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Abstract

In many industrialized economies, there is sharp contrast between rigid prices in product markets and volatile prices in commodity and asset markets. This paper presents an explanation of this phenomenon in the framework of imperfect competition and heterogeneous expectations. However, the driving force of excessive price sensitivity is different between commodity and asset markets. In commodity markets where firms determine quantity and price equates demand to supply, *seller* expectation heterogeneity implies sensitive prices. In asset markets with high transaction costs, more *buyer* expectation heterogeneity means more sensitive prices. Market integration is shown to increase this price sensitivity.

Keywords: Imperfect competition, Price sensitivity, Commodity markets, Asset markets, Market integration

JEL Classification: D84, E31, L16

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1. Introduction

Although everyday experience in the business world shows substantial discrepancy in opinion among business people (including economists), theoretical macroeconomic models have largely ignored the expectation heterogeneity among rational economic agents. This is partly due to practical difficulty in incorporating the heterogeneity explicitly, and more fundamentally due to theoretical difficulty in modeling its origin and persistence. However, this ignorance is clearly unsatisfactory, and macroeconomics has lost important insight in understanding the behavior of prices and quantities in the economy full of uncertainty and inadequate information. The purpose of this short paper is to fill this gap and to show that expectation heterogeneity may play a key role in the movement of prices and quantities.

The last decade is often characterized as the one of relative price stability, compared with turbulent prices in the 1970s. However, a stark contrast becomes more apparent than ever between relative rigidity of product prices and volatile prices of real assets such as real estates. Moreover, within product prices, rigid prices of differentiated products (often in consumer goods) are contrasted sharply with sensitive prices of homogenous commodities (in industrial goods). Turbulent asset price behavior has caused troubles in many countries including Japan and Scandinavian countries. There is serious concern about such price behavior in a world of increasingly integrated markets.

The purpose of this paper is to provide an integrated explanation of the above peculiarity in price behavior based on the heterogeneity of expectations among rational economic agents in the decentralized market under imperfect information, and to explore the effect on price behavior of growing integration of regional and national markets to the global one. I show that heterogeneity of expectations among rational agents makes homogeneous-commodity prices and real-asset prices excessively sensitive to changes in market conditions. Moreover, it is suggested that growing integration of regional and national markets leads to more volatile prices in these markets.

It should be noted at the outset that the explanation of excessive price sensitivity developed in this paper assumes that economic agents are *all* rational in expectation formation. All agents know the true structure of the market, and form expectation rationally in the sense that they use Bayesian updating. Thus, this paper differs from the literature of noise traders (see, for example, Shleifer and Summers, 1990) in which irrational (noise) traders are the culprit of volatile price behavior. This paper is also different from the social learning and herding literature (see, for example, Vives, 1996) in which lack of knowledge about the true structure of the market and resulting learning from others may cause turbulent price behavior. Here agents have perfect knowledge of the structure of the market, but expectation heterogeneity, which is (implicitly or explicitly) due to heterogeneous information about the change in the market condition, is the source of excessive price sensitivity.

2. Asset Markets

Let us first consider the market of real assets such as residential land and houses. In this paper, I take the land market as an example. Unlike well-organized financial markets, most land markets are plagued with high transaction costs and slow informational diffusion. Moreover, unlike financial markets where buyers and sellers are mostly institutional investors in the "Wall Street" having good access to capital markets, the majority of buyers and sellers in the land markets are ordinary men and women in the "Main Street" who do not have access to capital markets.

In such a market, high transaction costs imply insufficient arbitrage. This implies that sellers have some market power in the sense that, by changing their price, they can influence the *probability* of successful sale of their land. Thus, the market can be best described as the one of *probabilistically monopolistic competition.*

Slow information diffusion means that a substantial number of buyers are uninformed. These buyers are uncertain and have different opinions about the profitability of land in general. Some are optimistic and eager to buy, but others do not. In other words, buyers are different in their *willingness to buy.*

Sellers are also heterogeneous in their *urgency to sell* their land. Since capital markets are not perfect for "small guys" like them, failure to sell their land may cause a serious trouble for some of them.[1]

In this market, prices become excessively sensitive to market conditions, which are often called as market fundamentals, of which the intuitive explanation is the following. Note that an increase in the willingness-to-buy variance of buyers implies that there are more optimistic and pessimistic buyers but less buyers in the middle (around the average).

