Asymmetric Price Adjustments in Gasoline Retail Markets

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Abstract

We study pricing decisions of gasoline stations. A key feature of this market is downward stickiness: in response to a positive cost shock retail gasoline prices tend to increase quickly but they react slowly to a negative cost shock. We build a dynamic model in which a risk-averse station owner is financially constrained. Having to pay for deliveries in advance he increases prices quickly to cover expenses. When cost decreases prices decrease slowly as this is an opportunity to accumulate a buffer stock of assets. Our model produces price impulse responses that are close to the data.

1 Introduction

In this paper we study the retail gasoline market. It is populated by a large number of competitors selling a homogeneous product. So, we would expect retail prices to follow closely movements in the wholesale price as would be true in a frictionless market with perfect competition. Instead it features unusual price dynamics – downward price stickiness. That is the retail prices decrease slowly following a decrease in the wholesale price but increase quickly after an increase in the wholesale price. Figure

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1 displays the cumulative impulse response to changes in the wholesale gasoline price for Tompkins County in New York. Panel A shows that upward revisions in the wholesale price are passed on to consumers almost completely after only two weeks. On the contrary, panel B shows that downward revisions reach consumers only after about four weeks. This feature of the data is what we set to explain in this paper.

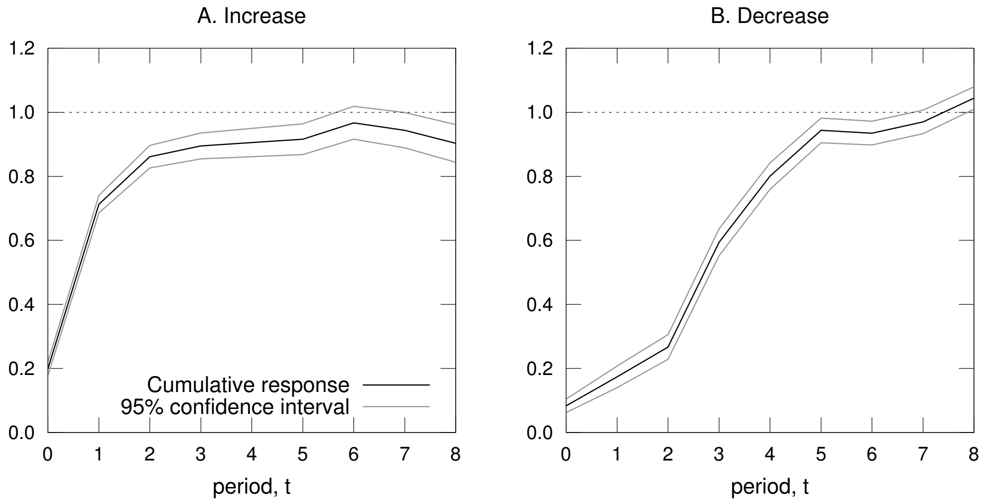


Figure 1: Cumulative impulse responses to a change in the wholesale price

We build an incomplete markets model that generates price dynamics close to the observed pattern. The key assumptions that generate such price behavior are that a gas station owner is 1) financially constrained and 2) he must pay for deliveries in advance. A gas station owner lets the price increase quickly to generate enough revenue to cover the next delivery. The owner may use his savings to help paying for new deliveries. Prices decrease slowly as this is the owner's chance to accumulate a buffer stock of assets for future purchases.

Our model offers a simple and intuitive explanation. Presence of financial constraints is hard to deny and the fact that deliveries have to be paid in advance is commonly referred to. Thus, we see our work as complementary to the existing literature that itself offers many alternative explanations. Borenstein and Shepard [2002] show that the same pattern is also observed in the upstream market where the wholesale price reacts asymmetrically to the refinery prices. Their explanation maintains that production lags and a limited inventory result in a slow response of the wholesale price to decreases in wholesalers' cost. Returning to the retail market, Borenstein and Shepard [1996] find that firms' pricing decisions are consistent with qualitative predictions of collusion models. When firms cooperate margins increase with expected demand and decrease with expected cost. As a result firms are more willing to increase the price which increases their margins and reluctant to start price decrease as this may trigger a string of price decreases.

Borenstein et al. [1997] posit that consumers have to search for their favorite station. Consumers, not being able to distinguish common and idiosyncratic cost shocks, search less when volatility of wholesale prices is high. Consumers search less after an increase in the retail price because they think it stems from an increase in the wholesale price. This gives firms more power and they charge a higher price, potentially over-reacting to a cost increase. Lewis [2011] assumes that consumers use the last observed price as their reference point. Consumers' search intensity increases/decreases when the observed price is above/below the reference point. A decrease in the wholesale price triggers only a small decrease in the retail price as consumers search less intensely.

Several papers argued that the retail gasoline price follows an Edgeworth price cycle. It consists of a period when sellers try to undercut each other until they reach the wholesale price and a "relenting" period when consumers restore prices to their individually optimal levels. In turn, cost fluctuations may trigger an asymmetric price response. An increase in the wholesale prices may signal the start of the "relenting" phase of the cycle, and a decrease in the wholesale price lets the firms have longer "undercutting" phase. Noel [2009] finds that Edgeworth cycles contribute significantly to the asymmetric passthrough of wholesale price changes. But he also finds that there are other components that influence the asymmetric price response.

