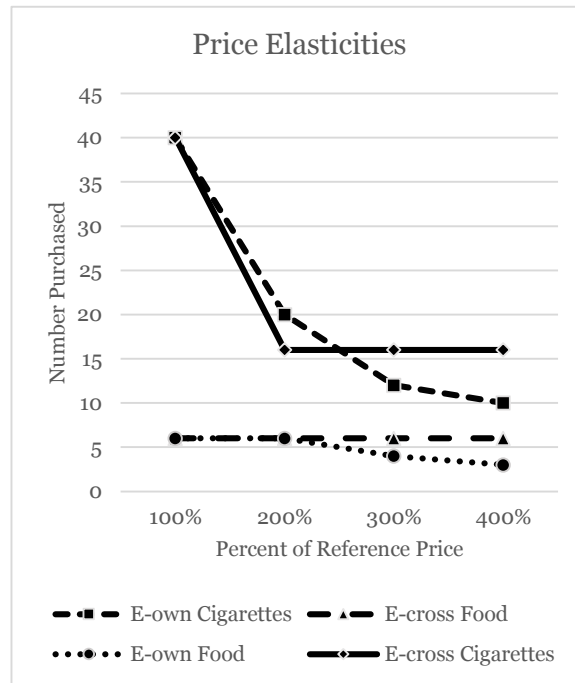
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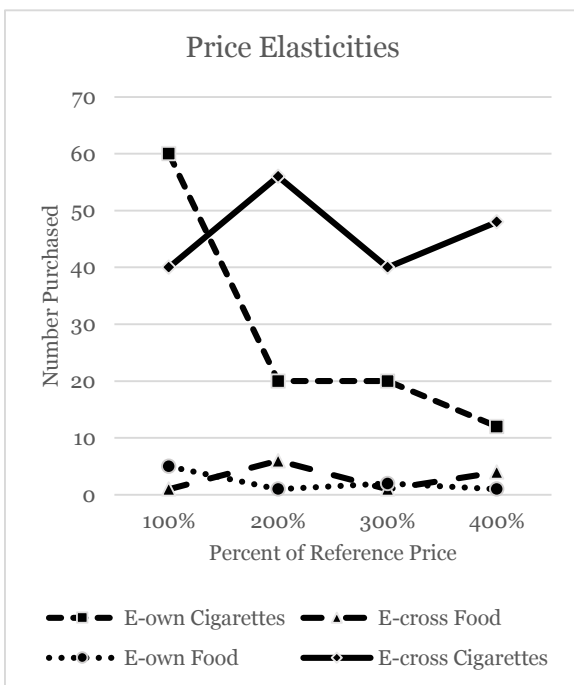
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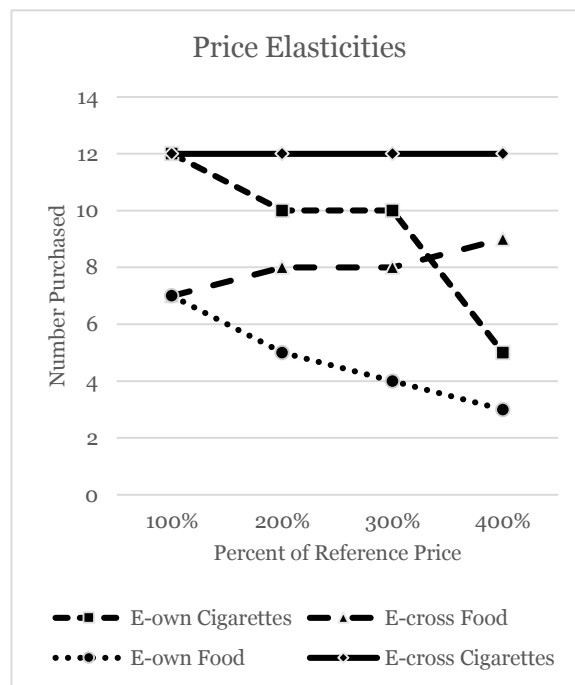
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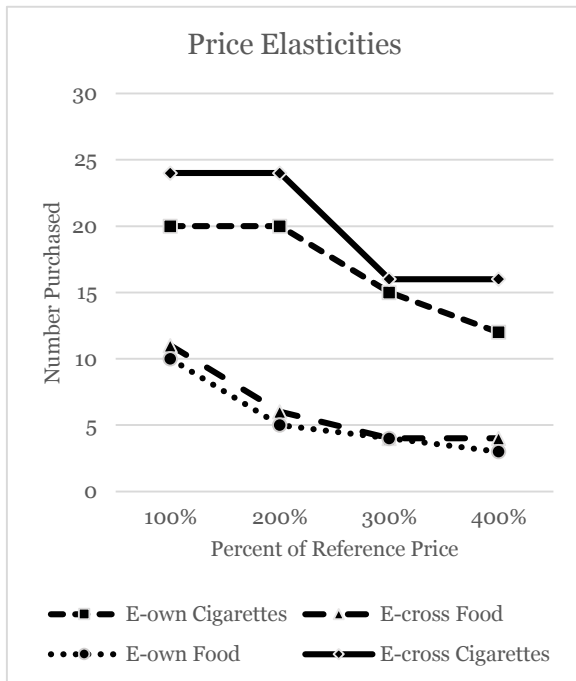
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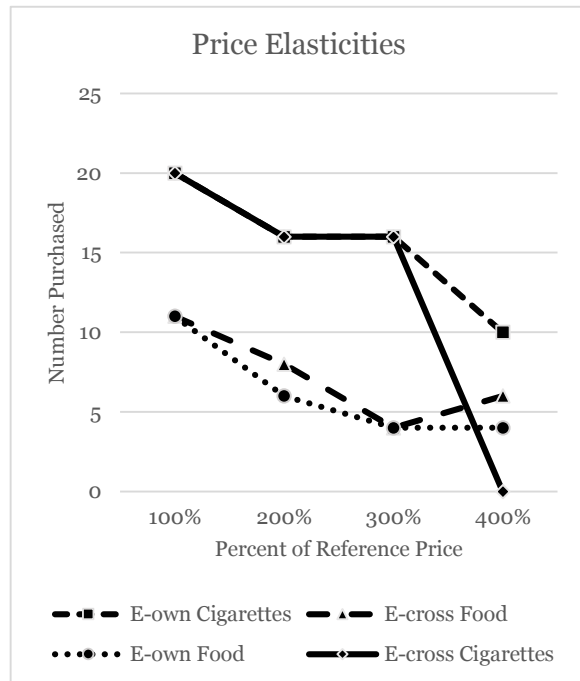
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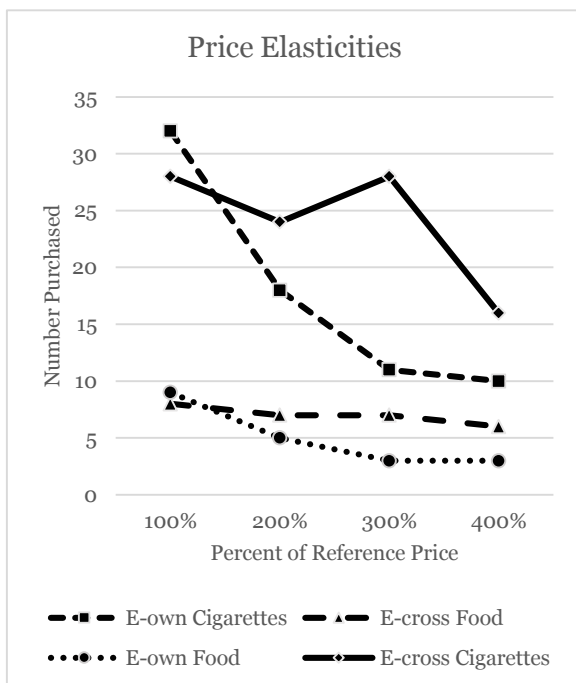