On one hand, let us first consider an "optimistic" seller who does not feel urgency to sell and whose land's intrinsic value (*i.e.*, its fundamental) is increased.

[1] This heterogeneity is one source of "noise" making uninformed buyers unable to get perfect information about the land from the price offer of its seller.

The seller can expect positive probability for his land to be sold even if he puts a higher price tag than the land's intrinsic value. Moreover, although a price increase reduces the probability of successful sale, the reduction of the sale probability is smaller if the buyers' willingness to buy is more dispersed. This is because a higher willingness-to-buy variance implies there are more people who are very optimistic (*i.e.*, a fatter tail on the *right*). Thus, this optimistic seller's optimal price is higher when the heterogeneity of buyers is greater. Optimism feeds itself.

On the other hand, consider a "pessimistic" seller who feels urgency to sell but whose land's intrinsic value is decreased. Then, the seller has to put a low price tag on his land in order to ensure successful sale. However, he has to lower his price further to ensure successful sale when the willingness-to-buy variance is increased. This is because a fatter tail on the *left* due to a higher willingness-to-buy variance implies that there are less average people but more pessimistic people than otherwise, and to entice pessimistic people to buy, this pessimistic seller's optimal price must be reduced further. Thus, pessimism also feeds itself.

2.1. A model of pobabilistically monopolistic competition

In order to formalize the intuition just presented, consider the following market of land. There are M pieces of land, and they are heterogeneous. One seller owns one piece of land. The intrinsic value[2] of the ith seller's land is

$$\log X_i = \log Y + \log W_i \tag{2.1}$$

where Y is the average intrinsic value and W_i is the idiosyncratic part.

[2]That is, the present discounted value of future rents.

To avoid the difficult problem of bargaining under imperfect information, I assume the seller determines the price, and that the buyer determines whether to buy or not. In addition, I employ the approximation $E(\log X) \approx \log E(X)$ in this section in order to make analysis simple.

There are N buyers. In order to incorporate high transaction costs and to keep analysis simple, I assume that one buyer visits only one seller randomly. In addition, I assume the number of buyers is smaller than the number of sellers ($N < M$) so that the seller expects at most only one buyer visits his land[3]. The jth buyer visits one seller (say i), gets price quotation P_i, updates their expectations about X_i, and buys from the seller if and only if his updated estimate of X_i exceeds P_i.

Taking account of the buyer behavior, the ith seller calculates the probability of successful sale when his price is P_i. Then, he determines his optimal price maximizing his expected wealth:

$$\underset{P_i}{Max} \quad EW_i = \phi(\log P_i)P_i + [1 - \phi(\log P_i)]\,(X_i - \Delta_i). \tag{2.2}$$

where $\phi(\log P_i)$ is the probability of successful sale. Here the urgency to sell is represented by $-\Delta_i$, which is the penalty that the ith seller incurs when the seller fails to sell the land. This is the source of seller heterogeneity. For simplicity, I assume $\log \Delta_i \sim N(0, \sigma_\delta^2)$, where $N(\mu, \sigma^2)$ denotes normal distribution with mean μ and variance σ^2.

[3]The assumption of one visit per buyer and the one that $N < M$ are not essential for the qualitative result of this paper, but their relaxation makes analysis extremely complicated without any further insights.

2.2. Heterogeneity of buyers' and probability of successful sale

The jth buyer has prior information about market conditions, gets the ith seller's price quotation, updates his expectation based on this information, and buys the land if his revised estimate of the land's value exceeds the quoted price. Rational expectation formation leads to the revised estimate X_j^* which is a log-linear function of his prior belief, Y_j^*, of the market average Y, and the price information, P_i, from the ith seller, such that

$$\log X_j^* = a \log Y_j^* + b \log P_i + c. \tag{2.3}$$

In a complete rational-expectations model, a, b, and c are determined endogenously (see Nishimura 1996). I treat them as constant here for simplicity, since it is sufficient for the purpose of this paper. (I later discuss necessary modification when these terms are endogenously determined.) The buyer buys the land if and only if $\log X_j^* > \log P_i$.

