Shrinking Goods and Sticky Prices: Theory and Evidence

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Abstract

If producers have more information than consumers about goods' attributes, then they may use non-price (rather than price) adjustment mechanisms and, consequently, the market may reach a new equilibrium even if prices remain sticky. We study a situation where producers adjust the quantity (per package) rather than the price in response to changes in market conditions. Although consumers should be indifferent between equivalent changes in goods' prices and quantities, empirical evidence suggests that consumers often respond differently to price changes and equivalent quantity changes. We offer a possible explanation for this puzzle by constructing and empirically testing a model in which consumers incur cognitive costs when processing goods' price and quantity information. The model is based on evidence from cognitive psychology and explains consumers' decision whether or not to process goods' price and quantity information. Our findings explain why producers sometimes adjust goods' prices and sometimes goods' quantities. In addition, they predict variability in price adjustment costs over time and across economic conditions.

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NEW YORK (CNN) -- When was the last time you carefully checked how much food is in the package? For example, a bag of Tostitos costs $3.29 in New York, as it has for years. But look at the weight: 13 1/2 ounces now, when it used to contain a full ounce more. The lower weight surprised one shopper: "It makes me very angry," she said. "You're paying the same price, but getting less for your money."

Frank Buckley, CNN Correspondent, January 16, 2001[1]

1. Introduction

While the economics literature considers the price system to be the focal mechanism for efficient allocation, price is just one of several product attributes. Other attributes include quantity (i.e., package size), quality, delivery place, delivery time, etc. As Carlton (1983, 1989), Blinder, et al. (1998), and Rosen (1974) argue, any of these attributes may change in response to changes in market conditions. For example, Carlton (1977, 1991) studies environments where delivery time and quality serve as the margin along which the adjustment takes place.

In this paper we consider the product quantity as an alternative margin of choice for adjustment. There is ample anecdotic evidence on quantity adjustment. For example, food manufacturers often downsize their product contents while their prices remain sticky.[2] Manufacturers also offer "value packs," larger packages for the same price. Both types of quantity adjustment, downsizing and upsizing, could be replaced by equivalent changes in prices. The main question we ask in this paper is, when is it optimal to adjust the price and when is it optimal to adjust the quantity.

Swan's (1970) theorem predicts that consumers should be indifferent between price and quantity changes as long as the unit prices are the same.[3] However, empirical evidence suggests that consumers often respond differently to equivalent changes in prices and quantities. For example, Gourville and Kohler (2004) find that consumers are more likely to respond to price increases than to quantity decreases. At the same time, anecdotic evidence suggests that consumers responding to quantity decreases often reduce their demand by more than they reduce it in response to an equivalent price

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[1] Source: http://premium.europe.cnn.com/2001/fyi/news/01/16/grocery.items/index.html.

[2] *NY Times* reported that "Aiming to offset increased ingredient and transportation costs, some of the nation's food manufacturers are reducing the size of packages. The price, of course, usually stays the same." According to a survey the article cites, 71 percent of the consumers believe that the main reason for product downsizing is to hide price increases. Amongst downsized products are Edy's ice cream, Dreyer's ice cream, Pampers diapers, Apple Jacks, Wheaties, Rice Krispies, Cocoa Krispies, Frosted Flakes, Cheerios, Corn Pops, Froot Loops, Doritos, Hellmann's Mayonnaise, Country Crock spread, Dial soap, Bounty paper towels, Dannon yogurt, Skippy peanut butter, Hershey's Special Dark chocolate bar, Iams cat food, Tropicana orange juice, Nabisco Chips Ahoy cookies, etc. Downsizing has been reported in other countries as well, including Canada, Israel, New Zealand, Oman, etc. Source: www.nytimes.com/2008/09/14/business/14feed.html?_r=1&ref=todayspaper&oref=slogin. Many consumer advocates update the list of shrinking products. See, for example, http://incredibleshrinkinggroceries.com.

[3] We use the term quantity to refer to goods' quantity per package . For example, the quantity of a Coca-Cola bottle is 0.5 litters in Europe and 20 fl oz in the US.

increase.[4,5] Price and quantity adjustments, therefore, might have different long run effects on demand (Blinder et al., 1998, Rotemberg, 2005).

In this paper, we construct, calibrate, and test a model which offers a possible explanation for consumers' behavior. In the model, consumers face cognitive costs of information processing and therefore, they must determine how attentive they are by deciding whether to process goods' price information, quantity information, both or neither (Navon and Gopher, 1979, Smith et al., 2003).[6] The model predicts that producers are more likely to decrease quantities than increase prices if consumers are price attentive while they are more likely to increase quantities than to reduce prices if consumers are quantity attentive. We find that in general, consumers are more likely to process goods' price information than quantity information. They are more likely to process both goods' price and quantity information when markets are competitive. The model and the estimation results also suggest that consumers' knowledge of price and quantity information might vary across goods and over the cycle.

We test the model's predictions using data from two surveys on consumers' knowledge of goods' prices and quantities. We find that consumers are more likely to recall goods' quantity during holidays than during other times. We also find evidence that consumers' characteristics and goods' attributes often affect the likelihood of recalling goods' prices and quantities. For example, consumers with large families are more likely to recall goods' prices and quantities. They are also more likely to recall goods' prices if price variance in the category is large and if the goods' are sold in multi-unit packs.

The paper is organized as follows. In section 2, we discuss cognitive costs of information processing and their implications for attention. In section 3, we construct the model. In section 4, we calibrate the model and conduct comparative static experiments. In section 5, we describe the data. In section 6 we test the model's predictions and report the estimation results. Section 7 concludes.

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[4] For example, one consumer who learned that an ice cream producer decreased the size of its products responded by: "Thanks goodness. This will give me a reason to stop buying ice cream." See: www.mouseprint.org/2008/05/12/ice-cream-scoop-major-brands-downsize-again/. See also www.movetonz.org/forum/whats-news/9724-buyers-disgusted-product-downsizing-tactics.html.

[5] Producers seem to respond to this asymmetry in consumers' behavior by strategic use of quantity adjustment instead of price adjustment because in some settings a quantity change may be more profitable than an equivalent price change. For example, Hershey changed the quantity of its bars 15 times during the inflationary period of the 1970s and 1980s but changed the price only 4 times (Knotek, 2011)..

[6] The notion of inattentive behavior that we study here is related to a similar notion studied, for example, in Mankiw and Reis (2002, 2007, 2010), Ball, et al. (2005), Reis (2006a, 2006b, 2009), Klenow and Willis (2007), Knotek (2010), and Ehrmann (2011), to rationally inattentive behavior as in Sims (2003), to absent minded behavior as in Ameriks, et al. (2004), and to the notion of imperfect memory used by some game theorists. Our implementation of the notion, however, differs from the above.

2. Information Processing Costs

Findings by cognitive psychologists suggest that performing cognitive tasks requires *attention*, which is a resource that the brain has in limited capacity (Navon and Gopher, 1979, Kahneman and Treisman, 1984). The amount of attention given to a task depends on its type and priority. High priority tasks and tasks that require large amount of cognitive effort usually receive more attention than routine or automatic tasks. Tasks which cannot receive attention at a given moment are cued until more attention is available.

Processing goods' price and quantity information costs time and effort, because it requires a performance of many subtasks, and each of these subtasks requires attention. For example, to process a good's price information, consumers have to locate the relevant price-tag, code it in visual memory, process it in working memory and finally, store it in long-term memory. These steps are repeated for every piece of information processed. While these subtasks are performed, other tasks and subtasks that require attention are cued. The time dedicated to processing goods' price and quantity information increases, therefore, linearly (or almost linearly) with the number of information pieces processed. Thus, to minimize processing costs, consumers might choose not to process some goods' price and quantity information (Thaler 2000, Levy, et al. 2011).

Following these insights, we construct a model in which consumers face cognitive costs of processing information and assess the cost and the benefits when deciding which information to process. Thus, in our model, processing goods' price and quantity information is costly and consumers choose whether to process goods' price information, quantity information, both, or neither.

3. The Model

(i) Consumers

All consumers are identical and there is a continuum of goods indexed by $i \in (0,1)$. Goods are sold in packages, and each consumer purchases $C(i)$ packages of good $i \in (0,1)$. Each package of good i contains $Q(i)$ units, which we denote as the *quantity* (i.e., the package size) of good i. Consumers therefore consume $C(i)Q(i)$ units of good *i*.

Each consumer is endowed with one unit of time which he uses for labor, leisure and processing goods' information. We denote the time consumers devote to processing goods' information by $\mathrm{T} \in [0,1]$, the time they devote to labor by $N \in [0,1-\mathrm{T}]$ and the time they devote to leisure by $L \in [0,1-\mathrm{T}-N]$. We denote their nominal wage by *W*. Thus, their nominal income, *Y*, is given by $Y = NW$.

Following Galí (2008, p. 41) and Blanchard and Fischer (1989, p. 376), we assume that goods are imperfect substitutes, and that the utility function is:

$$U(C,N,\mathrm{T}) = \frac{C^{1-\sigma}}{1-\sigma} - \frac{N^{1+\varphi}}{1+\varphi} - \frac{\mathrm{T}^{1+\varphi}}{1+\varphi}, \qquad \sigma \in (0,1), \quad \varphi \geq 0 \tag{1}$$

where C is a Dixit-Stiglitz consumption aggregator defined by

$$C = \left\{ \int_0^1 \left[C(i)Q(i) \right]^{\frac{\varepsilon-1}{\varepsilon}} di \right\}^{\frac{\varepsilon}{\varepsilon-1}}. \tag{2}$$

In this specification, $-\sigma$ is the elasticity of marginal utility with respect to consumption, $\varphi \geq 0$ is the elasticity of marginal disutility with respect to labor and with respect to the time devoted to processing goods' information, and $\varepsilon > 1$ is the elasticity of substitution between goods.

(ii) Producers

We focus on consumers' behavior and, therefore, we follow Reis (2006a) and Falkinger (2008) in assuming that producers' price setting decisions are driven by exogenous shocks to their marginal costs.

There is a continuum of monopolistically competitive producers $i \in (0,1)$. Each producer produces a single good, such that producer i produces good i. Producers face constant marginal costs. The marginal cost of producer i is $\Psi(i)$, with $E\{\Psi(i)\} = \Psi$.

Given consumers' utility function (1) and the elasticity of substitution between goods ε, the producers set their prices to equal the marginal costs times the desired markup (Galí, 2008, p. 44). Denoting the price of good i by $P(i)$, the desired markup, $\frac{\varepsilon}{\varepsilon-1}$, by μ, and the expected price by $P^e \equiv E[P(i)]$, we have:

$P(i) = \mu\Psi(i)$, and (3)

$P^e = \mu\Psi$. (4)

We assume that proportion $1-\theta \in (0,1)$ of the producers face marginal costs equal to the expected cost, Ψ.

The rest, proportion $\theta \in (0,1)$ of the producers, face marginal cost shocks $\eta(i)$. Their marginal costs are therefore $\Psi(i) = \Psi + \eta(i)$. We assume that the marginal cost shocks follow a symmetric, i.i.d. distribution with mean 0 and constant variance. We also assume that $|\eta(i)| < \Psi \quad \forall i \in (0,1)$, to ensure that the marginal costs of all producers are positive.

A proportion $\theta_P \in (0,\theta)$ of the producers who face cost shocks adjust their prices. The price that these producers set is given by

$$P(i) = \mu\left[\Psi(i) + \eta(i)\right]. \tag{5}$$

The rest of the producers who experience cost shocks, proportion $\theta_Q \equiv \theta - \theta_P$, respond by adjusting their quantities.[7] Denoting the expected quantity as $Q^e \equiv E[Q(i)]$, these producers adjust their quantities to

$$Q(i) = \kappa(i)Q^e, \tag{5'}$$

where $\kappa(i)$ is the proportion of the expected quantity that solves:

$$\frac{P(i)}{Q^e} = \frac{P}{\kappa(i)Q^e}. \tag{6}$$

Equation (6) states that the *unit-price* of good i, $\frac{P(i)}{Q(i)}$, is the same whether the producer adjusts the price (LHS) or the quantity (RHS) in response to a given cost shock. Solving (6) for $\kappa(i)$ yields:

$$\kappa(i) = \frac{\Psi}{\Psi + \eta(i)} \tag{7}$$

Thus, producers who do not experience a marginal cost shock set the quantity equal to the expected quantity, Q^e. Producers who experience a cost shock either adjust the price according to (5) or the quantity according to (5') and (7).

[7] Although we do not model the producers' decision process, it is likely that decisions on whether to adjust prices or quantities depend on the exact nature of the shocks and on the market structure. For example, some producers argue that in competitive markets, it is sometimes better to downsize a good than to increase its price. Source: www.usatoday.com/money/industries/food/2008-06-11-shrinking-sizes_N.htm.

(iii) Consumers' Decision Making Process

We assume consumers purchase goods in shops, that all shops are identical and that the travel costs are zero. When in a shop, consumers have the option of processing goods' price information, goods' quantity information, both or neither. All goods enter the utility function symmetrically and, therefore, consumers treat them symmetrically. We assume, therefore, that consumers either choose to process the price information of all goods, or they choose not to process the price information of any good. Similarly, we assume that consumers either choose to process the quantity information of all goods, or they choose not to process the quantity information of any good.[8]

Consumers therefore choose one of four attention modes. *Price attentive* consumers (*PA*) process only good's price information. They therefore know the price of every good $P(i)$, $i \in (0,1)$, but assume that all goods' quantities are equal to the expected quantity, Q^e. *Quantity attentive* (*QA*) consumers process only goods' quantity information. Therefore, they know the quantity of every good $Q(i)$, $i \in (0,1)$, but assume that all goods' prices are equal to the expected price, P^e.

Price and quantity attentive consumers (*PQA*) process both the price and the quantity information of every good i. They therefore know the price $P(i)$, and the quantity $Q(i)$ of every good $i \in (0,1)$. *Inattentive* consumers (*IA*) do not process goods' price nor goods' quantity information. They, therefore, assume that every good's price and quantity equal their expected values P^e and Q^e, respectively**.**

We denote the cost of processing one price information by τ_P and the cost of processing one quantity information by τ_Q. To ensure that consumers can process both price and quantity per package information, we assume that $\tau_P + \tau_Q \leq 1$. The discussion above suggests that the time required for information processing increases linearly with the number of price and quantity information processed. Therefore, the cost of being price and quantity inattentive is therefore zero, the cost of being price attentive is

[8] This assumption is similar the one made by Gabaix and Laibson (2006) and Armstrong and Chen (2009) who assume that a certain proportion of the consumers have information about all goods, while the rest of the consumers do not have information about any good.

