THE WELFARE EFFECT OF PRICE STABILIZATION POLICY

YOSHIHIRO KOBAYASHI
Professor
Faculty of Economics and Bussiness Administration
Hokkaido University

It is well known as the Pigovian Third Postulate that economic welfare increases when the situation is stabilized compared with when it is not. We can say it has been implicitly supported without confirming whether it was true or not. In the case of price stabilization the economic evaluation of how much it is or is not desirable varies with the theoretical stand of economics. For instance, given a variation in general price level, we can say it is desirable that the price level is stable. If we draw on the concept of partial equilibrium in analyzing a variation in price of a product of a particular industry, we can look on price stability as also desirable for this industry.

When analyzed in the context of general equilibrium, which addresses itself to relativeness in price as a whole, however, price flexibility constitutes an indispensable condition for the optimum resource allocation. As an application of this approach to the evaluation of market performance in the case study of industrial organization, we judge that a large fluctuation of price of a product of a particular industry is desirable because we can regard it as an index of competitiveness of this industry, the price serving as a signal for movement of resources. But an extreme price fluctuation may make supply and demand not adjustable in a short span of time because of poor elasticity of supply. In this case price fluctuation is not desirable.

Waugh threw doubt in regard to a generally accepted view which favored price stability against instability. He expounded, using an arithmetic method, that price stability did not improve consumer's welfare. About twenty years later Oi argued price instability was more desirable for producer's welfare than price stability. Having further integrated these two arguments, Massell came to support price stability as desirable for the whole economy.(1)

This question about whether or not price stability is desirable is encountered in various fields; for instance, price stabilization policy under which an authority sets up a buffer stock of a product through the purchase in a period of excess supply and reduce it through the sale in a period of short supply, or behavior in avoiding a risk of income variation due to price variation. Massell(2) and Mckinnon(3) dealt with the two instanced cases, while Turnovsky(4) conducted a dynamic analysis of welfare effect resulting from price stabilization.

Aiming at solving the question of price stabilization policy by applying our concept thereto, this paper is divided into three sections. Section 1 surveys papers presented by Waugh, Oi and Massell and shows the features of their arguments. Then, section 2 examines the arguments of Mckinnon and Massell's late papers as examples of application to this question. Finally, section 3 applies our concept to the welfare effect of stabilization of energy price in Japan.

(1) F. V. Waugh, "Does the Consumer Benefit from Price Instability?" Quarterly Journal of Economics. 58, 1944, pp. 602–614.
W. Y. Oi, "The Desirability of Price Instability Under Perfect Competition," Econometrica 29, 1961, pp. 58–64.
B. F. Massell, "Price Stabilization and Welfare," Quarterly Journal of Economics 83, 1970, pp. 284–298.

(2) B. F. Massell, "Some Welfare Implications of International Price Stabilization," Journal of Political Economy 79, 1970, pp. 404–417.

(3) R. I. Mckinnon, "Future Markets, Buffer Stocks and Income Stability for Primary Producers," Journal of Political Economy 75, 1967, pp. 844–861.

(4) S. T. Turnovsky, "Stabilization Rules and the Benefits from Price Stabilization," Journal of Public Economics 9, 1978, pp. 37–57.

1. PRICE STABILITY AND ECONOMIC WELFARE — A SURVEY —

It is Frederick Waugh who for the first time dwelled on a view that price stability does not benefit consumers, differently from a generally accepted view of looking on price stability as desirable for consumers.(1) His argument can be summarized as follows. Let us consider a single commodity and assume as negatively sloped demand curve for it.

Waugh says, "Let the price of any commodity or service be p_1 in one period of time and p_2 in another equal period. If these prices are unequal, every individual consumer of the commodity or service will enjoy a greater average consumer's surplus in the two periods than if the price were stabilized at the arithmetic mean, $p_0=\frac{1}{2}(p_1+p_2)$.(2)

He argues using the concept of consumer's surplus. It is clear that an increase in consumer's surplus which is brought forth by a decrease in price is larger than a decrease in consumer's surplus brought forth by an increase in price.

The assumption of a negatively sloped demand curve plays a crucial role in Waugh's argument. If the elasticity of demand is zero, the gain from a decrease in price is offset by a loss from an increase in price. It is also apparent that the larger the elasticity of demand is, the more is the gain from price instability.

This argument is advanced by the theory of partial equilibrium using the concept of consumer's surplus. Waugh extended it to the general case using an indifference curve and reached the same conclusion.

He says, "If any consumer can spend a given amount of money for all goods and services in n equal periods of time, and if the price of any particular good or service varies, the same total expenditure of money could always be so distributed among the n periods as to leave the consumer better off than he could be if the price were stable at

$$p_0=\frac{1}{n}(p_1+p_2+\cdots+p_n)."^{(3)}$$

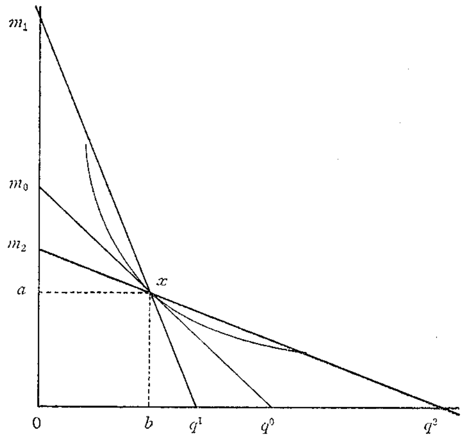

Fig. 1-1.