Our work also relates to the literature on monetary policy and price stickiness. Recognising that price setters react differently to positive and negative shocks may affect how policy makers conduct monetary policy. Models used for computing optimal monetary policy feature exogenous restrictions on firms' pricing decisions (different forms of price stickiness), *e.g.* firms must set prices a period in advance. Recently, with the availability of product-level data, menu-cost models became popular. In a menu-cost model seller faces a cost to change its price. This results in price changes being less frequent and larger in magnitude. However, these models have a number of shortcomings. For example, Midrigan (2009) argues that the menu-cost model generates unrealistic level of synchronization across firms. Midrigan (2009) then extends the model to a multi-product setting with economies of scale in repricing. According to this model once some product's price has to be updated other products may be repriced at the same time. This generates a large number of small price changes as observed in the data. But this does not generate the downward rigidity studied in this paper.

In this paper we concentrate on a very special type of business which is a gas station. While a gas station together with an adjacent store fits well into the multi-product description, owners often use a rule-of-thumb when setting gas price.[1] Such decisions ignore any complementarities in pricing of other products available for purchase at the station. Furthermore, even though store sales carry a significant markup they account for less than a quarter of the business revenues. Pricing gasoline to attract more clients into the store may generate significant losses for the business. So, we conclude that as a first approximation we can abstract from the pricing complementarities between gasoline and products sold in a convenience store.

We assume that an owner is a risk-averse agent with a limited access to credit. This is a reasonable assumption both for independent stations and for gas stations selling "branded" gasoline. In the latter case the model corresponds to an environment with a gas station run by an agent who is expected to generate a stable profit stream. That is in one scenario gas station returns represent income of an independent owner and in the other they are dividends of the franchiser.

The key assumption is that owners are credit constrained. PMCI (2002) report that about half of gasoline stations are independently owned. In the entrepreneurship guide "My Gas Station Guide" (2003) the authors stress the point that to run a gasoline station substantial liquid capital is needed to maintain gasoline inventory. The minimum that is contractually required by the oil companies from stations selling branded fuel is in the range of $200,000 to $500,000. Also financial constraints are restrictive when a station is part of a network. When the wholesale price goes up

[1] This is based on the survey of gas station owners.

and stations need funds to cover their deliveries the network owner would have to extend credit to all stations in the network. Thus, movements in the wholesale prices are like aggregate shocks to the network owner and would require a significant credit capacity to weather such shocks. Presence of financial constraints generates asymmetric response of retail prices. Credit constrained gas sellers willingly raise prices to accumulate enough revenues to purchase now costlier gasoline in the future. At the same time gas prices decrease slowly as owners accumulate buffer stock of assets for adverse future.

Our model also predicts that pricing decisions are forward-looking – that is they take into account a possibility of an increased *future* cost. Consistent with our findings, PMCI (2002) reports that the price setting at the stations occurs based on the "replacement cost" of gasoline - estimated cost of the next delivery.

The rest of the paper proceeds as follows: we provide empirical evidence for the retial price downward stickiness in section 2. Sections 3 and 4 describe the model and the equilibrium conditions. Section 5 contains the results of the numerical analysis and section 6 concludes.

2 Empirical evidence

We collected weekly[2] price data on 45 gas stations in Tompkins County region (NY, USA) for the period of August 25, 2008 till May 22, 2011. Figure 2 plots the movements of the wholesale gasoline prices and average retail gasoline prices in our sample. To see whether there are asymmetries in the movements of retail prices in response to the movements of wholesale price we employ a simple linear regression approach as in Karrenbrock (1991). Denoting retail price in period t by R_t, and wholesale price in period t by W_t:

$$\Delta R_t = a_0 + \sum_{i=0}^{p} a_{1i} W^{+}_{t-i} + \sum_{i=0}^{q} a_{2i} W^{-}_{t-i} + e_t$$

[2]Weekly data was generated from daily observations using simple average.