$\int_0^1 \tau_P di = \tau_P$, the cost of being quantity attentive is $\int_0^1 \tau_Q di = \tau_Q$ and the cost of being price and quantity attentive is $\int_0^1 \left(\tau_P + \tau_Q\right) di = \tau_P + \tau_Q$.

We denote the demand of consumers for good i in attention mode $\kappa \in \{PA,\ QA,\ PQA,\ IA\}$ by $C_\kappa(i)$ and the consumption bundle of consumers in attention mode κ by C_κ.

Following Galí (2008), we define the price level that consumers face in attention mode $\kappa \in \{PA,\ QA,\ PQA,\ IA\}$ by $P_\kappa = \frac{1}{C_\kappa}\left[\int_0^1 C_\kappa(i)P(i)di\right]$. Consumers choose the attention mode that maximizes their utility subject to the time constraint, $L + N + \mathrm{T} \le 1$, and their preferences for labor, leisure and information processing.

The demand of *price attentive* (PA) consumers for good i, $C_{PA}(i)$, and the price level they face, P_{PA}, are respectively, given by (see the appendix)

$$C_{PA}(i) = \left[\frac{P(i)^{-\varepsilon}}{\int_0^1 P(j)^{1-\varepsilon} dj}\right] Y_{PA}, \text{ and} \tag{8}$$

$$P_{PA} = \frac{\int_0^1 P(j)^{1-\varepsilon} dj}{\left[\int_0^1 P(j)^{1-\varepsilon} Q(j)^{\frac{\varepsilon-1}{\varepsilon}} dj\right]^{\frac{\varepsilon}{\varepsilon-1}}}. \tag{9}$$

The demand of *quantity attentive* (QA) consumers for good i, $C_{QA}(i)$, and the price level they face, P_{QA}, are given respectively by (see the appendix)

$$C_{QA}(i) = \left[\frac{Q(i)^{\varepsilon-1}}{\int_0^1 Q(j)^{\varepsilon-1} dj}\right] \frac{Y_{QA}}{P(i)}, \text{ and} \tag{10}$$

$$P_{QA} = \frac{\int_0^1 P(j)Q(j)^{\varepsilon-1} dj}{\left[\int_0^1 Q(j)^{\varepsilon-1} dj\right]^{\frac{\varepsilon-1}{\varepsilon}}}. \tag{11}$$

The demand of *price and quantity attentive* (PQA) consumers for good i, $C_{PQA}(i)$, and the price level they face, P_{PQA}, are given respectively by (see the appendix)

$$C_{PQA}(i) = \frac{\left[\frac{P(i)}{Q(i)}\right]^{1-\varepsilon} Y_{PQA}}{P(i)\int_0^1 \left[\frac{P(i)}{Q(i)}\right]^{1-\varepsilon} dj}, \text{ and} \tag{12}$$

$$P_{PQA} = \left\{\int_0^1 \left[\frac{P(j)}{Q(j)}\right]^{1-\varepsilon} dj\right\}^{\frac{1}{1-\varepsilon}}. \tag{13}$$

The demand of *price and quantity inattentive* (IA) consumers for good i, $C_{IA}(i)$, and the price level that they face, P_{IA}, are given respectively by (see the appendix)

$$C_{IA}(i) = \frac{Y_{IA}}{P(i)}, \text{ and} \tag{14}$$

$$P_{IA} = \left\{\int_0^1 \left[\frac{P(i)}{Q(i)}\right]^{\frac{\varepsilon}{\varepsilon-1}} di\right\}^{\frac{\varepsilon}{1-\varepsilon}}. \tag{15}$$

Thus, equation (14) states that inattentive consumers spend an equal fraction of their income on each good. Thus, the number of units of each good $i \in (0,1)$ they purchase equals their expenditure on that good, Y_{IA}, divided by the good's price $P(i)$. Consequently, they do not substitute goods that have high unit-prices, $\frac{P(i)}{Q(i)}$, with goods that have lower unit-prices, and therefore they face a higher price level than consumers who do substitute.

Price and quantity attentive consumers, on the other hand, process both goods' price information and goods' quantity information. Therefore, equation (12) states that they base their consumption decisions on the ratio of goods' unit-prices, $\frac{P(i)}{Q(i)}$ and an aggregate of all goods' unit-prices, $\int_0^1 \left[\frac{P(j)}{Q(j)}\right]^{1-\varepsilon} dj$. Consequently, they substitute high

unit price goods with low unit price goods and therefore, the price level they face (13), is lower than the price level inattentive consumers face.

Price attentive consumers substitute high price goods with low price goods, but they do not substitute goods that have small quantities with goods that have large quantities. Thus, their demand for good i, (8), depends negatively on the ratio of goods' prices and an aggregate of all prices, $\int_0^1 P(j)^{1-\varepsilon}\,dj$, but it does not depend on goods' quantities. The penalty price attentive consumers pay for not processing goods' quantity information is therefore given by the effect that goods' quantities have on the denominator of (9). Because price attentive consumers do not process goods' quantity information, goods with small quantity enter the denominator with the same weight as goods with large quantity. Consequently, goods with small quantity decrease the denominator and, therefore, increase the price level that price attentive consumers face.

Quantity attentive consumers substitute goods with small quantities with goods with large quantities, but they do not substitute goods that have high prices with goods that have low prices. Thus, the share of income that quantity attentive consumers spend on good i, (10), depends positively on the ratio of the good's quantity, $Q(i)$, and an aggregate of all goods' quantities, $\int_0^1 Q(j)^{\varepsilon-1}\,dj$. The penalty quantity attentive consumers pay for not processing goods price information is given by the positive effect that prices have on the numerator of (11). Because quantity attentive consumers do not process price information, goods with high prices are given the same weight in the numerator of (11) as goods with lower prices and, therefore, goods with high prices increase the price level quantity attentive consumers face.

Because price attentive and quantity attentive consumers make some of the substitutions that price and quantity attentive consumers make but not all, the price level they face is lower than the price level that inattentive consumers face but higher than the price level that price and quantity attentive consumers face.

Given the price level under each attention mode, consumers choose the attention mode that maximizes their utility (1), subject to their income and time constraints:

$$\max\left[U_k\left(C,N,\mathrm{T}\right)\right]=\max\left\{\frac{C_k^{\,1-\sigma}}{1-\sigma}-\frac{N_k^{\,1+\varphi}}{1+\varphi}-\frac{\mathrm{T}_k^{\,1+\varphi}}{1+\varphi}\right\} \tag{16}$$

s.t.

$$C_k P_k = Y_k \tag{17}$$

$$N_k \in [0, 1 - \mathrm{T}_k] \tag{18}$$

where C_k is the aggregate consumption (2) in attention mode k, N_k is the time dedicated to labor in attention mode k,

$$\mathrm{T}_k = \delta_P(k)\tau_P + \delta_Q(k)\tau_Q \tag{19}$$

is the time spent on processing goods' information in attention mode k, δ_P and δ_Q are indicator functions defined by

$$\delta_p(k) = \begin{cases} 0 & if \quad k \in \{QA, \quad IA\} \\ 1 & if \quad k \in \{PA, \quad PQA\} \end{cases} \text{ and} \tag{20}$$

$$\delta_q(k) = \begin{cases} 0 & if \quad k \in \{PA, \quad IA\} \\ 1 & if \quad k \in \{QA, \quad PQA\} \end{cases}, \tag{21}$$

$$Y_k = N_k W \tag{22}$$

is consumers' nominal income, P_k is the price level consumers face in attention mode k, which satisfies

$$C_k P_k = \int_0^1 C_k(i) P_k(i)\, di, \tag{23}$$

and $k \in \{PA, QA, PQA, IA\}$.

The first order necessary conditions with respect to C_k and N_k respectively are:

$$C_k^{-\sigma} = \lambda P_k \tag{24}$$

and

$$-N_k^{\varphi} = -\lambda \ W. \tag{25}$$

Dividing (25) by (24) and rearranging terms, we find that as long as the time constraint (18), is not binding, aggregate consumption is given by:

$$C_k = \left(\frac{W}{P_k}\right)^{\frac{1}{\sigma}} N_k^{\frac{-\varphi}{\sigma}}. \tag{26}$$

Substituting (26) in the budget constraint (17), we find that as long as the time constraint (18) is not binding, the time dedicated to labor N_k, is given by $\left(\frac{W}{P_k}\right)^{\frac{1-\sigma}{\varphi+\sigma}}$. If

the time constraint is binding, consumers dedicate to labor all the time that they do not spend on processing goods' information. Thus,

$$N_k = \begin{cases} \left(\frac{W}{P_k}\right)^{\frac{1-\sigma}{\varphi+\sigma}} & if \quad \left(\frac{W}{P_k}\right)^{\frac{1-\sigma}{\varphi+\sigma}} \le 1-\left(\delta_p(k)\tau_p + \delta_Q(k)\tau_Q\right) \\ 1-\left(\delta_p(k)\tau_p + \delta_Q(k)\tau_Q\right) & if \quad \left(\frac{W}{P_k}\right)^{\frac{1-\sigma}{\varphi+\sigma}} > 1-\left(\delta_p(k)\tau_p + \delta_Q(k)\tau_Q\right) \end{cases} \tag{27}$$

Consumers' nominal income (22), is therefore given by

$$Y_k = \begin{cases} W^{\frac{1+\varphi}{\varphi+\sigma}} P_k^{\frac{\sigma-1}{\varphi+\sigma}} & if \quad \left(\frac{W}{P_k}\right)^{\frac{1-\sigma}{\varphi+\sigma}} \le 1-\left(\delta_p(k)\tau_p + \delta_Q(k)\tau_Q\right) \\ \left[1-(\delta_p(k)\tau_p + \delta_Q(k)\tau_Q)\right]W & if \quad \left(\frac{W}{P_k}\right)^{\frac{1-\sigma}{\varphi+\sigma}} > 1-\left(\delta_p(k)\tau_p + \delta_Q(k)\tau_Q\right) \end{cases} \tag{28}$$

Since consumers spend all their income on consumption, aggregate consumption is equal to real income $\frac{Y_k}{P_k}$, and is therefore given by

$$C_k = \frac{Y_k}{P_k} = \begin{cases} \left(\frac{W}{P_k}\right)^{\frac{1+\varphi}{\varphi+\sigma}} & if \quad \left(\frac{W}{P_k}\right)^{\frac{1-\sigma}{\varphi+\sigma}} \le 1-\left(\delta_p(k)\tau_p + \delta_Q(k)\tau_Q\right) \\ \left[1-(\delta_p(k)\tau_p + \right. & \\ \left. \quad +\delta_Q(k)\tau_Q\right]\frac{W}{P} & if \quad \left(\frac{W}{P_k}\right)^{\frac{1-\sigma}{\varphi+\sigma}} > 1-\left(\delta_p(k)\tau_p + \delta_Q(k)\tau_Q\right) \end{cases} \tag{29}$$

Substituting (21), (27) and (29) in (1), we obtain the consumers' utility:

$$U_k = \frac{1}{1-\sigma}\left(\frac{W}{P_k}\right)^{\frac{(1+\varphi)(1-\sigma)}{\varphi+\sigma}} - \frac{1}{1+\varphi}\left(\frac{W}{P}\right)^{\frac{(1+\varphi)(1-\sigma)}{\varphi+\sigma}} - \frac{\left(\delta_p\delta_Q(k)\tau_Q\frac{W}{P}\tau_p + \delta_Q\delta_Q(k)\tau_Q\frac{W}{P}\tau_Q\right)^{(1+\varphi)}}{1+\varphi} \tag{30}$$

if

$$\left(\frac{W}{P_k}\right)^{\frac{1-\sigma}{\varphi+\sigma}} \le 1-\left(\delta_p\delta_Q(k)\tau_Q + \delta_Q\delta_Q(k)\tau_Q\right),$$

and

$$U_k = \frac{1}{1-\sigma}\left\{\left[1-(\delta_p(k)\tau_p + \delta_Q(k)\tau_Q)\right]\frac{W}{P_k}\right\}^{1-\sigma}$$
$$-\frac{1}{1+\varphi}\left[1-\left(\delta_p\delta_Q(k)\tau_Q\frac{W}{P}\tau_p + \delta_Q\delta_Q(k)\tau_Q\frac{W}{P}\tau_Q\right)\right]^{(1+\varphi)} \quad (30')$$
$$-\left(\delta_p\delta_Q(k)\tau_Q\frac{W}{P}\tau_p + \delta_Q\delta_Q(k)\tau_Q\frac{W}{P}\tau_Q\right)^{(1+\varphi)}$$

if

$$\left(\frac{W}{P}\right)^{\frac{1-\sigma}{\varphi+\sigma}} > 1-\left(\delta_p\delta_Q(k) + \delta_Q\delta_Q(k)\right).$$

Taking the nominal wage W, and the costs of processing goods' information τ_P and τ_Q as given, consumers choose the attention mode which maximizes their utility:

$$\max U = \max\left\{U_{PA}, U_{QA}, U_{PQA}, U_{IA}\right\} \quad (31)$$

Since all consumers are identical, all of them choose the same attention mode and therefore, all the consumers face the same price level.

4. Calibration and Comparative Statics

(i) Benchmark Economy

To study consumers' choices of attention modes, we calibrate the model for a benchmark economy and simulate it to study the effects of changes in the model's parameters. For the benchmark economy, we assume that the elasticity of marginal utility with respect to consumption, σ, is –0.2 and the elasticity of marginal disutility with respect to labor, φ, is 0.1. Thus, the marginal utility with respect to consumption decreases relatively slowly, and the marginal disutility with respect to labor increases almost linearly.

Following Barsky et al.'s (2003), we set the mark up $\mu = \frac{\varepsilon}{\varepsilon-1} = 1.1$ and therefore the elasticity of substitution between goods, ε, equals 11. We normalize the nominal wage, *W*, the producers' expected marginal cost, Ψ, and the expected quantity per package, Q^e to equal one.

Bils and Klenow (2004) and Nakamura and Steinsson (2008) report that the monthly frequency of consumers' goods' price changes is between 11%–25% per month.

We therefore set the fraction of producers who experience marginal cost shocks and adjust their goods' prices, θ_P, to 0.15.

Following Gourville and Kohler (2004) who study changes in the prices and quantities of four goods and report that the monthly frequency of changes in quantities is between 2.7% and 8.2%, we set the fraction of producers who experience marginal cost shocks and adjust their goods' quantities, θ_Q, equal to 0.05.

