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# How Much Do Prices Respond to Demand and Supply Shocks?*

Seong-Hoon Kim** · Seongman Moon***

*This paper presents a theoretical examination of price responses to movements in demand and supply where firms face either unwanted inventories or stockouts in each period. The response mechanism consists of two complementary motives that arise when operating under uncertain business environments. To an increase in demand, a firm has a motive to lower its price reflecting lower effective marginal costs but also has another motive to raise its price to rebalance expected marginal revenues associated with two distinct demand states, unwanted inventories and stockouts. These two motives cancel out each other at optimum, resulting in a limited response of prices to demand shocks. To a cost-push shock, the firm has a motive to raise its price reflecting higher effective marginal costs for a given output level and is further prompted to raise prices reflecting a higher expected value of unit inventory. The two motives push prices up in the same direction, resulting in a large response of prices to supply shocks.*

JEL Classification: E30, L11
Keywords: Demand Shock, Supply Shock, Price Responsiveness, Effective Marginal Cost, Loss-balancing

## I. Introduction

The responsiveness of prices to demand and supply movements is a crucial question in economics because it helps explain short-run output fluctuations. Prior research has focused on the frequency of price changes,[1] but this paper shifts the

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** First Author, Research Professor, Graduate School of Environmental Finance, Yonsei University -- Mirae, Korea, 26493. Email: s.kim.econ@gmail.com
*** Corresponding Author, Professor, Department of Economics, Jeonbuk National University, Korea, 54896. Email: nopasanada0501@gmail.com
[1] See, for example, Lucas (1972), Rotemberg (1982), Calvo (1983), Mankiw and Reis (2002), Woodford (2002), and Midrigan (2011).

focus to the magnitude of price changes and their dependence on the nature of shocks. The theory presented predicts that prices respond little to demand shocks but much to supply shocks.

The framework used in this theory, developed by Kim and Moon (2017), highlights two complementary motives that shape a firm's pricing and production decisions where its sales performances and profits are stochastic. Any firm that needs to set prices and produce outputs before knowing its precise market demand like most businesses in the real world would end up with either of two loss consequences: unwanted inventories (excess supply) versus unwanted stockouts (excess demand). Two complementary motives may emerge then. On one side, a firm has a "cost-compensating" motive to reflect some additional costs associated with the increased probability of being left with unwanted inventories. On the other side, the firm also has a "loss-balancing" motive to balance contingent losses that arise from two distinct states.

The two motives also come into play in response to movements in demand and work to reoptimize the probabilities of unwanted inventories and stockouts. An increase in demand induces a firm to lower its price for each given level of output to reflect the lower effective marginal costs of unwanted inventories. At the same time, as the favorable demand shock generates imbalances in losses between two distinct demand states, the firm has a motive to raise prices, thereby reducing the stretched amount of marginal revenue associated with excess demand. These opposing motives cancel out each other at optimum, resulting in a limited response of prices to demand shocks.

A cost-push shock, by contrast, increases the effective marginal costs of production and induces a firm to raise its price for each given level of output. At the same time, the shock increases the expected value of unwanted inventories, in turn increasing the marginal revenue associated with excess supply. The firm will raise prices, with a motive to rebalance marginal revenues associated between two distinct demand states. As the two motives let prices move in the same direction, prices will respond greatly to the adverse supply shock.

Our theory is supported by recent microeconomic evidence on price-setting behaviors. For instance, Gagnon and Lopez-Salido (2019) find that prices change little to even large demand shocks such as mass population displacement and shopping sprees around hurricanes and snowstorms, using a weekly scanner data set from US supermarket chains. Moreover, the size of price responses is barely relevant to price stickiness in that such small price responses to large demand shocks are made amid frequent price changes.

Eichenbaum et al. (2011) use a similar weekly scanner data set, but shift their focus to the sources of large price movements. They find that although prices typically change every two weeks, the magnitude of price changes is contained within a narrow band, which they call "reference prices." They further find that large price movements are associated with shifts of the reference levels, which occur systematically in relation to changes in costs. In other words, prices hover around reference levels most times unless the reference levels themselves shift, and large price movements are observed typically when costs change.[2]

These studies jointly support the predictions of our theory: Eichenbaum et al. (2011) provide evidence of large price movements to cost shocks, while Gagnon and Lopez-Salido (2019)'s findings are evidence of little price responses to demand shocks.

A number of empirical studies examining the size of unconditional price changes document the prevalence of small price adjustments, which is also closely related to the baseline prediction of our model. For example, Klenow and Kryvtsov (2008) examine the BLS microdata set for items of the US CPI and find that more than 40% of regular price changes are smaller than 5% in absolute value. These findings are consistent around the world: Wulfsberg (2009) documents that nearly half of price changes are smaller than 5% in Norway; Barros et al. (2012) report a similar result for Brazil and Vermeulen et al. (2012) for the Euro area.

This paper provides a unified explanation for such scattered pieces of empirical evidence, which have long been found across different countries but without a theory. Furthermore, our theory contributes to the literature on the causes and mechanisms that underlie short-run output fluctuations. Most of the existing studies assume price stickiness and take it as a convenient device for generating large output movements in response to demand shocks. We shift the focus from frequency to magnitude and demonstrate how demand shocks and supply shocks can lead to considerable different price responses.

The rest of the paper is structured as follows: Section 2 develops a dynamic model of monopolistic pricing and production decisions by extending the static model of Kim and Moon (2017). Section 3 examines some key properties of the model. Section 4 presents theoretical predictions and quantitative results. Section 5 concludes.

## II. Setup

We have expanded the static model proposed in Kim and Moon (2017) into a dynamic model with an infinite horizon.[3] The fundamental business environment

[2] Midrigan (2011) uses a different term "regular prices" corresponding to the notion of "reference prices" and finds similar price behaviors. Using store-level scanner data collected at Dominick's Finer Foods in the Chicago area, he finds that prices change frequently but tend to return to "regular prices", which themselves barely change.

[3] Kim and Moon (2017) developed a static model in which firms have to handle uninsurable business losses to address why we observe unclear and mixed cyclical behaviors of markups. The paper

remains the same, where firms need to set prices and produce goods without prior knowledge of their market demand. However, in the dynamic model, firms base their pricing and production decisions on their expectations of future business conditions such as the evolution of production costs and demand distributions. At the start of each period $t$, a firm sets price $p_t$ and produces output $y_t$ before the realization of demand $d_t$. Once the price $p_t$ and output $y_t$ are decided, the market demand $d_t$ is determined upon the realization of a random demand factor $x_t$:

$$d_t = x_t D(p_t),$$

where the demand function $D$ is twice-continuously differentiable with $D_p < 0$ and follows the standard property that $2D_p(p) + pD_{pp}(p) < 0$, indicating a decreasing marginal revenue as the price $p$ increases.

Market demand evolves along the transition path of the probability distribution function for $x$. Let the distribution function be denoted by $F(x;\theta)$, where the second argument $\theta$, an $m\times 1$ vector, characterizes the distribution function $F$. The distribution function is continuous and differentiable for given $\theta$; $f(x;\theta) = \frac{\partial F(x;\theta)}{\partial x} > 0$. $\theta$ is assumed to be realized at the beginning of each period according to the transition function $G$ following a Markov process, $G(\theta',\theta) = \Pr(\theta_{t+1} \leq \theta' \mid \theta_t = 0)$.