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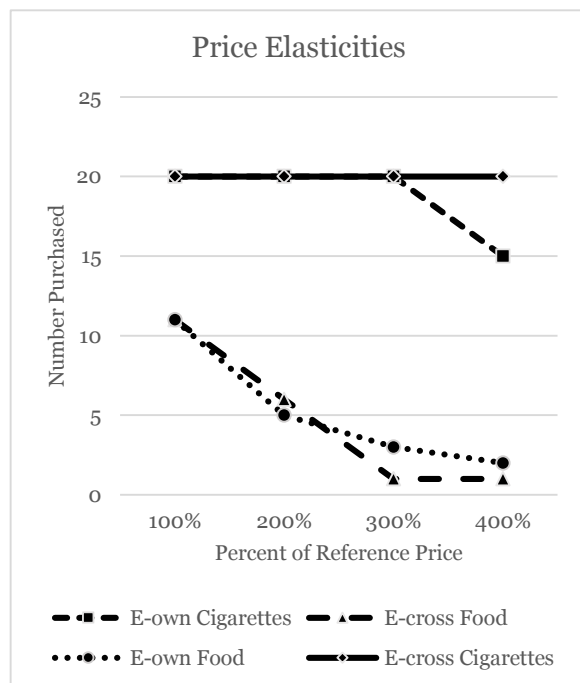
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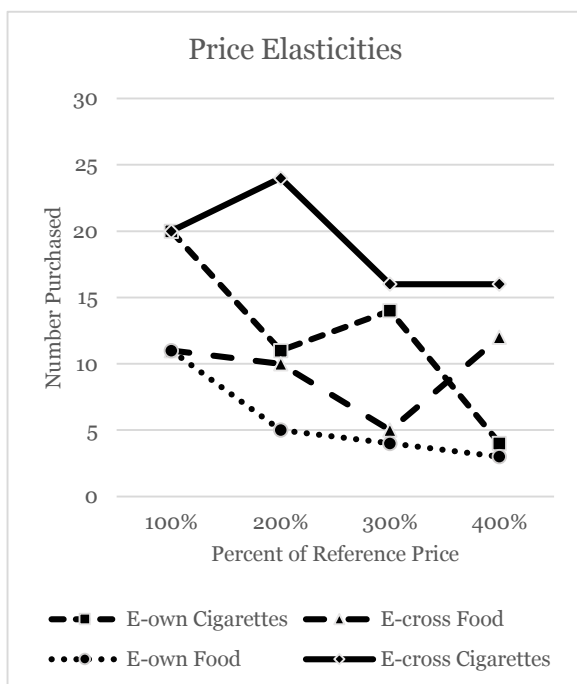
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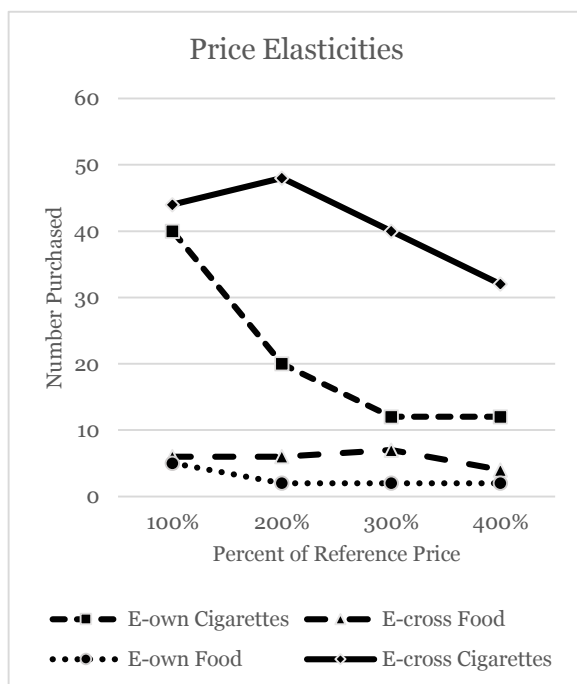
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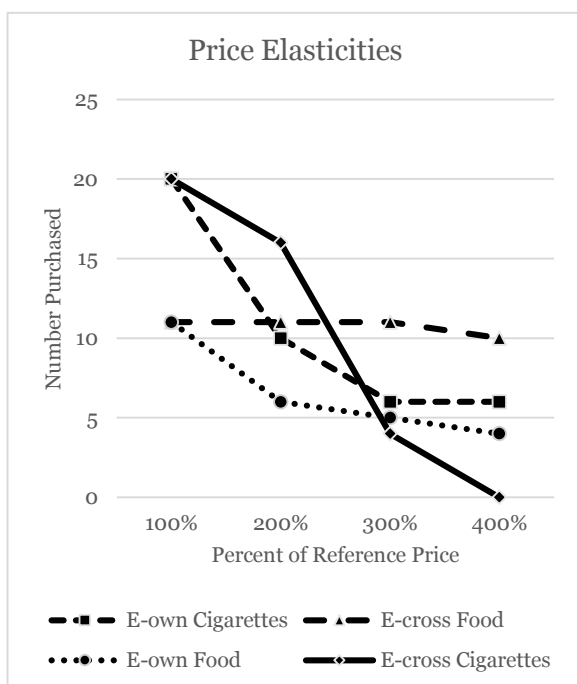
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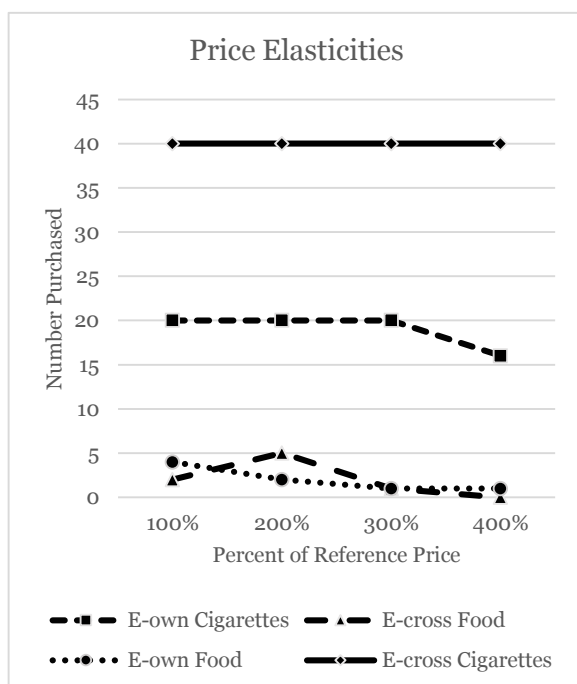