We assume that half of the producers who experience a marginal cost shock experience a positive shock, $\eta_h > 0$ and half experience a negative shock, $\eta_l < 0$. In addition, we assume that $\eta_h = |\eta_l|$. Following Nakamura and Steinsson (2008) who report that most price changes are in the range of 10%–30%, we set $\eta_h = |\eta_l| = 0.15$.

Figure 1 divides the τ_P, τ_Q space into four regions, indicating the combinations of the price information processing cost (τ_P) and the quantity information processing cost (τ_Q) for which consumers are: price attentive (PA), quantity attentive (QA), price and quantity attentive (PQA), and inattentive (IA). According to Figure 1, consumers are price and quantity attentive if both $\tau_P < 0.024$ and τ_Q is in the range 0.05–0.08. If $\tau_P > 0.024$ and $\tau_Q > 0.005$, consumers are inattentive. They are price attentive if $\tau_Q > 0.008$ and $\tau_P < 0.024$. They are quantity attentive if $\tau_P > 0.024$ and $\tau_Q < 0.005$.[9]

Thus, consumers are inattentive even if the total cost of processing price and quantity information is relatively small and they are more likely to be price attentive than quantity attentive. There are two reasons for the last result. First, we assume that more producers adjust prices than quantities. Consequently, consumers have greater benefits from processing goods' price than quantity information. Second, prices enter the budget constraint, while quantities enter the utility function. An increase in prices, therefore, has a linear effect because it reduces the number of units consumers can buy whereas a decrease in quantity has a smaller than linear effect on utility because quantities appear in the utility function with coefficient less than 1.

[9] Interpreting the time unit in the model as one month, with 4 weeks/month, 5 days/week, 16 hours/day for labor and leisure, and consumers make 8 shopping trips per month, consumers are price and quantity inattentive if processing goods' price and quantity information costs more than a total of 20–60 minutes. For example, when $\tau_Q = 0.008$ and $\tau_P = 0$, consumers need $0.008 \times 4 \times 5 \times 16 \times 60 \approx 160$ minutes/month for processing goods' information. With 8 shopping trips/month, they need 160/8= 20 minutes per shopping trip.

The model, therefore, explains both Fox and Hoch's (2005) finding that over 90 percent of consumers are price and quantity inattentive and Gourville and Kohler's (2004) finding that consumers are more likely to respond to price increases than to quantity decreases.

(ii) Changing the Elasticity of Marginal Utility w.r.t. Consumption and Labor

Figure 2 depicts the effect of increasing consumers' elasticity of marginal utility with respect to consumption, $-\sigma$, from –0.2 to –0.05. When $-\sigma$ increases, consumers have greater incentive to process goods' price and quantity information because their utility from consumption increases. Consumers, therefore, devote time and effort to processing goods' price and quantity information for greater costs of information processing than consumers in the benchmark setting.

Figure 3 shows the effect of increasing consumers' elasticity of marginal disutility with respect to labor , φ, from 0.1 to 0.15. When φ increases, consumers choose to process goods' price and quantity information for higher costs of information processing. The reason is that as φ increases, consumers lose more utility from any given amount of time they dedicate to labor. They are therefore more willing to trade time devoted to labor for time devoted to information processing.

(iii) Changing Consumers' Wage

Figure 4 depicts the effect of decreasing the wage (*W*) from 1 to 0.9. Changing *W* has two opposite effects on consumers' choices of attention mode. On the one hand, there is a negative substitution effect, because when *W* increases, time becomes more valuable. On the other hand, there is a positive income effect, because when *W* increases, consumers can purchase more packages, and therefore their benefits from lower price level increase. Thus, the total effect of the change in the consumers' wage is ambiguous.[10] Simulations using different values of *W* suggest, however, that when consumers' income decreases, the positive income effect usually dominates the negative substitution effect. Low-income consumers are, therefore, more likely to process goods' price and quantity information than consumers with average incomes, which is consistent with the findings reported by Gabor and Granger (1961, 1966) and Falkinger (2008).

[10] Hoch, et al. (1995) find that income has an ambiguous effect on the price elasticity of food and cleaning detergents.

(iv) <u>Changing the Fraction of Producers Who Adjust Goods' Price/Quantity</u>

Figures 5 and 6 depict the effects of increasing the shares of producers who adjust prices, θ_P, and quantities, θ_Q. In Figure 5, θ_P increases from 0.15 to 0.25 while in Figure 6, θ_Q increases from 0.05 to 0.2. The effects of both changes are similar. When the fraction of producers who adjust their goods' prices, θ_P, or quantities, θ_Q, increases, consumers become price and quantity attentive for larger costs of processing goods' price and quantity information. The reason is that when the fraction of producers who adjust either their goods' prices or quantities increases, the variance of goods' unit-prices, $Var\left[\frac{P(i)}{Q(i)}\right]$, increases and, therefore, consumers have greater incentives to process goods' price and quantity information.

(v) <u>Changing the Elasticity of Substitution between Goods</u>

Figure 7 depicts the ceteris paribus effect of increasing the elasticity of substitution ε, from 11 to 21.[11] When ε increases, consumers become price and quantity attentive for larger costs of processing goods' price and quantity information. The reason is that when ε increases, consumers are more willing to substitute high unit-price goods with low unit-price goods and, therefore, they benefit more from processing goods' price and quantity information.

(vi) <u>Changing the Expected Marginal Cost</u>

Increasing the expected marginal cost Ψ, leads to a proportional increase in the expected unit-price of all goods. This has two opposite effects on consumers' choices of attention modes. On the one hand, higher expected unit-price has a negative income effect, because an increase in the average price reduces real income. On the other hand, increasing the expected price while holding the size of the marginal cost shocks unchanged reduces the substitution effect, because the relative differences between goods that their price differs from the expected price and goods that their prices equal the expected price become smaller. Thus, the total effect of an increase in Ψ is ambiguous. For example, holding everything else the same as in the benchmark economy, as long as Ψ is between 1 and 2.5 consumers process goods' price and quantity information only

[11] Without the ceteris paribus constraint, an increase in the elasticity of substitution from 11 to 21 would have caused producers to reduce their markups from 1.1 to 1.05.

for smaller costs of information processing than in the benchmark economy. If $\Psi > 2.5$, as in Figure 8 where $\Psi = 3$, the income effect dominates and consumers are price and quantity attentive for larger costs of processing goods' price and quantity information than consumers in the benchmark economy.

(vii) <u>Changing the Expected Quantity</u>

Figure 9 depicts the effect of an increase in goods' expected quantity, Q^e, from 1 to 1.5. When Q^e increases, consumers become price and quantity attentive for larger costs of processing goods' price and quantity information. The reason is that when Q^e increases, consumers receive more utility from each package they purchase. Consequently, they have greater incentives to process goods' price and quantity information.

(viii) <u>Changing the Size of the Marginal Cost Shock</u>

Figure 10 depicts the effect of an increase in the absolute value of the marginal cost shocks from $|\eta| = 0.15$ to $|\eta| = 0.2$. When $|\eta_h|$ and $|\eta_l|$ increase, consumers become price and quantity attentive for larger costs of processing goods' price and quantity information. The reason is that when $|\eta_h|$ and $|\eta_l|$ increase, the variance of goods' unit-prices increases and, therefore, consumers lose more utility if they do not process either goods' price or quantity information.

4. Data

Our data comes from two surveys conducted in Israel during 2005–2008. In the first survey, we sampled consumers in two supermarkets (supermarkets 1 and 2 in Table 1) and in the second, in 13 supermarkets (supermarkets 3–15 in Table 1). 11 of the 15 supermarkets belong to large national chains and the rest are either unaffiliated or affiliated with local chains.

The supermarkets are located in 7 cities. About half of the supermarkets are *discount* supermarkets which offer lower prices, lower quality of services and usually carry fewer brands than other supermarkets. Some information about the supermarkets and the consumers who live in the cities where they are located is given in Tables 1–3.

During the survey period, the Israeli GDP grew at an annual rate of 4%–6.5%.[12] The annual inflation during 2005–2007 was between 0%–2%. It increased to 3.7% in 2008.[13]

In both surveys, consumers were approached as they came out of supermarkets, immediately after they finished their shopping. The theory of retrieval cues (Laibson, 2001, Smith et al., 2003) suggests that consumers are more likely to succeed in retrieving information about goods' prices and quantities at the exit from supermarkets than in other places because there they usually have more retrieval cues.[14]

Consumers who agreed to participate were first asked about their socio-economic status and then they were shown a list of goods.[15] Consumers usually needed about five minutes to answer all the questions.

The first survey was conducted before, during and after the Passover holiday in April–May 2005. In that survey, the list of goods included 10 goods that were sold at a price discount, 10 goods that were sold at a quantity discount, and 10 goods that were sold at their list prices.[16] Consumers were asked, however, only about goods they purchased in their current shopping trips. For each good, consumers were asked to recall whether or not it was offered at a discount. Table 4 gives information about the sampled goods.

The second survey was conducted as follows: in Supermarkets 3–5 during April–July 2006, in Supermarkets 6–9 during April–July 2007 and in Supermarkets 10–15 during April–October 2008. The lists consumers were shown contained goods belonging to one of 17 categories, which represent a large proportion of the goods sold in Israeli supermarkets. Table 5 offers the list of categories. It also offers summary statistics of the goods that were sampled in Supermarket 3.[17] Consumers were asked only about goods they purchased in their current shopping trip. For each of these goods, consumers were asked to recall the good's price and quantity. Consumers were also asked about purchase frequency of the goods, about the number of packages they purchased in the current

[12] Source: www.cbs.gov.il/shnaton60/st14_02x.pdf.
[13] Source: www.cbs.gov.il/www/price_new/g1_2_h.pdf.
[14] We were not allowed to interview them inside the supermarkets.
[15] We asked about 30% of the subjects on their socio-economic status after they finished the main part of the questionnaire. This did not significantly affect the responses.
[16] For each supermarket, the lists were updated every week. An example of a *price discount* is a 6-pack of 1.5L bottles of Pepsi sold for NIS 21.89 instead of the list price of NIS 26.40 (i.e., a lower price for the same quantity). An example of a *quantity discount* is Coca-Cola sold in bottles of 1.75L instead of the standard 1.5L for the same price (i.e., a higher quantity for the same price). "Value packs" and "Bonus packs" sometimes offered by US retailers is an example of a quantity discount.
[17] We present Supermarket 3 data as an example because the frequency of price changes in Supermarket 3 is similar to the one we find in many of the other supermarkets in the dataset.

shopping trip, about consumption frequency of these goods, and whether the goods are usually consumed by themselves, by their spouses, by their children or by their friends and relatives.[18]

5. Empirical Tests and Estimation Results

(i) Test 1: Consumers' Attention to Goods' Prices and Quantities

In the second survey, consumers exiting supermarkets were asked to recall the prices and quantities of goods they bought. The psychology literature on depth of processing and memorizing techniques suggests that the probability of successfully storing and recalling information is correlated with the time and effort dedicated to processing it (Smith, et al., 2003, p. 278). We therefore use the errors that consumers make in recalling price and quantity information as a proxy for the time and effort they devote to processing goods' price and quantity information (Vanhuele and Drèze, 2002).

The mean absolute price error in our sample is 33%, which is similar to the figure reported by Vanhuele and Drèze (2002). The mean absolute quantity error is close to 450% suggesting that consumers face greater difficulties in processing quantity information than price information. Indeed, evidence suggests consumers and students alike face significant difficulties when facing problems about measurement units. [19] In addition, the cognitive information processing cost is usually larger for quantity than price because it is usually easier to find price information than quantity information (Miyazaki et al., 2000).

Following the model, we assume that the likelihood of correctly recalling goods' price and quantity information depends on consumers' and goods' attributes and on market conditions. Because we are interested in consumers' knowledge of both prices and quantities, we estimate two regressions. In one, the dependent variable is the absolute percentage error consumers make in recalling goods' price information. In the second, the dependent variable is the absolute percentage error made in recalling quantity information. Because the errors in recalling the price and quantity information of the same good might be correlated, we use the SUR approach. In both regressions, we include the same set of independent variables: A gender dummy (1 if a consumer is a

[18] The survey was conducted in Hebrew. An English version of the questionnaire is available upon request.
[19] In US standard math exams, for example, about 50 percent of the students fail in questions involving measurement units. Source: www.k12.wa.us/research/pubdocs/pdf/mathbook.pdf. See also the discussion on the failure of the metric education system in the UK and its possible implications for consumers: www.bwmaonline.com/The%20Failure%20of%20Metrication%20by%20Education.htm.

woman), an education dummy (1 if a consumer has an *academic degree*), a large family dummy (1 if a consumer's *family* has *more than five members*), a religion dummy (1 if a consumer defines himself as *moderately religious*), a discount supermarket dummy (1 if it is a *discount supermarket*), a location dummy (1 if a supermarket is located *outside a city*), a duration dummy (1 if the good is consumed *within a short period*), a package dummy (1 if a good is sold in *multi-unit packages*), the goods' *price* and *quantity* as *recalled* by the consumer, the category-level *average price* and the *average quantity*, the category-level *standard deviation of prices* and *quantities*, the year 2008 dummy, a holiday dummy (1 if a good was purchased during *a holiday* period) and fixed effects for goods' categories, for consumers' age groups and for the cities where the supermarkets are located.[20]

We do not have any specific hypothesis about the gender dummy, and we include it to avoid missing variables bias. We expect subjects with academic background to have lower information processing costs, because evidence from psychology literature suggests that the ability to obtain higher education is correlated with better memorization and retrieval skills (Dehn, 2008). We expect consumers with large households to have greater benefits from processing price and quantity information because such consumers often purchase large quantities of each good.

Consumers with a moderate-Jewish religious background often purchase only goods that satisfy strict Kosher requirements. Therefore, brands that satisfy religious consumers' Kosher requirements often have greater market power among religious consumers than among the general population. The discussion following Figure 7 suggests, therefore, that religious consumers will tend to be less likely to process goods' price and quantity information.

We expect that consumers who shop in discount supermarkets are likely to have lower opportunity cost of time and tighter budget constraints than consumers who shop in more expensive locations. We therefore expect consumers shopping in discount supermarket to be more likely to process goods' price and quantity information. We do not have a priori expectations about consumers who shop in supermarkets located outside cities, because although such supermarkets tend to be discount supermarkets, they often appeal mostly to consumers with cars who shop on their way home.

[20] We also added a variable for the consumers' average expenditure, but it was insignificant in both this and the regression reported in section (ii), perhaps because we used relatively large expenditure brackets in the survey, and consequently much of the variance between consumers was lost.

