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§ I Introduction

When general secretary Mikhail Gorbachev started on March in 1985, he had many compulsory policies, like as, an anti-corruption, an anti-alcoholism and an expansion of national defense and so on. But, at the beginning of 1986, he changed his social and economic policies from the compulsory policies to the unrestricted policies. He took the new policies, perestroyka (restructuring), glasnost (speaking out publicly) and novoye myshleniye (new thinking). Therefore, "Gorbachev's reform" was not his policy from the beginning. It seems that the changing of his policies is caused by the declining of the Soviet economy. From 1980 to 1986, the average growth rate of Soviet economy was 1.4%. In 1960's, the average economic growth rate was 7.0%. Recently the central economic system does not work efficiently. Gorbachev wanted to accelerate the economic development of the Soviet Union and took the policies of economic reform.

In January in 1988, the "State Enterprise Law" came into force. This law is one of the Gorvachev's economic reforms. This state enterprise law has many characters.

(1) The state enterprise must be managed under the perfect self-supporting system and the self-financing system.

(2) The state enterprise is given the approval of the principle of worker's self-management. The workers can elect the state enterprise manager by themselves.

(3) The centralized rationing system of materials and machines will be changed to the free wholesale trade system.

(4) The state enterprise must make an effort to expand their total turnover by himself.

(5) As the state enterprise must have the self-management system, the authority of central planning bureau will gradually dicrease.

(6) The state enterprise will have the possibility of closing or bankrupt. Before this state enterprise law, the Soviet government supported the state enterprise which had a loss, but after this law, the state enterprise must be managed under the self-finincing system.

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The state enterprise law gave the free self-management system and, at the same time, uncertainty to the state enterprise. In the next two sections, we will study the economic model of state enterprise under the state enterprise law.

§ 2 Simple Model of State Enterprise

The production function of state enterprise is continous and differentiable,

$$Y = H\ (NL_0,\ K), \qquad \text{------(1)}$$

Y is product, N is number of workers, L_0 is working hours of the representative worker and K is capital. We assume that our economic model is a short-run analysis and the capital is constant. The production function is as follows,

$$Y = F\ (NL_0)\ . \qquad \text{------(2)}$$

We also assume the decreasing marginal product of labor.

$$\frac{dF}{dNL_0} = F' > 0\ , \qquad \frac{d^2F}{d\ (NL_0)^2} = F'' < 0\ . \qquad \text{------(3)}$$

The income of the representative worker of state enterprise is,

$$I = wL_0 + \alpha\ \{P_1\ (Y - X) + P_2X - C\}\ , \qquad \text{------(4)}$$

w is the wage rate, P_1 is the price of product at free market, P_2 is the price of product which the government purchases, X is the government purchasing, C is the total cost and α is the bonus parameter which is the ratio of profit distribution to workers.

The utility function of the representative worker is,

$$U = U\ [wL_0 + \alpha\ \{P_1\ (F\ (NL_0) - X + P_2X - C\}\ , L - L_0]\ . \qquad \text{------(5)}$$

The utility of the representative worker depends on his income and his leisure. L is free time of the representative worker and $L - L_0$ is leisure time. We assume that the utility function has following characters.

$$\left.\begin{array}{l} U_1 = \dfrac{\partial U}{\partial I} > 0\,, \quad U_{11} = \dfrac{\partial^2 U}{\partial I^2} < 0\,, \\[2ex] U_2 = \dfrac{\partial U}{\partial (L - L_0)} > 0\,, \quad U_{22} = \dfrac{\partial^2 U}{\partial (L - L_0)^2} < 0\,, \\[2ex] U_{12} = \dfrac{\partial U}{\partial (L - L_0) \partial I} = \dfrac{\partial U}{\partial I \partial (L - L_0)} = U_{21} > 0\,. \end{array}\right\} \quad \cdots\cdots(6)$$

The problem is that the representative worker of state enterprise maximize his utility under the condition of his total free hours. He decides how to distribute his free hours to work.

The maximization condition of the representative worker's utility is,

$$U_1 \cdot (w + \alpha P_1 NF) = U_2. \quad \cdots\cdots(7)$$

The condition (7) means that the marginal utility of income per an hour is equivalent to the marginal utility of leisure per an hour.

