Shrinking Goods

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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 don't change. 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.

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NEW YORK -- By now, it is the stuff of legend: in the 1980's, Robert L. Crandall, then the head of American Airlines, came up with the idea of removing just one olive from every dinner salad served to passengers. They would never notice, let alone squawk, he figured, and the airline could save some money. He was right, to the tune of $40,000 a year.

Claudia H. Deutsch, *New York Times*, May 6, 2001[1]

NEW YORK -- 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[2]

1. INTRODUCTION

Much of the existing economic literature focuses on the adjustment of prices, perhaps because it is the product attribute that is adjusted most often, or perhaps because it is the attribute to which buyers pay the greatest attention. However, other attributes, such as quality, delivery time, delivery place, terms of payment, etc., are also occasionally adjusted (Smith, 1956, Carlton, 1977, 1983, 1989, 1991, Santoni and Van Cott, 1980, Levy and Young, 2004, Gourville and Kohler, 2004, Chen et al. 2012).

One of the non-price attributes that is often adjusted is the products' *quantity-per-package*, to which we refer as the products' *quantity*. Casual observation suggests that food manufacturers often shrink their products (a phenomenon termed "weight-out" in the industry), but keep the prices unchanged. They also offer "value packs," larger packages for the same price. Hershey, for example, changed the size of its bars 15 times during the inflationary period of the 1970s and 1980s but changed the price only four times (Knotek, 2011).[3]

Although such quantity adjustment in response to changes in market conditions is often observed in the marketplace, the economics literature has not paid much attention to it, and our goal is to fill this gap in the literature. Swan's (1970) model suggests that consumers should be indifferent between equivalent quantity and price adjustments as long the per unit price is the same. Empirical evidence however, suggests that consumers

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[1] Source: www.nytimes.com/2001/05/06/business/and-to-penny-pinching-wizardry.html?pagewanted=all&src=pm.
[2] Source: http://premium.europe.cnn.com/2001/fyi/news/01/16/grocery.items/index.html.
[3] The *NY Times* reported in 2008 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, Sweden, the UK, etc. Source: www.nytimes.com/2008/09/14/business/14feed.html?_r=1&ref=todayspaper&oref=slogin. Some consumer advocates update the list of shrinking products. See, for example, http://incredibleshrinkinggroceries.com. See also www.mouseprint.org/2008/05/12/ice-cream-scoop-major-brands-downsize-again/, and www.movetonz.org/forum/whats-news/9724-buyers-disgusted-product-downsizing-tactics.html.

often respond differently to equivalent changes in prices and quantities. Gourville and Kohler (2004), for example, find that consumers are more likely to reduce the number of units they purchase in response to price increases than to equivalent quantity decreases. Simonson and Tversky (1992) suggest, on the other hand, that consumers are sometimes less attentive to prices than to other attributes of the goods.

We construct, calibrate, and test a model which offers a possible explanation for observed consumers' responses to price and quantity changes. Because the two attributes that we study in the model are the goods' price and quantity per package, we use the abbreviation *P&Q* to refer to a good's *price and quantity*.

In the model, consumers face cognitive costs of information processing and, choose whether to process goods' price information, quantity information, both or neither (Smith et al., 2003). The model predicts that consumers' characteristics and market conditions jointly determine the extent of the information the consumers will choose to process. The model also predicts that in most shopping environments, consumers are more likely to process goods' price information than quantity information, but for some parameter values, this result is reversed. For example, the model suggests that when the consumers purchase large quantities and derive high benefit from consumption they are more likely to process goods' quantity information than price information. Thus, during holidays when consumers purchase large quantities which they consume in social settings, they will be more attentive to quantity information than during non-holiday periods.

We test this and some of the model's other predictions using data from two surveys on consumers' knowledge of goods' prices and quantities. Consistent with the model, we find evidence that consumers' characteristics and goods' attributes affect the likelihood of recalling goods' prices and quantities. For example, variables measuring the family size, education level, package size, number of units in the package, and the variance of prices have a positive effect on the likelihood of consumers recalling the goods' prices, while opportunity cost of time have a negative effect. We also find evidence that consumers are significantly more likely to recall goods' quantities in holidays than in other times, which offers an explanation why producers tend to offer bonus-packs in holidays but shrink their products in other times.

The rest of 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.

2. INFORMATION PROCESSING COSTS

Empirical evidence in psychology suggests that performing cognitive tasks requires *attention* which is a scarce cognitive resource. The amount of attention paid to a task and the speed in which it is executed depends on its cognitive difficulty and priority (Friedman et al., 1988, Peng and Xiong, 2006). High priority tasks and tasks that require greater cognitive effort receive more attention than routine tasks. Tasks which receive insufficient attention are cued until more attention is available. Consequently, cognitive processes are often cued until enough attention becomes available (Navon and Gopher, 1979, Kahneman and Treisman, 1984).

Processing goods' P&Q information therefore costs both time and effort, because it consists of many cognitive tasks and each of these tasks 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 store it in long-term memory. Since the same process has to be repeated for processing the P&Q information of every good, the time dedicated to processing goods' P&Q information increases linearly (or almost linearly) with the number of information pieces processed (Navon and Gopher, 1979).

To minimize information processing costs, consumers might choose not to process some information (Thaler 2000, Chen, et al. 2008, Levy, et al. 2011). In our model, consumers therefore choose whether to process goods' price information, quantity information, both, or neither, by assessing the cost and the benefits of the information.

3. THE MODEL

(i) Consumers

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 call 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 $L \in [0,1-\mathrm{T}-N]$. Their nominal income, *Y*, is given by $Y = NW$, where *W* is the nominal wage.

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 spent on processing goods' information, and $\varepsilon > 1$ is the elasticity of substitution between goods.