At the beginning of each period $t$, the firm produces output $y_t$ and makes it available for sales together with inventory holdings $n_t = (s_{t-1} - d_{t-1})^+$ brought forward from period $t-1$. Given that $n_t$ is known at the beginning of period $t$, choosing the output level $y_t$ is equivalent to choosing the level of stock $s_t$ available for sales,

$$s_t = y_t + n_t. \tag{1}$$

We consider production technology with constant returns to scale and total production cost $C(y_t)$ to be proportional to output produced: $C(y_t) = c_t y_t$ with $c_t > 0$ for all $t$. This specification helps to formulate the monopolist's dynamic decision problem to a standard recursive structure of the Bellman equation. Given that carrying inventories $n_t$ from the previous period is costly, we also introduce the marginal cost of holding inventories, $q_t > 0$. We assume that $c_t$ and $q_t$ are realized at the beginning of each period.

We now define $\hat{x}$ as the *lowest* admissible value of the realized $x$ needed to clear the market:

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found that the cyclicality of markups depends on firms' fundamental characteristics such as their market power, production technology, and reservation value of products.

$$s_t = \hat{x}_t D(p_t). \tag{2}$$

With this identity (2), $(p_t, s_t)$ and $(p_t, \hat{x}_t)$ are one-to-one injective mapping and $s_t$ is monotone-increasing in $\hat{x}_t$ for every given $p_t$. Using this relationship, the *realized* period profit for a firm that starts with inventory holdings $n_t$ and ends with a realized market demand $d_t$ can be expressed as a function of $p_t$, $\hat{x}_t$, $n_t$, and $\theta_t$. This equation takes the form:

$$\begin{aligned}\pi(p_t, \hat{x}_t, n_t, \theta_t) &= p_t\{s_t - n_{t+1}\} - c_t(s_t - n_t) - q_t n_t \\ &= p_t\{\hat{x}_t - (\hat{x}_t - x_t)^+\}D(p_t) - c_t\{\hat{x}_t D(p_t) - n_t\} - q_t n_t,\end{aligned} \tag{3}$$

where $n_{t+1}$ is determined by the difference between $\hat{x}_t$ and $x_t$, multiplied by a factor $D(p_t); n_{t+1} = (\hat{x}_t - x_t)^+ D(p_t)$ such that $(\hat{x}_t - x_t)D(p_t)$ for $\hat{x}_t > x_t$ and zero otherwise. The first term in the equation represents the revenue generated by the sale of goods, while the second and third terms represent the production cost and the cost of holding inventory, respectively. The realized period profit $\pi$ appears random at the beginning of each period and thus the *expected* period profit at the time of making decisions for each period $t$ can be written as follows:

$$\begin{aligned}&W(p_t, \hat{x}_t, n_t, \theta_t) \\ &= \int_{x_t} \pi(p_t, \hat{x}_t, n_t, x_t) dF(x_t; \theta_t) \\ &= p_t D(p_t) \int_{\underline{x}(\theta_t)}^{\hat{x}_t} x_t dF(x_t; \theta_t) + p_t D(p) \int_{\hat{x}_t}^{\overline{x}(\theta_t)} \hat{x}_t dF(x_t; \theta_t) - c_t\{\hat{x}_t D(p_t) - n_t\} q_t n_t,\end{aligned} \tag{4}$$

where $\underline{x}(\theta)$ and $\overline{x}(\theta)$ are the lower and upper bounds of $x$ for the distribution function $F(x;\theta)$.

We assume that the firm makes pricing and production decisions to maximize the expected present value of the future profit stream:

$$\begin{aligned}&\max_{\{p_t, \hat{x}_t\}_{t=0}^{\infty}} E_0\left[\sum_{t=0}^{\infty} \beta^t \lambda_t W(p_t, \hat{x}_t, n_t, \theta_t)\right], \\ &\text{s.t. } n_{t+1} = (\hat{x}_t - x_t)^+ D(p_t) \quad \text{for all } t = 0,1,2,\ldots, \\ &\qquad \hat{x}_t D(p_t) \geq n_t, \\ &\qquad (n_0, \theta_0) \text{ given.}\end{aligned} \tag{5}$$

$E_t[\cdot]$ for $t = 0,1,\ldots$ denotes the expectations operator conditional on period-*t* information set. The constraint, $\hat{x}_t D(p_t) \geq n_t$, follows from the feasibility condition that $y_t \geq 0$ and thus $s_t \geq n_t$ for all *t*'s. $\beta$ is a subjective discount factor lying between 0 and 1 and thus $\beta\lambda_{t+1} / \lambda_t$ is seen as the stochastic discount factor over

$t$ and $t+1$.

Notably, the cost of stockouts is implicitly contained in the model's economic profits as lost sales opportunities. This cost reflects the fact that customers who cannot purchase the product may turn to buying a competitor's product. The cost can be further explicitly specified to include other costs associated with stockouts, such as reputation damage, which could also affect the firm's future sales. We leave the explicit inclusion of such costs for numerical analysis later without unnecessary complications.

## III. Optimal Policy Rules

The optimal pricing and production policies that solve the dynamic decision problem (5) satisfy the first-order conditions with respect to $\hat{x}_t$ and $p_t$:

$$W_{\hat{x}}(p_t,\hat{x}_t,n_t,\theta_t)+E_t\left[\Lambda_{t+1}\int_{\underline{x}(\theta_t)}^{\hat{x}_t}\{c_{t+1}-q_{t+1}\}D(p_t)dF(x_t;\theta_t)\right]=0, \tag{6}$$

and

$$\begin{aligned} &W_p(p_t,\hat{x}_t,n_t,\theta_t)\\ &\quad +E_t\left[\Lambda_{t+1}\int_{\underline{x}(\theta_t)}^{\hat{x}_t}\{c_{t+1}-q_{t+1}\}\{\hat{x}_t-x_t\}D_p(p_t)dF(x_t;\theta_t)\right]=0, \end{aligned} \tag{7}$$

where $\Lambda_{t+1}=\beta\frac{\lambda_{t+1}}{\lambda_t}$, and $W_{\hat{x}}$ and $W_p$ are the first-order derivatives of the expected period profit $W$ defined by (4):

$$\begin{cases} W_{\hat{x}}(p_t,\hat{x}_t,n_t,\theta_t) &= D(p_t)[\int_{\hat{x}_t}^{\overline{x}(\theta_t)} p_t dF(x_t;\theta_t)-c_t], \\ W_p(p_t,\hat{x}_t,n_t,\theta_t) &= \int_{\underline{x}(\theta_t)}^{\hat{x}_t}\hat{x}_t[D(p_t)+p_tD_p(p_t)]dF(x_t;\theta_t) \\ &\quad +\int_{\hat{x}_t}^{\overline{x}(\theta_t)}\hat{x}_tD(p_t)dF(x_t;\theta_t)+\hat{x}_tD_p(p_t)[\int_{\hat{x}_t}^{\overline{x}(\theta_t)} pdF(x_t;\theta_t)-c_t]. \end{cases} \tag{8}$$

By substituting back with (8) and rearranging them, we can reduce (6) and (7) to

$$\underbrace{c}_{\text{MC.Y}}=\underbrace{p\int_{\hat{x}}^{\overline{x}(\theta)}dF(x;\theta)}_{\text{MR.Y.XD}}+\underbrace{E\left[\Lambda'\int_{\underline{x}(\theta)}^{\hat{x}}(c'-q')dF(x;\theta)\right]}_{\text{MR.Y.XS}}, \tag{9}$$

and

$$0 = \underbrace{\hat{x}D(p)\int_{\hat{x}}^{\overline{x}(\theta)} dF(x;\theta)}_{\text{MR.P.XD}} + \underbrace{\int_{\underline{x}(\theta)}^{\hat{x}} x\{D(p)+D_p(p)p\}dF(x;\theta) - E\left[\Lambda'\int_{\underline{x}(\theta)}^{\hat{x}}(c'-q')xD_p(p)dF(x;\theta)\right]}_{\text{MR.P.XS}}, \tag{10}$$

respectively, where we use "prime (′)" to denote the next period ones while removing time subscripts. A set of acronyms in the language of economics accompanies the static version of the model developed in Kim and Moon (2017) (p.535 provides details).[4] For example, "MR.Y.XD" can be read as the expected marginal revenue (MR) w.r.t. production decision (Y) over excess demand states (XD).