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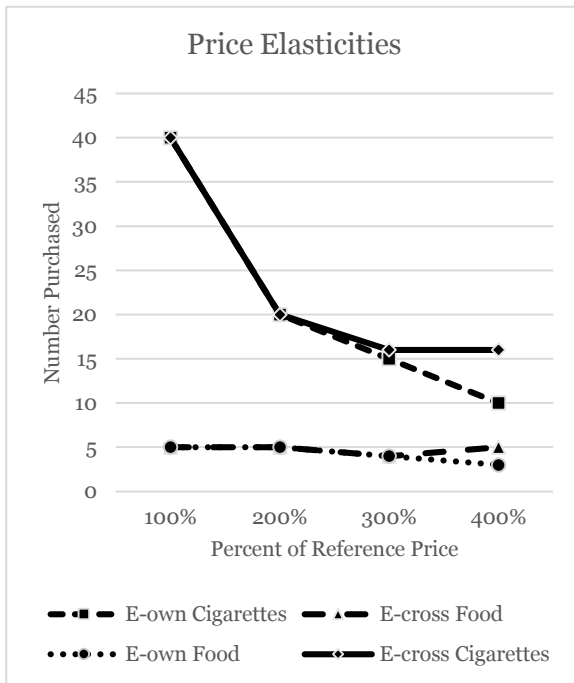
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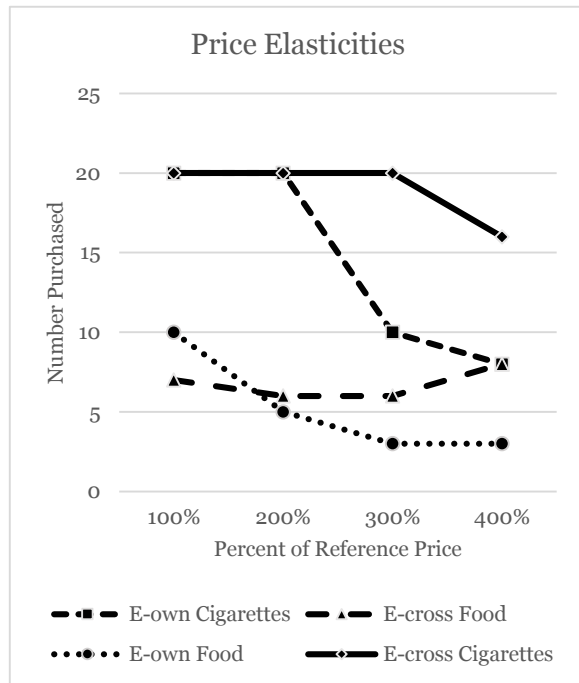
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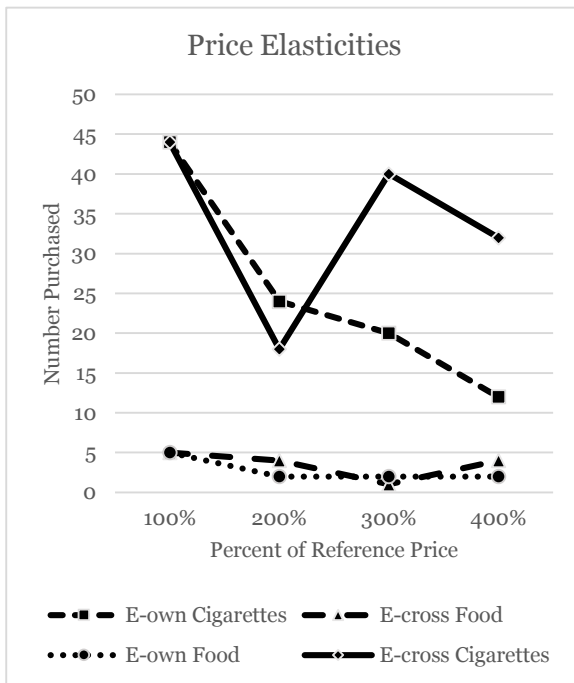
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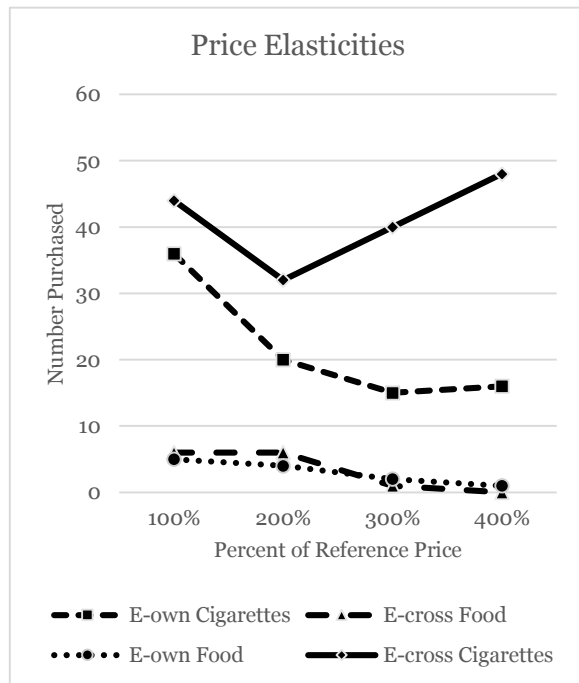
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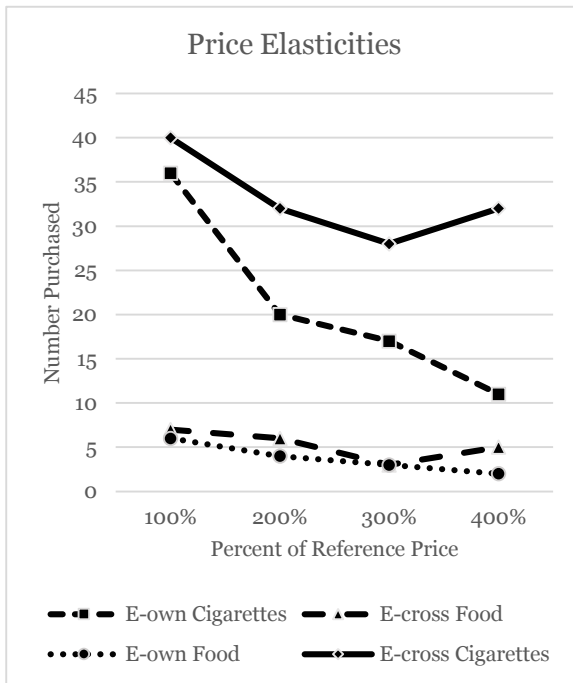