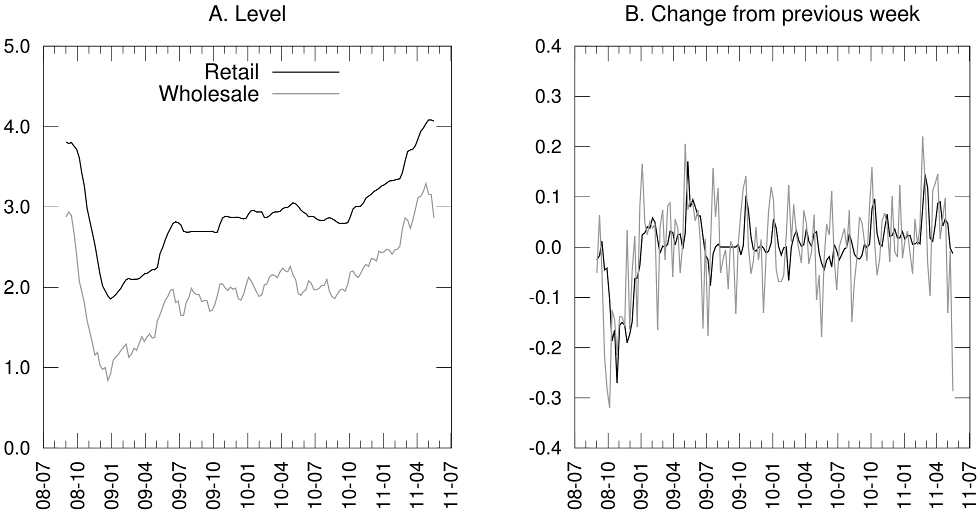


Figure 2: Retail and wholesale price dynamics

where

$$\begin{aligned}\Delta R_t &= R_t - R_{t-1}, \\ W_t^+ &= \max\{0, W_t - W_{t-1}\}, \\ W_t^- &= \min\{0, W_t - W_{t-1}\}.\end{aligned}$$

The estimation results for $p = q = 4$ (adjustments completed in one month) and $p = q = 8$ (accordingly two months) are in Table (1). Tests of symmetry hypotheses are in Table (2).

The coefficients reveal that increase in the wholesale price is passed through to retail prices relatively faster than decrease: 80 to 90 cents of 1$ increase in wholesale price is transferred to the retail price already by the end of 2nd week, while it takes about 4 weeks to reach this level of response when the wholesale price goes down.

	1		2	
	Coefficient	Standard error	Coefficient	Standard error
W_t^+	0.2082**	(0.0122)	0.1934**	(0.0117)
W_{t-1}^+	0.4732**	(0.0144)	0.5144**	(0.0143)
W_{t-2}^+	0.1661**	(0.0111)	0.1479**	(0.0109)
W_{t-3}^+	−0.0114	(0.0105)	0.0341**	(0.0108)
W_{t-4}^+	0.025**	(0.0097)	0.0103	(0.0100)
W_{t-5}^+	-	-	0.0103	(0.0099)
W_{t-6}^+	-	-	0.0514**	(0.0104)
W_{t-7}^+	-	-	−0.0234*	(0.0113)
W_{t-8}^+	-	-	−0.0410**	(0.0097)
W_t^-	0.0768**	(0.0103)	0.0778**	(0.0112)
W_{t-1}^-	0.1148**	(0.0118)	0.0907**	(0.0125)
W_{t-2}^-	0.1377**	(0.0130)	0.0932**	(0.0118)
W_{t-3}^-	0.3686**	(0.0125)	0.3276**	(0.0136)
W_{t-4}^-	0.2516**	(0.0136)	0.2056**	(0.0139)
W_{t-5}^-	-	-	0.1431**	(0.0123)
W_{t-6}^-	-	-	−0.0083	(0.0127)
W_{t-7}^-	-	-	0.0347**	(0.0120)
W_{t-8}^-	-	-	0.0746**	(0.0122)
constant	0.0034**	(0.0012)	0.0054**	(0.0014)
Adj-R^2	0.7612		0.7669	

Significance levels: ** - 1%, * - 5%.

Table 1: Effect of changes in wholesale price on changes in retail price

	1					2				
$H_0 := 0$	Coeff	t-stat	$H_A :\neq 0$	$H_A :> 0$	$H_A :< 0$	Coeff	t-stat	$H_A :\neq 0$	$H_A :> 0$	$H_A :< 0$
$W_t^+ - W_t^-$	0.1314	7.00	0.000	0.000	1.000	0.1156	6.04	0.000	0.000	1.000
$\sum_{i=0}^{1} W_{t-i}^+ - \sum_{i=0}^{1} W_{t-i}^-$	0.4898	17.96	0.000	0.000	1.000	0.5393	17.50	0.000	0.000	1.000
$\sum_{i=0}^{2} W_{t-i}^+ - \sum_{i=0}^{2} W_{t-i}^-$	0.5182	16.99	0.000	0.000	1.000	0.5940	17.06	0.000	0.000	1.000
$\sum_{i=0}^{3} W_{t-i}^+ - \sum_{i=0}^{3} W_{t-i}^-$	0.1382	4.10	0.000	0.000	1.000	0.3006	7.54	0.000	0.000	1.000
$\sum_{i=0}^{4} W_{t-i}^+ - \sum_{i=0}^{4} W_{t-i}^-$	-0.0882	-2.43	0.015	0.992	0.008	0.1053	2.31	0.021	0.011	0.989
$\sum_{i=0}^{5} W_{t-i}^+ - \sum_{i=0}^{5} W_{t-i}^-$	-	-	-	-	-	-0.0275	-0.56	0.573	0.713	0.287
$\sum_{i=0}^{6} W_{t-i}^+ - \sum_{i=0}^{6} W_{t-i}^-$	-	-	-	-	-	0.0323	0.70	0.483	0.242	0.758
$\sum_{i=0}^{7} W_{t-i}^+ - \sum_{i=0}^{7} W_{t-i}^-$	-	-	-	-	-	-0.0259	-0.60	0.550	0.725	0.275
$\sum_{i=0}^{8} W_{t-i}^+ - \sum_{i=0}^{8} W_{t-i}^-$	-	-	-	-	-	-0.1415	-3.25	0.001	0.999	0.001

Table 2: Test of symmetry of retail gasoline price response to changes in wholesale price

3 Model

The owner of a gasoline station is risk-averse and ranks consumption according to:

$$U = E_t \sum_{j=0}^{\infty} \beta^j u(c_{t+j}), \quad \beta \in (0,1), \tag{1}$$

where $\{c_t\}$ is a stochastic consumption process. The gasoline station is equipped with a gasoline reservoir with volume $T \gg 0$. We assume that the owner starts with amount of assets enough to fill up the tank. The owner faces an exogenous borrowing limit $B = 0$. The owner can save money at the bank account at a zero rate.