Equations (9) and (10) characterize the two optimality conditions in terms of marginal analysis in economics. Equation (9) is the standard statement of MR=MC. But this time, because the production decision is made before the realization of demand shock, the firm needs to take into account two distinct states of excess demand and excess supply. Therefore, an ex-ante optimal production decision will be made where the marginal cost equals the expected marginal revenues summed over the two distinct states: XD and XS. To appreciate some unique features of the condition in comparison with the standard "MR=MC" statement, we rewrite (9) to

$$p = \left\{1 - \frac{F(\hat{x};\theta)}{\underbrace{1-F(\hat{x};\theta)}_{\text{XS/XD odds}}}\right\}\{c - E[\Lambda'(c'-q')]F(\hat{x};\theta)\}. \tag{11}$$

This expression can be seen as a dynamic version of the one that was proposed by Prescott (1975) and has repeatedly appeared in the literature to capture the idea of effective marginal cost pricing under demand uncertainty (for example, Eden (1990), Rotemberg and Summers (1990), Dana (1998, 1999), and Kim and Moon (2017)). The term denoted by "XS/XD odds" amounts to some additional cost attributable to demand uncertainty. As a whole, (11) shows a schedule for the firm's willingness to supply by adding the shadow cost of production under demand uncertainty to the traditional supply curve. As in Kim and Moon (2017), we refer to the condition as an *offer curve* to differentiate it from the traditional supply curve.

Equation (10) states that, for a given production level, the firm's optimal pricing is made at which the expected marginal revenues over the two distinct states (XD

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[4] MC stands for marginal cost; MR for marginal revenue; Y for w.r.t. production; P for w.r.t. pricing; XD for excess demand; and XS for excess supply.

and XS) cancel out each other. The firm's ex-ante chosen price for a given level of production will result in either state of excess demand or excess supply ex post. The state of excess demand (excess supply) means that the price set ex ante turns out too low (high), in turn meaning that a marginally higher price would make additional revenue (loss). Therefore, an ex-ante optimal pricing decision, as enunciated in MR.P.XD+MR.P.XS=0 from equation (10), seeks to balance the two marginal revenues associated with XD and XS states. We refer to the condition as a *hedge curve* to highlight the firm's balancing motive.

A dynamic relationship that commonly appears across the two conditions associates the marginal revenue with XS states. This is because unwanted inventories are modeled to be carried forward next period, whereas stockouts are not.[5] The marginal revenues associated with XS states are formed on the difference between future production costs and future inventory-holding costs (i.e., $c'-q'$) to measure how much the marginal impacts of XS states affect the future profit stream. In other words, this term shows how much the firm can save tomorrow if it carries forward one additional unit of output produced today. Its expected present value, namely, $E[\Lambda'\int_{\underline{x}(\theta)}^{\hat{x}}(c'-q')dF(x;\theta)]$, can be thus seen as a "forward-looking reservation price" at which the firm is indifferent between selling an additional unit in the present and carrying it forward to the future.

The following result ensures that under a certain condition, the two optimality conditions constitute an optimal set of pricing and production.

**Lemma.** *Let $\theta$ be a fixed parameter. A set of pairs $(p,\hat{x})$ satisfying equation (9) generates an upward-sloping curve (which we call an offer curve). By contrast, a set of pairs $(p,\hat{x})$ satisfying (10) generates a downward-sloping curve (which we call a hedge curve) under the condition that $\frac{\hat{x}f(\hat{x};\theta)}{1-F(\hat{x};\theta)}\varepsilon(p)>\frac{p}{p-E[\Lambda'(c'-q')]}$, where $\varepsilon(p)$ denotes the price elasticity of demand.*

*Proof.* To prove that an offer curve is upward-sloping, we will show that $\frac{dp}{d\hat{x}}\Big|_{\text{eq. (9)}}>0$ for all $\hat{x}$ along (9). Similarly, to prove that a hedge curve is downward-sloping, we will show that $\frac{dp}{d\hat{x}}\Big|_{\text{eq. (10)}}<0$ for all $\hat{x}$ along (10) under the stated condition. The complete proof can be found in the Appendix. □

This result helps clearly visualize the two optimality conditions (9) and (10) through the association of $p$ and $\hat{x}$. Equation (9) depicts a positive relationship between $p$ and $\hat{x}$, whereas (10) shows a negative relationship between $p$ and $\hat{x}$ under the stated condition.

The stated condition for a downward-sloping hedge curve is worth appreciating.

[5] If the model is extended to include explicit cost of stockout, the marginal revenues are associated with XD states as well. We provide such a model later in Section 4.2 for numerical analysis.

The ratio, $\frac{\hat{x}f(\hat{x};\theta)}{1-F(\hat{x};\theta)}$, on the r.h.s. of the condition can be read the elasticity of excess demand probability w.r.t. $\hat{x}$ because $\frac{\hat{x}f(\hat{x};\theta)}{1-F(\hat{x};\theta)} = [\frac{d\{1-F(\hat{x};\theta)\}}{1-F(\hat{x};\theta)} / \frac{d\hat{x}}{\hat{x}}]$. Thus, the condition requires the firm never to set prices within the inelastic range of the excess demand probability, similar to the standard textbook statement that a monopolist never sets prices within the inelastic range of market demand.

Given that the two curves described above complement each other, the firm's optimal pricing and production decisions are made where the two curves intersect.

# IV. Price Responsiveness to Demand and Supply Shocks

## 4.1. Price Response Mechanism

The two curves represent two motives that emerge from where a firm faces stochastic business outcomes that may lead to unwanted inventories or unwanted stockouts. On one side, a firm has a "cost-compensating" motive, by which it reflects the shadow cost of production under demand uncertainty on its supply schedule. On the other side, the firm also has a "loss-balancing" motive, by which it seeks to balance contingent losses that arise from two distinct states.

These two motives also work to rebalance the probabilities of such outcomes in response to changing business conditions. This mechanism results in different price responses based on the nature of shocks faced by the firm. We begin by examining price responses to demand shocks and then contrast them with price responses to cost shocks.

### *Price Response to Demand Shocks*

To understand how a firm reoptimizes its pricing and production decisions, we will consider a demand shock that takes the form of a changing mean of $x$ following a lognormal distribution. The following result presents the mechanism by which prices respond to an increase in demand.

**Proposition 1.** *Consider a log-normal distribution for* $x : \ln(x) \sim \mathcal{N}(\mu,\sigma^2)$. *Suppose an increase in* $\mu$ *from* $\theta = \{\mu,\sigma^2\}$. *On impact, the offer curve (9) associates every given* $\hat{x}$ *with a lower price following an increase in* $\mu$, *whereas the hedge curve (10) associates every given* $\hat{x}$ *with a higher price under the condition of Lemma.*

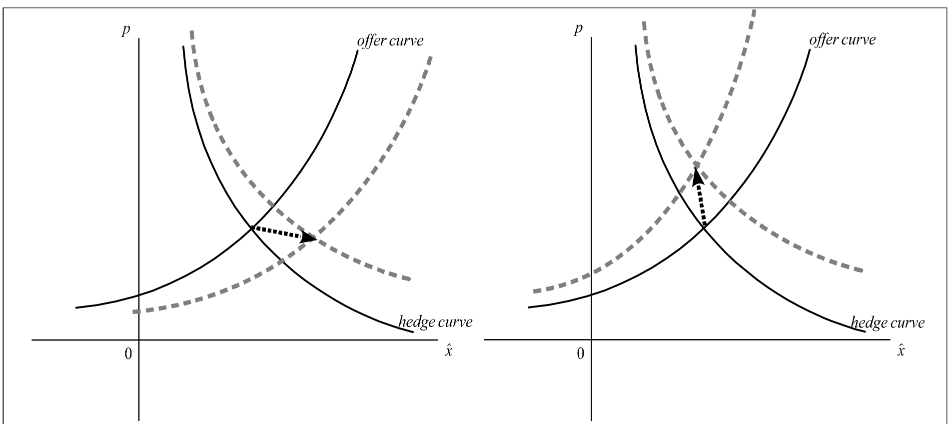
*Proof.* The proof consists of two main parts. First, we demonstrate that the optimality conditions (9) and (10) are no longer valid after the demand shock. Second, we show that these conditions can be restored through the reoptimization of pricing and production, subject to the condition stated in the Lemma. A complete proof is provided in the Appendix. □