Goods that are consumed within a short period are usually goods for which consumers have greater appetite than goods consumed over longer periods. Thus, we expect that consumers are more likely to correctly recall the prices and quantities of such goods. Goods sold in multi-unit packs offer greater quantity per package and, therefore, consumers have greater incentives to process their price and quantity information. However, it is also harder to process the quantities of multi-unit packs because the calculation involves a multiplication operation.[21] We hypothesize, therefore, that consumers are more likely to correctly recall multi-unit packs' prices, but we do not have ex-ante predictions about the effect that multi-packs have on the likelihood of recalling quantity information.

Evidence from marketing literature suggests that consumers form reference prices for product categories, and that these reference prices depend either on the recalled prices of selected brands (*internal* reference prices) or on the average price in the category (*external* reference price). According to this literature, consumers tend to choose brands that offer them the lowest price relative to the reference price rather than the brands that offer them the lowest absolute prices (Kalyanaram and Winer, 1995, Mazumdar and Papatla, 2000). We therefore include in the regression, goods' recalled prices and quantities together with the average prices and quantities in the category to avoid a missing variables bias.[22]

The model suggests that an increase in the variance of goods' prices and quantities make consumers more likely to process goods' price and quantity information. Increasing the variance, however, also increases the cost of processing price and quantity information because there is more information to process. We therefore do not have ex-ante prediction on the effects of increasing the variance of prices and quantities.

The inflation in Israel was 3.7 percent in 2008, whereas during earlier years it hovered around 0 percent. 2008 was also a year of economic slowdown and, therefore, many consumers experienced a decrease in their incomes. We therefore include a 2008 dummy to control for these two effects. Because moderate inflations are often associated with an increase in the share of producers who adjust prices, the discussions following Figure 4, 5 and 6 suggest that in 2008 consumers should be more likely to devote time

[21] For example, the quantity of a 6-pack of Pepsi (16 fl oz per bottle) is 6×16= 96 fl oz.
[22] We find that omitting these variables affects the significance of some of the other variables but it usually has only a small effect on the size of the coefficients.

and cognitive effort to processing goods' price and quantity information than in 2006 and 2007 (Gagnon, 2009).

As discussed above, consumers are likely to have greater marginal benefits from consumption in holidays than in other times both because they have more leisure and because consumption in holidays often takes place in social settings. Thus, we hypothesize that during holidays, consumers should be more likely to process goods' price and quantity information.

Because the dependent variables are the absolute percentage errors consumers make, negative coefficients indicate better recall. We, therefore, expect that the variables that increase consumers' benefits from information processing to have negative coefficients in both regressions, while the variables that increase the costs of information processing to have positive coefficients. In addition, we expect that variables that affect the costs side have stronger effects in the quantity regression than in the price regression because the cost of processing quantity information is greater, and also because the evidence suggests that changes in cognitive costs affect behavior more when the cognitive costs are high than when they are low. For example, Kahneman and Frederick (2002, p. 68) find that if cognitive costs are low, all subjects tend to process information efficiently but if cognitive costs are high subjects with less efficient processing skills use heuristics instead of efficient processing.

The estimation results are reported in Table 6. From the discussion above it follows that the coefficients of *academic degree*, *family has more than five members*, *discount supermarket*, *goods consumed within a short period*, *year 2008* and *holiday*, should have negative coefficients. The variable *moderately religious* should have a positive coefficient. We find that the coefficients of all these controls except for the coefficient of *families with more than five members* are indeed significant in at least one of the regressions and all the statistically significant coefficients have the expected signs.[23] As hypothesized above, the effects are greater in the quantity regression than in the price regression, because the costs of processing quantity information is greater than the costs of processing price information. All the coefficients are at least marginally significant in the quantity regression but some are not significant in the price regression.

Consistent with our hypothesis that during holidays consumers have greater marginal utility from consumption, we find that during holidays consumers are more

[23] In our sample, there is relatively low variance in the family size. The largest families have 6 members and the average families have about 4 members.

likely to correctly recall both goods' prices and quantities. Thus, the results suggest that producers face different demand elasticities for prices and quantities in holidays relative to other time, which may partly explain the greater price rigidity observed during holidays (Warner and Barsky, 1995, Chevalier et al., 2003, Levy et al., 2010).

The results also suggest that goods' attributes have the expected effects. Consumers are more likely to correctly recall the quantities of *goods consumed within a short period* and the prices of goods sold in *multi-packs*. At the same time, they are less likely to correctly recall the quantities of goods sold in multi-packs, suggesting that although consumers have greater incentives to process the quantities of multi-packs than of other goods, the greater cognitive costs required for processing the quantities in multi-packs relative to other goods have an even greater effect.

Increasing the category variance has a similar effect to selling goods in multi-packs. Thus, increasing the variance of prices in a category seems to increase the likelihood of correctly recalling price information. At the same time, an increase in the variance of the quantities in a category reduces the likelihood of a correct recall. The results, therefore, suggest again that the costs of processing quantity information are greater than the costs of processing price information. Thus, if the variance of prices increases, the positive effect of an increase in the benefits dominates (Krieder and Han, 2004). If the variance of quantities increases, the negative effect of the increase in the costs dominates.[24]

The coefficients of *woman* are positive and significant in both regressions. Thus, in our data, men tend to make smaller errors than women.[25] The discussion above suggests that consumers should be more likely to recall goods price and quantity information in 2008 than in 2006 and 2007. Consistent with these predictions, the coefficients of the *2008 dummy* are negative in both regressions.

The *holiday* coefficients are negative in both regressions, suggesting, as discussed above, that consumers have higher marginal utility from consumption in holidays, and therefore, they are more likely to process price and especially quantity information.

[24] We included the recalled prices and quantities and the categories' average prices and quantities to control for reference price effects. The coefficients we obtained for *categories' average prices* and *categories' average quantities* are negative, whereas the coefficients of the *recalled price* and *recalled quantities* are positive, suggesting that consumers in our sample use external reference prices. The positive effects of *recalled prices* and *quantities* suggest that as goods' prices and quantities increase, so does the range of possible errors.

[25] Studies suggest that women pay more attention than men to prices (Raajpoot, et al. 2008). However, modern social trends are altering the traditional roles, and consequently the shopping behavior, of men and women (Mortimer, 2009).

(ii) <u>Test 2: Consumers' Attention to Price and Quantity Discounts</u>

Some authors criticize the use of price recall information as a proxy for the knowledge that consumers have about goods' prices because price recall surveys ask for information that consumers might store in non verbal code and therefore, consumers might fail to give correct answers even if they know them (Monroe and Lee, 1999, Vanhuele and Dréze, 2002).[26] We, therefore, use data from the first survey to study the likelihood that consumers correctly recall whether or not goods are offered at a discount. This offers a more conservative test than the one reported in section (i) for several reasons. First, the gains from processing discount information can be large.[27] Second, discount information is usually more visible and, therefore, easier to process than other types of price and quantity information. Third, recalling whether or not a good is sold at a discount involves only a yes-or-no answer, and therefore it is easier to recall than the goods' exact price and quantity (Monroe and Lee, 1999, Vanhuele and Drèze, 2002). Indeed, we find that consumers correctly recall whether or not a good is offered at a discount in about 70% of the cases, whereas Vanhuele and Dréze (2002) report that only about 2% of the consumers correctly recall goods' exact prices.

Following our model, we assume that the likelihood that consumers correctly recall goods' price and quantity information depends on their choice of attention mode and on goods' attributes. We further assume that consumers choose between two attention modes, *attentive* and *inattentive*, where attentive consumers are more likely to recall whether or not a good is offered at a discount. In addition, we assume that goods' attributes have the same effect on both types of consumers. Following Gupta and Chintagunta (1994), we use a logistic mixture model to simultaneously estimate the effects of the consumers' and goods' attributes. Thus, we maximize:[28]

$$Log(L) = \sum_{i=1}^{N} \log\Big[P\big(Consumer\ with\ attributes\ X_i\ chose\ mode\ k\big)\times P\big(The\ consumer\ gave\ response\ c\ when\ the\ purchased\ good\ has\ attributes\ Z_j\big)\Big] \quad (32)$$

[26] According to cognitive psychologists there are two ways of storing information in memory. *Explicit* memory is for storing information used verbally. *Implicit* memory is for storing information used in non-verbal settings, e.g., riding a bike (Smith et al. 2003, p. 269). Monroe and Lee (1999) suggest that asking consumers to give verbal responses to questions about goods' prices might underestimate their knowledge, because they likely use non-verbal code to store information in long-term memory. They argue that because price information is used for internal comparisons, it is likely to be stored in implicit memory and consequently, consumers are likely to find it difficult to recall them verbally.
[27] The average discount at the two supermarkets surveyed was 15%–20% of the list prices.
[28] We have tried logit and multi-logit specifications as well. In all cases, we obtained similar results.

where L is the likelihood function, N is the number of consumers, P is the logistic probability function, $k \in \{attentive, inattentive\}$, $c \in \{correct, incorrect\}$, X_i is the set of attributes of consumer i, and Z_j is the set of attributes of good j.

We assume that consumers' attributes, include the following dummy variables: *woman*, *academic degree*, *large family*, *moderately religious*, *age* (1 if a *consumer* is *45–55 years old*), *cashier-parking* (1 if a consumer answered that both *the number of cashiers* and *the availability of parking* are very important to him), and *Passover* (1 if the observation was collected during the Passover holiday).

We hypothesize that the effect of *woman*, *academic degree*, *large family* and *moderately religious* variables will be similar to what we discussed in section (i). We include the *age* variable because pre-tests and previous empirical studies suggest that consumers in the 40–55 age group are more likely than other consumers to correctly recall goods' prices (Fox and Hoch, 2005).[29] We include the *cashier-parking* variable because consumers who care more about both the number of parking places and the number of cashiers are more likely to be time constrained and, therefore, less likely to process goods' price and quantity information. We include the *Passover* variable because it is one of the main holidays in the Jewish calendar, and the main family get-together event. The discussion above suggests, therefore, that consumers should be more likely to process goods' price and quantity information in Passover than in other periods.

We assume that goods' set of attributes include the following dummy variables: *small-discount* (1 if the discount < 10 percent), *supermarket 2* (1 if the good was purchased at *supermarket 2* and 0 if it was purchased at supermarket 1), *price discount* (1 if a good was offered at a price discount), *quantity discount* (1 if a good was offered at a quantity discount), and interactions of the *Passover* dummy and "*more than NIS 20*" dummy (1 if a good costs NIS 20 or more), *price discount* and *quantity discount*.[30] We also include fixed effects for goods' categories, to control for variation in the market structure.

We include the *small-discount* variable because the model suggests that consumers are less likely to process goods' price and quantity information if the benefit from doing so is relatively small. In addition, empirical evidence suggests that consumers

[29] We also estimated the regression with age fixed effects. The results were similar to what we report here.
[30] We chose to define goods costing more than NIS 20 (about $5)as "expensive" because NIS 20 is about double the average cost of a good in a supermarket in the sample period (source: www.cbs.gov.il/reader/?MIval=/prices_db/). The coefficient of the main effect of "*costs NIS 20 or more*" is statistically insignificant and has no significant effect on other coefficients. We therefore dropped it from the regression.

are less likely to process information about small discounts than about larger ones (Krieder and Han, 2004, Chen et al., 2008). We include the *Supermarket 2* variable to control for differences in consumers' behavior between Supermarket 1 which is a discount supermarket and Supermarket 2 which is located in a high income neighborhood. *Price* and *quantity discounts* control for whether a good was offered at a price or a quantity discount. Their coefficient can indicate which type of a discount is more likely to be processed and correctly recalled by consumers. We expect that because processing price information is easier than processing quantity information, consumers are more likely to recall price discounts than quantity discounts.

The model predicts that holding the relative size of price changes the same, consumers should be more likely to process goods' price and quantity information if the goods' prices are high. We expect, therefore, that the coefficient of the interaction term of *more than NIS 20* and *Passover* is positive, i.e., consumers are more likely to process goods' information if the goods are relatively expensive.

We include the interaction terms of *Passover* and the *price* and *quantity discounts* because the model suggests that during holidays consumers dedicate more time and cognitive effort to processing goods' price and quantity information. The interaction terms between Passover and price and quantity discounts control for any changes in the likelihood consumers correctly recall price and quantity discounts during Passover period relative to other periods.

The results of the maximum likelihood estimation of (32) are reported in Table 7 along with robust standard errors. The coefficients of *woman* and *academic degree* are not significant, although their signs are consistent with the regression in section (i). As expected, the coefficient of *large families* is positive and significant.

Consumers in the 45–55 age group are, as predicted above, more likely than consumers of other age to correctly recall discounts. As predicted, *moderately religious* consumers are less likely to correctly recall discounts. The coefficient of the *Passover* dummy is positive and significant, suggesting that consumers indeed have greater marginal utility from consumption and, therefore, devote more time and effort to processing goods' price and quantity information..[31]

There is an alternative explanation, however. During Passover there are more discounts than during other times, and therefore they are more noticeable. To account for

[31] The Passover period in Israel is similar to the Christmas period in the US (Warner and Barsky, 1995, Chevalier et al., 2003, Levy et al., 2010).

this, we take advantage of the fact that most discounts start one week before the Passover holiday and last one week beyond Passover. Thus, consumers face the same number of price and quantity discounts in all these three weeks. If consumers are more attentive to discounts because they are more noticeable, then consumers should be equally likely to recall whether or not a good is offered at a discount during all these three weeks. On the other hand, if consumers are more likely to recall discounts only when they have high marginal utility of consumption, they will be more likely to recall discounts only during Passover.

We use ANOVA to compare the likelihood that consumers correctly recall whether or not goods are offered at a discount during these three weeks. We find no statistical differences between the probability of correctly recalling discounts in the weeks before and after Passover ($F = 0.14$, $p > 0.7$), but the probability of correctly recalling discounts during the week of the holiday is significantly greater than in the weeks before ($F = 32.65$, $p < 0.01$) and after the holiday ($F = 19.33$, $p < 0.01$). This suggests, therefore, that the increase in the likelihood of correctly recalling discounts is, as we hypothesize, due to higher marginal utility of consumption and not due to the higher salience of the discounts.

The effects of goods' attributes are as follows. As predicted above, consumers are less likely to recall *discounts* of *10 percent or less*. They are also less likely to recall discounts if they shop at the expensive *supermarket 2*.

The coefficient of the interaction of *holiday* and *costs NIS 20 or more* is positive and significant, suggesting that consumers are more likely to process the price and quantity information of more expensive goods.