In Fig. 1 output q is measured in the horizontal axis and money expenditure is measured in the ordinate axis. When price is stabilized at p_0, m_0q_0 is a budget line. A consumer chooses point x if he is rational, because the indifference curve is in contact with the budget line at the point. He expends ob dollars to buy goods and services at the expense of money am_0. He expends oa dollars to buy other goods and services. Let us consider a case that $p_1>p_0$. If the price of a good rises to p_1, a new budget line becomes m_1q_1. He can consume ob to buy goods and services and consumes oa dollars to buy other goods and services. But he will choose an other point which is in contact with the above indifference curve. In this situation $m_1>om_0$; in other words, he must expend more money.

Let us consider another case that $p_2<p_0$. The budget line becomes m_2q_2. He can also choose x, but he will choose another point which is in contact with the above indifference curve.

$$p_0=\frac{1}{2}(p_1+p_2)\,, \qquad m_0=\frac{1}{2}(m_1+m_2)$$

Money expenditure remains unchanged regardless of whether price may stabilize or not. But utility is larger in price instability than stability.

Waugh asserts validity of his argument, answering to a criticism he predicts. However his argument only concerns to the effect which price stability has on consumer's welfare as he recognizes himself.

How does it influence producers? This problem was shown by Oi.[4]

He proposed to analyze the behavior of a competitive firm faced with an uncertain demand. Such uncertainty takes the form of instability in price of a product produced by the firm, said he. He concluded that instability in price would always result in a greater total return. His argument is as follows :

The firm is a price taker, as he assumes perfect competition. The cost function remains stable so that it does not shift.

The profit function is shown as an increasing function of price. He assumes that the firm forecasts two prices p_1, p_2, each occurring in the same probability. Expected price p_0 is

$$p_0 = 0.5(p_1 + p_2)$$

Profits corresponding to p_0, p_1, p_2 are π_0, π_1, π_2, respectively, where π is a simple-valued function of price. The profit function is a curve in the form illustrated in Fig. 1-2. It can be drawn as a monotonously increasing function, convex to the price axis. Expected profit, π_0, can be found by taking the height of a chord connecting π_1 and π_2 at point $p = p_0$.

Next, consider a second alternative set of prices, p_1^*, p_2^* with p_0 remaining the same.

$$p_0 = 0.5(p_1^* + p_2^*)$$

$$p_1^* < p_1,\ p_2 < p_2^*$$

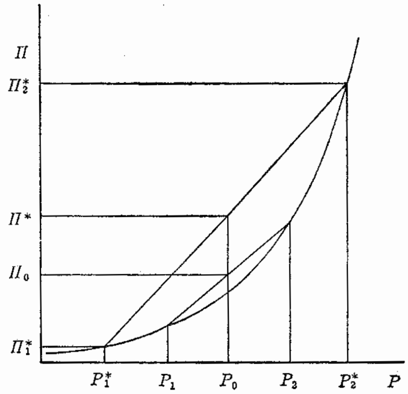

Fig. 1-2.

Expected profit, π^*, can be found by taking a chord connecting π_1^* and π_2^* at point $p = p_0$. It can be seen $\pi^* > \pi_0$.

He states the following proposition : Given a fixed expected value of price, p_0, the greater is the variability of price about p_0, the greater will be the expected profit.(5)

If price p remains stable at p_0, the profit is minimum. This has been Oi's argument.

The crucial point in it is the assumption that the cost curve has an increasing slope, in other words, the profit function is a monotonously increasing function of price. While Waugh showed that instability in price brought forth by shifts of a supply curve improves consumer's welfare compared with the case in which price remains stable at the arithmetic average under the assumption of a negatively sloped demand curve, Oi stated that instability in price brought forth by shift of a demand curve increases producer's gain compared with the case in which price remains stable at the arithmetic average under the assumption of a positively sloped supply curve.

Does instability in price increase social gain, if we integrate these two arguments into a whole? This question was solved by B. F. Massell.[6] He examines each and says, "Oi's results depend on the assumption, not made explicit in his analysis, that there is a zero covariance between shifts in the supply curve and changes in the price. His analysis is based on a stationary supply curve, in which case the covariance is trivially zero. Thus, price changes are due solely to shifts in demand. A similar condition holds for Waugh's results. His analysis implicitly assumes that the demand curve is stationary, so that price changes arise solely from shifts in supply. In this sense, the two sets of results can not both hold simultaneously."[7]

Having integrated both Massell proposed that these two price fluctuations can arise from shifts in either supply or demand or both. Consider the case in which price fluctuation arises from the shift of a supply curve. In Fig. 1-3 let S_1, S_2 be supply curves and let them occur in the same probability; then

$$\mu_p = \frac{1}{2}(p_1 + p_2)$$

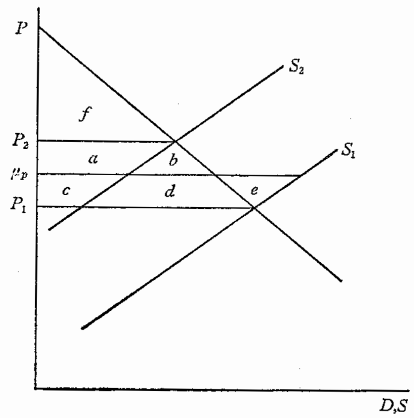

Fig. 1-3.