A favorable demand shock leads to a higher probability of stockouts and a lower probability of unwanted inventories for every given $(p,\hat{x})$. That is, the favorable demand shock $(\mu' > \mu)$ is expressed as a first-order stochastic dominance in that $1-F(\hat{x};\mu') > 1-F(\hat{x};\mu)$ for every given $\hat{x}$. This means that the firm is more likely to face lost sales opportunities and less likely to be left with unwanted inventories. As a result, condition (9) breaks down as the r.h.s. of (9) exceeds the marginal production cost $c$. To restore the condition, the firm needs to lower prices for every given $\hat{x}$ (or increasing production for every given $p$). As a result, the offer curve shifts downward (or shifts outward) as shown in Figure 1(a).

At the same time, the favorable demand shock breaks condition (10) and leads the r.h.s. of (10) to exceed zero. To restore the condition, the firm needs to raise prices for every given $\hat{x}$ (while also increasing production for every given $p$). As a result, the hedge curve shifts upward as shown in Figure 1(a).

These results can be intuitively understood. The offer curve is underlain by a "cost-compensating" motive, upon which firms set prices according to the schedule of effective marginal costs. Given that the favorable demand shock means being more likely to sell for every given output level, the effective marginal costs fall for every given output level; thus, the offer curve shifts down.

**[Figure 1]** Price response mechanism: demand shock vs. cost shock




(a) Shifts to demand shock (b) Shifts to cost-push shock

The hedge curve is underlain by a "loss-balancing" motive, upon which firms set prices to remove any imbalances in marginal revenues associated with excess demand and excess supply. As the marginal revenue associated with excess demand (MR.P.XD) increases in response to the favorable demand shock and the marginal revenue associated with excess supply (MR.P.XS) decreases, firms will raise prices to rebalance the marginal revenues by moving some of the increase in MR.P.XD to cover some of the decrease in MR.P.XS for every given output level. The hedge curve shifts up.

Altogether, the two motives induce opposite price responses to the favorable demand shock. Prices little respond to demand shocks.

***Price Response to Supply Shocks***

The response mechanism based on the two motives remains applicable to shocks of various types, although the resulting pricing behaviors may vary. Next, we shift our focus to the supply side and investigate how a firm adjusts its pricing and production decisions in response to a positive shock to production cost.

**Proposition 2.** *Let $c$ be a stochastic process with a positive autocorrelation. Suppose a positive shock to $c$. Then, the offer curve (9) and the hedge curve (10) both associate every given $\hat{x}$ with a higher price on impact.*

*Proof.* The proof consists of two main parts. First, we demonstrate that the shock causes the two optimality conditions (9) and (10) to break down. Then, we show that one can restore them by reoptimizing price and production as stated. The complete proof can be found in the Appendix. □

As for condition (9), a cost-push shock increases present and future production costs ($c$ and $c'$). However, the maximum possible change in the r.h.s. is smaller than the shock size on immediate impact because the stochastic discount factor and the probability of excess supply are both less than 1. Therefore, the cost-push shock makes condition (9) break down toward the l.h.s larger for every given $(p,\hat{x})$. To restore the condition, the firm needs to raise prices for every given $\hat{x}$. As a result, the offer curve shifts upward as shown in Figure 1(b).

The response of the firm to the cost-push shock with respect to condition (10) is more straightforward. The adverse supply shock affects the condition to the extent that it adds to expected future production costs $(c')$, leading it to break down as its whole r.h.s expression now falls below zero for every given $(p,\hat{x})$. To restore the condition (10), the firm needs to raise prices for every given $\hat{x}$. As a result, the hedge curve also shifts upward as shown in Figure 1(b).

Intuitively, an increase in production costs causes the two motives to react in the same direction. Firms with the cost-compensating motive will raise prices when the effective marginal costs increase, which is indeed so this time by the cost-push shock. The offer curve thus shifts up.

At the same time, the cost-push shock raises the future production costs, in turn raising the value of future inventories that are carried forward in the state of excess supply. As the marginal revenue associated with the excess supply becomes greater than before (or, the marginal loss expected in the state of excess supply becomes smaller now), firms with the loss-balancing motive will raise prices and thus the hedge curve shifts up.

Altogether, the two motives make prices respond to the same direction in response to the cost-push shock. Prices are highly responsive to supply shocks.

**[Table 1]** Benchmark model: Parameter values and steady states

| Parameter values | | | | | | | Steady states | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $a$ | $\varepsilon$ | $\beta$ | $\rho_\mu$ | $\rho_c$ | $\rho_\Lambda$ | $\rho_q$ | $\mu^{ss}$ | $\sigma^{ss}$ | $c^{ss}$ | $\Lambda^{ss}$ | $q^{ss}$ | $p^{ss}$ | $\hat{x}^{ss}$ | $s^{ss}$ |
| 1 | 6 | 0.99 | 0.9 | 0.9 | 0.9 | 0.9 | 1 | 0.5 | 1 | 0.99 | 0.5 | 1.23 | 2.21 | 0.56 |

## 4.2. Numerical Analysis

We now consider a demand function with constant elasticity that is used extensively in the macroeconomics literature: $D(p) = ap^{-\varepsilon}$ with the price elasticity of demand $\varepsilon > 1$.[6] For a log-normal distribution for $x$, $\ln(x) \sim \mathcal{N}(\mu, \sigma^2)$, we have (9) and (10) as follows: $(\Lambda' = \beta\lambda' / \lambda)$

$$c = p\{1 - F(\hat{x};\theta)\} + E[\Lambda'(c' - q')]F(\hat{x};\theta), \tag{12}$$

$$0 = \hat{x}\{1 - F(\hat{x};\theta)\} + \frac{1}{2}\{1 - \phi(p)\}\exp\left(\frac{\sigma^2}{2} + \mu\right)\left[1 - \operatorname{erf}\left(\frac{\sigma^2 + \mu - \ln\hat{x}}{\sigma\sqrt{2}}\right)\right], \tag{13}$$

where

$$F(\hat{x},\theta) = \frac{1}{2} + \frac{1}{2}\operatorname{erf}\left(\frac{\ln x - \mu}{\sigma\sqrt{2}}\right), \quad \theta = \{\mu, \sigma^2\},$$

and

$$\phi(p) = \varepsilon\left(\frac{p - E[\Lambda'(c' - q')]}{p}\right),$$

with the Gauss error function, erf($x$), defined by

[6] Strictly speaking, the demand function should be written as $D(p) = a(p / P^A)^{-\varepsilon}$, where $P^A$ is the aggregate price index. However, since the aggregate price index is given exogenously in our partial equilibrium model, we have normalized it and set $P^A = 1$.