The gasoline station operates at a local retail gasoline market. Verlinda (2008) and Deltas (2008) show that price asymmetries in the gasoline market are often positively associated with the degree of retail market power. Boresnstein and Shepard (2002) on the other hand suggest that there is no direct evidence that greater market power results in greater asymmetry in the adjustment of gasoline prices: the length of retail prices response increases for both increases and drops in the wholesale price. So, the monopoly power may be an amplifying but not a generating factor for the asymmetric passthrough of the cost shocks. We analyze a more tractable model of local retail market with a single gas station. The firm faces an inverse demand function:

$$p_t = P(q_t), \quad P' < 0.$$

The revenue from selling quantity q is denoted by $S(q) \equiv qP(q)$. We assume the gasoline demand to be deterministic. Borenstein and Shepard (1996) point out that variability in the gasoline market demand is well predicted by seasonal changes and holidays.

Gasoline supply is infinitely elastic at the current wholesale market price g_t. Gasoline price follows an AR(1) process with known parameters. Only current bank account balance can be used for this purpose. The owner cannot borrow against sales revenue.

4 Recursive Formulation

Let $V(a, b|g)$ be the life-time utility of an owner with assets a and volume b of gasoline at the station when the wholesale gasoline price is g. Then V must satisfy the following Bellman equation:

$$V(a,b|g) = \max_{c,q,d} \left\{ u(c) + \beta E\Big[V(a', b'|g') \Big] \right\}. \tag{2a}$$

subject to

$$\kappa: \quad dg \leq a, \tag{2b}$$

$$\lambda: \quad b' = b - q + d, \tag{2c}$$

$$\mu: \quad a' = a + S(q) - c - dg, \tag{2d}$$

$$\gamma: \quad a' \geq -B, \tag{2e}$$

$$\delta: \quad b' \geq 0, \tag{2f}$$

$$\nu: \quad q \leq b, \tag{2g}$$

$$\eta: \quad b' \leq T, \tag{2h}$$

where multipliers used to construct the Lagrangian are listed on the left side of each constraints.

Assuming a risk-averse owner is realistic for a small independent gasoline station. One might object if this is a reasonable assumption for a station that is part of a brand network. In this case we can re-interpret this setting as the one in which the owner of a network cares about both present discounted value of a stream of profits and profit stability.

4.1 Equilibrium

Equilibrium is defined by a list of functions $(c(a,b|g), q(a,b|g), d(a,b|g))$ that solves optimization problem (2). The set of equilibrium conditions for this problem is:

$$
\begin{aligned}
q: &\quad 0 = S'(q)\mu - \lambda - \nu, && \text{(3a)}\\
d: &\quad 0 = -\kappa g + \lambda - \mu g, && \text{(3b)}\\
c: &\quad 0 = u'(c) - \mu, && \text{(3c)}\\
a': &\quad 0 = \beta E[V'_{a'}(a', b'|g')] - \mu + \gamma, && \text{(3d)}\\
b': &\quad 0 = \beta E[V'_{b'}(a', b'|g')] - \lambda + \delta - \eta, && \text{(3e)}
\end{aligned}
$$

Combining the above equations with the envelope conditions $V_a(a,b|g) = \mu + \kappa$ and $V_b(a,b|g) = \lambda + \nu$ we get the following characterization of the optimal decisions:

$$
\begin{aligned}
1 &= \beta E_{g'}\left[\frac{u'(c') + \kappa'}{u'(c)}\right] + \frac{\gamma}{u'(c)}, && \text{(4a)}\\
1 &= \beta E_{g'}\left[\frac{u'(c')S'(q')}{u'(c)S'(q)}\right] + \frac{\nu + \delta - \eta}{u'(c)S'(q)}, && \text{(4b)}\\
S'(q) &= (1 + \kappa/\mu)g + \nu/\mu. && \text{(4c)}
\end{aligned}
$$

The first Euler equation indicates that the owner prefers smooth consumption.[3] Suppose that $\gamma = \kappa' = 0$. Then we get a standard consumption Euler equation. When borrowing constraint is binding ($\gamma > 0$) then consumption is being shifted towards future period, allowing to accumulate money in the bank account. When the owner anticipates to be liquidity constrained tomorrow ($\kappa' > 0$) he also decides to consume less today. This also implies (by (4c)) that the owner plans to sell less tomorrow and at a higher price – this also allows accumulating extra funds.