The second sufficient condition of utility maximization is,

$$U_{11}(w + \alpha P_1 NF')^2 - 2U_{12}\,(w + \alpha P_1 NF') + U_{22} + U_1 \alpha P_1 N^2 F'' < 0\,. \quad \cdots\cdots(8)$$

Next we will study the comparative statics of economic parameter change.

$$\frac{\partial L^0}{\partial \alpha} = -\frac{U_1 P_1 NF' + (P_1\,(Y - X) + P_2 X - C)\ \{(w + \alpha P_1 NF')\ U_{11} - U_{12}\}}{D}. \quad \cdots\cdots(9)$$

The effect of bonus parameter to lalor supply is written in the equation (9), D stands for the second sufficient condition of utility maximization(8).
If the balance of revenue and expenditure of state enterprise is held, then an increase of bonus parameter will increase working hours.

$$\frac{\partial L_0}{\partial w} = -\frac{U_1 + \{(w + \alpha P_1 NF')\ U_{11} - U_{12}\}\ L_0}{D}. \quad \cdots\cdots(10)$$

$$\frac{\partial L_0}{\partial P_1}=-\frac{U_1\alpha NF'+\alpha(Y-X)\ \{(w+\alpha P_1NF')\ U_{11}-U_{12}\}}{D}. \qquad \text{------(11)}$$

The influences of wage rate and price of free market to labor supply are not obvious.

$$\frac{\partial L_0}{\partial P_2}=-\frac{\{(w+\alpha P_1NF')\ U_{11}-U_{12}\}\ \alpha X}{D}>0. \qquad \text{------(12)}$$

An increase of the public price decreases working hours and increases leisure hours and vice versa. It brings high income to workers and they enjoy leisure time.

$$\frac{\partial L_0}{\partial X}=\frac{(\alpha P_1NF'U_{11}-U_{12})\ (\alpha-P_2)}{D}. \qquad \text{------(13)}$$

An influence of government purchasing to labor supply is not obvious. But if the state enterprise does not have the bonus system, then an increase of government purchasing decreases working hours and increases leisure hours.

$$\frac{\partial L_0}{\partial C}=\frac{\alpha\ \{(w+\alpha P_1NF')\ U_{11}-U_{12}\}}{D}>0. \qquad \text{------(14)}$$

An increase of total cost increases working hours and decreases leisure hours. An increase of total cost will bring a decrease of bonus and then the workers want to increase their bonus.

If workers obtain an certain income from the government purchasing, then they need not increase working hours and they enjoy their leisure time. But workers want to increase their income from the free market and to increase their working hours, if he has a possibility of losing his certain bonus.

§ 3 State Enterprise under Uncertainty

Before the state enterprise law, the state enterprise was managed by the central planning. But after that law, the state enterprise became to have a self-management system and uncertainty. In this section, we will study the economic model of state enterprise under uncertainty.

We assume that the production function of free market product is different from the one of product for government purchasing. The production function of free market is,

$$Y = Y\ (NL_1), \qquad \text{------(15)}$$

and the production function for government purchasing is,

$$X = X\ (N\ (L_0 - L_1)), \qquad \text{------(16)}$$

L_1 is the labor input for producing free market goods and $L_0 - L_1$ is the labor input for producing government purchasing. Both production function have the following characters, that is, the decreasing marginal product of labor.

$$Y' = \frac{dY}{d\ (NL_1)} > 0\ ,\ Y'' = \frac{d^2 Y}{d\ (NL_1)^2} < 0\ ,$$

$$\text{------(17)}$$

$$X' = \frac{dX}{d\ (N\ (L_0 - L_1))} > 0\ ,\ X'' = \frac{d^2 Y}{d\ (N\ (L_0 - L_1))^2} < 0\ .$$

We assume that the price of free market has uncertainty.

$$P_1 = \overline{P}_1 + \theta, \qquad \text{------(18)}$$

P_1 is the random variable and $-\theta$ is the random variable of uncertainty. $\overline{P}_1$ is the expected value of P_1. $\phi(P_1)$ is the probability density function. The expected value of θ is 0 ($E\ [\theta] = 0$) and we assume $\frac{\partial P_1}{\partial \theta} > 0$.