$$\mathrm{erf}(x) = \frac{2}{\sqrt{\pi}} \int_0^x \exp(-t^2)dt .$$

We consider a spread-preserving positive demand shock and allow $\mu$ to shift over time. We assume that $\mu$ follows a stationary AR(1) process:

$$\mu' = (1-\rho_\mu)\mu^{ss} + \rho_\mu \mu + e_\mu ,$$

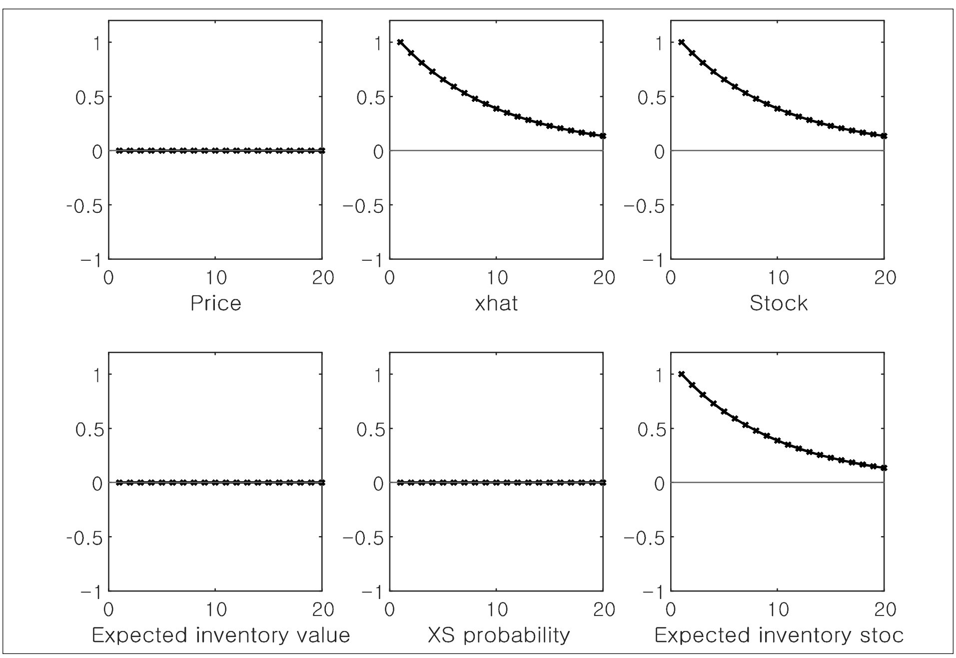
where $\mu^{ss}$ denotes the steady state value of $\mu$, $\rho_\mu$ its autoregressive coefficient, $e_\mu$ *i.i.d.* normal disturbances with mean zero.

We also consider fluctuations in the marginal costs of production $c$ and assume that $c$ follows a stationary AR(1) process:

$$c' = (1-\rho_c)c^{ss} + \rho_c c + e_c ,$$

where $c^{ss}$ denotes the steady state value, $\rho_c$ autoregressive coefficient, and $e_c$ *i.i.d*. normal disturbances with mean zero.

**[Figure 2]** Impulse responses to a demand shock




Note: The line with crosses traces the movements of variables over 20 periods in response to shocks to the demand distribution $(\mu)$. The size of the shock is normalized to 1% of its steady state level and the size of responses is expressed in % deviation from the steady state.

We similarly assume AR(1) processes for the transition of the stochastic discount factor $(\Lambda' = \beta\lambda' / \lambda)$ and the cost of inventory holdings $(q)$.

Table 1 presents parameter values and steady states for the model. $\rho$ indicates the AR(1) autocorrelation coefficient of a variable. The superscript "*ss*" appended to a variable indicates the steady state value of that variable. We set these parameter values following the literature: the demand elasticity $\varepsilon$ is set to 6, as it is usually assumed between 3 and 10 in the literature. The subjective discount factor $\beta$ is set to 0.99, implying that one period in the analysis can be considered a quarter in the calendar. As part of a robustness check, we also carry out quantitative analysis with different parameter values and find that our results remain to hold qualitatively.

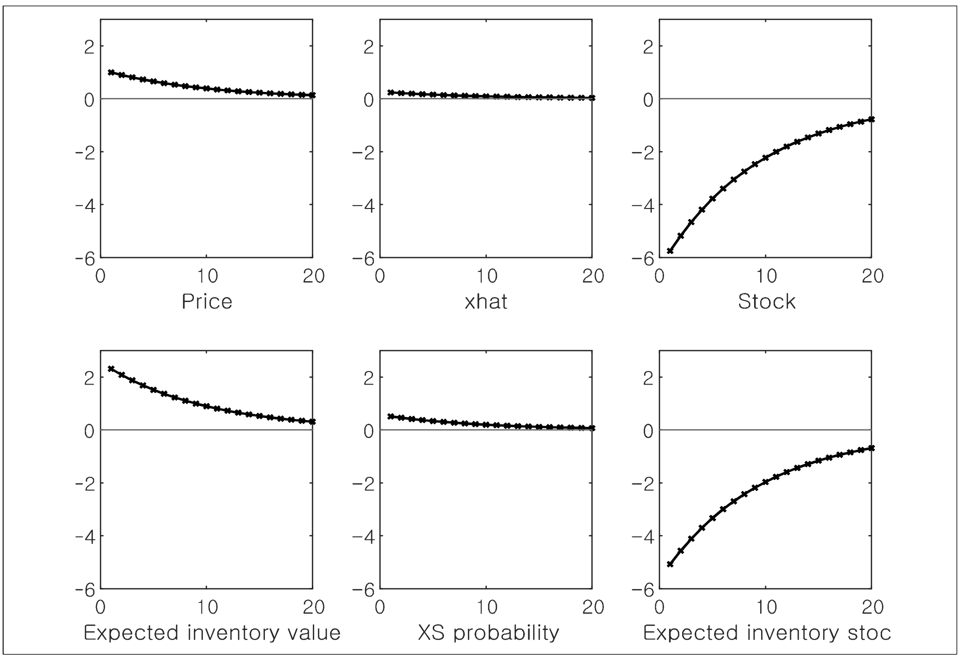
Figures 2 and 3 show impulse responses of prices $(p)$, threshold value $(\hat{x})$, stock levels $(s)$, expected value of unit inventory $E[\Lambda' \int_{\underline{x}(\theta)}^{\hat{x}} (c' - q') dF(x;\theta)]$, XS probability $F(\hat{x};\theta)$, and expected inventory stock $E[n'] = E[(\hat{x} - x)^{+} D(p)]$ over the subsequent 20 periods to demand and cost shocks at time 0, respectively. In each case, the size of the shock is normalized to 1% of its steady state level and the size of responses is expressed in % deviation from the steady state. The quantitative results confirm the key predictions of Propositions 1 and 2.

Figure 2 demonstrates results from the demand shock. Prices respond little to a positive increase in demand on impact and throughout the whole time horizon. This result remains unchanged irrespective of shock persistence. By contrast, the level of $\hat{x}$ rises on impact by about 1% from its steady state level and gradually decreases toward the steady state. These contrasting behaviors of $p$ and $\hat{x}$ are what has been expected for the case of demand shocks as well illustrated by Figure 1 (a). Furthermore, the optimal responses of output stock $s$ can be easily understood from the joint movements of $(p, \hat{x})$. As defined by equation (2), $\{(p,s)\}$ has a one-to-one map to $(p, \hat{x})$. Given that $p$ responds little while $\hat{x}$ adjusts by about 1% before gradually returning to its steady state, the stock $s$ also increases immediately by about 1% followed by gradual fall. As a whole, the numerical experiments show that demand shocks lead to a small price adjustment and make it contrast with output responses. This is exactly as predicted by Proposition 1.

The lower three panels contain extra information. The unresponsive XS probability implies that $\hat{x}$ responds proportionally to the size of shock to $\mu$. The expected value of unit inventory is neither responsive to the demand shock because the future marginal costs of production and inventory holdings ($c'$ and $q'$) are exogenously given. The expected inventory stock increases as the firm optimally raises the level of stocks in response to the favorable demand.