The second Euler equation indicates that the owner would like to smooth sales of gasoline, which is achieved if $\delta = \eta = \nu = 0$. If gasoline balance is too high ($\eta > 0$) the sales must relatively increase. If gasoline balance is too low ($\delta > 0$) the sales must relatively decrease.

[3] As discussed above consumption could be also interpreted as a pay-out to the brand owner.

The third condition states that unless $\kappa > 0$ and $\nu > 0$ the owner behaves like a monopolist: setting a static monopolistic price. When the station cannot fully fund the next delivery ($\kappa > 0$) sales have to be reduced and the price increased. This gives the owner a chance to replenish his bank account.

The case when $\nu > 0$ arises when the tank balance is low and the station is constrained in how much it can sell. According to the third condition the station must reduce the quantity that it sells, therefore increase the price.

5 Results

5.1 Parameters

The owner's utility function is assumed to be $u(c) = \sqrt{c}$. We assume that one period corresponds to one week and set $\beta = 0.998$.

The borrowing limit is set to 0, so that the owner cannot borrow only save, as discussed in the introduction. This is consistent with the real life evidence - even the owners of the stations under a franchise license mentioned that it is really difficult to get gasoline delivery in advance of payment. Furthermore we assume that the owner saves at a zero interest rate: $R = 1$. Given that β is fairly close to 1 it seems like an innocuous assumption. It can also be justified on the grounds that the interest rate determined in the general equilibrium version of the model had to be less then $1/\beta$ in any case. On another hand gas station business requires a significant amount of working capital. So, all the business bank deposits are short term and yield virtually zero return.

We consider constant elasticity demand function $P(q) = q^{-\frac{1}{\epsilon}}$, with $\epsilon = 11$. First, this is in line with empirical evidence,[4] and second this insures that markup in the model is at most 10%.

For simplicity we consider only two levels of the wholesale price, and analyze how and through which channels the retail price changes in response to the wholesale cost variation. Average gasoline wholesale price is assumed to be 1 with log-volatility 2%,

[4]For a range of estimates for price elasticity see Houde (2008).

so the levels of prices considered are $g = (0.9860; 1.0142)$. The transition matrix assumes the following transition probabilities for the wholesale gasoline price process:

$$P(g'|g) = \begin{bmatrix} 0.9, & 0.1 \\ 0.1, & 0.9 \end{bmatrix}.$$

The gasoline reservoir capacity is set to $T = 2$. Under the assumed demand function and the wholesale price levels the static monopolistic quantity is $q^m = \left(\frac{\epsilon g}{\epsilon - 1}\right)^{-\epsilon} = (0.4095; 0.3000)$, so the assumed upper bound on tank capacity is not constraining for most of the refilling needs.

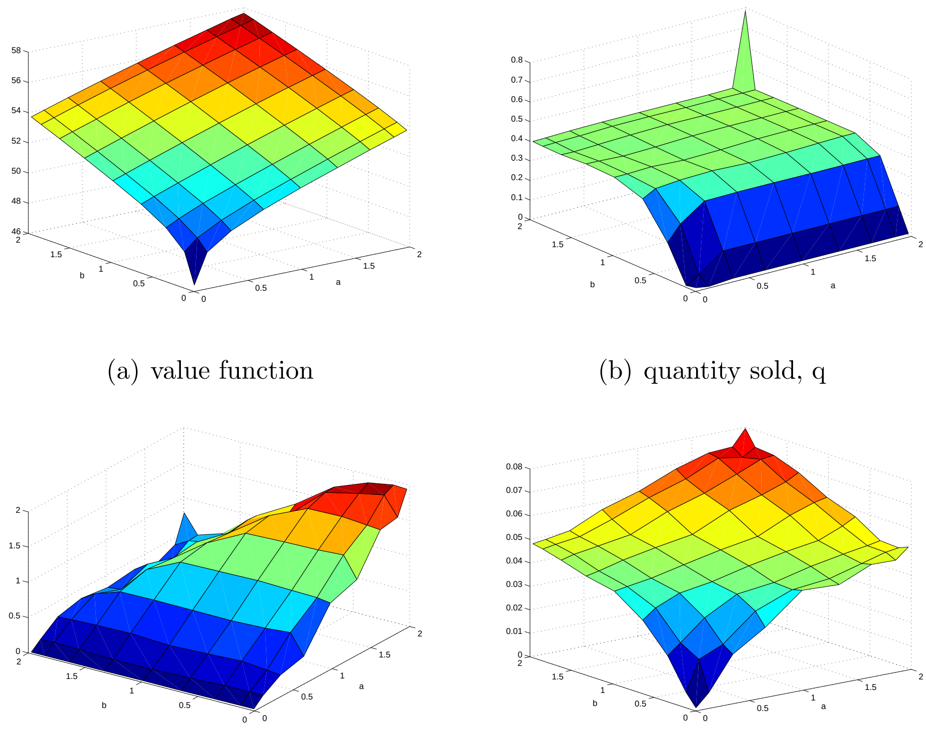
5.2 Numerical results

The problem (2) requires numerical methods to be solved. We approximate $V(\cdot, \cdot|g)$ using collocation method with Chebychev basis functions. The resulting value function and policy functions for quantity sold, delivery ordered and consumption are plotted in Figure (3). The policies depicted in Figure (3) are for low level of the wholesale price.