He says, "μ_p can be achieved through a costless storage activity. A buffer stock is set up, with a buying and selling price equal to μ_p, thereby establishing the market price at this level." If price is held at μ_p, a rise in price from p_1 to μ_p brings a gain, $c+d+e$, to producers and a loss, $c+d$, to consumers. Therefore, social net gain is e. On the contrary, a fall in price from p_2 to μ_p brings a gain $a+b$ to consumers and a loss a to producers. Net gain is b. Ultimately to stabilize price at μ_p brings net gain, $c+d+e-a$, to producers and net loss, $c+d-(a+b)$ to consumers and a net gain to the two groups jointly of $b+c$. He says, "the gain to consumers (producers) is sufficiently large to permit compensation, leaving both parties better off."[8]

On the basis of the above-mentioned graphical explanation, making a general formulation and analyzing the effect of stability policy on social gain, Massell concluded that the more variable the price is, the larger is gain from stabilization policy and also that the larger are the shifts of demand and supply curves, the larger is the gain from this policy.[9]

We can explain it graphically. Let q_0, q_1, q_2 be the quantities of demand corresponding to p_0, p_1, p_2 respectively; then

$$p_1 - p_0 = \delta k \qquad p_0 - p_2 = \delta j$$
$$q_0 - q_1 = \Delta k \qquad q_1 - q_0 = \Delta j$$

Welfare loss is $(q_0 - q_1)(p_1 - p_0) = \frac{1}{2} \Delta k\, \delta k$, when price rises from p_0 to p_1. On the other hand, welfare gain is $(q_2 - q_0)(p_0 - p_2) = \frac{1}{2} \Delta j\, \delta j$, when price falls from p_0 to p_2. If price fluctuation is symmetrical, $p_1 - p_0 = p_0 - p_2$. Therefore, consumer's gain increases to $\frac{1}{2}(\Delta k\, \delta k + \Delta j\, \delta j)$ when price is instable compared with the case in which price is stable.

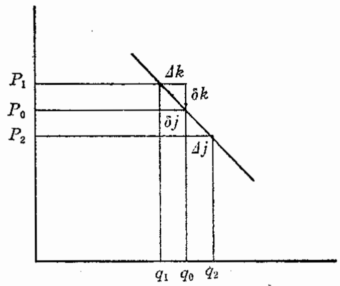

Fig. 1-4.

(1) F. Waugh, "Does the Consumer Benefit from Price Instability ?" Quarterly Journal of Economics 58, 1944.

(2) ibid pp. 603-604.

(3) Waugh, ibid pp. 606-607.

(4) Walter Oi, "The Desirability of Price Instability under Perfect Competition," Econometrica 1961, Vol. 29.

(5) Oi, ibid.

(6) Benton F. Massell, "Price Stabilization and Welfare," Quarterly Journal of Economics, Vol, 83, 1969.

(7) ibid, p. 288.

(8) ibid, p. 289.

(9) Massell formulated it as follows:

A supply and a demand function include shift parameters which are stochastic variables.

(1) $S = \alpha p + X \qquad \alpha \geq 0$

(2) $D = -\beta p + Y \qquad \beta \geq 0$

(1) represents a supply function and (2) a demand function. In the equations p, prices, α and β, are assumed as constants, X, Y are shift parameters of (1) and (2) respectively; μ_x, μ_y are means at X, Y; σ_{XX} and σ_{yy} are variances of X, Y; σ_{Xy} is a covariance. For simplification, assume $\sigma_{Xy} = 0$. The equilibrium price and quantity traded are given by (3) and (4), respectively.

(3) $p = \dfrac{X - Y}{\alpha + \beta} \qquad \alpha + \beta > 0 \quad p \geq 0$

(4) $q = \dfrac{\alpha Y + \beta X}{\alpha + \beta} \qquad q \geq 0$

The mean price, μ_p, is known and a decision is made to eliminate price fluctuations by establishing a buffer stock authority that stands ready to buy or sell at μ_p stocks held by the authority and stored at zero cost (p. 291).

Considering Fig. 1-1 and letting G be producer's gain (i.e., an increase in producer's surplus). We can write

$$(5)\qquad G_p=\frac{1}{2}(\mu_p-p)\left[s(p)+s(\mu_p)\right]$$

where

$$(6)\qquad \mu_p=\frac{\mu_y-\mu_x}{\alpha+\beta}$$

Substituting (1), (2) and (6) into (5) and simplifying,

$$(7)\qquad G_p=\frac{1}{2}\left[\frac{\mu_y-\mu_x-(y-x)}{\alpha+\beta}\right]\left[2x+\frac{\alpha(\mu_y-\mu_x+y-x)}{\alpha+\beta}\right]$$

Integrating over X and Y, the expected value of the gain can be written

$$(8)\qquad E(G_p)=\frac{(\alpha+2\beta)\,\sigma_{XX}-\alpha\sigma_{yy}}{2(\alpha+\beta)^2}$$

Consumer's gain can be expressed similarly to the producer's gain. Let us consumer's gain from price stabilization be G_c, then

$$(9)\qquad E(G_c)=\frac{(2\alpha+\beta)\,\sigma_{xy}-\beta\sigma_{xx}}{2(2\alpha+\beta)^2}$$

Total gain G is the sum of consumer's and producer's gains.

$$(10)\qquad G=G_p+G_c$$

Substituting (8) and (9) into (10) and simplifying,

$$(11)\qquad E(G)=\frac{\sigma_{yy}+\sigma_{xx}}{2(\alpha+\beta)}$$

which is necessarily nonnegative and is positive if either σ_{yy} or σ_{xx} is positive. This means that $E(G)$ is positive is either demand curve or supply curve shifts. Price variance is given by

$$(12)\qquad \sigma_{pp}=\frac{\sigma_{yy}+\sigma_{xx}}{(\alpha+\beta)^2}$$

Thus, $E(G)$ is shown as

$$(13)\qquad E(G)=\left[\frac{\alpha+\beta}{2}\right]\sigma_{pp}$$

The larger σ_{pp} is, the larger is social gain from price stabilization.

