Aggregate Supply Function in Supply-Side Economics : New Dimensional and Mathematical Solution*

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Abstract

This paper tries to clarify the shape and form of the aggregate supply curve in supply-side economics. The analysis in the paper indicates that the slope of the short-run aggregate supply curve is upward-sloping in case of supply-side economics, and that a tax cut policy causes a shift of the aggregate supply curve to the right, and consequently it produces an increase in output and a fall in the price levels as wel. This also discusses some policy implications suggested by the analysis in the paper.

Contents

1. Introduction

The most important policy implication derived from a supply-side model is that a reduction in the tax rate could increase an aggregate supply and output. This implies the shift of an aggregate supply curve. Then, the policy effects quite differ by the shape of the aggregate supply curve. Therefore, in order to exactly evaluate the policy effects of the supply-side tax cut policy, the shape and form of the aggregate supply curve in supply-side economics must be clarified. The purpose of this paper is to solve this problem.

2. A Preliminary Consideration

To put it briefly, a distinctive characteristic of supply-side economics is that it identifies the effect of any changes in government policy as a change in the relative price(s), and to analyze the responses of households and firms to such relative price changes. In other words, in many respects, supply-side economics is nothing more than classical or neoclassical economics rediscovered[1]. To cite words of famous advocates of supply-side economics, "supply-side economics is merely the application of price theory —so-called "microeconomics" —in the analysis of problems concerning economic aggregates —so-called "macro-

economics"",[2] and "supply-side economics is little more than a new label for standard neoclassical economics".[3]

Therefore, as a matter of course, the supply-side model has the structure and characteristics quite analogous to those of the neoclassical model. A supply-side model developed by Canto, Joines, and Laffer (1981; 1983b), for example, supposed that labor supply is a function of the net-of-tax real wage rate, that the wages and prices are completely flexible, and that the labor market always clears.[4] In their model, therefore, an aggregate supply curve is a vertical.

Now, what the labor market always clears implies that the labor supply is a function of the real wage, that the movement of the wages and prices is completely flexible, and that workers can accurately predict the price levels of the next periods (i.e. there is no money illusion). This is just the "world of classical school". Consequently, the aggregate supply curve in supply-side economics is considered to have exactly the same shape as one in classical economics.

However, we have to note how "expectations" is dealt with by supply-siders. They tend to reject the perfect foresight which is a premiss of classical economics and the rational expectations hypothesis which is a distinguishing feature of new classical economics as too far extreme assumption. For example, Feldstein (1982) criticizes a conclusion in Barro (1974) which is based on the rational expectations hypothesis: fiscal policies can not affect the aggregate demand, and disproves his conclusion in both theory and evidence. Yet, on the other hand, it is a fact that supply-siders attach much importance to expectations. Feldstein (1980) insists, for example, that precommitted future tax cuts, as soon as it is announced, can increase savings, investment, and work effort without unwanted revenue loss, as it stimulates people's economic incentives, and that the good incentives of a precommitted series of tax cuts, if it is done right, can be almost as large as those tax cuts occurred immediately. Summers (1981) shows theoretically that a policy of announcing a future reductions in the corporate tax rate has a significantly greater short-run impact on investment than the immediate implementation policy, and therefore it will spur investment with no current revenue loss.

Thus, in analyzing the aggregate supply function in supply-side economics, firstly we must take into consideration a delicate posture toward expectations of supply-siders. Secondly, the aggregate supply function is, in the long-run, vertical at the natural level of real output of the economy, since the actual price levels are just equal to the expected price level. Hence, what comes into question is the shape and form of the aggregate supply function in the short-run. Thirdly, in the analysis of the question mentioned above, we must explicitly incorporate the taxes into the model, since the purpose of the analysis in this paper is a solution of a shape and form of the aggregate supply function in supply-side economics.

3. The Model

From the reasons mentioned above, a short-run aggregate production function takes the following form:

$$Q = Q(L, \bar{K}) \qquad (1)$$

where Q represents output, and L and K, labor and capital, respectively.