(ii) <u>Producers</u>

We focus on consumers' behavior and, therefore, we follow 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 that the producers are engaged in monopolistic competition and given the substitution between goods, the producers set their prices to equal the marginal cost, $\Psi(i)$, times the desired markup, $\mu = \frac{\varepsilon}{\varepsilon - 1}$. Denoting the price of good i by $P(i)$, and the expected price by $P^e \equiv E[P(i)]$, we have:

$$P(i) = \mu \Psi(i), \text{ and} \tag{3}$$

$$P^e = \mu \Psi . \tag{4}$$

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 a marginal cost shock $\eta(i)$. Therefore, marginal costs of these producers are $\Psi(i)=\Psi+\eta(i)$. We assume that the marginal cost shocks follow a symmetric iid 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.[4] To maximize profits, producers that adjust quantity choose the new quantity such that the unit price of the good, $\frac{P(i)}{Q(i)}$, is the same as if the price was adjusted and the quantity was unchanged. Denoting the expected quantity as $Q^e\equiv E[Q(i)]$, the adjusted quantity therefore satisfies:

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

where $\kappa(i)$ 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 that experience a cost shock, either adjust the price according to (5) or the quantity according to (5') and (7).

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

(iii) Consumers' Decision Making Process

Consumers can process goods' price information, goods' quantity information, both or neither. All goods enter the utility function symmetrically. We assume, therefore, that consumers choose either to process the price information of all goods, or not to process the price information of any good. Similarly, they either choose to process the quantity information of all goods, or they choose not to process the quantity information of any good. [5]

Consumers therefore choose between four attention modes. *Price attentive* consumers (*PA*) process only good's price information. They 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. 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. *P&Q attentive* consumers (*PQA*) process both the price and the quantity information of every good i. They 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 assume that every good's P&Q equal their expected values P^e and Q^e, respectively**.**

We denote the cost of processing a price information by τ_P and the cost of processing a quantity information by τ_Q. To ensure that consumers can process both P&Q per package information, we assume that $\tau_P + \tau_Q \leq 1$. Since the time required for information processing increases linearly with the information processed, the cost of being IA is zero, the cost of being PA is $\int_0^1 \tau_P di = \tau_P$, the cost of being QA is $\int_0^1 \tau_Q di = \tau_Q$ and the cost of being PQA is $\int_0^1 (\tau_P + \tau_Q) di = \tau_P + \tau_Q$.

The demand of consumers for good i in attention mode $\kappa \in \{PA,\ QA,\ PQA,\ IA\}$ is denoted $C_\kappa(i)$. The consumption bundle of consumers in attention mode κ is denoted C_κ.

The price level that consumers face in attention mode $\kappa \in \{PA,\ QA,\ PQA,\ IA\}$ is

[5] Armstrong and Chen (2009) assume that a certain proportion of the consumers have information about all goods, while the rest do not have information about any good.

$P_\kappa = \frac{1}{C_\kappa}\left[\int_0^1 C_\kappa(i)P(i)di\right]$. 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 *P&Q 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 *P&Q 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)

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

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

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.

P&Q attentive consumers process both goods' price information and 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, $\int_0^1\left[\frac{P(j)}{Q(j)}\right]^{1-\varepsilon}dj$. Since they substitute high unit price goods with low unit price goods, 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). Goods with small quantity enter the denominator with the same

weight as goods with large quantity and consequently they decrease the denominator and, therefore, increase the price level.

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 on the aggregate of all goods' quantities, $\int_0^1 Q(j)^{\varepsilon-1} dj$. The penalty that quantity attentive consumers pay for not processing goods price information is therefore given by the positive effect that prices have on the numerator of (11). Goods with high prices are given the same weight in the numerator of (11) as goods with lower prices and they consequently increase the price level.

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

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

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

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

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

and

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

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

is consumers' nominal income, P_k is the price level 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 (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) into (17), we find that as long as (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 (18) is binding, then 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 equals the real income $\frac{Y_k}{P_k}$ given by

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

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

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

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 W, τ_P and τ_Q as given, consumers choose the attention mode which maximizes their utility:

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

Since all consumers are identical, all consumers choose the same attention mode and 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 to study the effects of changes in the model's parameters. As a benchmark we assume that $\sigma = -0.2$ and $\phi = 0.1$. Thus, the marginal utility of consumption decreases relatively slowly, and the marginal disutility of labor increases almost linearly. We set the mark up $\mu = \frac{\varepsilon}{\varepsilon - 1} = 1.1$ implying $\varepsilon = 11$ (Barsky, et al., 2003). We normalize W, Ψ, and Q^e to equal one.

Existing empirical studies report that the monthly frequency of consumers' goods' price changes is between 11%–25% per month. We therefore set $\theta_P = 0.15$. Gourville and Kohler (2004) report that the monthly frequency of changes in quantities is between 2.7%–8.2%. We thus set $\theta_Q = 0.05$. 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, $\eta_l < 0$. We assume further that $\eta_h = |\eta_l|$. The literature reports that most price changes are in the range of 10%–30%. We therefore set $\eta_h = |\eta_l| = 0.15$.

The results of this benchmark calibration are presented in Figure 1. The lines in the figure divide the τ_P, τ_Q space into four regions, indicating the combinations of τ_P and τ_Q for which consumers are price attentive (PA), quantity attentive (QA), P&Q attentive (PQA), and inattentive (IA). According to Figure 1, consumers are P&Q attentive if both $\tau_P < 0.024$ and $\tau_Q \in [0.05, 0.08]$. 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 $\tau_Q < 0.005$.[6] Thus, consumers are inattentive even for small cost of processing P&Q information. They are also more likely to be price

[6] 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 8 shopping trips/month, consumers are P&Q inattentive if processing goods' P&Q information costs exceed 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. I.e., 20 minutes/shopping trip.

attentive than quantity attentive, both because more producers adjust prices than quantities and because changes in prices have both income and substitution effect while changes in quantities have only substitution effect since they change the utility but not the budget constraint. The model, thus, explains both Fox and Hoch's (2005) finding that over 90% of consumers are P&Q 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 $-\sigma$, from –0.2 to –0.05. When $-\sigma$ increases, consumers have greater incentive to process goods' P&Q information because their utility from consumption increases. They, therefore, process goods' P&Q information for greater costs of information processing than consumers in the benchmark setting. Figure 3 shows the effect of increasing φ from 0.1 to 0.15. When φ increases, consumers choose to process goods' P&Q information for higher information processing costs because they lose more utility from any amount of time they work. Therefore, they are more willing to trade time spent on work for time spent on information processing.

(iii) Changing Consumers' Wage

Figure 4 depicts the effect of decreasing 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 benefit from lower price level increases. Thus, the total effect of the change in W is ambiguous.[7] 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' P&Q information than consumers with average incomes, which is consistent with the findings reported by Gabor and Granger (1961, 1966) and Falkinger (2008).