Equilibrium condition (4c) states that, whenever the gasoline balance in the reservoir allows for that, the maximizing quantity for low level of wholesale price is $q_l^m = 0.4095$, the plateau level reached in subfigure (3b). Delivery policy function is increasing with bank account and decreasing with gasoline holdings in reservoir, while consumption is increasing in both assets.

In Figures (4) and (5) we plot series simulated using the computed parameters. The wholesale price series used for simulation of series showed in Figure (4) is non-random, it was generated without the transition matrix used in the computation. This is done to assess the long term effect of switching between two levels of gasoline cost.

Panel (4b) plots the changes in the retail price in response to changes in the wholesale price. As the wholesale price switches to the high level, the retail price increases steeply, but when the cost of gasoline goes down, the retail price drops not as fast, thus reproducing the price adjustment asymmetry that we saw in the data. The dotted lines represent the static monopolistic price for high and low wholesale cost, and the retail price eventually reaches those levels. Panel (4a) plots gasoline balance, quantities sold and delivered. First, delivery closely resemble quantity patterns, only slightly exceeding it (at most periods). When the wholesale price is low the reservoir is gradually filled building up a stock of cheap gasoline. As the price changes to high level, there is a temporary drop in delivery, so that almost all reserve of cheap gasoline is sold at the high price (notice again that the retail price rises very sharply). This leads to increase in bank account assets (panel (4d)). If the cost of gasoline stays high, the delivery returns to the level that is sufficient to replenish the tank after each sale; but the reservoir is not filled up as much at the high gasoline price as at the low level. The change of the price to the low level triggers again stocking up the gasoline reservoir and building up the bank account since the retail price decreases slower than the wholesale.