In this paper it is assumed, according to the

formulation in the supply-side models, that demand for and supply of labor are a function of the gross-of-tax and the net-of-tax wage rate, respectively. And also, in order to incorporate expectations into our model and to make our model consistent with the existing supply-side model, we now put the following assumptions about the behavior of the firms and workers. Firstly, the firms know the wage rate charged by workers and can predict the actual price levels accurately in the next period. Secondly, workers determine their supply based on an expected money wage rate which is obtained from the price levels expected by workers. Accordingly, the aggregate-demand for and -supply of labor are put as:

$$W_d = P \cdot f(L_d) \qquad (2)$$

and

$$W_s = P^e \cdot g(L_s) \qquad (3)$$

where W_d and W_s are the labor demand wage rate and the labor supply wage rate respectively. L_d and L_s are the total amount of labor demanded and the total amount of labor supplied, measured in terms of man-hours, respectively. P and P^e are the actual price levels and the expected price level respectively.

For simplicity, a tax on income of labor is assumed to be a proportional tax. Then, since the labor demand wage rate, W_d, multiplied by a proportional tax rate on labor income, t, is a tax on labor income, one obtains:

$$W_s = (1-t) W_d \qquad (4)$$

Eliminating W_s from equations (2), (3), and (4) gives us:

$$W_d = P \cdot f(L_d) \qquad (5)$$

and

$$(1-t) W_d = P^e \cdot g(L_s) \qquad (6)$$

Equating the aggregate-demand and -supply for labor gives us the equilibrium level of employment, L:

$$L = L_d = L_s \qquad (7)$$

The corresponding equilibrium level of the money wage rate, W, is:

$$W = W_d = \frac{1}{(1-t)} \cdot W_s \qquad (8)$$

Thus, we can now derive equations for both the aggregate-demand and -supply of labor in the equilibrium position. That is, the aggregate-demand and -supply for labor function are represented as:

$$W = P \cdot f(L), \quad f(L) \equiv \partial Q / \partial L > 0, \quad f' < 0 \qquad (9)$$

and

$$(1-t) W = P^e \cdot g(L), \quad g(L) > 0, \quad g' > 0 \qquad (10)$$

The labor market equilibrium condition is given by:

$$P \cdot f(L) = \frac{P^e}{(1-t)} g(L) \qquad (11)$$

The relationship between P and P^e can be expressed as:

$$P^e = \varepsilon P, \quad 0 \leq \varepsilon \leq 1 \qquad (12)$$

where ε is the adjustment parameter of expectations.

4. Analysis

A. *The shape of the aggregate supply function in supply-side economics*

Substituting equation (12) for equation (11), we can obtain:

$$P \cdot f(L) = \frac{\varepsilon P}{(1-t)} g(L) \qquad (13)$$

Totally differentiating equation (13) with respect to L and P, we get :

$$f(L)dP + Pf'(L)dL$$
$$= \frac{\varepsilon}{(1-t)} \cdot g(L)dP + \frac{\varepsilon P}{(1-t)} \cdot g'(L)dL \quad (14)$$

To simplify, let us assume that $P^e = P$ initially, and set the price level $P=1$, and we have :

$$f(L) = \frac{1}{(1-t)} \cdot g(L) = w \quad (15)$$

where w is the real wage rate, we know by definition that $w \equiv W/P$.

Therefore, we can rewrite the equation (14) as :

$$\left\{ f'(L) - \frac{\varepsilon}{(1-t)} \cdot g'(L) \right\} dL = \{(\varepsilon-1)w\} dP \quad (16)$$

From this movements in the equilibrium level of employment, L, which results from the changes in the price level, P, is given by :

$$\frac{dL}{dP} = \frac{(\varepsilon-1)w}{f'(L) - \frac{\varepsilon}{(1-t)} \cdot g'(L)} \gtreqless 0 \leftrightarrow \varepsilon \lesseqgtr 1 \quad (17)$$

Thus, from the equation (17) we have the slope of the aggregate supply curve as P changes.

$$\frac{dQ}{dP} = \frac{\partial Q}{\partial L} \cdot \frac{(\varepsilon-1)w}{f'(L) - \frac{\varepsilon}{(1-t)} \cdot g'(L)}$$
$$\gtreqless 0 \leftrightarrow \varepsilon \lesseqgtr 1 \quad (18)$$

We are afraid that the discussion extend to many divergences. In this paper, therefore, as we avoid getting into consideration on a difference in the mechanism of expectations' formulation of each of the schools in macroeconomics, we reduce these difference to a difference in a value of ε[5]. That is, we assume that, in the short-run, in case of the extreme Keynesians, $\varepsilon = 0$, one of monetarists and/or supply-siders, $0 < \varepsilon < 1$, and one of classical economics and/or new classical economics, $\varepsilon = 1$. Putting these value in the equation (18), one can obtain $\varepsilon = 0 \Rightarrow > 0$, $0 < \varepsilon < 1 \Rightarrow > 0$, $\varepsilon = 1 \Rightarrow 0$. From this, it is understood that the slope of the short-run aggregate supply function is vertical in classical economics and new classical economics, and the slope is upward-sloping in Keynesian, monetarist, and supply-side economics. It is also clear that the aggregate supply function in supply-side economics has a greater slope than that in Keynesian economics by the assumption.