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

Figures 5 and 6 depict the effects of increasing θ_P and θ_Q, respectively. In

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

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 θ_P or θ_Q increases, consumers become P&Q attentive for larger information processing costs because the variance of goods' unit-prices, $Var\left[\frac{P(i)}{Q(i)}\right]$, increases and, therefore, consumers have greater incentives to process goods' P&Q information.

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

Figure 7 depicts the ceteris paribus effect of increasing ε from 11 to 21.[8] When ε increases, consumers become P&Q attentive for larger information processing costs because consumers are more willing to substitute high unit-price goods with low unit-price goods and, therefore, they benefit more from processing goods' P&Q information.

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

Increasing 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, using the benchmark parameters, as long as $1 \le \Psi \le 2.5$, consumers will process goods' P&Q information only for smaller information processing costs than in the benchmark economy. If $\Psi > 2.5$, as in Figure 8 where $\Psi = 3$, the income effect dominates and consumers are P&Q attentive for larger information processing costs than in the benchmark economy.

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

Figure 9 depicts the effect of an increase in Q^e from 1 to 1.5. When Q^e increases, consumers become P&Q attentive for larger information processing costs

[8] 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.

because consumers receive more utility from each package they purchase. Consequently, they have greater incentives to process goods' P&Q information.

(viii) Changing the Size of the Marginal Cost Shock

Figure 10 depicts the effect of an increase in η from $|\eta| = 0.15$ to $|\eta| = 0.2$. When $|\eta_h|$ and $|\eta_l|$ increase, consumers become P&Q attentive for larger information processing costs because the variance of goods' unit-prices increases and, therefore, consumers lose more utility if they do not process either goods' P or Q information.

5. DATA

Our data comes from two surveys conducted in Israel during 2005–2008. Some summary statistics on the supermarkets sampled and the consumers surveyed are given in Tables 1–3. In the first survey, we sampled consumers in two supermarkets (supermarkets 1 and 2 in Table 1). In the second survey, we sampled consumers 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.

Although, not representing the entire Israeli retail food industry, the supermarkets and the consumers sampled are a fairly good representative of pricing and promotion practices, and shopping patterns, common in Israel. During the survey period, the Israeli GDP grew at an annual rate of 4%–6.5%.[9] The annual inflation during 2005–2007 was between 0%–2%. It increased to 3.7% in 2008.[10]

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 supermarket exit than in other places because there they usually have more retrieval cues.[11] Consumers who agreed to participate were first asked about their socio-economic status and then they were shown a

[9] Source: www.cbs.gov.il/shnaton60/st14_02x.pdf.
[10] Source: www.cbs.gov.il/www/price_new/g1_2_h.pdf.
[11] We were not allowed to interview them inside the supermarkets.

list of goods.[12] 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.[13] Consumers were asked only about goods they purchased in their current shopping trips. For each good, consumers were asked to recall whether or not the good 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 each of 17 categories, which represent a large proportion of the goods sold in Israeli supermarkets. Table 4 offers the list of categories. As an example of the goods that were sampled, Table 5 offers summary statistics of the goods that were sampled in Supermarket 3.[14] Consumers were asked only about goods they purchased in their current shopping trip. For each goods, they were asked to recall the good's P&Q. They were also asked about purchase frequency of the goods, about the number of packages they purchased in the current 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.[15]

6. 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 information 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 likelihood that consumers correctly recall P&Q information as a proxy for the time and effort they

[12] 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.
[13] The lists were updated every week. An example of a *price discount* is a 1.5L bottle of Pepsi sold for NIS 3.89 instead of the list price of 4.99 (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" are examples of quantity discounts. We collected some of the data around holiday periods because in Israel many food retailers offer quantity discounts during these periods.
[14] We present supermarket 3 data as an example. The other supermarkets exhibit a similar behavior..
[15] The survey was conducted in Hebrew. An English version of the questionnaire is available upon request.

devote to processing the goods' P&Q 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, in contrast, is close to 450%, an order of magnitude higher. This is consistent with the evidence that consumers and students alike have difficulties when facing problems with varying measurement units (Chen, et al., 2012). Recall that in case of prices, the only unit of measurement is the dollar. In the case of quantity, in contrast, there are several units (Kilogram, Pound, Ounce, Liter, etc., not all decimal/metric) which along with their factions (grams, oz, milliliters, etc.) lead to multiple measurement units.[16] In addition, price information is usually more noticeable (prices are displayed in larger fonts, more colorful signs, etc.) than quantity information. The cognitive cost of processing price information is therefore likely to be smaller than the cost of processing quantity information (Miyazaki et al., 2000).

The model suggests that the likelihood of correctly recalling goods' P&Q information depends on consumers' and goods' attributes and on market conditions. Because we are interested in consumers' knowledge of both prices and quantities, we use SURE to estimate two regressions simultaneously. In one, the dependent variable is the absolute percentage error consumers make in recalling goods' prices. In the second, the dependent variable is the absolute percentage error they make in recalling quantities. Both regressions include the same set of independent variables: a gender dummy (1 if a consumer is a *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' *P&Q as recalled* by the consumer, the category-level *average price* and the *average quantity*, the category-level *standard deviation of prices* and *quantities*, a dummy for the year 2008, a holiday dummy (1 if a good was purchased during *a holiday* period) and fixed effects for goods' categories, for consumers' age and for the cities where the

[16] In US 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 of the metric education system in the UK: www.bwmaonline.com/The%20Failure%20of%20Metrication%20by%20Education.htm.

supermarkets are located.[17]

We do not have any specific hypothesis about the gender dummy, and we include it to avoid missing variables bias. Subjects with academic background are likely to have lower information processing costs, because evidence from psychology suggests that the ability to obtain higher education is correlated with better memorization and retrieval skills (Dehn, 2008). However, they may also have higher opportunity cost. Thus, the net effect depends on which of the two effects dominate. We expect consumers with large households to have greater benefits from processing P&Q information as they often purchase large quantities.

Consumers with a moderate-Jewish religious background often purchase only goods that satisfy strict Kosher requirements. Most other consumers are satisfied with regular Kosher certifications and thus the share of goods satisfying strict Kosher requirements is relatively small. Therefore, brands that satisfy religious consumers' Kosher requirements often have greater market power among religious consumers than in the general population. The discussion following Figure 7 suggests, therefore, that religious consumers will tend to be less likely to process goods' P&Q 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 these consumers to be more likely to process goods' P&Q information. We do not have a priori prediction about consumers who shop in supermarkets located outside cities, because although out of city supermarkets tend to be discount supermarkets, they often appeal mostly to consumers with cars who usually have higher opportunity cost of time than consumers that do not own cars.