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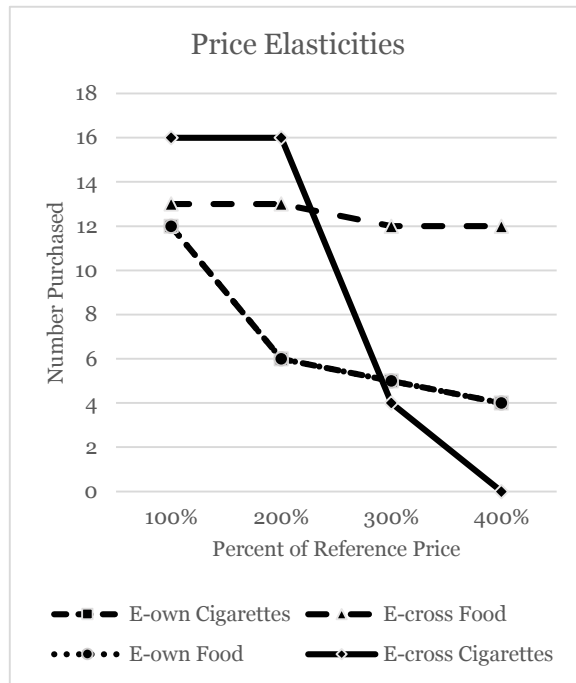
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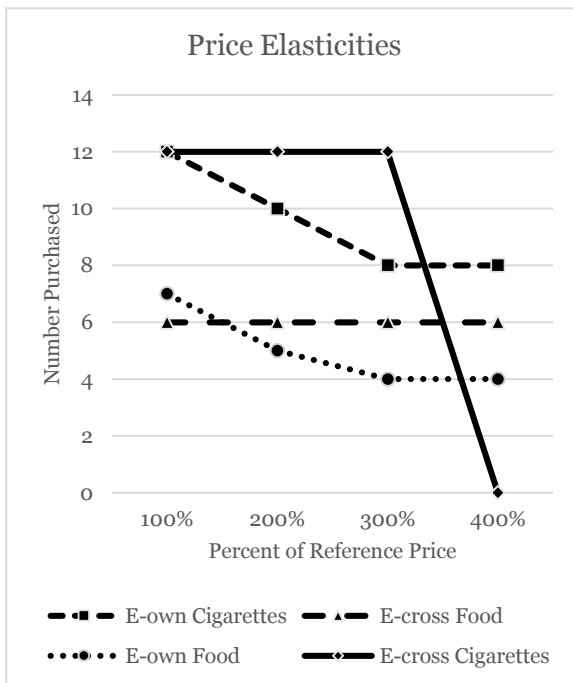
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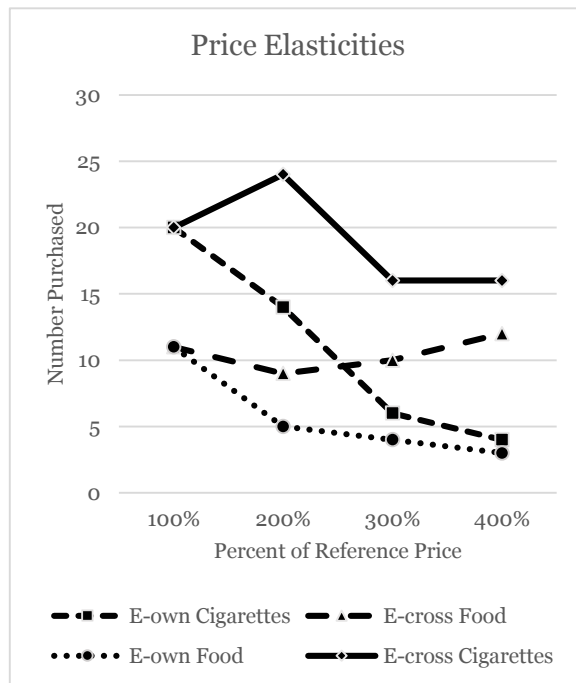
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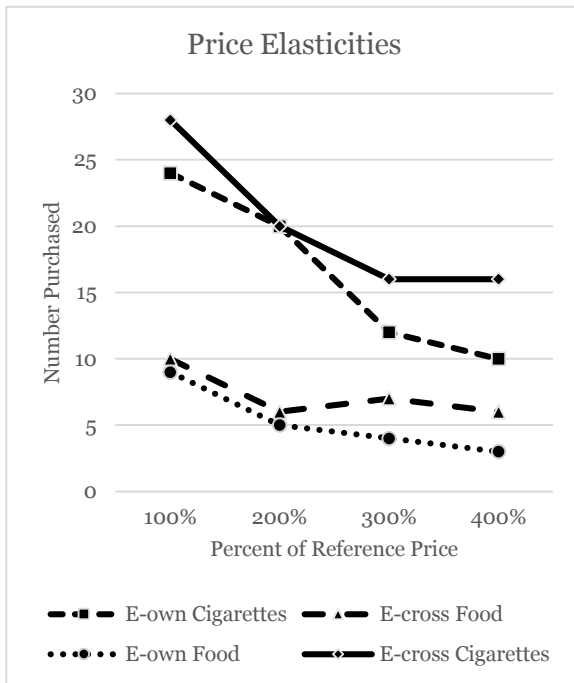
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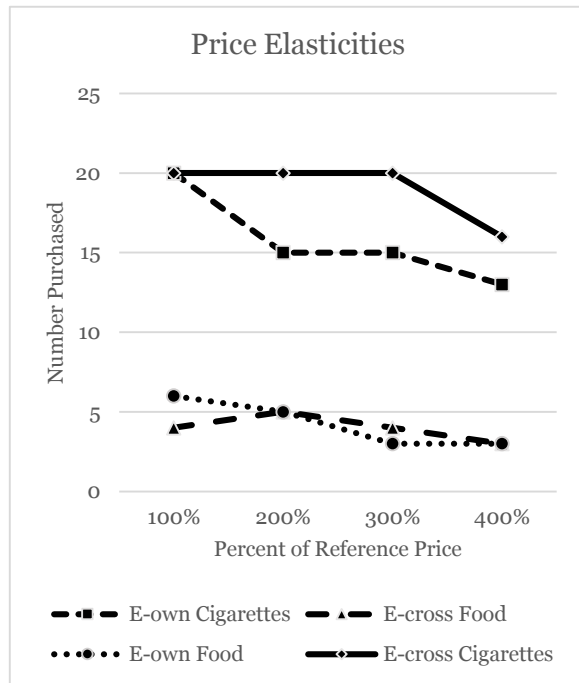