Let us ascertain these points geometrically. Suppose the actual prices levels rise from P_0 to P_1. Then, under the two assumptions made above, the aggregate demand curve for labor moves from $P_0 \cdot f(L)$ to $P_1 \cdot f(L)$. On the other hand, movement of the aggregate supply curve for labor can be distinguished into the following three cases, according to the differences in response of workers to the price variation.

First, when labor does not revise its expectations at all despite a rise of prices levels ($P^e_1 = P_0$), the relevant aggregate supply curve for labor remains $P^e_1/(1-t) \cdot g(L)(P^e_1 = P_0)$ and the equilibrium point of the labor market moves to K, as illustrated in figure 1(a). In this case, hence, the aggregate supply curve is upward-sloping and is shown by AS_1 in figure 1(c). This is the case with Keynesians who considers the labor supply as a function of the money wage.

Second, when labor instantly revises its expectations to a rise of prices levels and labor's (subjective) expectations of the price levels in the next period is just equal to the
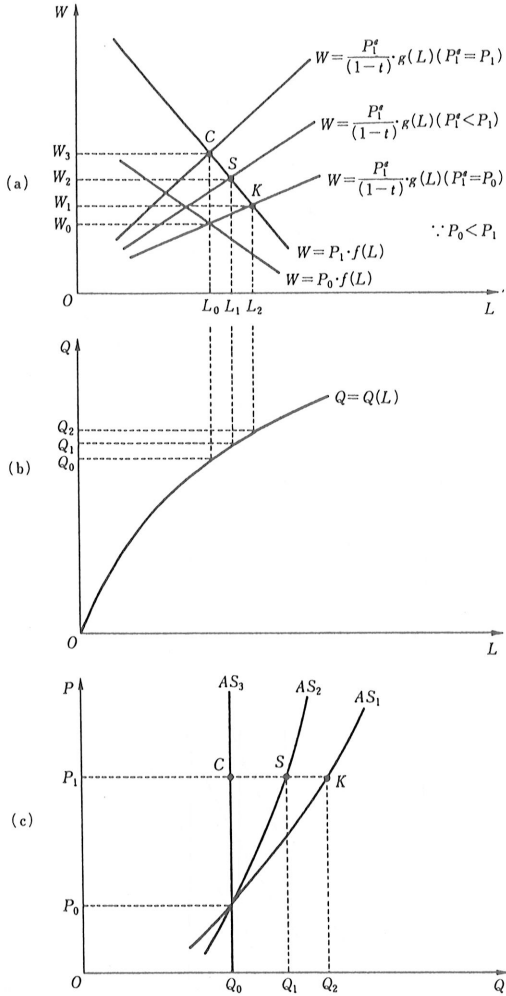
$$W = \frac{P_1^e}{(1-t)} \cdot g(L)(P_1^e = P_1)$$

$$W = \frac{P_1^e}{(1-t)} \cdot g(L)(P_1^e < P_1)$$

$$W = \frac{P_1^e}{(1-t)} \cdot g(L)(P_1^e = P_0)$$

$$\because P_0 < P_1$$

$$W = P_1 \cdot f(L)$$

$$W = P_0 \cdot f(L)$$

$$Q = Q(L)$$

Figure 1

run and in the long-run falls under this case.

Third, labor modefies the expected price levels with a rise in the price levels, but when the prediction is not perfect $(P^e_1 < P_1)$, the relevant supply curve of labor has its place in the somewhere between two cases above— for example, $P^e_1/(1-t) \cdot g(L)(P^e_1 < P_1)$. In this case, the aggregate supply curve has its place somewhere between AS_1 and AS_3, say, AS_2.

As mentioned above, supply-siders regard the labor supply as a function of the real wage, while they have a trend to deny an assumption of perfect foresight and a strict assumption of the rational expectations hypothesis. Also, they attach much importance to expectations. Therefore, it is thought that the aggregate supply function in supply-side economics has the shape of AS_2 in the short-run. In this case the slope of the aggregate supply curve depends upon a value of the adjustment parameter of expectations. Also, it is thought that in the long-run the slope of the aggregate supply curve is vertical, since the actual price level is just equal to the expected price level.