Goods that are consumed within a short period are often goods that are purchased often. Thus, we expect that consumers are more likely to correctly recall their prices and quantities. Goods sold in multi-unit packs offer greater quantity per package and, therefore, consumers have greater incentives to process their P&Q information. However, it is also harder to process the quantities of multi-unit packs because the calculation involves multiplication operations.[18] We hypothesize, therefore, that consumers are more likely to correctly recall multi-unit packs' prices, but we do not have ex-ante predictions

[17] Another variable, —average expenditure, was insignificant in both this and the regression reported in section (ii), perhaps because we used relatively large expenditure brackets, and consequently much of its variance was lost.
[18] For example, to find the quantity of a 6-pack Pepsi, 16 fl oz per bottle (96 fl oz.), the consumer has to multiply 6 by 16..

about the effect of multi-packs on the likelihood of recalling quantity information.

Marketing literature suggests that consumers form reference prices which depend either on the recalled prices of selected brands (*internal* reference prices) or on the average price in the category (*external* reference price). Consumers tend to choose brands with the lowest price relative to the reference price rather than the brands with 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.[19]

The model suggests that an increase in the variance of goods' prices and quantities make consumers more likely to process goods' P&Q information. Increasing the variance, however, also increases the cost of processing P&Q information because there is more information to process. We therefore cannot predict the effects of increasing the variance of prices and quantities.

The inflation in Israel was 3.7% in 2008, up from 0% during earlier years. 2008 was also a year of economic slowdown, with many consumers experiencing a decrease in their incomes. We therefore include a 2008 dummy to control for these two effects. Because inflation increases the share of producers who adjust prices and quantities, the discussions following Figure 4, 5 and 6 suggest that in 2008 consumers would devote more effort to processing goods' P&Q information than in 2006 and 2007.

Consumers are likely to have greater marginal benefits from consumption in holidays for two reasons. First, consumers usually have more time for leisure during holidays. Second, consumption in holidays often takes place in social settings and, therefore, consumption in holidays offers a conspicuous benefit in addition to the utilitarian benefit (Bagwell and Bernheim, 1996). The model suggests that the greater the marginal utility of consumption, the more likely it is that the consumer will process goods' P&Q information. The model also predicts that marginal utility of consumption has greater effect on the likelihood that consumer will process quantity information than price information. We therefore expect that the holiday effect will be more significant in the quantity regression than in the price regression.[20] However, because during holidays

[19] 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.

[20] During regular weeks, the quantity purchased remains stable and thus consumers pay more attention to prices than quantities. During holiday periods, however, because of the social consumption, the consumers need to assess how much they need to buy, forcing them to be more attentive to quantities than during non-holiday weeks. Thus, during non-holiday periods, when there is a greater price variation, consumers are relatively more attentive to prices, while during holidays, when there is a greater quantity variation, consumers are relatively more attentive to quantities.

price elasticity may be lower (Warner and Barsky, 1995), the direction of the net effect is unclear a priori.

Because the dependent variables measure percentage errors, negative coefficients indicate better recall. We therefore expect that the variables that increase consumers' benefits (costs) of information processing will attain negative (positive) coefficients. In addition, we expect that the effects are stronger for quantities than prices because the cost of processing quantity information is greater, and also because the evidence suggests that changes in costs and benefits of information processing affect behavior more when the cognitive costs are high (Kahneman and Frederick, 2002, p. 68).

The estimation results are reported in Table 6. The coefficients of *academic degree*, *family has more than five members*, *discount supermarket*, *goods consumed within a short period*, *year 2008* and *holiday*, are negative, while the coefficient of *moderately religious* is positive.[21] In addition, the coefficients of all these variables, except *families with more than five members*, are significant in the quantity regression and most are significant in both regressions. As discussed above, changes in costs and benefits of information processing are likely to have greater effects if the information processing costs are high. The greater significance of the coefficients in the quantity regression supports the hypothesis that consumers' characteristics and market conditions affect the probability of recall because they are correlated with the costs and benefits of information processing.

The findings strongly suggest that the consumers devote more cognitive effort to processing goods' information in holidays, suggesting that producers face different demand elasticities with respect to prices and quantities in holidays compared to other periods, which may partly explain the greater price rigidity observed during holidays (Warner and Barsky, 1995, Levy et al., 2010). These results may also be one explanation for the popularity of value packs and other kinds of quantity discounts in Israel during holidays.

The remaining coefficients are also significant in at least one of the regressions and the significant coefficients all have the expected signs. 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*. They are less likely to correctly recall the quantities of goods

[21] The coefficient of women is positive, suggesting that women are more likely to make large errors than men. This is unexpected because some evidence suggests that women pay more attention to prices than men (Raajpoot, et al. 2008). In our sample, however, it is likely that most responders are frequent shoppers and, therefore, the differences between men and women in our sample might be different than in the general population (Mortimer, 2009).

sold in multi-packs, suggesting that the greater cognitive costs required for processing the quantity information in multi-packs relative to other goods have a dominant effect.

Increasing the variance of prices (quantities) in a category increases (decreases) the likelihood of correctly recalling price information, suggesting again that the costs of processing quantity information exceed 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.[22]

(ii) Test 2: Consumers' Attention to Price and Quantity Discounts

The use of price recall information as a proxy for the knowledge that consumers have about goods' prices may underestimate the knowledge that consumers have because price recall surveys ask for verbal responses about information that consumers might store in non-verbal code. Consequently, consumers may fail to give correct answers even if they have a non-verbal representation of the correct value (Monroe and Lee, 1999, Vanhuele and Dréze, 2002).[23] In this section, therefore, rather than asking the consumers about goods' P&Q information, we focus on 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 are often large.[24] Second, discount information is usually more visible and, therefore, easier to process than other types of P&Q 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 retrieve it than the goods' exact P&Q even if the information is stored in a non-verbal code (Monroe and Lee, 1999, Vanhuele and Drèze, 2002).