Figure 3 shows the results from a cost-push shock. A 1% increase in the marginal production cost is reflected onto price change, driving prices up about 1% from the steady state level on impact. Prices then gradually return toward the steady state. By contrast, the level of $\hat{x}$ responds little to the cost-push shock.[7] These contrasting responses of p and $\hat{x}$ are as expected from Figure 1 (b), which illustrates how the hedge and offer curves shift for the case of supply shocks. The optimal responses of output stock $s$ can then be easily understood from the joint movements of $(p, \hat{x})$ along with equation (2). Given that $p$ increases by 1% while $\hat{x}$ responds little, the stock $s = \hat{x}ap^{-\varepsilon}$ will fall by as much as the magnitude of demand elasticity $\varepsilon$, which is arbitrarily assumed 6 in the present numerical experiment (Table 1 shows specific parameter values).

**[Figure 3]** Impulse responses to a cost-push shock




Note: The line with crosses traces the movements of variables over 20 periods in response to shocks to the production cost $(c)$. The size of the shock is normalized to 1% of its steady state level, and the size of responses is expressed in % deviation from the steady state.

Again, the lower three panels contain extra information. The increase in the expected value of unit inventory reflects the fact that it becomes more expensive to produce output due to the cost-push shock. The impulse responses for the other two variables can be also easily understood: the XS probability rises reflecting a small increase in $\hat{x}$ while the distribution function $F$ itself unchanged. The expected inventory stock falls on impact as the firm optimally reduces the level of stocks in

[7] However, the qualitative responses of $\hat{x}$ are ambiguous depending on the precise shifts of the hedge and offer curves. This is well illustrated by 1 (b).

response to the adverse cost shock.

We further check the quantitative robustness of these results. First, we examine a model that explicitly includes stockout costs. We introduce stockout costs by assuming that a certain fraction of customers who cannot buy products from a firm due to stockouts never return to the firm. That is, stockouts result in reputational damage that affects the firm's future sales. Let b denote the present value of future sales losses that arise from one unit of stockouts. We assume for simplicity that the marginal stockout cost is constant for each given period while being allowed to vary over time. Specifically, the period profit (3) is then changed to

$$\begin{aligned}\pi(p_t,\hat{x}_t,n_t,m_t,\theta_t) &= p_t\{s_t-n_{t+1}\}-c_t(s_t-n_t)-q_tn_t-b_tm_t\\ &= p_t\{\hat{x}_t-(\hat{x}_t-x_t)^+\}D(p_t)-c_t\{\hat{x}_tD(p_t)-n_t\}-q_tn_t-b_tm_t,\end{aligned}$$

where $m_t$ is the amount of stockouts that was brought from the previous period and thus $m_{t+1}$ is determined by the difference between $\hat{x}_t$ and $x_t$, multiplied by a factor $D(p_t); m_{t+1}=-(\hat{x}_t-x_t)^-D(p_t)$ such that $-(\hat{x}_t-x_t)D(p_t)$ for $\hat{x}_t<x_t$ and zero otherwise.

The first-order conditions derived from the corresponding maximization problem are obtained as follows:

$$\underbrace{c}_{\text{MC.Y}} = \underbrace{\{p-E[\Lambda'b']\}\{1-F(\hat{x})\}}_{\text{MR.Y.XD}} + \underbrace{E[\Lambda'\{c'-q'\}]F(\hat{x})}_{\text{MR.Y.XS}},$$

and

$$\begin{aligned}0 &= \underbrace{\hat{x}D(p)\{1-F(\hat{x})\}-E\left[\Lambda'b'D_p(p)\int_{\hat{x}}^{\infty}xdF(x)\right]}_{\text{MR.P.XD}}\\ &\quad \underbrace{+\int_0^{\hat{x}}x\{D(p)+pD_p(p)\}dF(x)-E\left[\Lambda'(c'-q')D_p(p)\int_0^{\hat{x}}xdF(x)\right]}_{\text{MR.P.XS}}.\end{aligned}$$

Using the same functions from the previous numerical analysis, the two optimality conditions can be expressed to

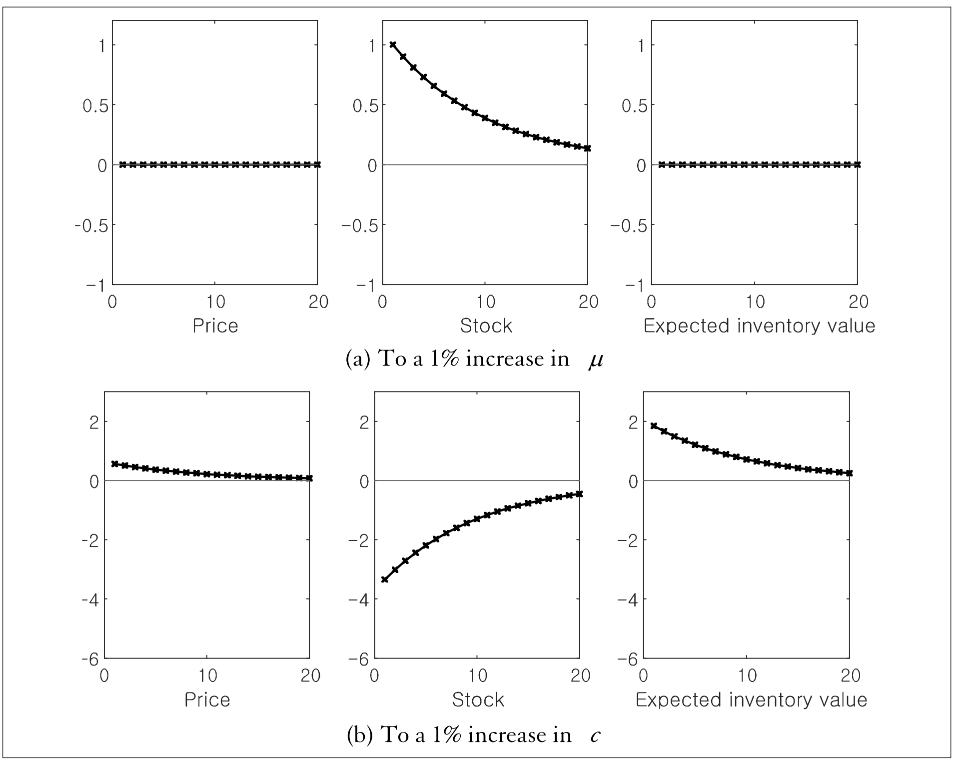
$$c=\{p-E[\Lambda'b']\}\left[\frac{1}{2}-\frac{1}{2}\text{erf}\left(\frac{\ln x-\mu}{\sigma\sqrt{2}}\right)\right]+E[\Lambda'(c'-q')]\left[\frac{1}{2}+\frac{1}{2}\text{erf}\left(\frac{\ln x-\mu}{\sigma\sqrt{2}}\right)\right], \text{ and}$$

$$0=\hat{x}\left[\frac{1}{2}-\frac{1}{2}\text{erf}\left(\frac{\ln x-\mu}{\sigma\sqrt{2}}\right)\right]+\frac{1}{2}\frac{\varepsilon}{p}E[\Lambda'b']\exp\left(\frac{\sigma^2}{2}+\mu\right)\left[1+\text{erf}\left(\frac{\sigma^2+\mu-\ln\hat{x}}{\sigma\sqrt{2}}\right)\right]$$

$$+\frac{1}{2}\{1-\phi(p)\}\exp\left(\frac{\sigma^2}{2}+\mu\right)\left[1+\mathrm{erf}\left(\frac{\sigma^2+\mu-\ln\hat{x}}{\sigma\sqrt{2}}\right)\right],$$

on which the impulse responses shown in Figure 4 are based. More precisely, the computation of impulse responses assumes that $b$, the marginal stockout cost, varies over time around the steady state of $b^{ss}=0.5$. All the other parameters are assumed the same as in Table 1 for (12) and (13). As before, the size of the shock is normalized to 1% of its steady state level and responses are in % deviation from the steady state. The impulse responses of prices and outputs are qualitatively the same whether with or without stockout costs. However, with stockout costs, outputs respond less to a cost-push shock than they do without stockout costs. The firm reduces production because it now puts more weight on XD states. Above all, the results are consistent with the predictions from Proposition 1 and