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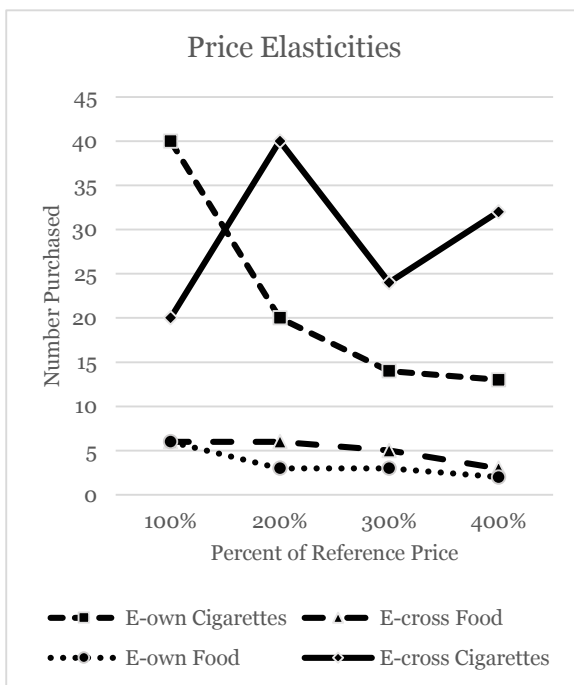
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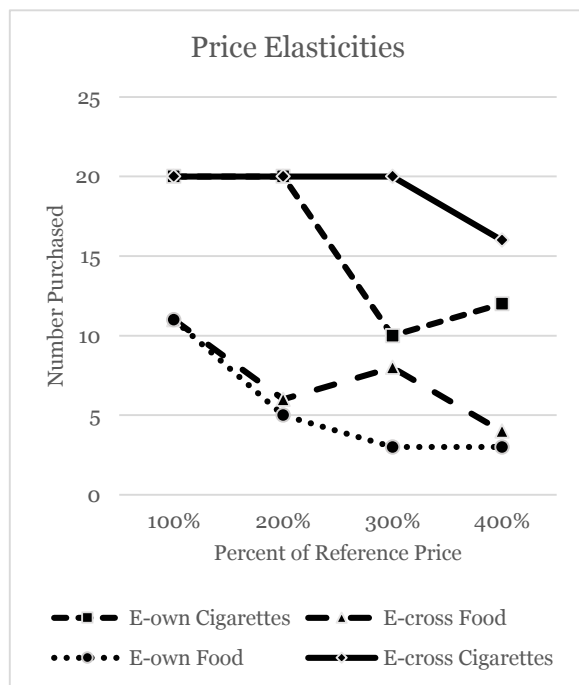
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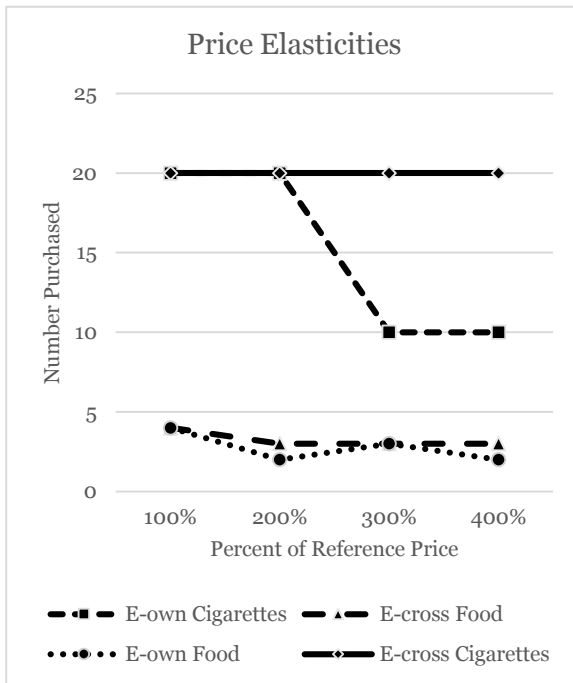
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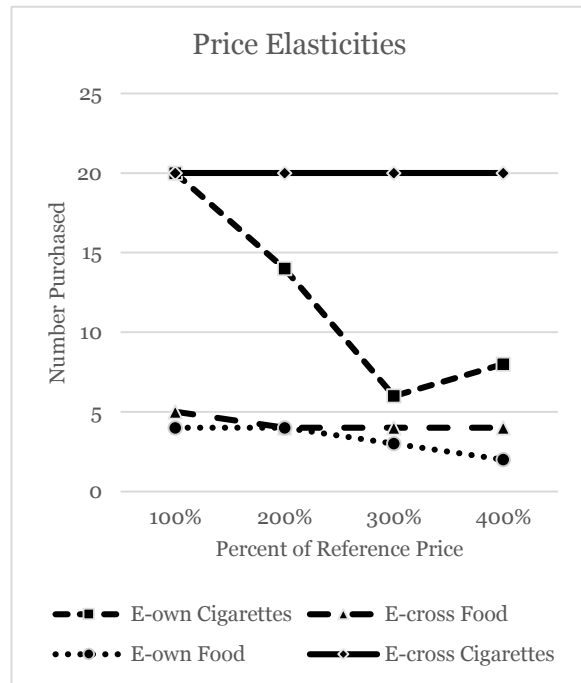
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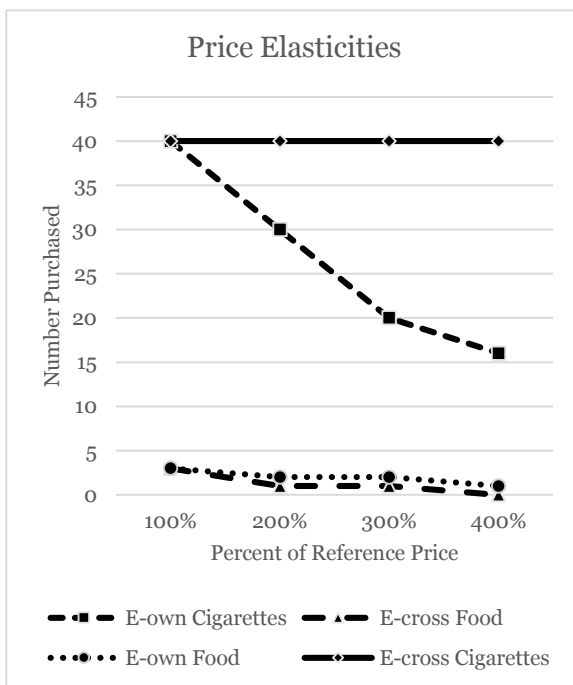