The expected value of the representative worker's utility is,

$$E\ [U\ (wL_0 + \alpha\ (P_1 Y\ (NL_1) + P_2 X\ (NL_0 - NL_1) - C))]$$

$$= \int_0^\infty U(wL_0 + \alpha\ (P_1 Y\ (NL_1) + P_2 X\ (NL_0 - NL_1) - C))\ \phi\ (P_1) \cdot dP_1.$$

$$\text{------(19)}$$

The representative worker maximizes his expected value of utility and the necessary condition of maximization is,

$$\frac{\partial E}{\partial L_1}=E\ [U'\cdot\alpha N\ (P_1Y'-P_2X')]=0\ . \qquad \text{------}(20)$$

The second sufficient condition of expected utility maximization is,

$$\frac{\partial^2 E}{\partial L^2{}_1}=E\ [U''\cdot\alpha^2N^2\ (P_1Y'-P_2X')+U'\cdot\alpha N^2\ (P_1Y''-P_2X'')]<0\ . \qquad \text{------}(21)$$

Next we will compare the equilibrium condition under certainty with the one under uncertainty.
From the equation (20), we obtain the following equation.

$$E\ [U']\cdot\alpha N\ [P_1Y'-P_2X']+cov\ [U'\cdot\alpha N\ (P_1Y'-P_2X')]=0\ . \qquad \text{------}(22)$$

As the following covariance is negative,(1)

$$cov\ [U'\cdot\alpha N\ (P_1Y'-P_2X')]<0\ . \qquad \text{------}(23)$$

then, we obtain the following inequality under the condition of uncertainty.

$$E\ [P_1Y'-P_2X']=E\ [P_1]\ Y'-P_2X'>0\ . \qquad \text{------}(24)$$

On the other hand, under the condition of certainty we obtain the following equality from the equilibrium condition.

$$P_1Y'=P_2X'. \qquad \text{------}(25)$$

Then, we get the following inequality

$$E\ [P_1]\ Y'>P_1Y'.$$

Finally, we study the influence of parameters to the behavior of the representative worker. We assume K. Arrow's decreasing-absolute risk aversion (DARA). Under the condition of DARA, the following expected value is negative.

$$E\ [U''\cdot\alpha N\ (P_1Y'-P_2X')]>0\ .^{(2)} \qquad \text{------}(26)$$

(1) Because, $\frac{\partial U'}{\partial\theta}=\alpha Y'\frac{\partial P_1}{\partial\theta}U''<0$ and $\frac{\partial\alpha N\ (P_1Y'-P_2X')}{\partial\theta}=\alpha NY'\frac{\partial P_1}{\partial\theta}>0$.

(2) This inequality is obtained from the mathematical appendix.

Comparative static analysis is performed by differentiating the equation (20).

$$\frac{\partial L_1}{\partial \alpha}=-\frac{E\ [U'N\ (P_1Y'-P_2X')+U''\alpha N\ (P_1Y'-P_2X')\ (P_1Y+P_2X-C)]}{E\ [A]}. \quad \text{------}(27)$$

The influence of the bonus parameter to labor supply is not obvious. If the state enterprise has the balance of revenue and expenditure, then an increase of the bonus parameter increases working hours. $E\ [A]$ stands for the second sufficient condition of expected utility maximization (21).

$$\frac{\partial L_1}{\partial w}=-\frac{E\ [U''\cdot \alpha NL_0\ (P_1Y'-P_2X')]}{E\ [A]}>0. \quad \text{------}(28)$$

The effect of the wage rate to labor supply is obvious. Under the condition of certainty, this effect was not obvious. In the case of uncertainty, an increase of wage rate increases working hours for production of free market goods and vice versa.

$$\frac{\partial L_1}{\partial P_2}=-\frac{E\ [U'\cdot \alpha NX'-U''\alpha^2NX\ (P_1Y'-P_2X')]}{E\ [A]}. \quad \text{------}(29)$$

The influence of the official price of government purchasing to working hours is not obvious. In the case of certainty, it was obvious.