B. The effects of the changes in the tax rates

Next, let us consider the effects of the changes in the tax rate. The total differential of the equation (11) with respect to L and t is:

$$\frac{P^e}{(1-t)^2} \cdot g(L)dt + \frac{P^e}{(1-t)} \cdot g'(L)dL$$
$$= P \cdot f'(L)dL \tag{19}$$

For simplicity, assuming that $P^e = P = 1$, then equation (19) simplifies to:

actual price levels in the relevant period $(P^e_1 = P_1)$, the relevant aggregate supply curve of labor becomes $P^e_1/(1-t) \cdot g(L)(P^e_1 = P_1)$, and the equilibrium point of the labor market is established in point C. Hence, in this case the aggregate supply curve is vertical and is shown by AS_3. Classical economics which assumes the complete and correct adjustment of P^e to P, and new classical economics, which premises the rational expectations hypothesis and regards labor supply as a function of the real wage both in the short-

$$\frac{1}{(1-t)^2} \cdot g(L)dt + \frac{1}{(1-t)} \cdot g'(L)dL$$
$$= f'(L)dL \qquad (20)$$

Multiplying $(1-t)^2$ to the both sides of equation (20), then we have:

$$g(L)dt + (1-t)g'(L)dL = (1-t)^2 f'(L)dL \qquad (21)$$

Rearranging the equation (21), we can yield:

$$\{(1-t)g'(L) - (1-t)^2 f'(L)\}dL = -g(L)dt \qquad (22)$$

Thus, the effects of the changes in the tax rate on the equilibrium level of employment is expressed as:

$$\frac{dL}{dt} = \frac{g(L)}{(1-t)\{(1-t)f'(L) - g'(L)\}}$$
$$\leqq 0 \leftrightarrow 0 < t \leqq 1 \qquad (23)$$

This implies that an increase in the tax rate decreases the equilibrium level of employment, and *vice versa*. This leads to the shift of the aggregate supply curve. This is illustrated in figure 2. Figure 2(c) represents the aggregate supply curve yielded from the equation (18). As made clear by the analysis previously, the vertical aggregate supply curves, t^C, represent the aggregate supply curve in classical or new classical economics, and the upward-sloping aggregate supply curves, t^K, represent that in Keynesians, monetarists, or supply-side economics. In any case, if a tax rate rises from t_1 to t_2, equilibrium level of employment decreases, and therefore output level decreases, and thereby the aggregate supply curve shifts to the left.

To summarize the results of the analysis above, it is that the short-run aggregate supply curve in supply-side economics is the upward-sloping, and a change in the tax rate
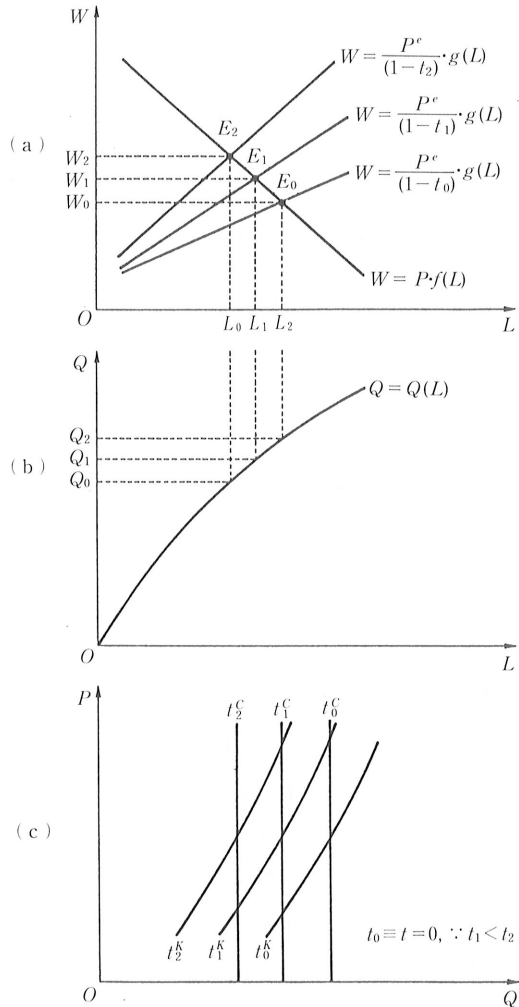

Figure 2

leads to the shift in the aggregate supply curve.