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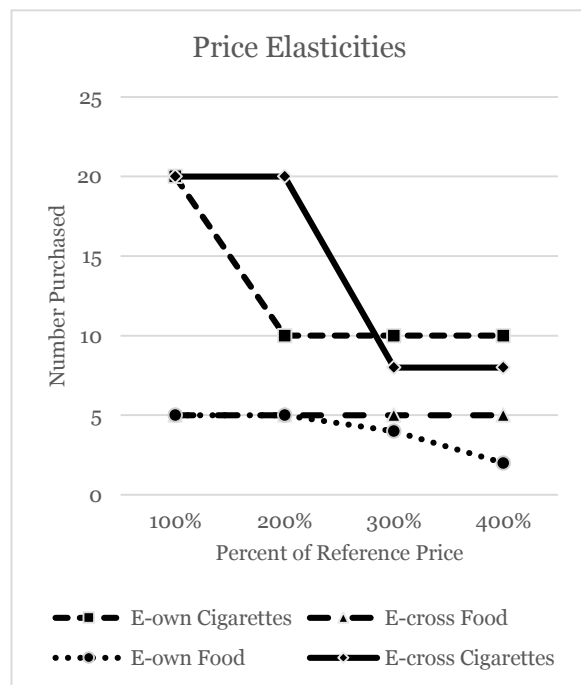
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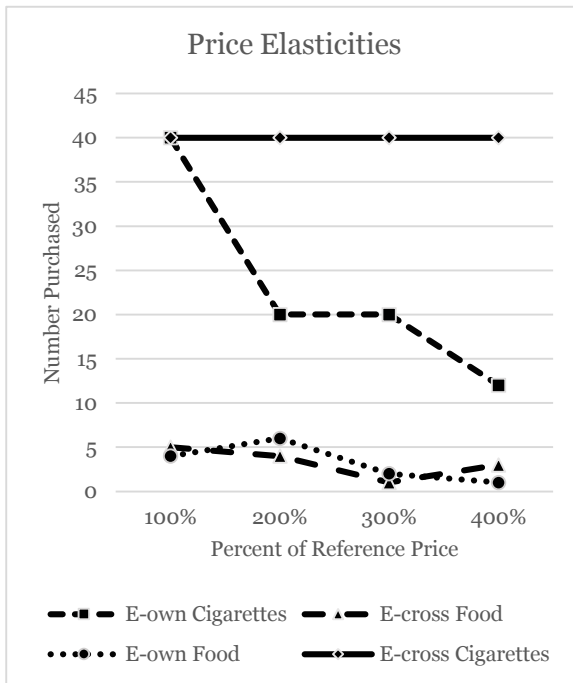
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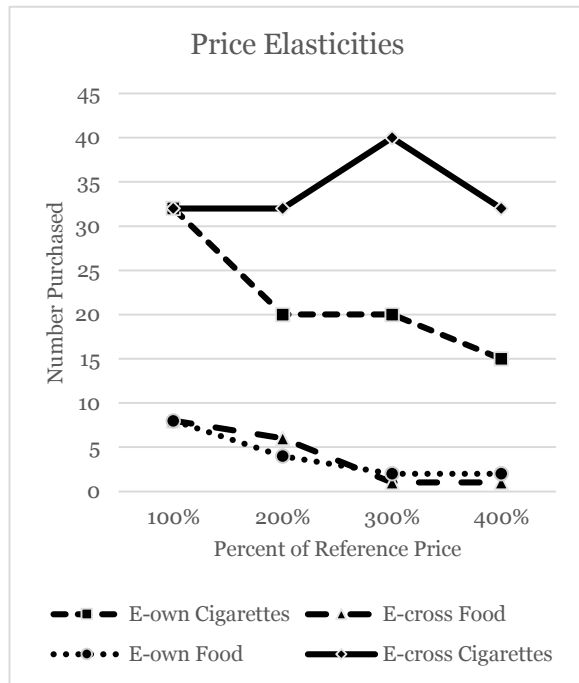
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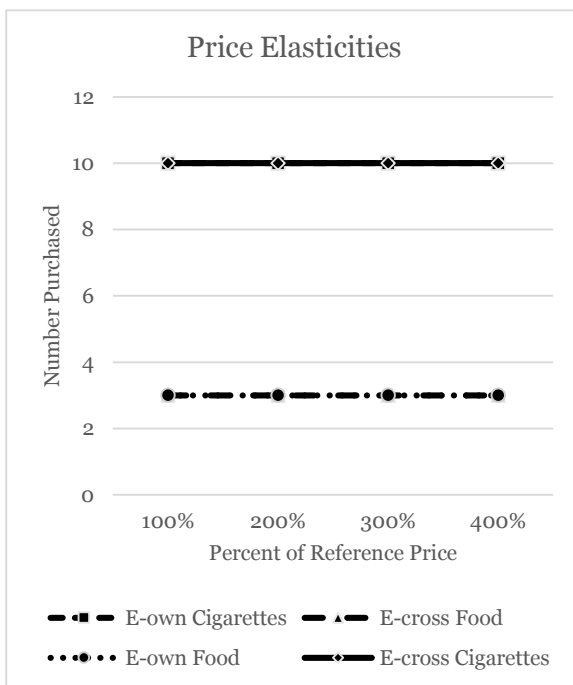
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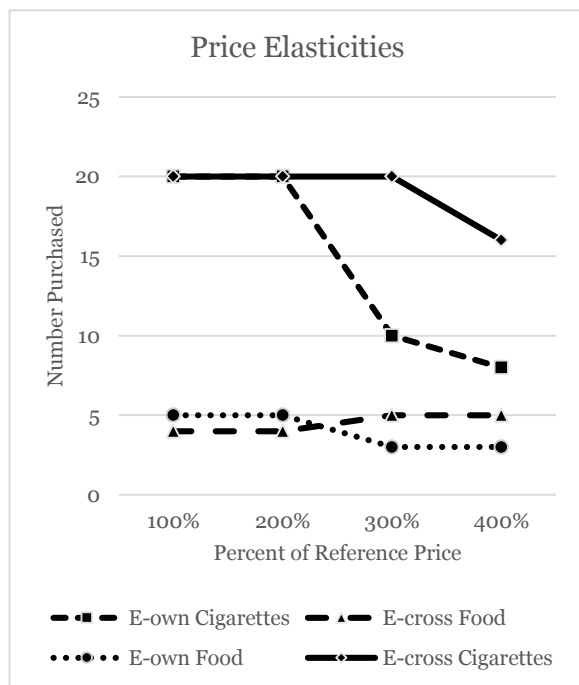