Here Y_j^* can be considered as the degree of the buyer's willingness to buy, or equivalently, his optimism. It is different among buyers. For analytic simplicity, I assume it is distributed according to the following Gibbs distribution function[4].

$$\Pr\left(\log Y_j^* \leq y^*\right) \equiv F\left(y^*\right) = 1 - \frac{1}{1+e^{ky^*}}. \tag{2.4}$$

The corresponding density function is

$$f\left(y^*\right) = \frac{1}{\left(1+e^{ky^*}\right)^2} k e^{ky^*} \tag{2.5}$$

Here the mean is assumed to be zero. The variance depends on k: as k increases, the variance decreases. This relation is depicted in Figure 1.

[4] Aoki (1996) shows that the Gibbs distribution may arise from an informational exchange processes.

The probability of successful sale is the product of (1) the probability with which the buyer visits this particular seller, which is equal to, under our assumption of random visiting, N/M, and (2) the probability that the visiting buyer's willingness to buy is so great as to have $\log X_j^* > \log P_i$, $\Pr\left(\log X_j^* > \log P_i\right)$.

Let us now consider the latter probability . Let the critical value y^{**} of $\log Y_j^*$ such that the buyer whose $\log Y_j^*$ exceeds y^{**} buys the land while the buyer having $\log Y_j^*$ smaller than y^{**} does not. Since we know (2.3) and that the buyer buys if and only if $\log X_j^* > \log P_i$, the critical value y^{**} is a function of $\log P_i$ such that

$$y^{**}(\log P_i) = r \log P_i + t : r = \frac{1-b}{a}; t = \frac{-c}{a}. \tag{2.6}$$

Because we have $\Pr\left(\log X_j^* > \log P_i\right) = \Pr\left(\log Y_j^* > y^{**}(\log P_i)\right)$, we get from (2.4)

$$\phi(\log P_i) = \left(\frac{N}{M}\right) \Pr\left(\log Y_j^* > y^{**}(\log P_i)\right) = \frac{N}{M}\frac{1}{1+e^{ky^{**}(\log P_i)}}.$$

Solving for the seller's optimal price rule and employing its log-linear approximation[5], we have

$$\log P_i = \frac{1}{rk-1}\left(\log X_i - \log \Delta_i\right) - \frac{1}{rk}\left[\log\left(rk-1\right) + kt\right] \tag{2.7}$$

[5]The first order condition can be written as

$$\begin{aligned} \exp\left\{-k\left(r \log P_i + t\right)\right\} &= H\left(\log P_i, \log X_i, \log \Delta_i\right) \\ &\equiv rk\left\{1 - \exp\left(\log X_i - \log P_i\right) + \exp\left(\log \Delta_i - \log P_i\right)\right\} - 1 \end{aligned}$$

From the first-order Taylor expansion of $\log H$ around $(\log P_i, \log X_i, \log \Delta_i) = (0,0,0)$, we get

$$\begin{aligned} &\log H\left(\log P_i, \log X_i, \log \Delta_i\right) \\ \approx\ &\log\left(rk-1\right) - \frac{rk}{rk-1}\left(\log X_i - \log \Delta_i\right). \end{aligned}$$

Substituting the latter expression into the former and rearranging terms, we obtain the optimal price rule in the text.

In order to make the above equilibrium exist, k must satisfy $rk > 1$, which I assume in this paper.

2.3. Buyer expectation heterogeneity and excessive price sensitivity

Let us now consider the effect of buyer expectation heterogeneity. If information is perfect, the price of land is equal to its intrinsic value X_i. However, if buyers are uninformed and their expectations are heterogeneous, (2.7) is the equilibrium price.

As explained earlier, an increase in the dispersion of buyer expectations is captured by a decrease in k (see Figure 1). The equilibrium price (2.7) shows that an increase in the heterogeneity of expectations (*i.e.,* an decrease in k) increases the sensitivity of the land price to the change in the intrinsic value X_i. Moreover, if the willingness-to-buy variance is sufficiently large (*i.e.*, $k < 2/r$), then it is straightforward to show that the coefficient of $\log X_i$ is greater than unity. This means that, if the buyers are sufficiently heterogeneous in their willingness to buy, the land market price is more sensitive to the change in market fundamentals than in the perfect-information market. The more dispersed the buyers' willingness is, the more volatile land prices are. Thus, the buyer expectation heterogeneity leads to excessive price sensitivity.