5. Concluding Remarks

Finally, this paper will be completed by referring to some policy implications suggested by the analysis in the paper. Let us consider a case of a reduction in the labor income tax rate. According to the discussion in conventional textbooks, in case of classical economics, as shown in figure 3, a tax cut policy increases an aggregate demand, but as
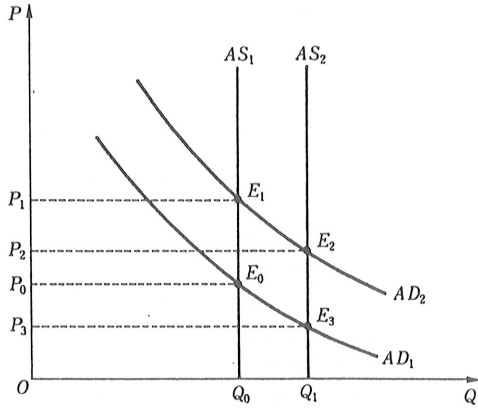
Figure 3

it is absorbed into the rise in the price levels, there is no increase in output (the change in the equilibrium point; $E_0 \Rightarrow E_1$). According to our model analysis, however, the tax reduction policy shifts the aggregate supply curve to the right, and therefore it leads to an increase in output (the change in the equilibrium point; $E_0 \Rightarrow E_2$).

In case of supply–side economics, the tax cut policy does not initially shift the aggregate demand curve, because the theoritical framework of supply–side economics rejects the multiplier effects of tax and expenditure policy,[6] whereas it causes right–ward shift in the aggregate supply curve (in figure 4, $AS_1 \Rightarrow$
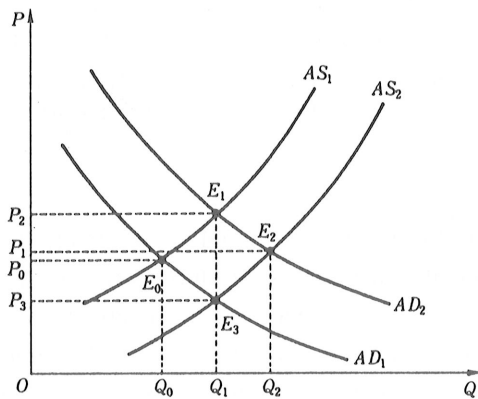
AS_2). Consequently, in case of supply–side economics, a tax reduction policy causes an increase in output and a fall in the price level, as shown in figure 4 (the change in the equilibrium point; $E_0 \Rightarrow E_3$). As mentioned before, although the approach of supply–side economics does not essentially differ from that of classical economics at all, the distinction in policy effects as described above arises from a difference in the shape and form of the aggregate supply function between the two.

Now, the size of effects of a tax cut policy on output and the price levels depends on the slope of the aggregate supply function as well as the size of the shift in it. The size of the shift in the aggregate supply curve induced by the change in the tax rate depends upon the elasticity of labor supply to the net–of–tax wage rate. Therefore, in order to judge whether a tax cut policy increases output or not, it is necessary to see the elasticities of labor supply. Table 1 shows in a summary fashion the results of a number of econometric studies on the uncompensated net–of–tax wage rate elasticity of labor supply in the U.S. economy. Of course, their studies are different in the measure of the wage, the data year or time period, the functional form, and the methods of estimation each to each. The numbers in table 1, therefore, cannot be simply compared with one another, but they will provide us with a reference data for choosing a plausible aggregate labor supply elasticity.

As shown in the table, elasticity estimates for males, ranging from −0.35 to +0.30, are mostly small or negative. Also, the estimates for females disperse in a wide range between −0.095 and +1.60. Now, taxes generally do not vary much with sex, race, or age. Therefore, relevant labor supply elas-