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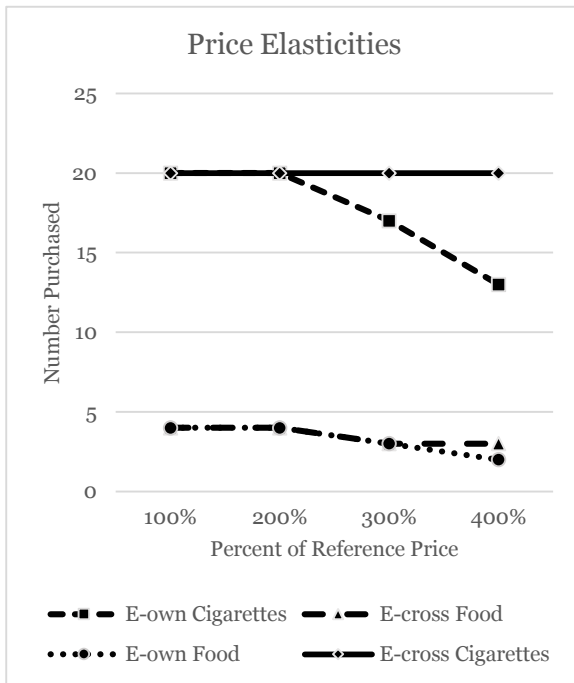
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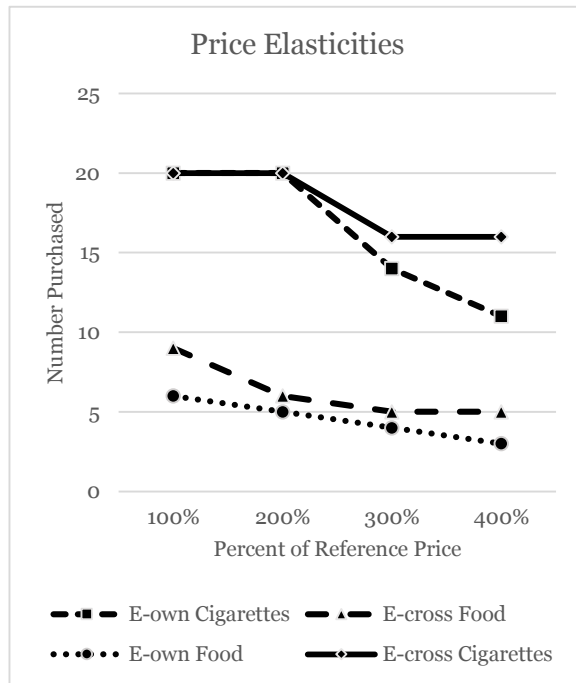
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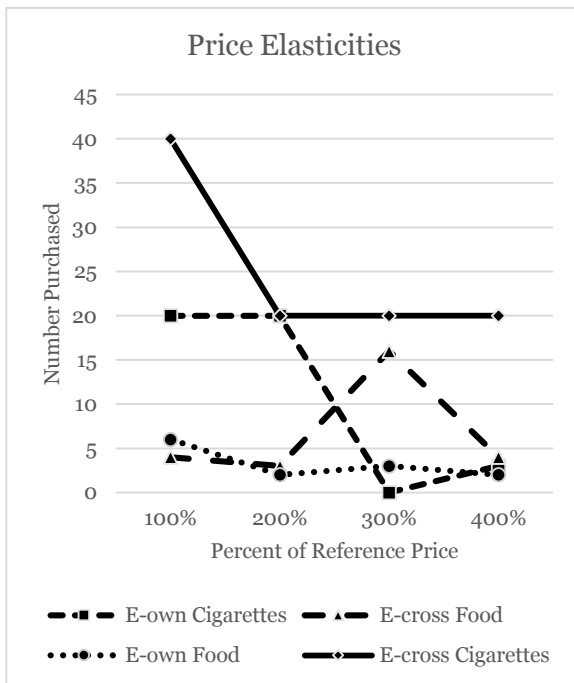
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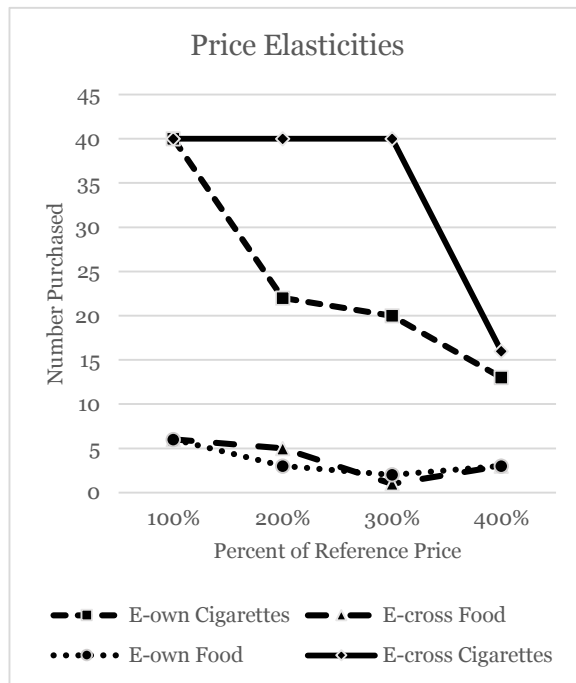
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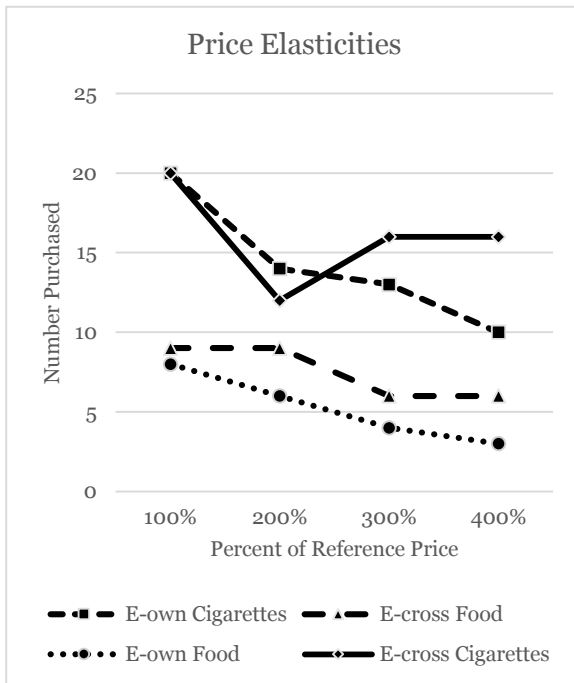