The above discussion is based on the assumption that a, b, and c in (2.3) are constant. As explained earlier, they must be endogenously determined in a complete rational-expectations equilibrium model. However, it can be shown (see Nishimura 1996) that the basic characteristics are preserved in the corresponding full rational-expectations equilibrium. Intuitively, this can be explained in the following way. Full rational-expectations equilibrium is characterized by buyers' utilization of information content of prices. In general, buyers think a high price is a sign of high intrinsic value and *vice versa*. Thus, on one hand, the optimistic seller's optimal price increases further than otherwise, since his higher price may lead the buyer to think the land's value is higher. On the other hand, the pessimistic seller's optimal price decreases further than otherwise, since his low price may be taken as a sign of low land value so that he has to lower his price further in order to ensure successful sale. Thus, fully rational expectation formation accentuates the excessive sensitivity.

2.4. Market integration and asset prices

Now let us turn to the effect of market integration. Integration of the symmetric two land markets means that buyers can now buy land in a land market which was unaccessible in the past. Since land is immobile, there is no change on the supply side. Thus, market integration implies an influx of new buyers uninformed of the market. This is likely to increase buyer heterogeneity, that is, to decrease k.[6] Then, the volatility of the market is increased.

3. Commodity Markets

Let us now turn to industrial commodity markets. On the one hand, industrial commodities such as steel sheets involves substantial fixed costs so that the number of firms is finite. On the other hand, since these commodities are homogeneous, the market is wide and deep, and arbitrage within it is relatively easy. In addition, there is a non-trivial production period, so that firms have to

[6] Market integration implies an increase in N. But it changes equilibrium in this market only if it is accompanied by a change in buyer heterogeneity (see (2.7)).

determine their quantity of production before having perfect knowledge of the market. Thus, the market is best described as Cournot quantity competition under imperfect information.

Before explaining the model, it is worthwhile to discuss the result in an intuitive way. It is now well-known that differential information about general market conditions and resulting expectation heterogeneity on the side of differentiated-product manufacturers lead to rigid prices in imperfectly competitive economies (Andersen 1985; Nishimura 1986). This is because individual rationality implies conservative expectations when there are idiosyncratic noises. Since the expectations are conservative, pricing decision based on such expectations becomes conservative, leading to rigid prices in differentiated-product markets.

The same conservatism, however, affects the market in the opposite direction in homogeneous-commodity markets where decision is made with respect to quantity rather than price. Conservative expectations make quantity decision rather insensitive to changes in market conditions, and thus prices bear the burden of adjustment. Thus, an increase in the heterogeneity of sellers, caused by an increase in the idiosyncracy in their information, makes expectations more conservative, and thus leads to more volatile prices.

3.1. A simple Cournot model with a product period and differential information

Consider a simple linear-demand quadratic-production-cost model. The reverse demand function is

$$P = (a + u) - bQ : \qquad a > 0, \ b > 0 \tag{3.1}$$

where P is the price, Q is the total supply of the commodity, and u is a random variable such that $u \sim N(0, \sigma_u^2)$. (For analytic simplicity, I ignore the possibility that $a + u < 0$). There are N symmetric firms maximizing their profit:

$$\Pi_i = PQ_i - \left(c_0 Q_i + c_1 Q_i^2\right) : \qquad c_0 > 0,\ c_1 > 0 \tag{3.2}$$

where Q_i is the ith firm's supply. N is fixed and assumed to be sufficiently large so that the law of a large number applies.

Because of the production period, these firms must determine their production level Q_i before they have perfect knowledge about the market condition u as well as the others' quantity decision. They are, however, assumed to obtain idiosyncratic information z_i about the market condition u such that

$$z_i = u + v_i \tag{3.3}$$

where v_i is independent of u, and $v_i \sim N(0, \sigma_v^2)$. This is the source of expectation heterogeneity among firms.

The firm maximizes the expectation of its profit conditional on information z_i, with respect to its decision variable Q_i. Optimal decision of the firm is characterized by

$$X_i = gE(u \mid z_i) - (N-1)\, hE(X_{-i} \mid z_i) \tag{3.4}$$

where $E(x \mid z_i)$ denotes the expectation of x conditional on z_i, and

$$X_i = Q_i - \overline{Q} \text{ and } X_{-i} = Q_{-i} - \overline{Q},$$

in which $\overline{Q}$ is the long-run quantity of the firm when u is identically zero[7], Q_{-i} is the average quantity of the other firms[8], $g = \left[2\left(b + c_1\right)\right]^{-1}$, and $h =$

[7]That is, $\overline{Q} = (a - c_0) / \{b + 2c_1 + bN\}$.