The coefficients of both *price discount* and *quantity discount* are positive and significant. However, the coefficient of *price discount* is significantly greater than the coefficient of *quantity discount* ($\chi^2_{(1)} = 3.17,\ p < 0.1$), which suggests that during non-holidays consumers are more likely to process goods' price information than quantity information. During holidays, however, the interaction of *holiday* and *price discount* is insignificant, whereas the interaction of *holiday* and *quantity discount* is positive and significant. Thus, during holidays consumers are marginally more likely to recall quantity discounts than price discounts ($\chi^2_{(1)} = 3.51,\ p < 0.1$). This may explain why producers in Israel are more likely to offer quantity discounts in Passover and other major holidays than in other times. During the sample period, for example, almost half of the discounts

offered during the Passover at both supermarkets were quantity discounts compared with a much smaller proportion in other periods.

6. Conclusions

A large body of empirical research suggests that nominal price rigidity is a common phenomenon. Nominal price rigidity, however, might be inconsequential for efficient allocation if some other attribute of the product changes while the price remains unchanged. For example, Carlton (1989, 1991), Gabaix and Laibson (2006), Levy et al. (2010) and Armstrong and Chen (2009) suggest that if producers have more information than consumers about goods' attributes, they may use non-price (rather than price) adjustment mechanisms and, consequently, the market may reach a new equilibrium even if prices remain unchanged.

In this paper, we study an economy where producers sometimes adjust goods' quantity (per package) rather than prices in response to changes in market conditions. According to Swan's (1970) theorem, consumers should be indifferent between price and quantity adjustments as long as the unit-prices are the same. Empirical evidence, however, suggests that consumers often respond to price adjustments differently than to quantity adjustments.

We construct, calibrate, and test a model that offers a possible explanation for this finding. In the model, consumers face cognitive information processing costs and have to choose whether to process goods' price information, goods' quantity information, both, or neither.

We test the model's predictions using data from two surveys we conducted in Israel on the information consumers have about goods' prices and quantities. The model and the empirical findings suggest that information processing costs are important determinants of the information consumers have on goods' prices and quantities.

The study has some limitations. First, the model we formulate is static. Extending the model to a dynamic, strategic setting may be useful for understanding the effects of information processing costs on consumers' behavior and on producers' adjustment strategies over the cycle. A dynamic model may also assist in studying the behavior of producers if consumers' information processing costs lead to antagonization costs (Blinder et al., 1998, Rotemberg, 2005). Also, we focus on consumers' decision and therefore the proportion of the producers that respond to cost shocks by adjusting their price/quantity is given exogenously. An extension of our model could consider

endogenizing these decisions. On the empirical front, more work is needed to assess the empirical relevance of cognitive processing costs for consumers' behavior, and for understanding the responses of producers and consumers to changes in these costs (Rotemberg, 1983, 2005, Gabaix et al., 2006). More research is needed also to better understand consumers' responses to quantity decreases, because the anger consumers often express when they discover a quantity decrease, can affect the long-term relationship between producers and consumers (Blinder et al., 1998, Rotemberg 2005). Studying the relevance of our findings for other non-price adjustment mechanisms such as quality adjustment (e.g., Armstrong and Chen, 2009) can be another fruitful direction for future research..

APPENDIX

1. Demand of Price Attentive Consumers and the Price Level They Face

Price attentive consumers process all goods' price information but they assume that all goods' quantity per package equal the expected quantity per package Q^e. For a given income, maximizing utility is equivalent to maximizing the consumption bundle. Price Attentive consumers, therefore, choose $C_{PA}(i)$ for all $i \in (0,1)$ which maximizes

$C_{PA} = \left\{ \int_0^1 \left[C_{PA}(i) Q^e \right]^{\frac{\varepsilon-1}{\varepsilon}} di \right\}^{\frac{\varepsilon}{\varepsilon-1}}$, subject to the income constraint:

$$\int_0^1 C_{PA}(i) P(i) di = Y_{PA} \,. \tag{A1.1}$$

Denoting the Lagrange multiplier with λ, the Lagrangian is given by

$$\ell = \left\{ \int_0^1 \left[C_{PA}(i) Q^e \right]^{\frac{\varepsilon-1}{\varepsilon}} di \right\}^{\frac{\varepsilon}{\varepsilon-1}} + \lambda \int_0^1 \left[Y_{PA} - C_{PA}(i) P(i) \right] di \tag{A1.2}$$

Differentiating (A1.2) with respect to $C_{PA}(i)$ and setting the result equal to zero, yields:

$$\left\{ \int_0^1 \left[\left[C_{PA}(i) Q^e \right]^{\frac{\varepsilon-1}{\varepsilon}} di \right] \right\}^{\frac{\varepsilon}{\varepsilon-1}-1} \left[C_{PA}(i) Q^e \right]^{\frac{-1}{\varepsilon}} Q^e = \lambda P(i) \tag{A1.3}$$

Differentiating with respect to $C_{PA}(j)$ and setting the result equal to zero yields

$$\left\{ \int_0^1 \left[\left[C_{PA}(i) Q^e \right]^{\frac{\varepsilon-1}{\varepsilon}} di \right] \right\}^{\frac{\varepsilon}{\varepsilon-1}-1} \left[C_{PA}(j) Q^e \right]^{\frac{-1}{\varepsilon}} Q^e = \lambda P(j) \tag{A1.4}$$

Dividing (A1.3) by (A1.4) yields:

$$\left[\frac{C_{PA}(j)}{C_{PA}(i)} \right]^{\frac{1}{\varepsilon}} = \frac{P(i)}{P(j)} \tag{A1.5}$$

Thus, the consumption of good j as a function of the consumption of good i is given by:

$$C_{PA}(j)=\left[\frac{P(i)}{P(j)}\right]^{\varepsilon} C_{PA}(i) \tag{A1.6}$$

Using (A1.6) to substitute for the consumption of each good $j \in (0,1)$ in the budget constraint (A1.1), we obtain:

$$\int_0^1 \left[\frac{P(i)}{P(j)}\right]^{\varepsilon} C_{PA}(i)P(j)dj = Y_{PA} \tag{A1.7}$$

Rearranging the LHS yields:

$$C_{PA}(i)P(i)^{\varepsilon}\int_0^1 P(j)^{1-\varepsilon}\,dj = Y_{PA} \tag{A1.8}$$

Therefore,

$$C_{PA}(i)=\frac{Y_{PA}}{P(i)^{\varepsilon}\int_0^1 P(j)^{1-\varepsilon}\,dj}=\left[\frac{P(i)^{-\varepsilon}}{\int_0^1 P(j)^{1-\varepsilon}\,dj}\right]Y_{PA}. \tag{A1.9}$$

The price index that price attentive consumers face is defined by:

$$C_{PA}P_{PA} = \int_0^1 C_{PA}(i)P(i)di \tag{A1.10}$$

where C_{PA} is the aggregate consumption bundle of price attentive consumers. It is defined by $C_{PA}=\left\{\int_0^1 \left[C_{PA}(i)Q(i)\right]^{\frac{\varepsilon-1}{\varepsilon}} di\right\}^{\frac{\varepsilon}{\varepsilon-1}}$. We use some good $i \in (0,1)$ as a numeraire and we use (A1.6) to substitute for the consumption of every good $j \in (0,1)$ in both sides of (A1.10). Doing so yields:

$$\left[\int_0^1 \left[C_{PA}(i)\left[\frac{P(i)}{P(j)}\right]^{\varepsilon} Q(j)\right]^{\frac{\varepsilon-1}{\varepsilon}} dj\right]^{\frac{\varepsilon}{\varepsilon-1}} P_{PA} = \int_0^1 C_{PA}(i)\left[\frac{P(i)}{P(j)}\right]^{\varepsilon} P(j)dj \tag{A1.11}$$

Dividing both sides of (A1.11) by $C_{PA}(i)$ and $P(i)^{\varepsilon}$ we obtain:

$$\left[\int_0^1 P(j)^{1-\varepsilon} Q(j)^{\frac{\varepsilon-1}{\varepsilon}} dj\right]^{\frac{\varepsilon}{\varepsilon-1}} P_{PA} = \int_0^1 P(j)^{1-\varepsilon} dj \tag{A1.12}$$

Thus, the price level price attentive consumers face is given by:

$$P_{PA} = \frac{\int_0^1 P(j)^{1-\varepsilon} dj}{\left[\int_0^1 P(j)^{1-\varepsilon} Q(j)^{\frac{\varepsilon-1}{\varepsilon}} dj\right]^{\frac{\varepsilon}{\varepsilon-1}}} \tag{A1.13}$$

2. Demand of Quantity Attentive Consumers and the Price Level They Face

Quantity attentive consumers process all goods' quantity per package information but they assume that all goods' prices equal the expected price P^e. They, therefore, choose $C_{QA}(i)$ for every $i \in (0,1)$ which maximizes $C_{QA} = \left\{\int_0^1 \left[C_{QA}(i)Q(i)\right]^{\frac{\varepsilon-1}{\varepsilon}} di\right\}^{\frac{\varepsilon}{\varepsilon-1}}$ subject to the budget constraint

$$\int_0^1 C_{QA}(i)P^e di = Y_{QA} \tag{A2.1}$$

Denoting the Lagrange multiplier with λ, the Lagrangian is given by

$$\ell = \left\{\int_0^1 \left[C_{QA}(i)Q(i)\right]^{\frac{\varepsilon-1}{\varepsilon}} di\right\}^{\frac{\varepsilon}{\varepsilon-1}} + \lambda\int_0^1 \left[Y_{QA} - C_{QA}(i)P^e\right] di \tag{A2.2}$$

Differentiating (A2.2) with respect to $C_{QA}(i)$, and setting the result equal to zero yields:

$$\left\{\int_0^1 \left[C_{QA}(i)Q(i)\right]^{\frac{\varepsilon-1}{\varepsilon}} di\right\}^{\frac{\varepsilon}{\varepsilon-1}-1} \left[C_{QA}(i)Q(i)\right]^{\frac{-1}{\varepsilon}} Q(i) = \lambda P^e \tag{A2.3}$$

Differentiating (A2.2) with respect to $C_{QA}(j)$ and setting the result equal to zero yields:

$$\left\{\int_0^1 \left[C_{QA}(i)Q(i)\right]^{\frac{\varepsilon-1}{\varepsilon}} di\right\}^{\frac{\varepsilon}{\varepsilon-1}-1} \left[C_{QA}(j)Q(j)\right]^{\frac{-1}{\varepsilon}} Q(j) = \lambda P^e \tag{A2.4}$$

Dividing (A2.3) by (A2.4) yields:

$$\left[\frac{C_{QA}(j)}{C_{QA}(i)}\right]^{\frac{1}{\varepsilon}} \left[\frac{Q(i)}{Q(j)}\right]^{\frac{\varepsilon-1}{\varepsilon}} = 1 \tag{A2.5}$$

Rearranging terms, we find that:

$$C_{QA}(j)^{\frac{1}{\varepsilon}} = C_{QA}(i)^{\frac{1}{\varepsilon}} \left[\frac{Q(j)}{Q(i)}\right]^{\frac{\varepsilon-1}{\varepsilon}} \tag{A2.6}$$

Thus, the consumption of good j as a function of the consumption of good i is given by:

$$C_{QA}(j) = \left[\frac{Q(j)}{Q(i)}\right]^{\varepsilon-1} C_{QA}(i) \tag{A2.7}$$

Using (A2.7) to substitute for the consumption of each good $j \in (0,1)$ in the budget constraint (A2.1), we obtain:

$$\int_0^1 \left[\frac{Q(j)}{Q(i)}\right]^{\varepsilon-1} C_{QA}(i)P^e dj = Y_{QA} \tag{A2.8}$$

Rearranging the LHS we get:

$$C_{QA}(i)Q(i)^{1-\varepsilon} P^e \int_0^1 Q(j)^{\varepsilon-1} dj = Y_{QA} \tag{A2.9}$$

Dividing by $Q(i)^{1-\varepsilon} P^e$ yields the number of units of good i that quantity attentive consumers expect to purchase:

$$C_{QA}(i)=\left[\frac{Q(i)^{\varepsilon-1}}{\int_0^1 Q(j)^{\varepsilon-1}dj}\right]\frac{Y_{QA}}{P(i)} \tag{A2.10}$$

However, because the actual price of good i, $P(i)$, might deviate from the expected price P^e, the actual amount of good i that quantity attentive consumers purchase is given by:

$$C_{QA}(i)=\frac{Q(i)^{\varepsilon-1}Y_{QA}}{P(i)\int_0^1 Q(j)^{\varepsilon-1}dj} \tag{A2.11}$$

The price index that quantity attentive consumers face is defined by:

$$C_{QA}P_{QA}=\int_0^1 C_{QA}(i)P(i)di \tag{A2.12}$$

where C_{QA} is the aggregate consumption bundle of quantity attentive consumers. It is defined by $C_{QA}=\left\{\int_0^1\left[C_{QA}(i)Q(i)\right]^{\frac{\varepsilon-1}{\varepsilon}}di\right\}^{\frac{\varepsilon}{\varepsilon-1}}$.