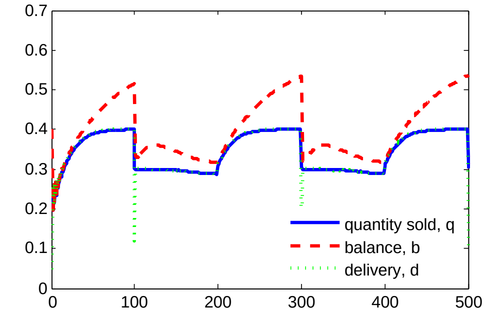
(a) value function

(b) quantity sold, q

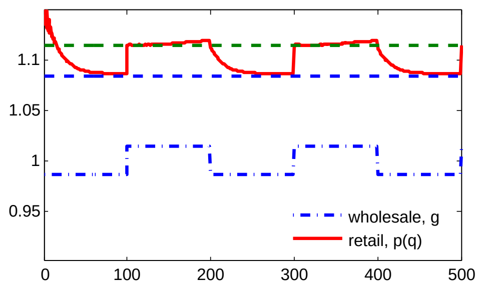
(c) delivery, d

(d) consumption, c

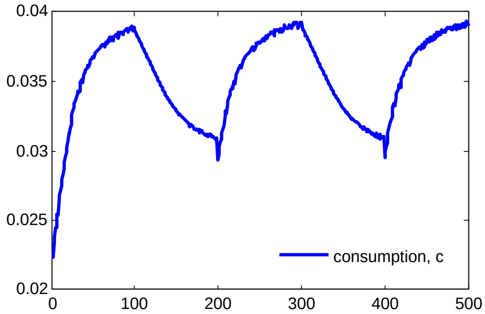
Figure 3: Policy functions



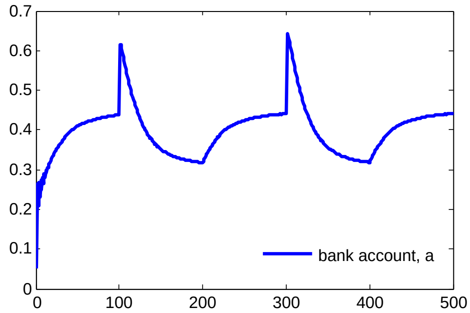
(a) quantities



(b) prices



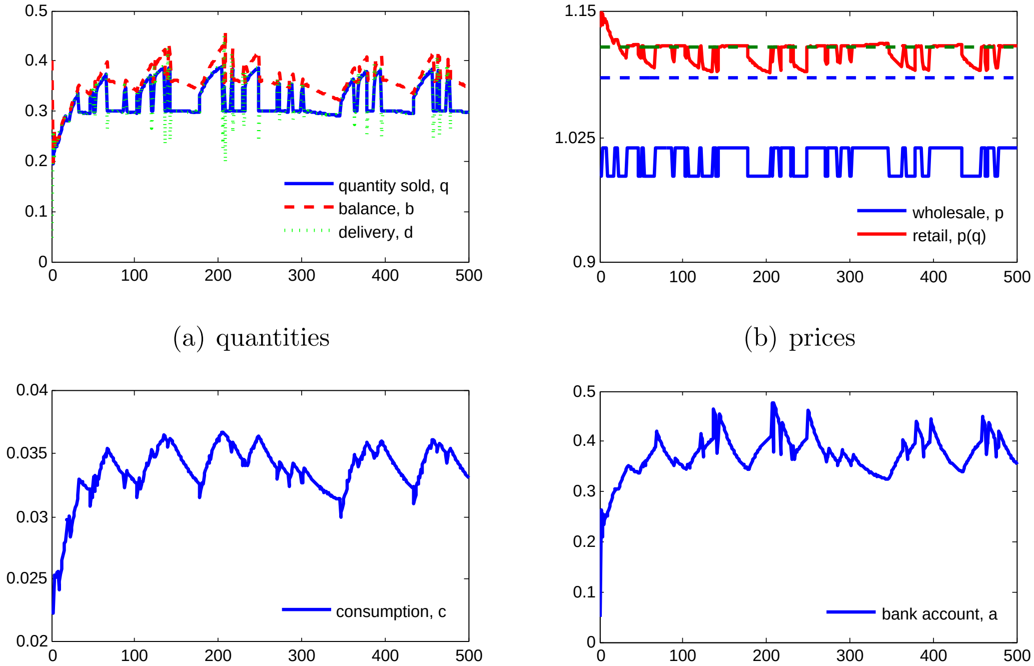
(c) consumption



(d) bank account

Figure 4: Simulation results, non-random wholesale price

Figure (5) on the next page plots the series simulated using the randomly generated wholesale prices (employing the transition matrix used in the computation). The effects of building up the gasoline reserve when the price is low and using it up quickly as soon as price drops hold in this scenario as well. Figure (6) shows a close up of a portion of panel (5b) plot; for better visualization the retail and wholesale price series in this plot are normalized by dividing by the mean. It can be seen that in most cases the retail prices adjust to increase in the wholesale price over one period, while usually it takes at least two periods for retail price to reflect the drop in the cost of gasoline.



(a) quantities (b) prices

(c) consumption (d) bank account

Figure 5: Simulation results, random wholesale price

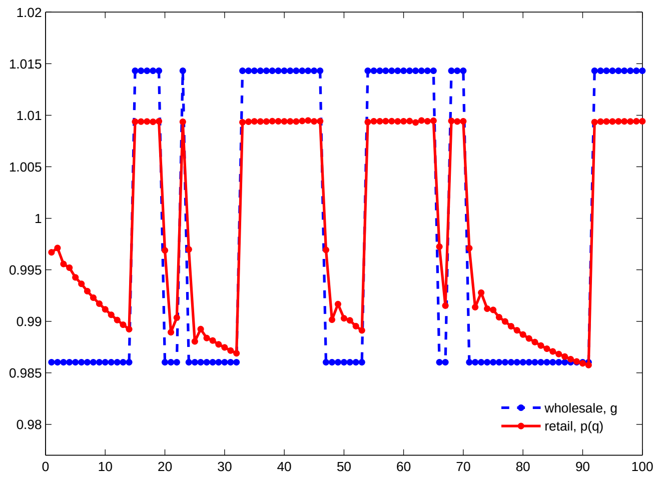


Figure 6: Simulation results, random wholesale price, closeup

Tables (3) and (4) provide the results of quantitative analysis on simulated data similar to the one conducted in part 2 of the paper. The observation that most of the price drop is passed through in two periods while increase in the cost shows after one period is supported by the numbers. So, 85 percent of increase in the wholesale price is reflected in the retail price during the first period already, while it takes two periods to carry 78 percent of the drop. The results in Table (4) also suggest that the biggest discrepancy between rate of retail price increase and decrease in response to respective change in the wholesale price is observed in the first period.

	Simulated data			Real data		
	Coefficient		Standard error	Coefficient		Standard error
W_t^+	0.8514	**	(0.0035)	0.1934	**	(0.0117)
W_{t-1}^+	0.1453	**	(0.0036)	0.5144	**	(0.0143)
W_{t-2}^+	-0.0110	**	(0.0036)	0.1479	**	(0.0109)
W_{t-3}^+	-0.0031		(0.0036)	0.0341	**	(0.0108)
W_{t-4}^+	-0.0020		(0.0036)	0.0103		(0.0100)
W_{t-5}^+	0.0036		(0.0036)	0.0103		(0.0099)
W_{t-6}^+	0.0052		(0.0036)	0.0514	**	(0.0104)
W_{t-7}^+	0.0016		(0.0035)	−0.0234	*	(0.0113)
W_{t-8}^+	0.0002		(0.0036)	−0.0410	**	(0.0097)
W_t^-	0.4254	**	(0.0035)	0.0778	**	(0.0112)
W_{t-1}^-	0.3644	**	(0.0036)	0.0907	**	(0.0125)
WD_{t-2}^-	-0.0164	**	(0.0035)	0.0932	**	(0.0118)
W_{t-3}^-	0.0315	**	(0.0035)	0.3276	**	(0.0136)
W_{t-4}^-	0.0084	*	(0.0036)	0.2056	**	(0.0139)
W_{t-5}^-	0.0114	**	(0.0035)	0.1431	**	(0.0123)
W_{t-6}^-	0.0060		(0.0036)	−0.0083		(0.0127)
W_{t-7}^-	0.0052		(0.0035)	0.0347	**	(0.0120)
W_{t-8}^-	0.0037		(0.0035)	0.0746	**	(0.0122)
constant	-0.0001		(0.0001)	0.0054	**	(0.0014)
Adj-R^2	0.9451			0.7669		