Consumers, therefore, are likely to have greater incentives and face smaller cognitive costs when processing discount information than when processing goods' P&Q information. Indeed, we find that consumers correctly recall whether or not a good is

[22] We included the recalled prices and quantities and the categories' average prices and quantities to control for reference price effects. The coefficients of *categories' average prices* and *categories' average quantities* are negative, whereas the coefficients of the *recalled price* and *recalled quantities* are positive, suggesting that consumers 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.

[23] There are two systems for storing information in memory. *Explicit* memory is for storing information used verbally. *Implicit* memory is for storing information used in non-verbal settings, (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 codes 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.

[24] The average discount at the two supermarkets surveyed was 15%–20% of the list prices.

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 the model, we assume that the likelihood that consumers correctly recall goods' P&Q 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:[25]

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

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 cohort are more likely than other consumers to correctly recall goods' prices (Fox and Hoch, 2005).[26] We include the *cashier-parking* variable because consumers who care more about both factors are more likely to be time constrained and, therefore, less likely to process goods' P&Q information. The *Passover* variable is one of the main holidays in the Jewish calendar, and the main family get-together event. Consumers, therefore, should be more likely to process goods' P&Q information in Passover than in other periods.

[25] We have tried logit and multi-logit specifications as well. In all cases, we obtained similar results.
[26] We also estimated the regression with age fixed effects. The results were similar to what we report here.

Goods' 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), *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*.[27] We also include fixed effects for goods' categories.

We include the *small-discount* variable because the model above suggests that consumers are less likely to process goods' P&Q information if the benefit from doing so is small. In addition, empirical evidence suggests that consumers 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. *P&Q 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' P&Q information if the goods' prices are high. We expect, therefore, that the coefficient of the interaction term of *more than NIS 20* and *Passover* will be 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 *P&Q discounts* because we expect that consumers have greater marginal utility from consumption in holidays than in other periods. The model also suggests that marginal utility from consumption has greater effects on the likelihood of processing quantity information than price information. We therefore hypothesize that the interaction of Passover and quantity discounts should have greater effect than the interaction of Passover and price discounts.

The results of the maximum likelihood-estimation of (32) are reported in Table 7 along with robust standard errors. The coefficient of *academic degree* is not significant,

[27] 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*" was statistically insignificant and had no effect on other coefficients. We therefore dropped it from the regression.

although its sign is consistent with the regression in section (i).[28] The coefficient of *large families* is positive and significant. Consumers in the 45–55 age-group are more likely to correctly recall discounts. *Moderately religious* consumers are less likely to correctly recall discounts. The coefficient of the *Passover* dummy is positive and significant, suggesting that consumers devote more time and effort to processing goods' P&Q information.[29]

To test whether the consumers are more attentive to goods' P&Q information because they have greater benefit, as suggested by Warner and Barsky (1995) or because during Passover there are more discounts and, consequently, discounts are more noticeable, we take advantage of the fact that most discounts start a week before the Passover and last one week beyond Passover. Thus, consumers face the same number of P&Q 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.

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 P&Q 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 greater than the

[28] The coefficient of *women* is insignificant in this regression as well.
[29] The Passover period in Israel is similar to the Christmas period in the US (Warner and Barsky, 1995).

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 more likely to recall quantity discounts than price discounts ($\chi^2_{(1)} = 3.51,\ p < 0.1$). This may explain the popularity of quantity discounts during Passover and other holidays. 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.

The results of the discount recall regression, therefore, strengthen the results of the P&Q regressions. Both sets of results suggest that consumers' characteristics, goods' attributes and market conditions are important determinants of the likelihood that consumers will process goods' P&Q information. Both sets of regressions also suggest that because market conditions and consumers' characteristics vary over periods, the likelihood that consumers will process P&Q information will vary as well. During non-holidays, for example, consumers are more likely to process goods' price information than quantity information.

7. 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), 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 the theoretical section, 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 P&Q adjustments as long as they are equivalent in terms of the price per unit. However, the model suggests that consumers are likely to respond differently to equivalent P&Q adjustments because consumers face cognitive information processing

costs which force them to choose whether to process goods price information, 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.

Although the study suggests a possible explanation for the empirical finding that consumers respond differently to P&Q adjustments, it has several limitations. On the theory front, our model is static. Modeling a dynamic, strategic setting, although not easy, will be useful for understanding the effects of information processing costs on consumers' behavior and on producers' adjustment strategies over the cycle. Also, the firms in our model adopt a mark-up pricing which might be suboptimal when facing inattentive consumers.[30] Consequently, our model yields a corner solution with no dispersion in the extent of consumers' attention to products' prices and quantities. Future studies should therefore model the firm's optimal price-setting along with the consumers' optimal choice of attention mode.

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. In our survey data, despite our efforts, there likely are missing variables, and thus our empirical evidence should be interpreted as suggestive. More research is needed 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. 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.

[30] For example, the price elasticity of demand will not necessarily equal ε if some consumers are inattentive.

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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[31]	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.