We use some good $i\in(0,1)$ as a numeraire and we use equation (A2.7) to substitute for the consumption of every good $j\in(0,1)$ in both sides of (A2.12). Doing so yields

$$\left\{\int_0^1\left\{\left[\frac{Q(j)}{Q(i)}\right]^{\varepsilon-1}C_{QA}(i)Q(j)\right\}^{\frac{\varepsilon-1}{\varepsilon}}dj\right\}^{\frac{\varepsilon}{\varepsilon-1}}P_{QA}=\int_0^1\left[\frac{Q(j)}{Q(i)}\right]^{\varepsilon-1}C_{QA}(i)P(j)dj \tag{A2.13}$$

Dividing both sides by $C_{QA}(i)$ and $Q(i)^{1-\varepsilon}$ we get:

$$P_{QA}\left[\int_0^1 Q(j)^{\varepsilon-1}dj\right]^{\frac{\varepsilon-1}{\varepsilon}}=\int_0^1 P(j)Q(j)^{\varepsilon-1}dj \tag{A2.14}$$

Thus, the price level that quantity attentive consumers face is given by:

$$P_{QA} = \frac{\int_0^1 P(j)Q(j)^{\varepsilon-1}dj}{\left[\int_0^1 Q(j)^{\varepsilon-1}dj\right]^{\frac{\varepsilon-1}{\varepsilon}}} \tag{A2.15}$$

3. Demand of Price and Quantity Attentive Consumers and the Price Level They Face

Price and quantity attentive consumers choose $C_{PQA}(i)$ for every $i \in (0,1)$ which maximizes $C_{PQA} = \left\{\int_0^1 \left[C_{PQA}(i)Q(i)\right]^{\frac{\varepsilon-1}{\varepsilon}} di\right\}^{\frac{\varepsilon}{\varepsilon-1}}$, subject to the budget constraint:

$$\int_0^1 C_{PQA}(i)P(i)\,di = Y_{PQA} \tag{A3.1}$$

Denoting the Lagrange multiplier with λ, the Lagrangian is given by:

$$\ell = \left\{\int_0^1 \left[\left[C_{PQA}(i)Q(i)\right]^{\frac{\varepsilon-1}{\varepsilon}} di\right]\right\}^{\frac{\varepsilon}{\varepsilon-1}} + \lambda\int_0^1 \left[Y_{PQA} - \left(\tau_P + \tau_Q\right)W - C_{PQA}(i)P(i)\right]di \tag{A3.2}$$

Differentiating (A3.2) with respect to $C_{PQA}(i)$ and setting the result equal to zero yields

$$\left\{\int_0^1 \left[\left[C_{PQA}(i)Q(i)\right]^{\frac{\varepsilon-1}{\varepsilon}} di\right]\right\}^{\frac{\varepsilon}{\varepsilon-1}-1} \left[C_{PQA}(i)Q(i)\right]^{\frac{-1}{\varepsilon}} Q(i) = \lambda P(i) \tag{A3.3}$$

Differentiating (A3.2) with respect to $C_{PQA}(j)$ and setting the result equal to zero yields

$$\left\{\int_0^1 \left[\left[C_{PQA}(i)Q(i)\right]^{\frac{\varepsilon-1}{\varepsilon}} di\right]\right\}^{\frac{\varepsilon}{\varepsilon-1}-1} \left[C_{PQA}(j)Q(j)\right]^{\frac{-1}{\varepsilon}} Q(j) = \lambda P(j) \tag{A3.4}$$

Dividing (A3.3) by (A3.4) yields:

$$\left[\frac{C_{PQA}(j)}{C_{PQA}(i)}\right]^{\frac{1}{\varepsilon}}\left[\frac{Q(i)}{Q(j)}\right]^{\frac{\varepsilon-1}{\varepsilon}}=\frac{P(i)}{P(j)} \tag{A3.5}$$

Rearranging terms, we find that:

$$C_{PQA}(j)^{\frac{1}{\varepsilon}}=\frac{P(i)}{P(j)}\left[\frac{Q(j)}{Q(i)}\right]^{\frac{\varepsilon-1}{\varepsilon}}C_{PQA}(i)^{\frac{1}{\varepsilon}} \tag{A3.6}$$

Thus, the consumption of good j as a function of the consumption of good i is given by:

$$C_{PQA}(j)=\left[\frac{P(i)}{P(j)}\right]^{\varepsilon}\left[\frac{Q(j)}{Q(i)}\right]^{\varepsilon-1}C_{PQA}(i) \tag{A3.7}$$

We use equation (A3.7) to substitute for the consumption of every good $j\in(0,1)$ in the budget constraint (A3.1). Doing so yields:

$$\int_0^1\left[\frac{P(i)}{P(j)}\right]^{\varepsilon}\left[\frac{Q(j)}{Q(i)}\right]^{\varepsilon-1}C_{PQA}(i)P(j)dj=Y_{PQA} \tag{A3.8}$$

Rearranging the LHS yields:

$$C_{PQA}(i)Q(i)^{1-\varepsilon}P(i)^{\varepsilon}\int_0^1\left[\frac{Q(j)}{P(j)}\right]^{\varepsilon-1}dj=Y_{PQA} \tag{A3.9}$$

Thus, the demand function of price and quantity attentive consumers for good i is given by

$$C_{PQA}(i)=\frac{\left[\frac{Q(i)}{P(i)}\right]^{\varepsilon-1}Y_{PQA}}{P(i)\int_0^1\left[\frac{Q(j)}{P(j)}\right]^{\varepsilon-1}dj}=\frac{\left[\frac{P(i)}{Q(i)}\right]^{1-\varepsilon}Y_{PQA}}{P(i)\int_0^1\left[\frac{P(i)}{Q(i)}\right]^{1-\varepsilon}dj} \tag{A3.10}$$

The price level that price and quantity attentive consumers face is defined by:

$$C_{PQA}P_{PQA}=\int_0^1 C_{PQA}(i)P(i)di \tag{A3.11}$$

where C_{PQA} is the aggregate consumption bundle of price and quantity attentive consumers. It is defined by $C_{PQA}=\left\{\int_0^1\left[C_{PQA}(i)Q(i)\right]^{\frac{\varepsilon-1}{\varepsilon}}di\right\}^{\frac{\varepsilon}{\varepsilon-1}}$.

We use some good $i \in (0,1)$ as a numeraire and we use (A3.7) to substitute for the consumption of every good $j \in (0,1)$ in both sides of (A3.11). Doing so yields

$$\left\{\int_0^1 \left\{\left[\left[\frac{P(i)}{P(j)}\right]^{\varepsilon}\left[\frac{Q(j)}{Q(i)}\right]^{\varepsilon-1} C_{PQA}(i)Q(j)\right]\right\}^{\frac{\varepsilon-1}{\varepsilon}} dj\right\}^{\frac{\varepsilon}{\varepsilon-1}} P_{PQA} =$$

$$= \int_0^1 \left[\frac{P(i)}{P(j)}\right]^{\varepsilon}\left[\frac{Q(j)}{Q(i)}\right]^{\varepsilon-1} C_{PQA}(i)P(j)dj \qquad \text{(A3.12)}$$

Dividing both sides by $C(i)$, $P(i)^{\varepsilon}$, and $Q(i)^{1-\varepsilon}$, we obtain:

$$\left\{\int_0^1 \left[\frac{Q(j)}{P(j)}\right]^{\varepsilon-1} dj\right\}^{\frac{\varepsilon}{\varepsilon-1}} P_{PQA} = \int_0^1 \left[\frac{Q(j)}{P(j)}\right]^{\varepsilon-1} dj \qquad \text{(A3.13)}$$

Thus, the price level that price and quantity attentive consumers face is given by:

$$P_{PQA} = \left\{\int_0^1 \left[\frac{Q(j)}{P(j)}\right]^{\varepsilon-1} dj\right\}^{\frac{1}{1-\varepsilon}} = \left\{\int_0^1 \left[\frac{P(j)}{Q(j)}\right]^{1-\varepsilon} dj\right\}^{\frac{1}{1-\varepsilon}} \qquad \text{(A3.14)}$$

4. Demand of Inattentive Consumers and the Price Level They Face

Price and quantity inattentive consumers assume that all goods' prices equal the expected price, P^e, and that all goods' quantity per package equal the expected quantity per package, Q^e. They, therefore, maximize $\left\{\int_0^1 \left[C_{IA}(i)Q^e di\right]^{\frac{\varepsilon-1}{\varepsilon}}\right\}^{\frac{\varepsilon}{\varepsilon-1}}$, subject to the budget constraint

$$\int_0^1 C_{IA}(i)P^e di = Y_{IA} \qquad \text{(A4.1)}$$

Denoting the Lagrange multiplier with λ, the Lagrangian is given by

$$\ell = \left\{ \int_0^1 \left[C_{IA}(i) Q^e \right]^{\frac{\varepsilon-1}{\varepsilon}} di \right\}^{\frac{\varepsilon}{\varepsilon-1}} + \lambda \int_0^1 \left[Y_{IA} - C_{IA}(i) P^e \right] di \tag{A4.2}$$

Differentiating (A4.2) with respect to $C_{IA}(i)$, and setting the result equal to zero yields:

$$\left\{ \int_0^1 \left[C_{IA}(i) Q^e \right]^{\frac{\varepsilon-1}{\varepsilon}} di \right\}^{\frac{\varepsilon}{\varepsilon-1}-1} \left[C_{IA}(i) Q^e \right]^{\frac{-1}{\varepsilon}} Q^e = \lambda P^e \tag{A4.3}$$

Differentiating (A3.2) with respect to $C_{IA}(j)$ and setting the result equal to zero yields:

$$\left\{ \int_0^1 \left[C_{IA}(i) \omega Q^e \right]^{\frac{\varepsilon-1}{\varepsilon}} di \right\}^{\frac{\varepsilon}{\varepsilon-1}-1} \left[C_{IA}(j) Q^e \right]^{\frac{-1}{\varepsilon}} Q^e = \lambda P^e \tag{A4.4}$$

Dividing (A3.3) by (A3.4) yields:

$$\left[\frac{C_{IA}(j)}{C_{IA}(i)} \right]^{\frac{1}{\varepsilon}} = 1 \tag{A4.5}$$

Thus, the consumption of good j as a function of the consumption of good i is given by:

$$C_{IA}(j) = C_{IA}(i) \tag{A4.6}$$

To find the consumption that price and quantity inattentive consumers expect we use (A4.6) to substitute the consumption of each good $j \in (0,1)$ in the budget constraint (A4.1). Doing so yields:

$$\int_0^1 C_{IA}(i) P^e dj = Y_{IA} \tag{A4.7}$$

Thus the expected consumption is:

$$C_{IA}(i) = \frac{Y_{IA}}{P^e} \tag{A4.8}$$

However, because the actual price $P(i)$ can deviate from the expected price P^e, the actual amount that price and quantity inattentive consumers purchase is given by:

$$C_{IA}(i) = \frac{Y_{IA}}{P(i)} \tag{A4.9}$$

The price level that price and quantity inattentive consumers face is defined by:

$$C_{IA}P_{IA} = \int_0^1 C_{IA}(i)P_{IA}(i)di \tag{A4.10}$$

where C_{IA} is the aggregate consumption bundle of price and quantity inattentive consumers. It is defined by $C_{IA} = \left\{ \int_0^1 \left[C_{IA}(i)Q(i) \right]^{\frac{\varepsilon-1}{\varepsilon}} di \right\}^{\frac{\varepsilon}{\varepsilon-1}}$.

We use some good $i \in (0,1)$ as a numeraire and we use equation (A4.6) to substitute for the consumption of every good $j \in (0,1)$ in both sides of (A4.10). Doing so yields

$$\left\{ \int_0^1 \left[\frac{Y_{IA}Q(i)}{P(i)} \right]^{\frac{\varepsilon-1}{\varepsilon}} di \right\}^{\frac{\varepsilon}{\varepsilon-1}} P_{IA} = \int_0^1 \frac{Y_{IA}}{P(i)} P(i)\, di \tag{A4.11}$$

Dividing both sides by Y_{IA} we get:

$$\left\{ \int_0^1 \left[\frac{Q(i)}{P(i)} \right]^{\frac{\varepsilon-1}{\varepsilon}} di \right\}^{\frac{\varepsilon}{\varepsilon-1}} P_{IA} = 1 \tag{A4.12}$$

Thus, the price level that price and quantity inattentive consumers face is given by:

$$P_{IA} = \left\{ \int_0^1 \left[\frac{Q(i)}{P(i)} \right]^{\frac{\varepsilon-1}{\varepsilon}} di \right\}^{\frac{\varepsilon}{1-\varepsilon}} = \left\{ \int_0^1 \left[\frac{P(i)}{Q(i)} \right]^{\frac{\varepsilon}{\varepsilon-1}} di \right\}^{\frac{\varepsilon}{1-\varepsilon}} \tag{A4.13}$$

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Table 1. Descriptive Statistics of the Supermarkets Surveyed

Supermarket	City	Supermarket Chain	Discount	Type of Location	Location
1	Petah-Tiquah	Shufersal	Yes	Shopping Zone	Outside
2	Rehovot	Blue Center	No	Street	Suburb
3	Givat Shemuel	Blue Center	No	Shopping Center	City Center
4	Petah-Tiquah	Private	Yes	Shopping Zone	Outside
5	Bnei Beraq	Blue Center	Yes	Street	City Center
6 Alef	Petah-Tiquah	Shufersal	Yes	Shopping Zone	Outside
7 Yad Yitzhak	Petah-Tiquah	Private	Yes	Shopping Zone	Outside
8	Ramat-Gan	Shufersal	No	Shopping Center	City Center
9	Ramat-Gan	Blue Center	No	Shopping Center	Suburb
10	Netanya	Shufersal	Yes	Shopping Zone	Outside
11	Petah-Tiquah	Shufersal	Yes	Shopping Zone	Outside
12	Netanya	Shufersal	Yes	Shopping Zone	Outside
13	Tel-Aviv	Shufersal	Yes	Shopping Zone	City Center
14	Bat-Yam	Private	Yes	Shopping-Zone	City-Center
15	Tel-Aviv	Private	Yes	Shopping-Zone	Suburb

Notes:
There are two large supermarket chains, Shufersal and Blue Center.
Discount column indicates whether or not the supermarket is promoted as a low-price supermarket.

Table 2. Socio-Economic Status of Consumers by Cities Where the Supermarkets Are Located

City	Income in NIS	Unemployment	Computer	Cars	Household	Academics	Immigrants	Economic-Status
Petah-Tiquah	6,386	7.6%	63%	59%	3.2	15%	29.3%	7
Rehovot	6,952	8.2%	67%	74%	3.3	15%	20.8%	7
Givat Shemuel	7,412	7.8%	52%	60%	2.5	18%	10.2%	8
Bnei Beraq	4,735	10.6%	38%	18%	4.0	8%	6.9%	2
Netanya	5,339	12.9%	41%	54%	3.0	13%	26.6%	5
Bat-Yam	4,807	11.6%	37%	36%	2.8	11%	32.1%	6
Tel Aviv	7,214	10.0%	57%	46%	2.3	20%	12.2%	8

Notes:
Income = the average wage of an employed person in 2001 in NIS (The exchange rate was NIS4.21/US$1). Unemployment = unemployment rate in 2002. Computer = the share of households that owned at least one computer in 2002. Cars = the share of households with at least one car in 2002. Household = the size of the average household in 2002. Academics = the share of population with BA or higher degree in 1995. Immigrants = the share of population in 2002 that immigrated to Israel after 1989. Economic Status = Israel Central Bureau of Statistics index ranking cities on a scale of 1–10, where 1 indicates the lowest socio-economic status and 10 indicates the highest socio-economic status. Source: Israel Central Bureau of statistics (2002), and Israel Central Bureau of Statistics Socio-Economic Index for Cities, 1995, www.cbs.gov.il/mifkad/tables/pirsom13/13.xls.