Significance levels: ** - 0.01, * - 0.05

Table 3: Effect of changes in wholesale price on changes in retail price, simulated data

$H_0 := 0$	Coeff	t-stat	$H_A :\neq 0$	$H_A :> 0$	$H_A :< 0$
$W_t^+ - W_t^-$	0.4261	84.22	0.000	0.000	1.000
$\sum_{i=0}^{1} W_{t-i}^+ - \sum_{i=0}^{1} W_{t-i}^-$	0.0762	10.73	0.000	0.000	1.000
$\sum_{i=0}^{2} W_{t-i}^+ - \sum_{i=0}^{2} W_{t-i}^-$	0.0815	9.38	0.000	0.000	1.000
$\sum_{i=0}^{3} W_{t-i}^+ - \sum_{i=0}^{3} W_{t-i}^-$	0.0469	4.66	0.000	0.000	1.000
$\sum_{i=0}^{4} W_{t-i}^+ - \sum_{i=0}^{4} W_{t-i}^-$	0.0364	3.24	0.001	0.001	0.999
$\sum_{i=0}^{5} W_{t-i}^+ - \sum_{i=0}^{5} W_{t-i}^-$	0.0286	2.32	0.020	0.010	0.990
$\sum_{i=0}^{6} W_{t-i}^+ - \sum_{i=0}^{6} W_{t-i}^-$	0.0278	2.08	0.038	0.019	0.981
$\sum_{i=0}^{7} W_{t-i}^+ - \sum_{i=0}^{7} W_{t-i}^-$	0.0242	1.68	0.092	0.046	0.954
$\sum_{i=0}^{8} W_{t-i}^+ - \sum_{i=0}^{8} W_{t-i}^-$	0.0207	1.35	0.176	0.088	0.912

Table 4: Test of symmetry of retail gasoline price response to changes in wholesale price, simulated data

6 Conclusions

The model built in this paper accounts for downward stickiness of the gasoline retail prices: decreases in the wholesale price take more time to be passed-through into retail prices than increases do. The model price impulse responses match the data well. In the model 80% of pass-through for positive and negative shocks are completed in one and two periods respectively, similarly to the pattern in the data.

The key assumption that generates such price behavior is that a gas station owner is financially constrained and must pay for deliveries in advance. Thus, when the wholesale price is low the owner uses this period to 1) build up the gasoline reserves and 2) increase his bank account holdings. Owner's savings are used later, when the cost of gasoline increases and station revenues fall short of a cost of a new delivery.

However, in the data the largest correction to the retail prices occurs in the second and fourth week for positive and negative shocks respectively, while in the model the largest change happens in the first period. This effect might be moderated by including consumer search. It seems that if consumers could leave stations would change their prices more smoothly. It is a profitable direction to explore. It is possible to incorporate search into our model but we leave this for future research.

References

My Gas Station Guide, second edition, 2003.

Severin Borenstein and Andrea Shepard. Dynamic pricing in retail gasoline markets. *The RAND Journal of Economics*, 27(2):429–451, 1996.

Severin Borenstein and Andrea Shepard. Sticky prices, inventories, and market power in wholesale gasoline markets. *The RAND Journal of Economics*, 33(1):116–139, 2002.

Severin Borenstein, A. Colin Cameron, and Richard Gilbert. Do gasoline prices respond asymmetrically to crude oil price changes? *The Quarterly Journal of Economics*, 112(1):305–339, 1997.

G. Deltas. Retail gasoline price dynamics and local market power. *The Journal of Industrial Economics*, 56(3):613–628, 2008.

J.-F. Houde. Spatial differentiation in retail markets for gasoline. *American Economic Review*, Forthcoming.

J. D. Karrenbrock. The behavior of retail gasoline prices: Symmetric or not? *Federal Reserve Bank of St. Louis Review*, 73(4):19–29, 1991.

Matthew Lewis. Asymmetric price adjustment and consumer search: An examination of the retail gasoline market. *Journal of Economics and Management Strategy*, 20 (2):409–449, 2011.

V. Midrigan. Menu costs, multiproduct firms, and aggregate fluctuations. *Econometrica*, 79(4):1139–1180, 2011.

M. Noel. Do retail gasoline prices respond asymmetrically to cost shocks? the influence of Edgeworth cycles. *The RAND Journal of Economics*, 40(3):582–595, 2009.

PMCI. *Fact Sheet: Iowa Motor Fuels Supply and Price Volatility*, Spring/Summer 2002. `http://www.pmcofiowa.com/motor_fuel_supply_and_price_volatility.pdf`.

J. A. Verlinda. Do rockets rise faster and feathers fall slower in an atmosphere of local market power? evidence from the retail gasoline market. *The Journal of Industrial Economics*, 56(3):581–612, 2008.