[31] 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

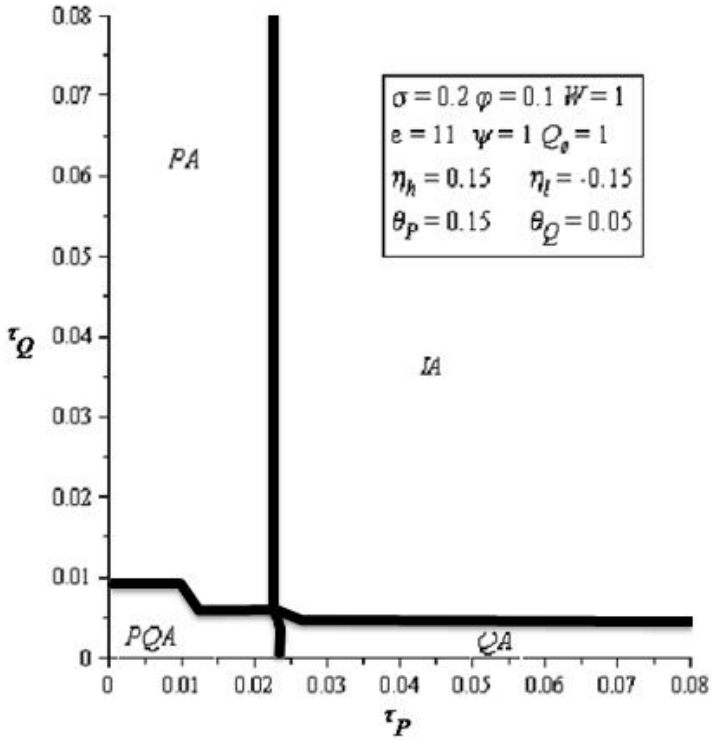
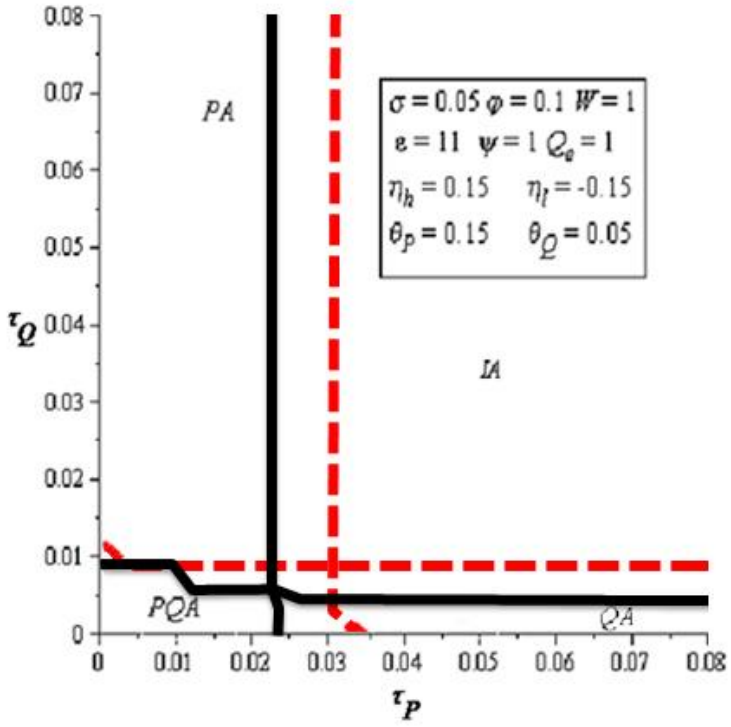


Figure 2. The effect of decreasing the absolute value of the elasticity of marginal utility with respect to consumption, σ, from 0.2 to 0.05



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

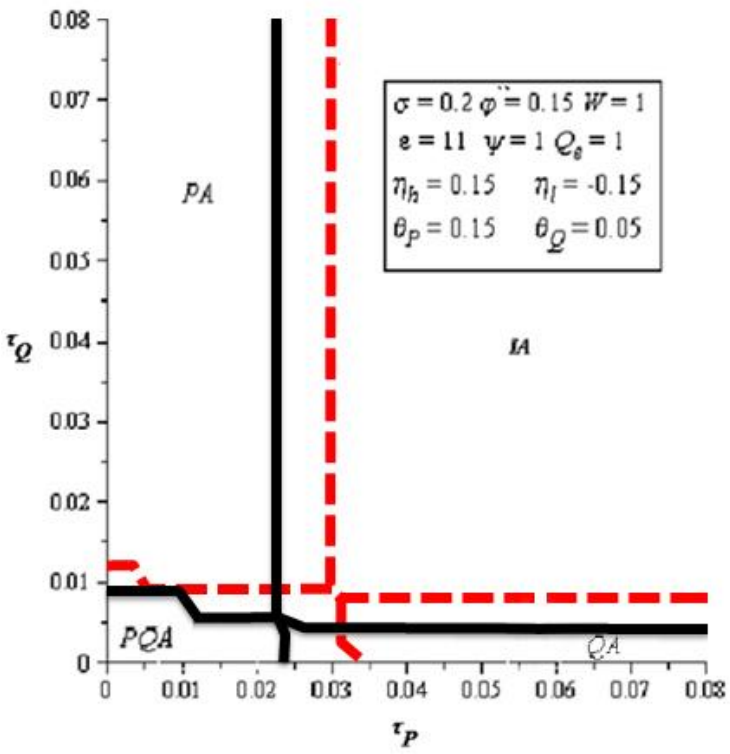
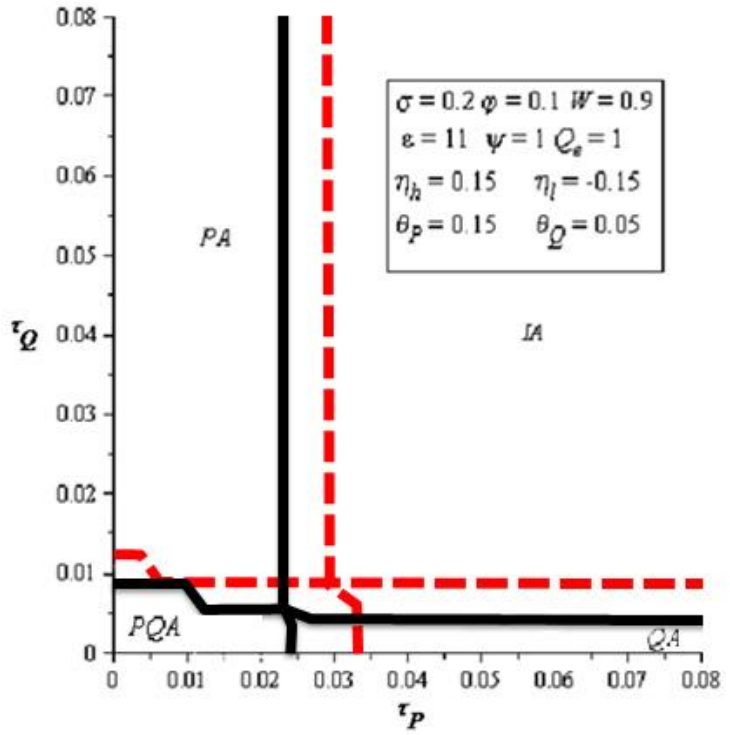


Figure 4. The effect of decreasing the nominal wage from $W = 1$ to $W = 0.9$



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.