Table 3. Summary Statistics of the Surveyed Consumers by Supermarket

Supermarket	Women	Age Group	Academics	Family Size	#Cars	Religious	Expenditures in NIS	#Goods	#Observations
1	56%	18–24 (24%)	35%	3.56 (1.24)	1.5 (0.86)	10%	270 (101.4)	8.0	46
2	59%	46–55 (29%)	58%	4.20	1.8 (0.82)	16.6%	359 (76.8)	5.6	208
3	70%	25–34 (34%)	56%	3.38 (1.59)	2.3 (0.68)	14.5%	226 (171)	2.4	152
4	57%	35–45 (33%)	61%	3.71 (1.36)	2.63 (0.69)	13.0%	468.5 (151.53)	5.2	100
5	70%	46–55 (46%)	56%	5.24 (1.16)	1.9 (0.8)	100%	353.65 (176.91)	3.1	41
6	44%	35–45 (39%)	53%	3.90 (1.49)	2.44 (0.85)	25.4%	131.58 (102.67)	5.1	114
7	49%	46–55 (30%)	50%	4.30 (1.43)	2.71 (0.96)	48.6%	221.43 (144.68)	4.6	70
8	71%	25–34 (32%)	56%	3.63 (1.61)	2.1 (0.74)	43.9%	321.95 (153.32)	4.4	41
9[32]	49%	Under 24 (31%)	85%	3.87 (1.67)	2.16 (0.86)	52.4%	197.83 (110.27)	2.5	61
10	71%	25–34 (34%)	56%	3.53 (1.40)	1.12 (0.81)	50.0%	264.5 (145.87)	4.7	100
11	57%	25–34 (55%)	70%	3.54 (1.29)	2.34 (0.69)	65.6%	400.0 (157.78)	3.6	99
12	57%	35–45 (34%)	53%	4.17 (1.46)	2.38 (0.70)	44.54%	475.91 (159.66)	2.3	110
13	58%	46–55 (37%)	47%	3.32 (1.49)	2.21 (0.80)	15.71%	409.29 (178.82)	4.1	70
14	66%	36–45 (28%)	27%	3.51 (1.33)	1.5 (0.93)	15%	386.67 (153.17)	3.75	60
15	65%	46–55 (28%)	32%	3.1 (1.26)	1.84 (1.33)	7%	274.16 (151,12)	8.1	60

Notes:
Supermarket = code of the supermarket (Table 1). Women = % of women. Age Group = the most common age group, in parentheses: the percentage of that group in the city population. Academics = % with a BA or higher degree. Family Size = the average family size with the standard deviation. #Cars = the average number of cars with the standard deviation. Religious = % of religious or very religious (orthodox Jews). Expenditure = average amount spent during a shopping trip with the standard deviation. #Goods = average number of sampled goods purchased. #Observations = number of consumers surveyed. The exchange rate during the period was NIS 4.37/US$1.

[32] This supermarket is located on a university campus and thus most shoppers there are students who usually buy only few items.

Table 4. Product Categories Included In the First Survey

Category	#Brands	*P* > NIS 20
Turkish Coffee	4	No
Instant Coffee	6	Yes
Bamba Peanut Snack	4	No
Lemon/Lime Soft Drink (6-Pack)	2	Yes
Mineral Water (6-Pack)	5	No
Coca Cola (6-Pack)	5	Yes
Orange Juice	6	No
Chocolate Spread	5	No
Soft Cheese	8	No
Yoghurt (8-pack)	4	No
Beer (6-pack)	2	Yes
Ice Cream	3	Yes
Sugar	2	No
Thick and Creamy Snack	2	No
Pasta and Rice	4	No
Dish Soap	5	No
Cleaning Detergent	4	No
Humus and Tahina salad	4	No
Ready Made Cake	4	No
Processed Meat	5	No
Shampoo	2	No
Pickled Cucumbers	2	No
BBQ Equipment	4	Yes
Basic Food	7	No
Tomato Concentrate	2	No
Fruits	1	No
Sweet Red Wine	2	No
Toilet Paper	2	No
Waffles	2	No
Crackers	4	No
Butter and Margarine	2	No
Clothing	2	No
Snack Cup Noodles	2	No
Ketchup	3	No
Ice Cream Snacks	2	Yes
Eggplant Salad	3	No
Cabbage Salad	4	No
Total	130	

Notes:
#Brand = number of brands in the category. *P* > NIS 20 = Is the average price in the category higher than NIS 20 or not?

Table 5. Summary Statistics for Product Categories in Supermarket 3

Category	Max Price	Min Price	Average Price	Average Quantity	Price Changes	Share of Consumers	frequency	Brands
Coca-Cola	6.29	4.42	5.04	1.63 liters	0.11	30%	0.30	4
Diet Coca-Cola	6.29	4.49	5.27	1.5 liters	0.05	20%	0.20	3
Mineral Water, 6-pack	15.99	10.00	14.19	9.75 liters	0.06	25%	0.25	4
Black Coffee	8.00	3.66	6.20	0.218kg	0.015	16%	0.16	8
Chocolate Waffles	5.40	1.30	12.83	0.325kg	0.006	4%	0.04	6
Bamba Peanut Snack	4.49	2.99	3.94	0.08kg	0	32%	0.32	7
Chocolate Spread	17.84	10.99	11.62	0.475kg	0.016	9%	0.09	4
Dairy Chocolate	10.99	5.49	10.34	0.098kg	0	9%	0.09	8
Canned Tuna	5.99	4.25	5.06	0.148kg	0.049	12%	0.12	7
Tomato Concentrate	9.23	5.99	5.06	0.38kg	0.036	9%	0.09	3
Canned Corn	10.98	5.49	7.00	0.44kg	0.0779	4%	0.04	5
Sugar	9.49	3.99	5.06	1.00 kg	0.03	4%	0.04	4
Eggs, medium size	20.99	9.40	15.92	12	0.068	17%	0.17	3
Cottage Cheese	5.79	4.82	12.14	0.25kg	0.064	37.5%	0.375	3
Diapers	71.99	39.98	57.38	54.18	0.018	4%	0.04	4
Fabric Softener	26.99	19.99	23.73	4 liters	0.052	7%	0.07	6
Plastic Cups	4.49	4.49	4.49	100	0	16%	0.16	1

Notes:

The prices in each category are reported for the categories' standard units, which are: 1.5 liters for the Coca-Cola, Diet Coca-Cola and mineral water categories; 100g for black coffee, chocolate waffles, dairy chocolate, canned tuna, tomato concentrate and canned corn categories; 8g for Bamba peanut snacks; 500g for chocolate spread; 250g for cottage cheese; 1kg for sugar; 4 liters for fabric softener, 12 eggs, 50 diapers and 100 plastic cups. The Average Quantity indicates the average package size/content in a category. In categories where packages contain more than one unit the average quantity reported is the number of unites per package(e.g., in the mineral waters category, each pack contains 6 bottles). The price changes column indicates the average number of price changes per week per category over the 11-weeks period. The Brands column indicates the number of brands sold in each category.

Table 6. Consumers' Knowledge of Goods' Prices and Quantities

Variable	Dependent Variable	
	Percentage Price Recall Error	Percentage Quantity Recall Error
Religion	-0.031 (0.082)	1.04* (0.625)
Academic	-0.015 (0.073)	-1.83*** (0.551)
Gender	0.119* (0.071)	0.889* (0.537)
Large Family	-0.075 (0.102)	-0.951 (0.773)
Discount Supermarket	0.051 (0.291)	-3.86* (2.21)
Outside City	0.19 (0.28)	2.52 (2.12)
Multi-Unit Pack	-1.09*** (0.123)	2.86*** (0.936)
Goods Consumed within a Short Period	0.008 (0.125)	-2.55*** (0.949)
Recalled Price	0.081*** (0.002)	-0.028** (0.014)
Average Category Price	-0.024*** (0.009)	0.055 (0.068)
Recalled Quantity	-0.0002 (0.0008)	0.079*** (0.007)
Average Category Quantity	-0.0003 (0.0013)	-0.145*** (0.01)
Category Price SD	-0.036*** (0.009)	-0.009 (0.07)
Category Quantity SD	-0.0004 (0.0007)	0.0209** (0.013)
Year 2008	-0.224* (0.144)	-6.75*** (1.11)
Holiday	-0.158* (0.096)	-1.62** (0.74)
Constant	0.248 (0.254)	4.5** (1.93)
Number of Observations	4184	4184
χ^2	2071.7***	1349.8***

Notes:
We used the SUR method. The dependent variables are the absolute values of the percentage *price recall error* and *quantity recall error*. Standard errors are reported in parenthesis.
*- Significant at 10%. **- Significant at 5%. ***-Significant at 1%.

Table 7. Probability of a Correct Recall, Conditional on Consumers' Attention Mode

Consumers' attributes		Goods' Attributes	
Religion	-0.257*	*Small Discount*	-1.153***
	(0.17)		(0.285)
Academic	0.111	*Supermarket-2 Dummy*	-0.935***
	(0.12)		(0.229)
Gender	-0.08	*Holiday* × *Expensive 20*	2.06***
	(0.119)		(0.422)
Large Family	0.659***	*Price Discount*	1.789***
	(0.21)		(0.24)
Middle Age	0.486***	*Quantity Discount*	1.315***
	(0.146)		(0.217)
Cashier-Parking	-0.271**	*Holiday* × *Price Discount*	-0.325
	(0.123)		(0.365)
Holiday	0.868***	*Holiday* × *Quantity Discount*	1.02***
	(0.154)		(0.3)
Constant	0.569***	Constant	0.871
	(0.125)		(0.639)
Number of Observations		1443	
Log Likelihood		-1597.94	
χ^2		57.85***	

Notes:
Consumers' Attributes = attributes which affect the probability that consumers are attentive. Goods' Attributes = attributes which affect the probability that consumers correctly recall whether or not a given good is offered at a discount. The dependent variable is *Correct Recall*. Robust standard errors are reported in parenthesis.
*- Significant at 10%. **- Significant at 5%. ***- Significant at 1%.

Figure 1. Baseline parameters

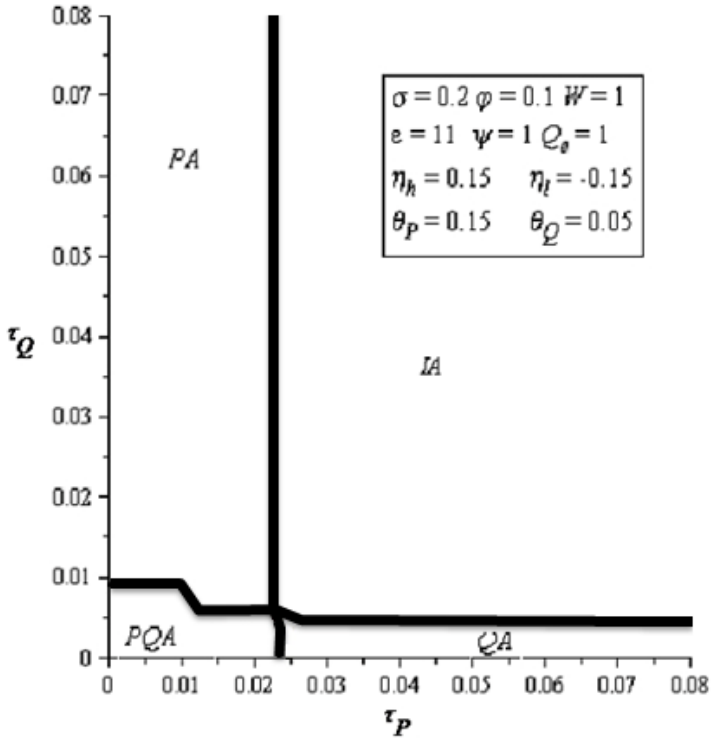
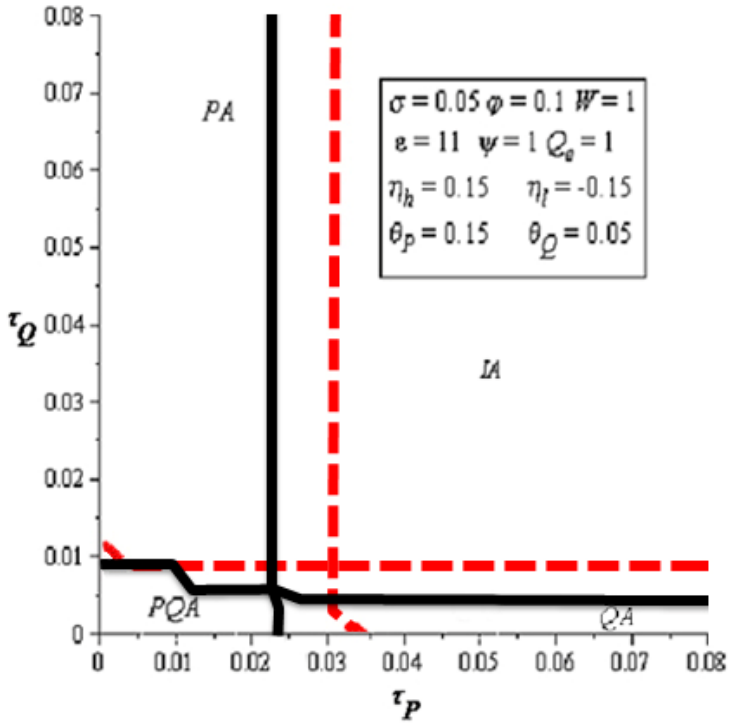


Figure 2. The effect of decreasing the absolute value of the elasticity of marginal utility with respect to consumption, σ, from 0.2 to 0.05



Note: PA = price attentive, QA = quantity attentive, PQA = price and quantity attentive, IA = inattentive

Figure 3. The effect of increasing the elasticity of marginal disutility with respect to labor, φ, from 0.1 to 0.15