2. APPLIED PROBLEM OF PRICE STABILIZATION POLICY

The welfare effect of price stabilization policy proposed by Waugh, Oi and Massell can be applied to various subjects. Let us list up some of them.

① It can be applied to stabilization of price and income in such an industry as agriculture, the product of which has a large price fluctuation and is difficult in having the output adjusted.

② It may be applied to the problem of avoidance of risk which arises from a change in exchange rate.

③ Price fluctuation fully influences his income for a producer of a single commodity. To avoid an income variation means to avoid risk or uncertainty. If the utility function of an economic unit consists of income and avoidance of risk from an income variation, we can use an analytical method for portfolio selection in analyzing a welfare effect of a stabilization policy.

④ While price stabilization brings forth a welfare gain, it may not be desired from the view point of resource allocation. Then, we are called on to solve this problem by differentiating between a welfare implication in the sense that price fluctuation serves as a signal for efficient resource allocation and a welfare effect in the sense that price stabilization increases a welfare gain.

Among these subjects, Mckinnon(1) and Massell(2) examined problems relating to ① and ③. Let us survey their arguments.

Mckinnon proposed forward selling or buying so that a risk of an income variation due to a price fluctuation should be decreased. In agriculture a price fluctuation brings about an income variation straightly. Therefore, to avoid a risk from an income variation it may be possible to reduce an income variation through forward selling at the planting time. Spot price is determined by supply and demand at the harvest time. It is the purpose of forward selling to reduce income variance which is brought about by a fluctuation in spot price and it is the problem to be solved that the optimum rate of forward selling should be determined to minimize the income variation. Planting quantity should be determined by the expectation of future price, but we assume it is given here. Let X be an output which is a stochastic variable because it changes according to weather. The expected mean value of X is μ_x and the variance of X is σ_{xx}, assumed as known.

A farmer contracts to sell X_f at price p_f at the planting time. Income, Y, is shown as follows:

(2-1) $$Y = pX + (p_f - p)\, X_f \text{(3)}$$

where PX is a revenue when he sells X at spot price p at the harvest time and $(p_f - p)\, X_f$ is a gain or loss from liquidating the commitment of futures (which approaches zero as X_f becomes small).

Mckinnon solves the value of X_f to minimize income variance, σ_{yy}, in gaining a constant Y.

The expected income is shown by (2-2), but it is independent of the choice of X_f.

(2-2) $$E(Y) = E(p \cdot X) + X_f E(p_f - p) = E(p \cdot X)$$

where p_f is a mean of expected price p; so, $E(p_f - p) = 0$. The expected value of income equals the expected value of $p \cdot X$ indifferent to X_f. Therefore, the farmer cannot increase or decrease Y by changing X_f. He engages himself in reducing income variance. In other words, his purpose is to avoid risk at no expense of expected income.

Risk, namely, income variance is as follows :

$$\sigma_{yy}=E\left[Y-E(Y)\right]^2 \tag{2-3}$$

Based on (2-1), we can get σ_{yy} as follows :

$$\begin{aligned}\sigma_{yy}&=E(Y^2)-\left[E(p\cdot X)\right]^2\\&=p_f^2\sigma_{xx}+\mu_{xx}\sigma_{pp}+2p_f\mu_x\rho_{\sigma x\sigma p}\\&\quad+(1+\rho)^2\sigma_{xx}\sigma_{pp}-2Y_fp_f\rho_{\sigma x\sigma p}-2X_f\mu_x\sigma_{pp}+X_f^2\sigma_{pp}\end{aligned} \tag{2-4}$$

where ρ shows a correlation between X and P. Income variation is explained by σ_x, σ_p, μ_x, p_f, p, ρ and X_f. Differentiating (2-4) with respect to X_f and equating to zero, we obtain X_f^*, the optimal value of X_f.

$$X_f^*=\rho p_f\frac{\sigma_x}{\sigma_p}+\mu_x \tag{2-5}$$

It is convenient to express X_f^* as a proportion of expected output μ_x.

$$\frac{X_f^*}{\mu_x}=\rho\frac{\sigma_x/\mu_x}{\sigma_p/p_f}+1 \tag{2-6}$$

where σ_x/μ_x is the coefficient of variation in output and σ_p/p_f is the coefficient of variation in prices. Based on (2-6), Mckinnon concluded as follows :

① The larger is the output variation relative to price variation, the smaller is the quantity of optimum forward selling.

② The larger is the negative correlation between output and price, the smaller is the quantity of optimum forward selling.[4] Massell, connecting this concept of reduction in income variance, which Mckinnon put forth, to stabilization policy by a buffer stock authority, proposed a model, solves two problems : increase in expected income and decrease in income variance.