[8]That is, $Q_{-i} = \left(\sum_{j \neq i} Q_j\right) / (N-1)$.

$b\left[2\left(b+c_1\right)\right]^{-1}$.

3.2. Seller expectation heterogeneity and sensitive commodity prices

As a frame of reference, consider the perfect-information case. Symmetric equilibrium under perfect information is immediately obtained from the above relation[9], in which the perfect-information price is determined by

$$P^{\text{perf}} = \overline{P} + \frac{b+2c_1}{b+2c_1+bN}u. \tag{3.5}$$

where $\overline{P}$ is the long-run price where u is identically zero.[10]

As usual, imperfect-information symmetric equilibrium can be derived by undetermined coefficient method. Since $z_i = u + v_i$, we obtain

$$E(u \mid z_i) = \gamma z_i, \text{ where } \gamma = \frac{\sigma_u^2}{\sigma_u^2+\sigma_v^2}$$

Using this expression we solve for imperfect-information equilibrium[11], in which

[9]From (3.4) we immediately obtain

$$X^{\text{perf}} = \frac{g}{1+(N-1)h}u.$$

From this expression, we obtain (3.5).

[10]That is,

$$\overline{P} = \frac{ab+2ac_1+bNc_0}{b+2c_1+bN}.$$

[11]Since N is large, we can use the law of a large number to get $X_{-i} = Ku$, where K is an undetermined coefficient. Then,

$$X_i = \{g\gamma - (N-1)hK\} z_i.$$

Symmetry implies

$$X_{-i} = (\{g\gamma - (N-1)hK\} u.$$

the price under expectation heterogeneity is

$$P^{\text{imp}} = P^{\text{perf}} + \frac{bN(1-\gamma)}{b+2c_1+bN}u. \tag{3.6}$$

The second term in (3.6) represents excess sensitivity due to heterogeneity.

It is evident that as the heterogeneity of expectations increases (that is, the variance σ_v^2 increases), the quantity becomes rigid and the price becomes sensitive. In the extreme, if $\sigma_v^2 \gg \sigma_u^2$, then quantity is almost unchanged and the price becomes highly sensitive to demand change u.

3.3. Market integration and excessive price sensitivity

Suppose that two independent markets are merged into one integrated market. Does such market integration increase excess price sensitivity or decrease it? The result obtained in the previous section is useful in answering this question. I am mostly concerned with the short run in this section: the price behavior immediately after the integration. The long run effect will be discussed afterward.

The integration of two symmetric markets with the demand (3.1), where demand shocks are perfectly correlated, implies the demand is now $P = (a+u) - b'Q$, where $b' = (1/2)b$. Moreover, it is likely that firms' information about the new market is less accurate than in the old market, since firms now face new demand and compete with new competitors. This implies variance of the noise in their information about u increases (σ_v^2 increases), so that the index of the "reliability" of information z_i, γ', now satisfies $\gamma' < \gamma$.

This implies $K = g\gamma - (N-1)hK$, implying

$$X^{\text{imp}} = \frac{g\gamma}{1+(N-1)h}u.$$

This implies (3.6).

Since I am concerned in the short run, I assume the number of firms in operation does not change after the market integration. Then, the number of firms in the new integrated market is $N' = 2N$. This implies that the degree of excess price sensitivity in the new market is

$$\left[\frac{\partial\left(P^{\text{imp}} - P^{\text{perf}}\right)}{\partial u}\right]_{\text{integrated}} = \frac{b'N'(1-\gamma')}{b' + 2c_1 + b'N'} = \frac{bN(1-\gamma')}{\frac{1}{2}b + 2c_1 + bN}$$
$$> \frac{bN(1-\gamma)}{b + 2c_1 + bN} = \left[\frac{\partial\left(P^{\text{imp}} - P^{\text{perf}}\right)}{\partial u}\right]_{\text{disjoint}} \tag{3.7}$$

The above expression shows that market integration leads to more volatile prices.