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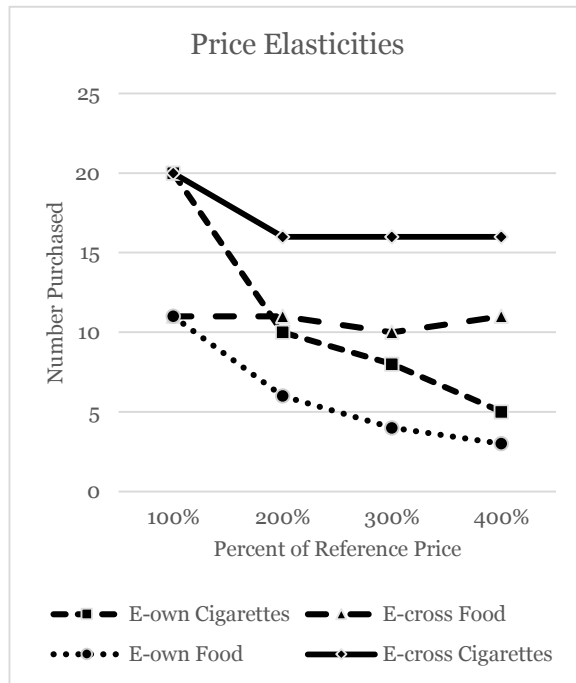
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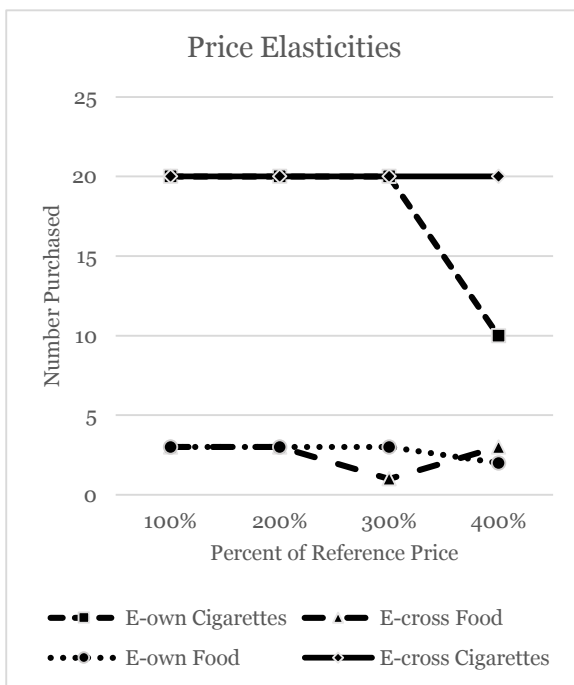
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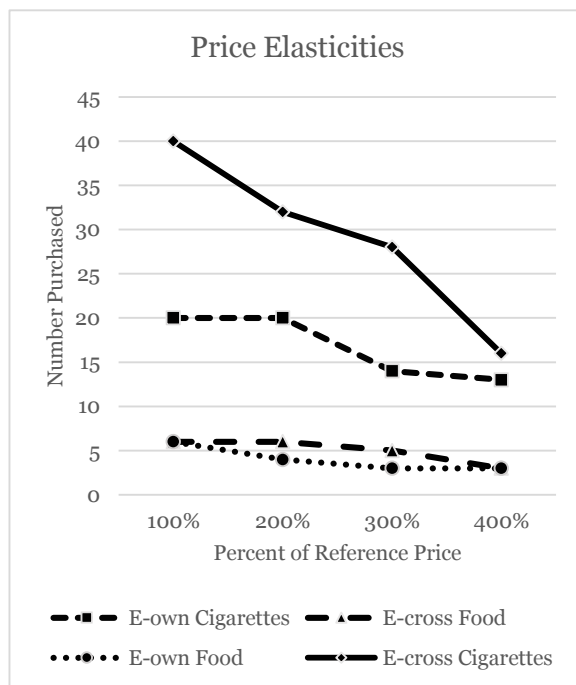
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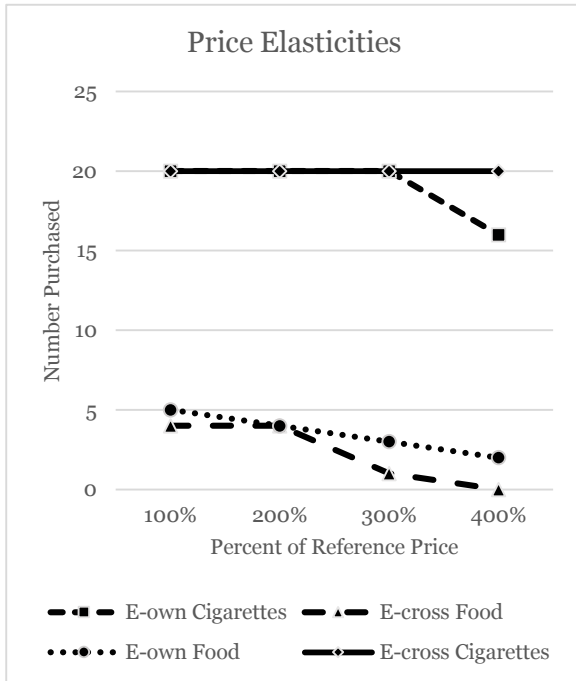
#83



#84



#85



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