Massell argued what effect the price stabilization policy would bring on producers through adjustment of a buffer stock. Generally speaking, producer's utility depends on producer's income and its variance. Therefore, the price stabilization policy may increase producer's expected gain through influencing his income and its variance. His model is as follows :

$$D=-\beta p+Y \tag{2-7}$$

$$S=X \tag{2-8}$$

(2-7) and (2-8) are a demand and a supply function, respectively, where X and Y are stochastic shift terms. Assume that X and Y are jointly normally distributed with means μ_x and μ_y, variances σ_{xx} and σ_{yy} and covariance $\sigma_{xy}=0$. Equilibrium price is

(2–9) $p=\frac{X-Y}{\beta}$

An average expected value of price, μ_p, and variance σ_{pp} are

(2–10) $\mu_p=\frac{\mu_y-\mu_x}{\beta}$

(2–11) $\sigma_{pp}=\frac{\sigma_{yy}-\sigma_{xx}}{\beta^2}$

Let us consider that the authority regulates shifts of demand, which is a factor of price variation, to regulate price so that the stabilized income should be secured for producers. Let regulated demand be D'. The intersection of D' and X brings forth expected income $E(Y)$.

(2–12) $D'=-\beta p+\mu Y$

We name (2–12) regulated demand curve. As D' does not shift, new price variance σ'_{pp} becomes,

(2–13) $\sigma'_{pp}=\frac{\sigma_{xx}}{\beta^2}$

Ruling out shifts term X, Y,

(2–14) $\sigma_{pp}-\sigma'_{pp}=\frac{\sigma_{yy}}{\beta^2}$

Massell's argument is formed by two steps. The first step is to depict a regulated demand curve and the second step is to change the slope of this curve by the intervention of a buffer stock authority.

By the second step we can expect that price variation by the variation of X (change in supply) may be ruled out.

Let us consider the rotation of the D' curve about point μ_p. By rotating D' Massell means changing its slope. He says, "The trick is to do this without altering μ_p, so that we preserve market equilibrium in a probabilistic sense."(5)

(2–10) can be arranged into.

(2–15) $\mu_y=\beta_p+\mu x$

To keep μ_p unchanged, we substitute (2–15) to (2–12) and obtain

(2–16) $D'=-\beta p+(\beta\mu_p+\mu x)$

This is a generalization of (2–12). Combining (2–16) with (2–8), we obtain (2–17). (Note that $D'=S$ and $S=X$.)

(2–17) $p'=\mu_p+\frac{\mu_x-X}{\beta}$

"It can be seen that $\mu'_p=\mu_p$, regardless of the value of β. It is therefore possible to rotate the demand curve as we please and still preserve equilibrium.

Although rotating the demand curve does not alter the expected value of the price, it does alter the price variance."[6] It is clear from (2-13), that σ'_{pp} reduces as β increases. In the limit as $\beta\rightarrow\infty$, $\sigma'_{pp}\rightarrow 0$. In this case whatever the value of X may be, price is stabilized fully.

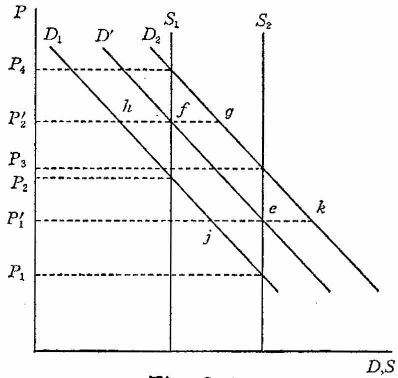

Fig. 2-1.

The above-mentioned argument is shown in Fig. 2-1, where D_1, D_2 are demand curves each with 0.5 probability; S_1, S_2 are supply curves also with 0.5 probability; D' has the same slope and is midway between two curves. "A buffer stock authority takes a position in the market, buying to peg the price above the market price and selling to reduce the price below the market price."[7] If $D=D_1$, the authority buys and if $D=D_2$ the authority sells so that he can hold D'.

By replacing D' to D, the authority can rule out the price variance based on the shift of curve D. On the other hand, price variation may arise from the shifts of S. If the slope of D' can be changed, the authority can reduce the price variation based on the shift of S.

Massell analyzes by substituting D' for D, how a price stabilization effect, influences producer's expected income. Let Q be an output of which quantity one cannot know ex ante. Price is also a stochastic variable. Both P and Q are normally distributed; μ_p and μ_q are means of expected value; σ_{qq} and σ_{pp} are variances of output and price respectively; σ_{pq} is covariance. Letting I be income,

(2-18) $$I=PQ$$

Mean value of I is

(2-19) $$\mu_I=\mu_p\mu_q+\sigma_{pq}$$

(2-20) $$\sigma_{pq}=\frac{\sigma_{yq}\sigma_{xq}}{\beta}$$

We can assume σ_{yq} (covariance of shifts in demand function and output)$=0$. But σ_{xq} (covariance of shifts in supply function and output) may be positive. If we assume $\sigma_{yq}=0$, then $\sigma_{xq}>0$, $\sigma_{pq}<0$ from (2-20). The variance of expected income is

(2-21) $\sigma_{II}=\mu_p^2\sigma_{qq}+\mu_q^2\sigma_{pp}+2\mu_p\mu_q\sigma_{pq}+\sigma_{qq}\sigma_{pp}+(\sigma_{pq})^2$

Massell examines the effect of price stabilization by two steps of analysis. The first is the effect of substituting demand curve D' for D on the expected income and the second is the effect of the changing slope of D' on the expected income.(8)

In the analysis of the first step, he shows $\sigma_{II}-\sigma'_{II}\geq 0$ and $\sigma_{II}-\sigma_{II}>0$ if $\sigma_{yy}>0$. It means that substituting D' for D reduces the new income variance, σ'_{II}, then σ_{II}. In the second step, he shows that the change in the slope of D' influences the expected income and its variance according to the values of μ_p, μ_q, μ_x, σ_q, σ_x, and σ_{qx}, especially $\rho=\frac{\sigma_{qx}}{\sigma_q\sigma_x}$. In case $\rho>0$, the situation is more complex. The value of β is small at the beginning. An increase in β will reduce σ'_{II}. But as β increases in value, it increases σ'_{II}. If $\beta\to\infty$, then $\sigma_{xx}/\beta\to 0$. If β is sufficiently large, σ'_{pp} reduces. It may increase μ_I, but it may also increase σ'_{II}.