$$\frac{\partial L_1}{\partial C}=\frac{E\ [U''\cdot \alpha^2N\ (P_1Y'-P_2X')]}{E\ [A]}<0. \quad \text{------}(30)$$

An increase of total cost decreases working hours for production of free market goods and increases working hours for production of government purchasing. In stead of decreasing of sale for free market goods, the state enterprise plans to obtain the certain amount sold for government purchasing. That is, the workers are afraid of decreasing of his bonus by increasing cost and then they want to get the certain income from the sale for government purchasing.

$$\frac{\partial L_1}{\partial \theta}=-\frac{E\ [U'\cdot \alpha NY'+U''\alpha^2N\ (P_1Y'-P_2X')\ Y]}{E\ [A]}>0. \quad \text{------}(31)$$

An increase of uncertainty of the free market price decreases working hours for the free market goods production and increases working hours for the production of government purchasing. That is, the state enterprise workers want to obtain the certain income source.

§ 4 Concluding Remarks

An inactivity of Soviet economy brought the economic reform "perestroyka". Gorbachev enforced the state enterprise law as one of the economic reform policies. In section 2, we made the economic model of state enterprise under the state enterprise law. We had one important conclusion that an increase of the official price for government purchasing decreases working hours and an increase of the official price for government purchasing decreases working hours and increase leisure hours. That is, if the workers are holding the certain income source, then they enjoy their leisure life. In section 3, as the state enterprise has the self-management system, the uncertainty of management increases. Under the condition of uncertainty, the state enterprise workers maximize their expected utility. An increase of the total cost decreases working hours for production of the free market goods and increases working hours for production of government purchasing. This conclusion means that in the case of uncertainty the state enterprise workers want to obtain the certain income source.

(Mathematical Appendix)

(Lemma I) Under the condition of K. J. Arrow's decreasing-absolute-risk-aversion hypothesis (*DARA*),

$$E\ [U''(I) \cdot \alpha N\ (P_1 Y' - P_2 X')] > 0.$$

(proof)

Define $P^0{}_1$ that satisfies the following equation,

$$P^0{}_1 Y'\ (NL_1{}^*) = P_2 X'\ (NL_0 - NL_1{}^*), \qquad \text{------(A-1)}$$

$L_1{}^*$ is the value that satisfies the equilibrium condition (20).

We also define I^0 that holds the following equation, that is, the equilibrium income for the representative worker.

$$I^0 = wL_0 + \alpha\ (P_1{}^0 Y\ (NL_1{}^*) + P_2 X\ (NL_0 - NL_1{}^*) - C).$$

If $I > I^0$, then

$$P^1 > P^0{}_1 = \frac{P_2 X'\ (NL_0 - NL_1{}^*)}{Y''\ (NL_1{}^*)}. \qquad \text{------(A}-2\text{)}$$

K. J. Arrow's decreasing-absolute-risk-aversion is,

$$-\frac{U''\ (I)}{U'\ (I)} < -\frac{U''\ (I^0)}{U'\ (I^0)}. \qquad \text{------(A}-3\text{)}$$

From the equations (A－2) and (A－3),

$$U''\ (I)\ \alpha N\ (P_1 Y'\ (NL_1{}^*) - P_2 X'\ (NL_0 - NL_1{}^*))$$

$$> \frac{U''\ (I^0)}{U'\ (I^0)} U'\ (I)\ \alpha N\ (P_1 Y'\ (NL_1{}^*) - P_2 X'\ (NL_0 - NL_1{}^*)). \qquad \text{------(A}-4\text{)}$$

Under the condition of equilibrium equation (20), the right-hand of the equation (A－4) is 0.

∴

$$U''\ (I) \cdot \alpha N\ (P_1 Y'\ (NL_1{}^*) - P_2 X'\ (NL_0 - NL_1{}^*)) > 0. \qquad \text{------(A}-5\text{)}$$

The expected value of the equation (A－5) is,

$$E\ [U''\ (I) \cdot \alpha N\ (P_1 Y' - P_2 X')] > 0. \qquad \text{------(A}-6\text{)}$$

We can also obtain the same conclusion in the case of $I \leqq I^0$ by the same way.

Q. E. D.

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