Market integration affects price sensitivity in three ways. Firstly, market integration implies more noisy environment in the short run, which increases quantity rigidity and thus enhances price volatility. Secondly, market integration also increases the number of firms, which accentuates the above effect of imperfect-information-induced rigid (inelastic) supply. Thirdly, however, market integration makes demand more elastic, which leads to less sensitive prices. In our framework of linear demand, the second quantity-rigidity-enhancing effect dominates the third quantity-elasticity-enhancing effect, so that the market integration unambiguously increases quantity rigidity and price volatility.

In the long run, the initial high sensitivity of prices is likely to go down. As firms accumulate information about the new integrated market, the noise level goes down making prices less sensitive to market conditions. Moreover, growing competition among firms drives some firms out of market, and thus the number of firms is likely to be reduced. This reduces the impact of imperfect-information-induced quantity rigidity.

4. A Concluding Remark on the Business Cycle

In this paper, it has been shown that heterogeneity of expectations makes prices excessively sensitive in homogeneous commodity markets with a non-trivial production period and real asset markets with substantial transaction costs. Moreover, the result suggests that, integration of regional markets to one national market, and of national markets to one global market, might contribute to growing price volatility observed in those markets in the last decade.

However, the driving force of excess price sensitivity is different between homogeneous-commodity markets and real-asset ones. In homogeneous-commodity markets where firms determine quantity and price equates demand to supply, noisy signals leading to *seller* expectation heterogeneity imply volatile prices. In real-asset markets with high transaction costs, more *buyer* expectation heterogeneity about market fundamentals means more volatile prices.[12]

Finally, a remark on the business cycle may be due. In this paper, I have implicitly assumed that the permanent component of the market fundamentals is

[12]Two remarks on the robustness of the results in this paper may be due. Firstly, the result of Section 2 does not depend on the particular assumption of unobservability of the average market price. In fact, Nishimura (1996) shows that qualitatively similar results are obtained in a model where buyers have contemporaneous information about the average market price. This is important, since buyers in real-asset markets usually have some information about the average through various sources. Moreover, availability of average price information yields several interesting results, but they are beyond the scope of this paper.

Secondly, the result in Section 3 depends actually on whether the strategic variables in question are strategic complements or substitutes. If they are strategic substitutes, we have volatile behavior of the variables, while we obtain rigid behavior in the case of strategic complements. Since quantities are strategic substitutes in our framework of symmetric Cournot competition, we have volatile behavior.

known to all market participants and only the transitory one is unknown. Then, I have shown that asset and commodity prices become excessively sensitive to temporary changes. However, in reality, firms and consumers cannot be certain whether changes they notice are transitory or permanent. Here, a classical problem of permanent-transitory confusion comes in. The excessive sensitivity of asset and commodity prices with respect to temporary changes means that observed asset and commodity prices are less informational with respect to permanent changes.

However, investment decision such as to build a plant and a house is based on expectations on permanent changes. Thus, the less informational prices are with respect to permanent changes, the more erratic investment is. This is likely to contribute to a greater instability of the economy.

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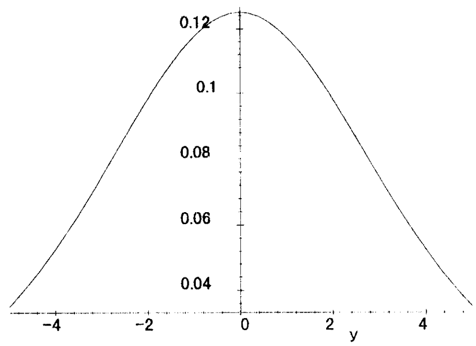
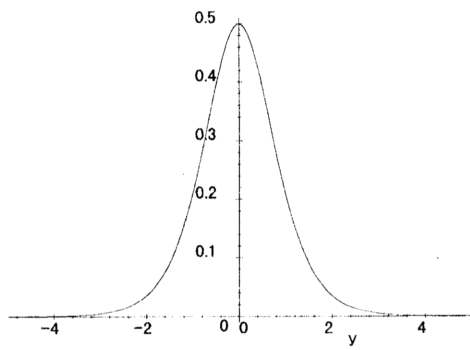


Case 1: $k = 1/2$



Case 2: $k = 2$

Figure 1