It is required to induce an optimum policy in the meaning of producer's utility maximization. Consider a producer who is a risk avertor and his utility function is $U=U(\mu_I, \sigma_{II})$.

In Fig. 2-2, σ_{II} is measured in the horizontal axis and μ_I is measured in the ordinate axis. Positively sloped indifference curves are pictured. Massell named the locus ABCDE Income Possibility Locus (IPL). The point A corresponds to market equilibrium which is free from intervention by the authority. By substituting D' for D, the authority can reduce σ_{II} without changing μ_I. It means a shift from A to B. As the next step, the authority rotates D'. As β increases, σ'_{pp} reduces. It may bring about an increase in μ'_I and a decrease in σ_{II}. This is shown as a shift from B to C. Then, μ_I can increase over C, but σ_{II} increases at the same time; μ_I is maximized at point E where β becomes ∞. The optimum point is D, at which IPL contacts with an indifference curve.

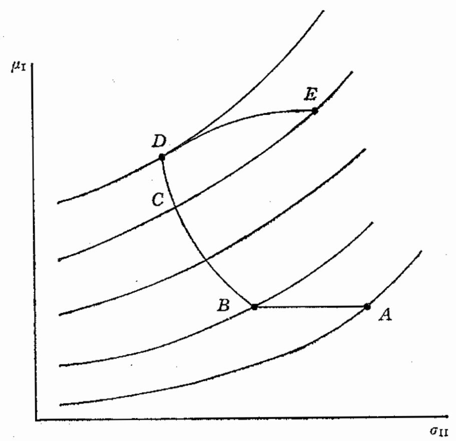

Fig. 2-2.

However, there are some difficult problems for practice of the authority. For example, parameters of this model are different in every producer. Not only this, but also X and σ_{xx} are different in each producer. But Massell's argument provides an important suggestion.

(1) R. I. Mckinnon, "Future Markets, Buffer Stocks and Income Stability for Primary Producers," Journal of Political Economy, Vol. 75, 1967.

(2) B. F. Massell, "Some Welfare Implications of International Price Stabilization," Journal of Political Economy Vol. 78, 1970.

(3) This can be expressed as follows:

$$Y=p(X-X_f)+P_f X_f$$

The first term of the right-hand side is sales at the harvest time and the second term is sales at the planting time.

(4) Mckinnon, ibid, pp. 851–852.

(5) Massell, op cit p. 406.

(6) ibid, p. 406.

(7) ibid, p. 407.

(8) See (2–26) in Footnote (9).

(9) Following (2–21), he shows his model.

At the first step, we assume the slope of D' equals the slope of D.

$$(2\text{–}22) \qquad \mu_I' = \mu_I$$

To exclude y does not influence σ_{xx} and σ_{pq}. Therefore it does not influence the mean value of expected income. (2–21) can be altered as

$$(2\text{–}23) \qquad \sigma_{II} = \mu_p^2 \sigma_{qq}+(\mu_q^2+\sigma_{qq})\frac{\sigma_{xx}+\sigma_{yy}}{\beta^2} +2\mu_p \mu_q \frac{-\sigma_{qx}}{\beta}+\frac{(\sigma_{qx})^2}{\beta^2}$$

The difference between σ_{II} and σ_{II}' lies only in the fact that $\sigma_{yy}=0$.

$$(2\text{–}24) \qquad \sigma_{II}-\sigma_{II}' = \frac{(\mu_q^2+\sigma_{qq})\,\sigma_{yy}}{\beta^2} \geq 0$$

Thus, if $\sigma_{yy}>0$, then $\sigma_{II}-\sigma_{II}'>0$.

The next step is as follows:

Noting $\sigma_{yq}=0$, if we substitute (2–20) and (2–19) for (2–22), we can get (2–25).

$$(2\text{–}25) \qquad \mu_I' = \mu_p \mu_q - \frac{\sigma_{xy}}{\beta}$$

where μ_I', μ_q and σ_{xq} do not change by the change of β. If we differentiate (2–25) with respect to β,

$$(2\text{–}26) \qquad \frac{\partial \mu_I'}{\partial \beta} = \frac{\sigma_{xq}}{\beta^2} \geq 0$$

If $\sigma_{xq}=0$, an increase in β (decrease in σ_{pp}) does not influence μ_I'. But if $\sigma_{xq}>0$, an increase in β increase μ_I'.