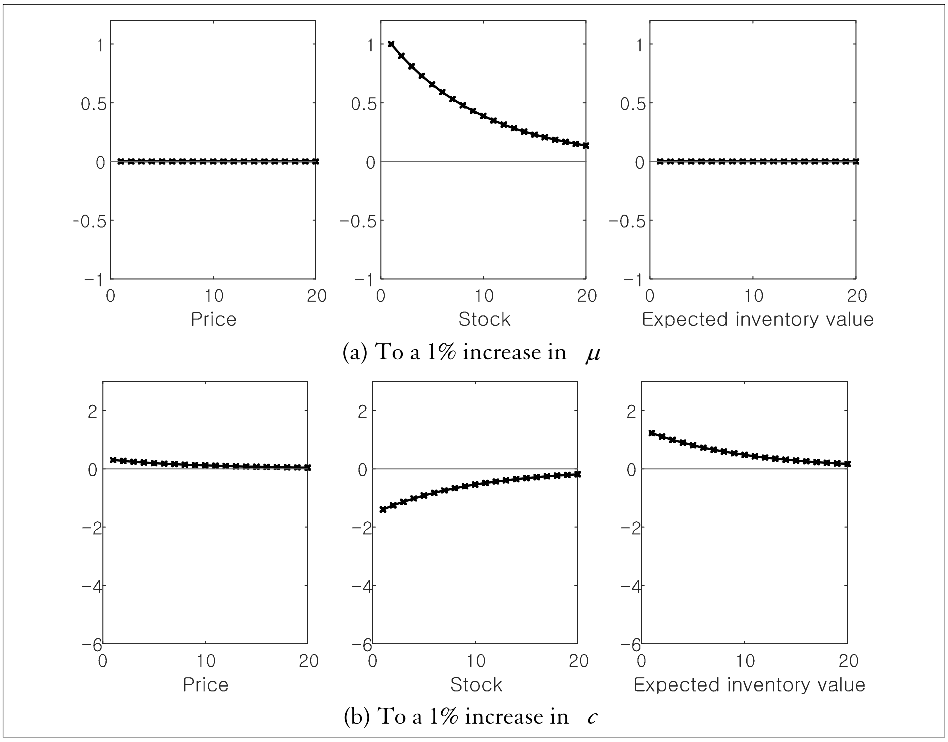
**[Figure 4]** Impulse responses of price and quantity: with explicit stockout costs




Note: The impulse responses are from a model with explicit inclusion of stockout costs. The computation is precisely based on where b denotes the marginal stockout cost that varies over time around the steady state of $b^{ss}=0.5$. All the other parameters are assumed the same as in Table 1 for (12) and (13). The size of the shock is normalized to 1% of its steady state level and responses are in % deviation from the steady state.

Secondly, we conduct quantitative examinations against another common specification of demand used in the literature. With linear demand, $D(p) = a - dp$, we find that, although the output response to the cost-push shock is relatively small compared with that to the constant elasticity case, the dynamic behaviors of prices and outputs in response to demand and supply shocks remain qualitatively identical. These results confirm again the predictions of Propositions 1 and 2 (Figure 5 is an example, where we use $D(p) = 1 - p/2$).

**[Figure 5]** Impulse responses of price and quantity: Linear demand




Note: The impulse responses are from a model with a linear demand function $D(p) = 1 - p/2$. All the other parameters than demand's are assumed the same as in Table 1 for (12) and (13). The size of the shock is normalized to 1% of its steady state level and responses are in % deviation from the steady state.

# V. Conclusions

The paper presents a theoretical model that examines how prices respond to changes in demand and supply. We consider firms that have to set prices and produce outputs before knowing its precise market demand. The main prediction of the model is that prices respond little to changes in demand but much to supply shocks. These conditional price movements have been found by empirical studies with data from many different countries, though less known due to the absence of a guiding theory.

Our theory provides new insights into how demand and supply shocks can lead to considerable different price movements. The different price responses to different shocks are explained within a unified framework in which the cost-compensating and loss-balancing motives interplay. The predicted sharp contrast in price responses between demand and cost shocks is consistent with recent microeconomic evidence that price changes are systematically related to cost changes but little to even large demand movements.

# Appendix

## Proof of Lemma

**(A) The XS curve upward-slopes.** Eq. (9) can be rewritten to and denoted by

$$M^S(p,\hat{x};\theta) = p\{1-F(\hat{x};\theta)\} + E[\Lambda'(c'-q')]F(\hat{x};\theta) - c = 0\,. \tag{A.1}$$

The derivative w.r.t. $p$ is then given by

$$M_p^S = 1 - F(\hat{x};\theta) > 0\,.$$

The derivative w.r.t. $\hat{x}$ is

$$M_{\hat{x}}^S = -\{p - E[\Lambda'(c'-q')]\} f(\hat{x};\theta) < 0\,,$$

because any optimal price must be greater than the forward-looking reservation price $E[\Lambda'(c'-q')]$.

Consequently,

$$\left.\frac{dp}{d\hat{x}}\right|_{\text{XS curve (9)}} = -\frac{M_{\hat{x}}^S}{M_p^S} > 0\,.$$

**(B) The XD curve downward-slopes.** Eq. (10) can be rewritten to and denoted by

$$\begin{aligned} M^D(p,\hat{x};\theta) &= \hat{x}D(p)\{1-F(\hat{x};\theta)\} \\ &\quad + \{D(p) + D_p(p)p - D_p(p)E[\Lambda'(c'-q')]\}\int_{\underline{x}(\theta)}^{\hat{x}} x dF(x;\theta) = 0\,, \end{aligned} \tag{A.2}$$

We have the derivative w.r.t. $p$ and obtain:

$$\begin{aligned} M_p^D &= \hat{x}D_p(p)\{1-F(\hat{x};\theta)\} + \{2D_p(p) + pD_{pp}(p) \\ &\qquad - E[\Lambda'(c'-q')]D_{pp}(p)\int_{\underline{x}(\theta}^{\hat{x}} x dF(x;\theta) < 0 \end{aligned}$$

because the standard property of demand (i.e., $2D_p(p) - pD_{pp}(p) < 0$ ) implies $2D_p(p) + \{p - E[\Lambda'(c'-q')]\}D_{pp}(p) < 0$.

We turn to the derivative of $M^D(p,\hat{x})$ w.r.t. $\hat{x}$ and obtain

$$\begin{aligned} M_{\hat{x}}^{D} &= D(p)\{1-F(\hat{x};\theta)\} + D_p(p)\{p - E[\Lambda'(c'-q')]\}\hat{x}f(\hat{x};\theta) \\ &= D(p)\{1-F(\hat{x};\theta)\}\left[1+\frac{pD_p(p)}{D(p)}\left\{\frac{p-E[\Lambda'(c'-q')]}{p}\right\}\frac{\hat{x}f(\hat{x};\theta)}{1-F(\hat{x};\theta)}\right] \\ &= D(p)\{1-F(\hat{x};\theta)\}\left[1-\varepsilon(p)\frac{\hat{x}f(\hat{x};\theta)}{1-F(\hat{x};\theta)}\left\{\frac{p-E[\Lambda'(c'-q')]}{p}\right\}\right] < 0 \end{aligned}$$

under the stated condition. Consequently,

$$\left.\frac{dp}{d\hat{x}}\right|_{\text{XD curve (10)}} = -\frac{M_{\hat{x}}^{D}}{M_{p}^{D}} < 0 .$$

## Proof of Proposition 1

**(A) The XS curve shifts down.** For a log-normal distribution for $x$, $\ln(x) \sim \mathcal{N}(\mu,\sigma^2)$, we will show that the condition (9) breaks down in response to an increase in $\mu$, leading (A.1) to be greater than zero.