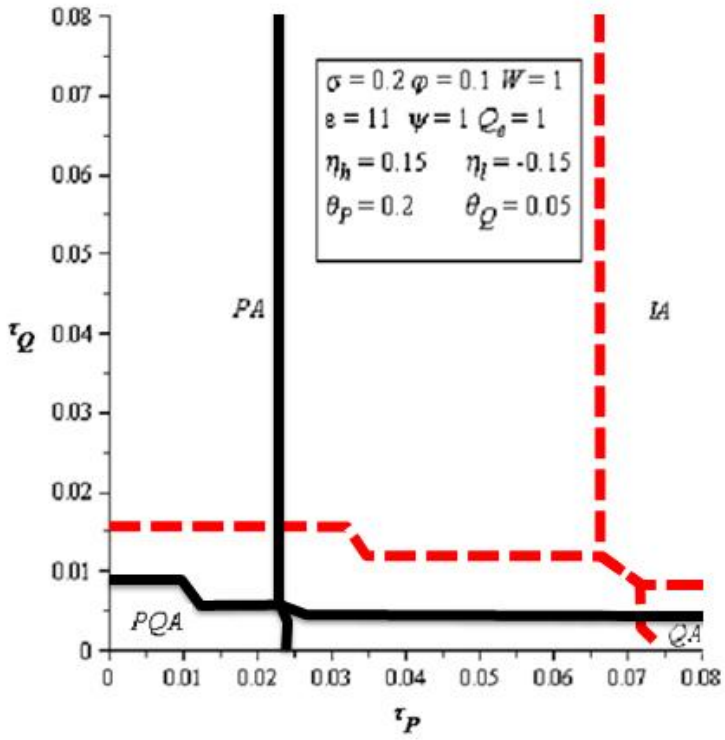
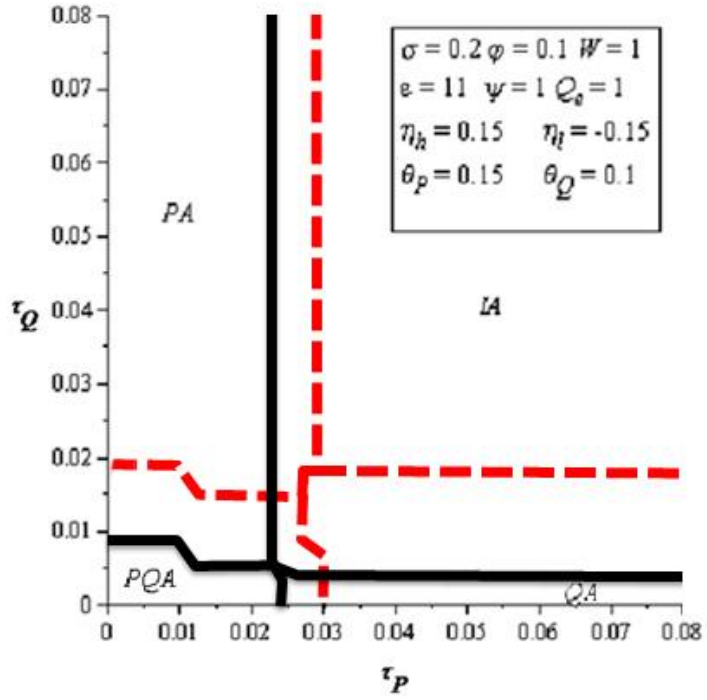


Figure 6. The effect of increasing the fraction of producers who experience marginal cost shocks and respond by adjusting goods quantity per package θ_Q from 0.05 to 0.1



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.

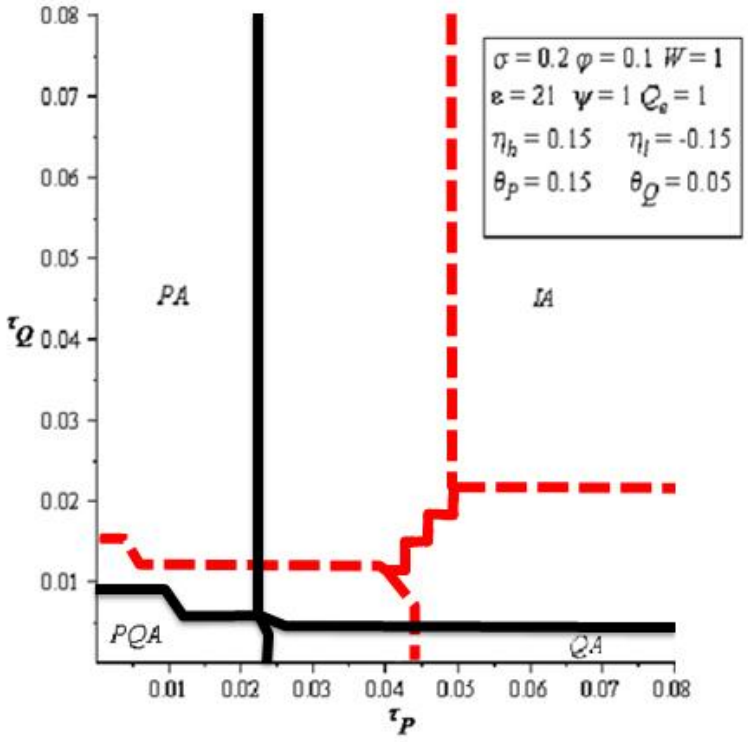
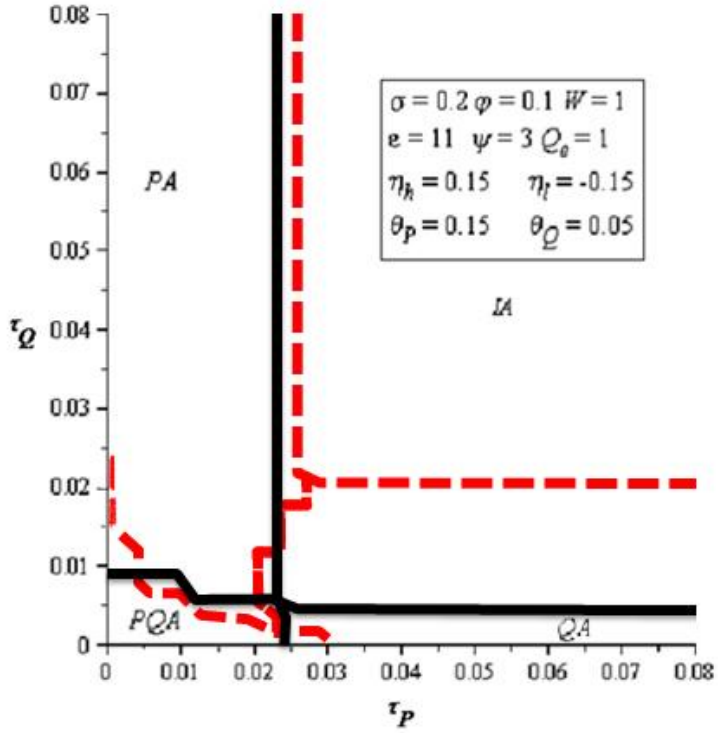