Next, he examines what influence β does bring on σ_{II}'. From (2–23) and (2–24)

$$(2\text{–}27) \qquad \sigma_{II}' = \mu_q^2 \sigma_{qq}+(\mu_q^2+\sigma_{qq}\frac{\sigma_{xx}}{\beta^2} -2\mu_p \mu_q \frac{\sigma_{qx}}{\beta}+\left(\frac{\sigma_{qx}}{\beta}\right)^2$$

Differentiating (2–27) with respect to β.

$$(2\text{–}28) \qquad \frac{\partial \sigma_{II}'}{\partial \beta} >0 \qquad \text{if } \beta<\frac{\sigma_{xx}(\mu_q^2+\sigma_{qq})+(\sigma_{qx})^2}{\mu_p \mu_q \sigma_{qx}}$$

Letting $\rho = \frac{\sigma_{qx}}{\sigma_q \sigma_x}$, (2–28) can be altered as follows:

(2–29) $$\frac{\partial \sigma'_{II}}{\partial \beta} > 0 \qquad \text{if } \frac{\sigma_x}{\beta} > \frac{\mu_p \mu_x \sigma_q \rho}{\mu_q^2 + \sigma_{qq}(1+\rho)^2}$$

Since $\sigma'_{pp} = \frac{\sigma_{xx}}{\beta^2}$ as you know from (2–13), $\frac{\sigma_x}{\beta}$ in (2–29) equals σ'_p. This is the standard deviation of price. Massell examines the effect of change in β according to each case $\rho = 0$ and $\rho > 0$, respectively.

3. STOCK COSTS AND NATIONAL SECURITY
— AN APPLICATION —

We want to examine in this section some applied problems relating to the above-mentioned arguments. As an example we consider a buffer stock policy about crude oil. In Japan ninety percent of energy supply depends on imports. It means Japan is susceptible to some risk as a result of the strategic price policy of OPEC. So, Japan joins in IEA organized by a number of countries to prepare themselves for a disruption in oil supply. The quantity of Japan's oil stock is equivalent to 120 days of consumption, which does not serve as a buffer stock to rule out price instability, but makes provision for national security. It can be considered, however, that the buffer stock authority intervenes in the market to stabilize oil price through adjustment of supply for domestic users.

A theoretical meaning of this problem lies in the point that we may generalize it to work out the theory of behavior of users who face uncertainty of supply. The authority under a policy to hold a buffer stock, sells it to domestic users when OPEC reduces supply or raises price. It presents us a theme for examination of price stabilization and its welfare effect by such a policy. Let us show the mechanism of price determination. OPEC, having a right to do so, determines formal price almost one-sidedly. But the formal price is different from the real market price. Even if OPEC may raise the price independently, however, the real market price declines, should an excess supply emerge. Fig. 3-1 shows the whole quantity of OPEC's exports in the horizontal axis. Assume that various types of crude oils are made homogeneous. OPEC determines price at p' when it supposes that demand of the whole world is D' and supply is S_1. But if p' is fairly high above the previous price level, importing countries reduce their imports; then D' shifts to D_1, followed by a decline of price from p' to p_1.

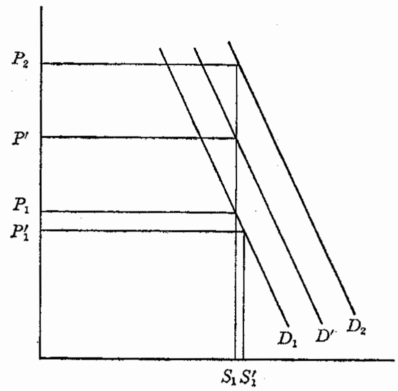

Fig. 3-1.

If p rises fairly high, compared with the value in the near past, curve D shifts. Therefore, the demand function of importing countries as a whole can be shown as follows:

$$D=-\beta p+X(\dot{p}, T), \qquad \frac{\partial X(\dot{p}, T)}{\partial \dot{P}}<0$$

or

$$D_t=-\beta p_t+X\left(\frac{p_t}{p_{t-1}}, T\right) \qquad \text{if time lag is introduced,}$$

where $X(\dot{p}, T)$ is a shift factor as a decreasing function of rising rate of price; T shows a factor representing technical progress on development of substitutable energy. It is reasonable for us to think, however, that the shifts take place discontinuously. Only if $\dot{p}$ is sufficiently large, the demand curve will shift.

If OPEC changes the price by a fairly large scale, the quantity of demand decreases. This is applicable to a country like JAPAN. If OPEC raises the price by reduction of supply, the demand curve shifts to the left. The new equilibrium point shifts to the left. The new price level may be high or low compared with the previous one according to the degree of shifts in the demand and the supply curve.

These situations are shown in Fig. 3-2. We can picture a locus of each equilibrium point. The slope of this locus may be positively sloped or negatively sloped according to the sensitivity of demand to price change. The process reaching each new equilibrium is as follows: At first quantity of supply S_1' is given, the demand curve being D_1'. At equilibrium point A, OPEC reduces supply to S_2'; then, the equilibrium point becomes B. But the demand curve shifts to D_2'; so, the new equilibrium point shifts further to C, which is high or low compared with A according to the shifts of the demand curve. Theoretically saying, this equilibrium point may be reached by infinite responses of supply and demand to each other. But in reality this may not happen. The demand function we showed at first was

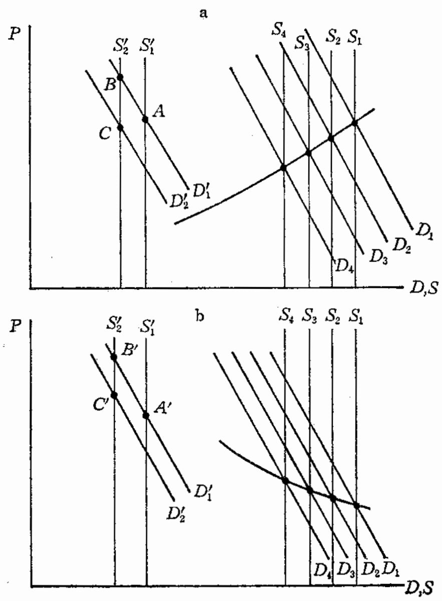

Fig. 3-2.

$$D=-\beta p+X(\dot{p}, T)$$

We intended to separate the effect of ordinary price change from effect of strategic large price change.