We have the partial derivative of $M^S(p,\hat{x};\theta)$ w.r.t. $\mu$ as follows:

$$\begin{aligned} M_{\mu}^{S} &= -p\frac{\partial F(\hat{x};\theta)}{\partial \mu} + E[\Lambda'(c'-q')]\frac{\partial F(\hat{x};\theta)}{\partial \mu} \\ &= -\{p - E[\Lambda'(c'-q')]\}\frac{\partial F(\hat{x};\theta)}{\partial \mu} > 0 \end{aligned}$$

Because $p - E[\Lambda'(c'-q')] > 0$ and $\frac{\partial F(\hat{x};\theta)}{\partial \mu} = -\hat{x}f(\hat{x};\theta) < 0$ for all $\hat{x}$'s. To hold (9) back, the firm needs to lower prices for every given $\hat{x}$ because $M_p^S > 0$ (as shown in the proof of Lemma).

**(B) The XD curve shifts up.** Similarly, we will show that the condition (10) breaks down in response to an increase in $\mu$, leading (A.2) to be greater than zero.

We have the partial derivative of $M^D(p,\hat{x};\theta)$ w.r.t. $\mu$:

$$M_{\mu}^{D} = -\hat{x}D(p)\frac{\partial F(\hat{x};\theta)}{\partial \mu} + \{D(p) + D_p(p)p - D_p(p)E[\Lambda'(c'-q')]\}\frac{\partial}{\partial \mu}\int_{\underline{x}(\theta)}^{\hat{x}} x dF(x;\theta) .$$

The last term can be rewritten as follows:

$$\frac{\partial}{\partial \mu}\int_{\underline{x}(\theta)}^{\hat{x}} x dF(x;\theta) = \hat{x}\frac{\partial F(\hat{x};\theta)}{\partial \mu} - \int_{\underline{x}(\theta)}^{\hat{x}} \frac{\partial F(x;\theta)}{\partial \mu} dx$$

$$= \hat{x}\frac{\partial F(\hat{x};\theta)}{\partial \mu} + \int_{\underline{x}(\theta)}^{\hat{x}} x dF(x;\theta)$$

where the first equality is obtained when applying integration by parts and the second equality is because

$$\int \frac{\partial F(x;\theta)}{\partial \mu} dx = -\frac{1}{\sigma\sqrt{2}}\frac{1}{\sqrt{\pi}}\int \exp\left(-\left(\frac{\ln x - \mu}{\sigma\sqrt{2}}\right)^2\right) dx = -\int x dF(x;\theta) .$$

Thus, we have

$$\begin{aligned} M_\mu^D &= D_p(p)\{p - E[\Lambda'(c'-q')]\}\hat{x}\frac{\partial F(\hat{x};\theta)}{\partial \mu} \\ &\quad + \{D(p) + D_p(p)\{p - E[\Lambda'(c'-q')]\}\}\int_{\underline{x}(\theta)}^{\hat{x}} x dF(x;\theta) \\ &= D_p(p)\{p - E[\Lambda'(c'-q')]\}\hat{x}\frac{\partial F(\hat{x};\theta)}{\partial \mu} - \hat{x}D(p)\{1 - F(\hat{x};\theta)\} \\ &= -\hat{x}[D_p(p)\{p - E[\Lambda'(c'-q')]\}\hat{x}f(\hat{x};\theta) - D(p)\{1 - F(\hat{x};\theta)\}] \end{aligned}$$

where the second equality directly follows from (10) and the third equality utilizes the fact that $\frac{\partial F(\hat{x};\theta)}{\partial \mu} = -\hat{x}f(\hat{x};\theta)$. We finally obtain it upon the elasticity notion as follows:

$$\begin{aligned} M_\mu^M &= -\hat{x}D(p)\left[\frac{pD_p(p)}{D(p)}\left\{\frac{p - E[\Lambda'(c'-q')]}{p}\right\}\hat{x}f(\hat{x};\theta) + \{1 - F(\hat{x};\theta)\}\right] \\ &= \hat{x}D(p)\left[\varepsilon(p)\left\{\frac{p - E[\Lambda'(c'-q')]}{p}\right\}\hat{x}f(\hat{x};\theta) - \{1 - F(\hat{x};\theta)\}\right] > 0 , \end{aligned}$$

under the condition from Lemma, $\varepsilon(p)\frac{\hat{x}f(\hat{x};\theta)}{1-F(\hat{x};\theta)} > \frac{p}{p-E[\Lambda'(c'-q')]}$. To hold (10) back, the firm needs to raise prices for every given $\hat{x}$ since $M_p^D < 0$ (as shown in the proof of Lemma).

## Proof of Proposition 2

**(A) The XS curve shifts up.** We have the partial derivative w.r.t. $c$ as follows:

$$M_c^S = E\left[\Lambda'\frac{\partial c'}{\partial c}\right]F(\hat{x};\theta) - 1 < 0 ,$$

as far as $c$ follows a stationary process. To hold (9) back, the firm needs to raise prices for every given $\hat{x}$ since $M_p^S > 0$ (as shown in the proof of Lemma).

**(B) The XD curve shifts up.** We have the partial derivative w.r.t. $c$ as follows:

$$M_c^D = -D_p(p)E\left[\Lambda' \frac{\partial c'}{\partial c}\right]\int_{\underline{x}(\theta)}^{\hat{x}} x dF(x;\theta) > 0 .$$

To hold (10) back, the firm needs to raise prices for every given $\hat{x}$ because $M_p^D < 0$ (as shown in the proof of Lemma).

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# 수요충격과 공급충격에 가격은 어떻게 반응하는가?*

김 성 훈** · 문 성 만***

초 록 이 논문은 가격이 수요나 공급 변화에 어떻게 반응하는 지에 관한 이론적 연구로, 독점적 경쟁 기업이 원치 않는 재고와 그 반대 상태인 품절 가능성을 사전에 미리 반영해서 가격과 생산량을 결정해야 하는 시장 환경을 고려한다. 여기서 제시된 가격 조정 메커니즘은, 수요 불확실성이 있는 비즈니스 환경에서 필요한 두 가지 상호 보완적 동기들로 구성된다. 원치 않는 재고와 품절 가능성이 상존할 때, 수요증가로 인해 줄어든 생산의 유효 한계비용은 가격 인하의 동기로, 수요증가로 인해 높아진 기대 한계수익은 가격 인상의 동기로 작동한다. 이 두 가지 동기는 새로운 기대이윤극대화 지점에선 서로 상쇄되어 수요충격에 대한 가격의 반응은 매우 제한적으로만 나타난다. 반면, 생산비용 상승과 같은 공급충격은 유효 한계비용을 높여 기업의 가격 인상을 유도하고, 이와 동시에 다음 기로 이전될 재고의 가치 상승으로 기대 한계수익도 높여 추가적인 가격 인상 동기로 작동한다. 따라서 공급충격에 대한 가격의 반응은 매우 크게 나타난다. 요약하면, 수요충격에 대한 가격의 반응은 제한적인 반면, 공급충격에 대한 가격의 반응은 크다.

**핵심 주제어: 수요충격, 공급충격, 가격 반응, 유효 한계비용, 손실 밸런싱**
**경제학문헌목록 주제분류: E30, L11**

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** 제1저자, 연세대학교 미래캠퍼스 환경금융대학원 연구교수, e-mail : s.kim.econ@gmail.com
*** 교신저자, 전북대학교 경제학과 교수, e-mail: nopasanada0501@gmail.com