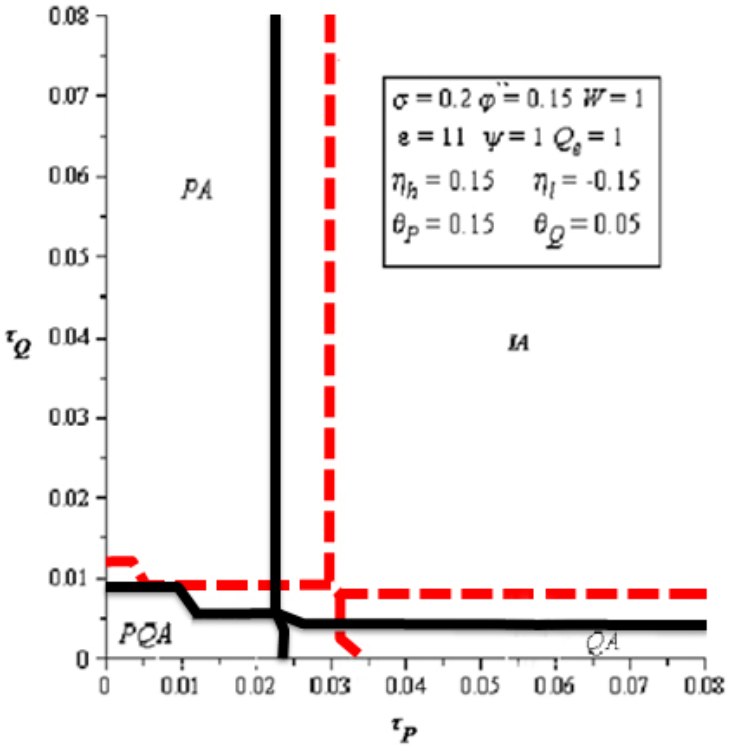
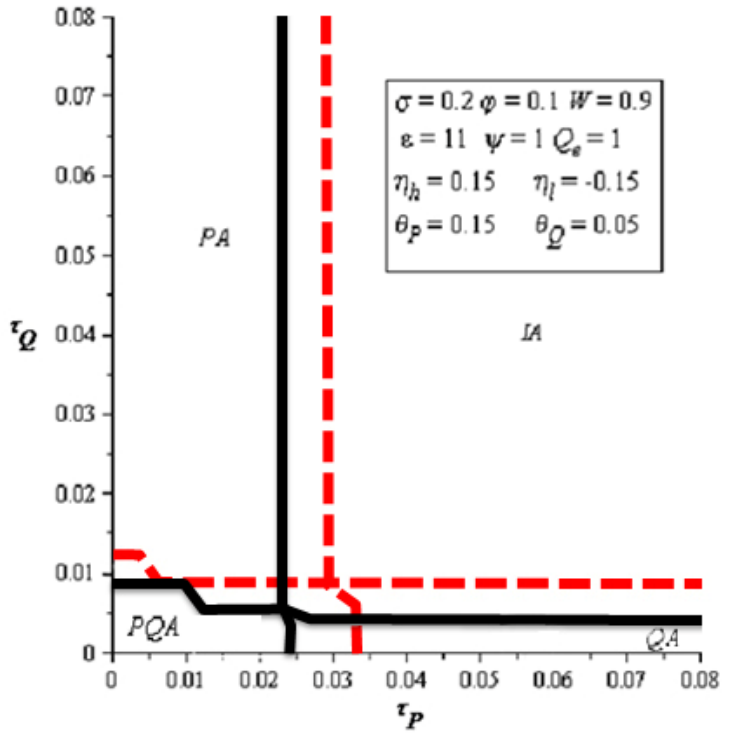


Figure 4. The effect of decreasing the nominal wage from $W = 1$ to $W = 0.9$



Note: PA = price attentive, QA = quantity attentive, PQA = price and quantity attentive, IA = inattentive

Figure 5. The effect of increasing the fraction of the producers who experience cost shocks and adjust their goods' prices, θ_P, from 0.15 to 0.2.

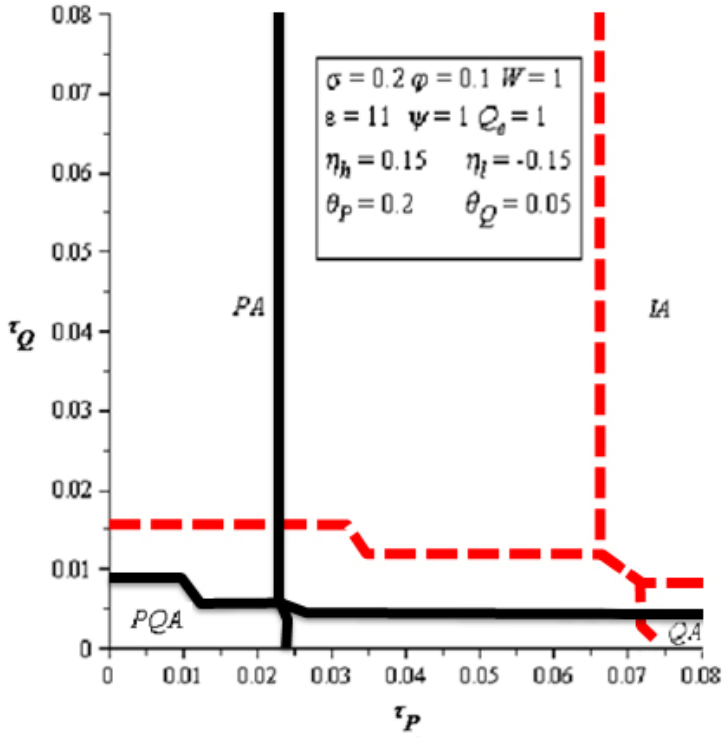
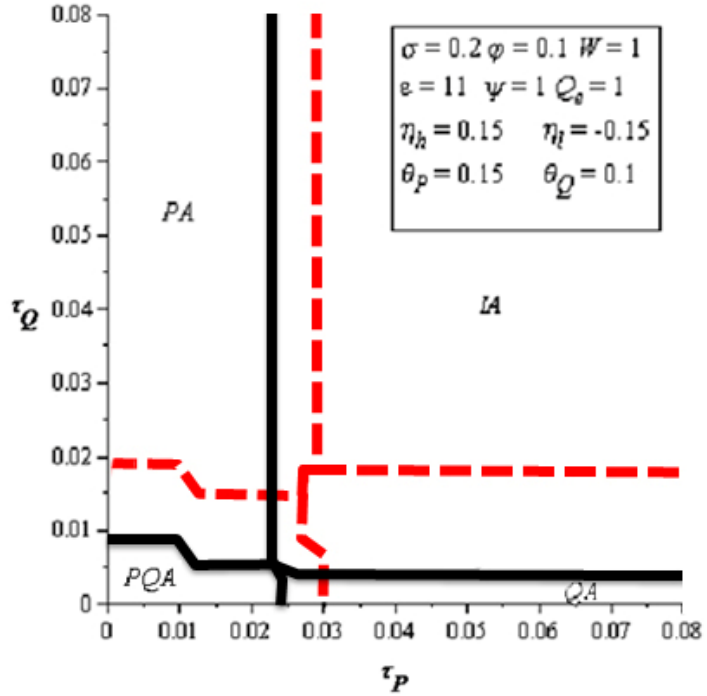


Figure 6. The effect of increasing the fraction of producers who experience marginal cost shocks and respond by adjusting goods quantity per package θ_Q from 0.05 to 0.1



Note: PA = price attentive, QA = quantity attentive, PQA = price and quantity attentive, IA = inattentive

Figure 7. The effect of increasing the elasticity of substitution, ε, from 11 to 21.

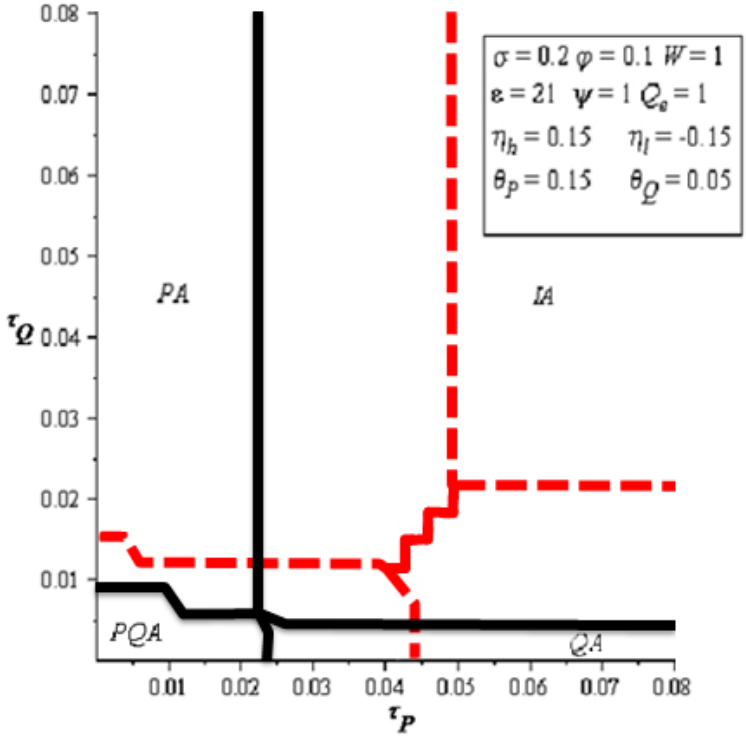
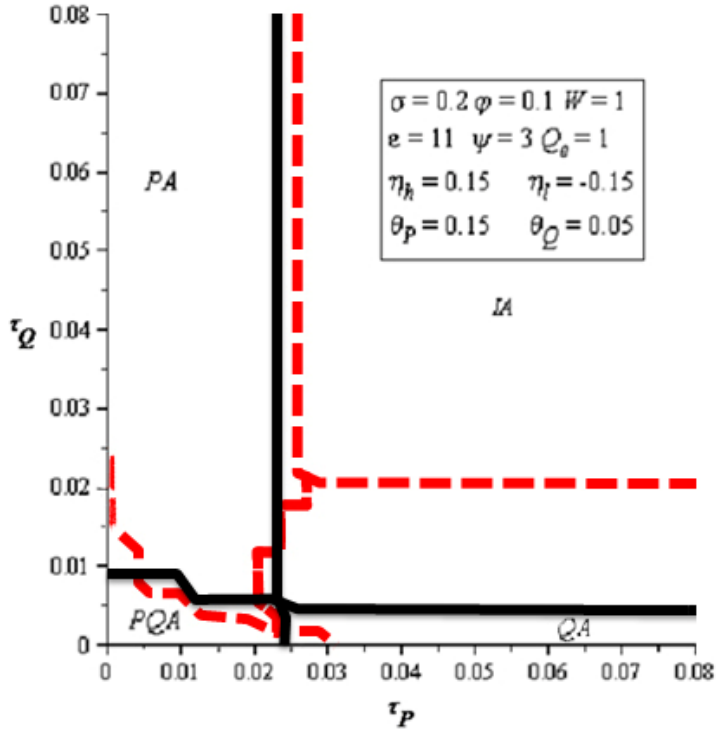


Figure 8. The effect of increasing the expected marginal cost, Ψ, from 1 to 3



Note: PA = price attentive, QA = quantity attentive, PQA = price and quantity attentive, IA = inattentive

Figure 9. The effect of increasing goods' expected quantity per package from 1 to 1.5

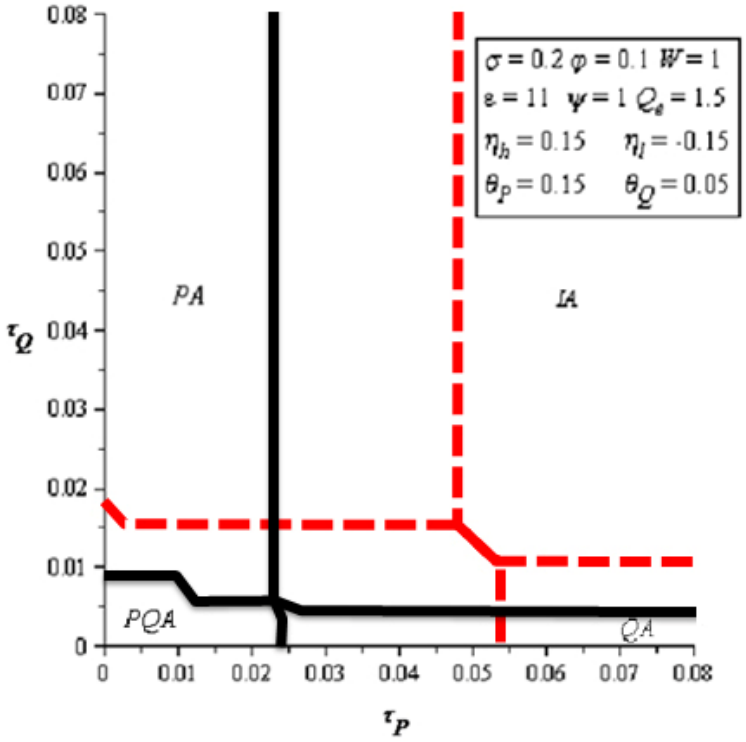
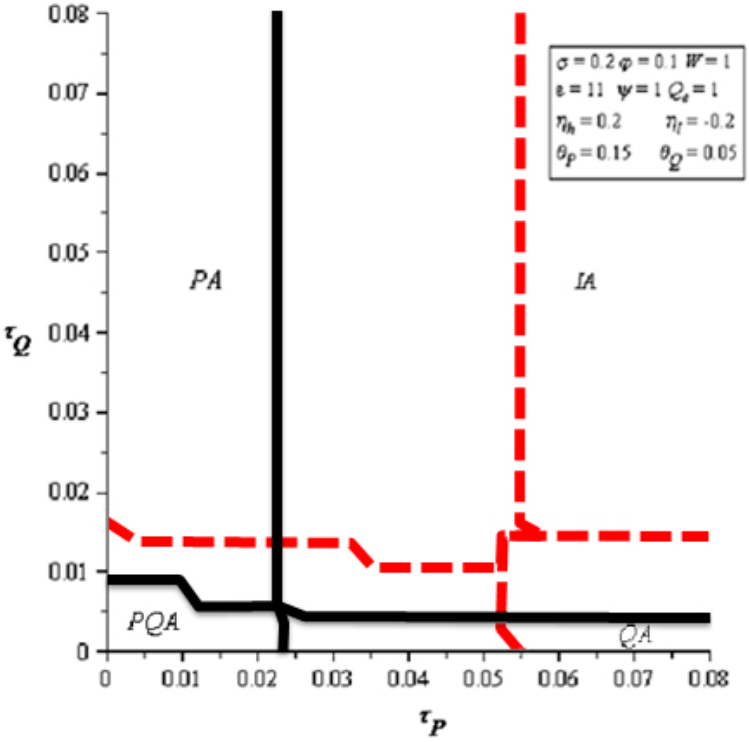


Figure 10. The effect of hanging the marginal cost shocks from $\eta_l = -0.15,\ \eta_h = 0.15$ **to** $\eta_l = -0.2,\ \eta_h = 0.2$



Note: PA = price attentive, QA = quantity attentive, PQA = price and quantity attentive, IA = inattentive

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