The second term of the right-hand side depends on rising rate of price and technical progress on development of substitutable energy. We can also include a buffer stock policy in this term. That the authority buys from OPEC (sells to domestic users) when price decreases (increases) means the shifts of the demand curve to the right (to the left). But a defect inherent to this argument is that OPEC raises the price but does rarely reduce it; as a result it is not clear when the authority should buy crude oil and increase a buffer stock.

An assumption that demand depends on rising rate of price $\dot{p}$ may be practical in reality, as shown in Fig. 3-3. In this case the supply curve can be regarded as a curve which shows OPEC's attitude to supply of crude oil.

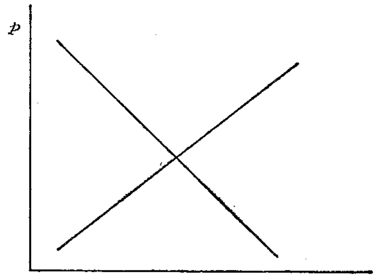

Fig. 3-3.

Let us show the process to reach at the equilibrium point in the case where the buffer stock authority intervenes in the oil market.

① The effect, when the authority sells (reduce the stock), is reflected by a shift of the supply curve to the left.

② But price does not instantaneously decrease. Then, consider the case in which OPEC intends to reduce production and raise the price. Even if the authority sells the stock, it may only mean an increases in supply in another market. Domestic users face dual markets, international and domestic, as well as dual suppliers, OPEC and the authority.

Therefore, oil prices may become p_1 and p_0, respectively in the international and the domestic market as in Fig. 3-4.

③ A decrease in price causes the demand curve to shift to the left.

④ The buffer stock policy by the authority has two effects: an increase in quantity of supply in the domestic market; a shift of the demand curve, which OPEC faces, to the left. If the authority can sufficiently shift the

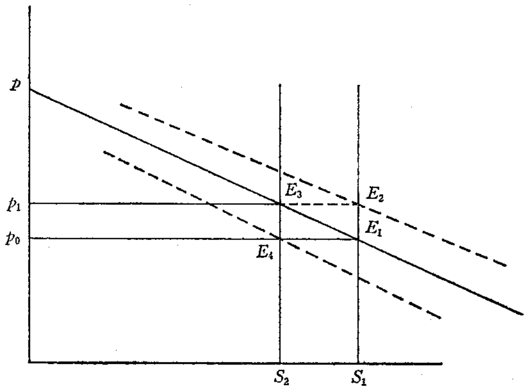

Fig. 3-4.

demand curve to the left until it intersects with S_2 at p_0, domestic users will not be worse off in spite of raise of price by OPEC.

⑤ On the other hand, when the authority buys crude oil and increases the buffer stock, the demand curve shifts to the right and price may rise.

⑥ It is more complicated to look into how the stabilization policy influences user's gain. We can assume that the demand curve means a marginal utility curve for domestic users. OPEC supplies S_1 in one period and S_2 in the next period. User's gain is $\bar{p}\,p_0E_1$ in the first period and $\bar{p}p_1E_3$ in the second period.

Period 1	Period 2	Total
$\bar{p}\,p_0E_1$	$\bar{p}\,p_1E_3$	$\bar{p}\,p_0E_1+\bar{p}\,p_1E_3$

In the case when the authority intervenes, user's gain is $\bar{p}\,p_0p_1$ even if OPEC's supply is S_2. But when OPEC supplies S_1, the demand curve may become D_2. If price rises up until p_1, user's demand must decrease until S_2. User's gain is $\bar{p}p_0E_1+\bar{p}p_1E_3$. Therefore, should price goes only upward, not downward, user's gain cannot be increased. In addition to it, we must consider stock holding costs. However, if such a case may arise that the authority can buy crude oil below p_1, welfare gain may result from a buffer stock policy. It will be the case when the real output exceeds the planned output. But you may object to this argument, because, if excess supply and price reduction occur ($S' > S_1$ $p' < p_0$), price stabilization does not improve user's gain since Waugh's argument is applicable in this case.

Although such a case seldom occurs, we can interpret it as follows (see Fig. 3-5): Domestic users do not need S, since a domestic demand is limited. And OPEC does not intend to sell crude oil at the price below p_0. In such a case, the authority can buy it at p_0 and sell it at p_0 when OPEC raises the price to p_1.

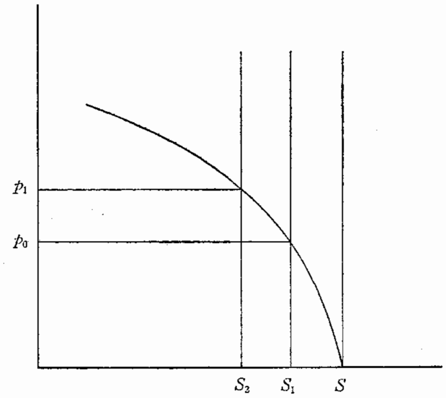

Fig. 3-5.

We have another theme concerning a response to OPEC's strategic behavior. It is forward buying that Mckinnon proposed in connection with agriculture. Then, which is more effective, buffer stock policy or forward buying? If stock holding costs are fairly large, the latter may be more effective than the former.

We will analyze it in future.