Figure 8. The effect of increasing the expected marginal cost, Ψ, from 1 to 3



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

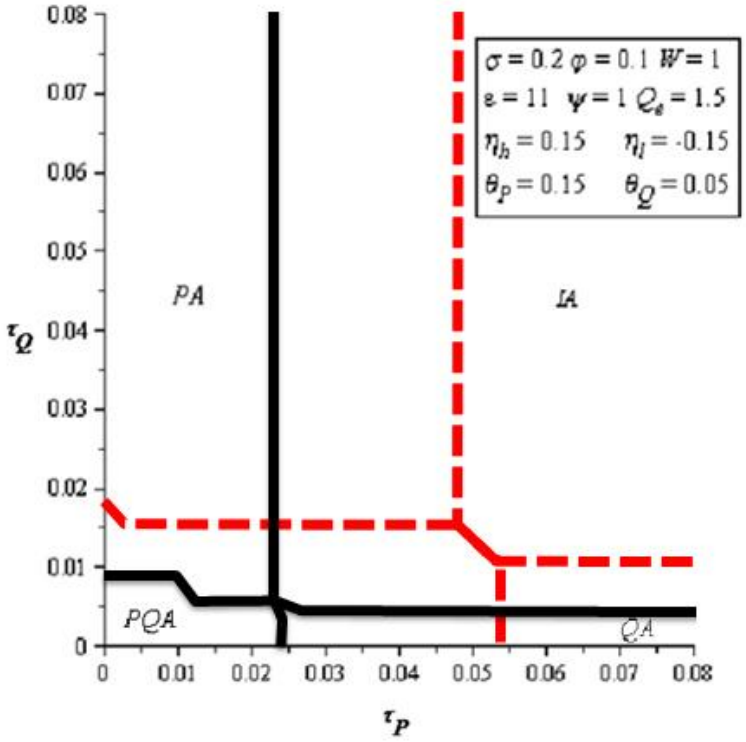
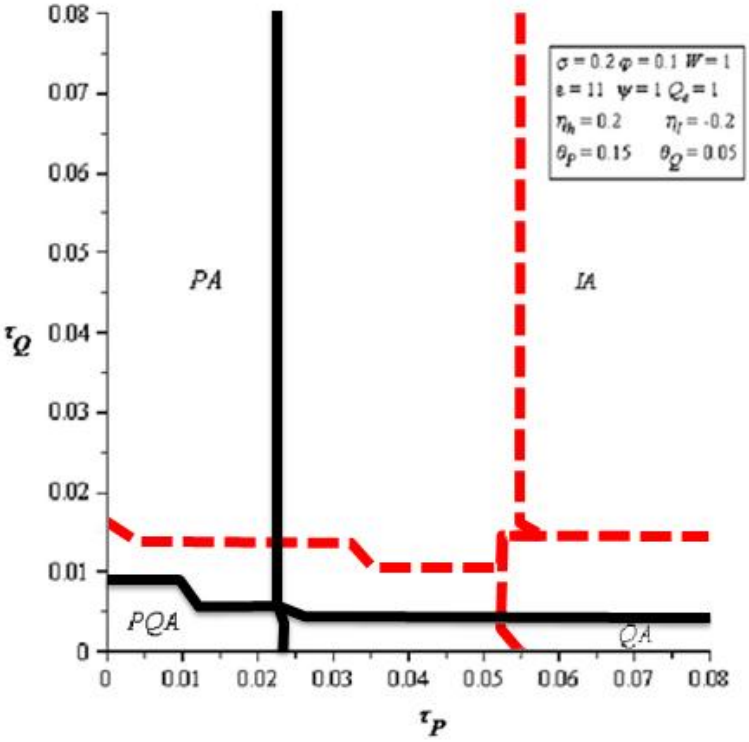


Figure 10. The effect of hanging the marginal cost shocks from $\eta_l = -0.15,\ \eta_h = 0.15$ **to** $\eta_l = -0.2,\ \eta_h = 0.2$



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

APPENDIX (NOT FOR PUBLICATION)

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 $C_{PA}(i),\ i \in (0,1)$, 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) w.r.t. $C_{PA}(i)$ 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 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 a good $i \in (0,1)$ as a numeraire and we use (A1.6) to substitute for the consumption of good $j \in (0,1)$ in both sides of (A1.10). This 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:

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

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 $C_{QA}(i),\ i \in (0,1)$, 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) w.r.t. $C_{QA}(i)$, 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 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 good $i\in(0,1)$ as a numeraire and we use equation (A2.7) to substitute for the consumption of good $j\in(0,1)$ in both sides of (A2.12). This 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

P&Q attentive consumers choose $C_{PQA}(i),\ i \in (0,1)$, 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) w.r.t. $C_{PQA}(i)$ 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) w.r.t. $C_{PQA}(j)$ 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 good $j\in(0,1)$ in the budget constraint (A3.1). This 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 P&Q 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 P&Q 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 P&Q 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 good $i\in(0,1)$ as a numeraire and we use (A3.7) to substitute for the consumption

of good $j \in (0,1)$ in both sides of (A3.11). This 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 P&Q 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

P&Q inattentive consumers assume that all goods' prices equal the expected price, P^e, and that all goods' quantity per package equals 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

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

Differentiating (A4.2) w.r.t. $C_{IA}(i)$, 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) w.r.t. $C_{IA}(j)$ 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 P&Q inattentive consumers expect we use (A4.6) to substitute the consumption of good $j \in (0,1)$ in the budget constraint (A4.1). This 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 P&Q inattentive consumers purchase is given by:

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

The price level that P&Q 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 P&Q 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 good $i \in (0,1)$ as a numeraire and we use equation (A4.6) to substitute for the consumption of good $j \in (0,1)$ in both sides of (A4.10). This 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 P&Q inattentive consumers face is given by:

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