Figure 4

Table 1

A. Males

Authors	Data Subset	Type of Data	Range of Estimates	
Finegan (1962)	Male family heads	Interoccupational	$-.35$ to	$-.25$
Rosen (1969)	Male family heads	Interindustry	$-.30$ to	$-.07$
Kalachek-Raines (1970)	Male family heads	U.S. cross-section	$+.05$ to	$+.30$
Owen (1971)	Male family heads	U.S. time-series	$-.24$ to	$-.11$
Greenberg-Kosters (1973)	Poor male family heads	U.S. cross-section	$-.16$ to	$-.05$
Boskin (1973)	Different male subgroups	U.S. cross-section	$-.07$ to	$+.18$
Hill (1973)	Poor male family heads	U.S. cross-section	$-.32$ to	$-.07$
Ashenfelter-Heckman (1973)	Male family heads	U.S. cross-section	$-.15$	
Fleisher-Parsons-Porter (1973)	Males age 45-59	U.S. cross-section	$-.2.5$ to	$-.10$
Ashenfelter-Heckman (1974)	Married males	U.S. cross-section	0	
Burtless-Hausman (1978)	Low-income males	Gary NIT cross-section	0	
Hausman (1981)	Married males	U.S. cross-section	0	

B. For Females

Authors	Data Subset	Type of Data	Range of Estimates	
Finegan (1962)	Females	Interoccupational	$-.095$	
Leuthold (1968)	Females	U.S. cross-section	$-.067$	
Kalachek-Raines (1970)	Females	U.S. cross-section	$+.20$ to	$+.90$
Boskin (1973)	Different female subgroups	U.S. cross-section	$-.04$ to	$+1.60$
Ashenfelter-Heckman (1974)	Married females	U.S. cross-section	$.87$	
Hausman (1981)	Married females	U.S. cross-section	$.9$	
Hausman (1981)	Female household heads	U.S. cross-section	$.5$	

C. Aggregate

Authors	Data Subset	Type of Data	Range of Estimates	
Winston (1966)	Aggregate	International cross-section	$-.11$ to	$-.05$
Lucas-Rapping (1970)	Short-run aggregate	Time-series	1.35 to	1.58
Lucas-Rapping (1970)	Long-run aggregate	Time-series	0 to	1.12

(Source) Charles L. Ballard, Don Fullerton, John, B. Shoven, and John Whalley, *A General Equilibrium Model for Tax Policy Evaluation* (Chicago and London : University of Chicago Press, 1985), pp. 136-7.

ticity must be an aggregate one or one for a whole society. Ballard, Fullerton, Shoven, and Whalley (1985) argue that $+0.15$ is an appropriate value of an aggregate labor supply elasticity (pp. 133-5).[7] Its ground is as follows. They chose a relatively high male elasticity of -0.10 and a relatively high female elasticity of $+0.90$ from the elasticity estimates of a wide range in table 1. Also, they discussed that since the meidan money income of male employees has consistently been twice as much as that of the females and

about a 1.7 ratio of males to females in the labor force, the ratio of male income should be at least 3.0 against that of female. The three-to-one weighted average is a $+0.15$ ($= 0.75 \times -0.1 + 0.25 \times 0.9$). Thus, they obtained an aggregate average elasticity of $+0.15$.

If we admit their value of the elasticity to be appropriate, then probably one may think that such low labor supply elasticity will indicate that a tax cut policy would have a little effect on an aggregate labor supply, and therefore it is not sufficient to increase output greatly. However, we must take account of the following problems.

Many of econometric studies on estimate of labor supply elasticity use hours worked as a proxy variable for labor supply. However, because of the institutional constraint about hours worked, this variable would not be expected to be responsive to tax rate changes to a great degree. It seems that the reason why the elasticity of aggregate labor supply with respect to the net-tax-wage rate (measured by hours of work) is low is largely due to the institutional factor. Thus, such low labor supply elasticity does not indicate immediately that a supply-side tax cut policy would have little or no effect on output and the aggregate supply. Supply-side economics lays stress on personal and private incentives. Variables, such as motivation, entrepreneurship, work intensity, the quality of work, innovation, may obviously respond to the changes in the tax rates. These variables are the elements that supply-siders emphasize as the driving force of economic development of capitalist society. However, they are difficult to be measured quantitatively. Here is the difficulties of judging effectiveness of the supply-side tax cut policy.

As pointed out before, the more elastic the labor supply becomes, the greater will be supply-side effects of the changes in the tax rates. Then, it seems that factors of production are generally more mobile within a national boundary than those across nations. In case of labor service, it is particularly the case. If so, supply-side or incentives effects of the changes in the tax rates which are asserted by supply-siders would have much more significance at the local level than at the national one. One of the causes of remarkable economic stimulus effect of 'proposition 13' in California and the tax reduction policy in Puerto Rico, both of which are recommended by supply-siders and are given by way of successful examples of a supply-side tax cut policy by them, must have been the high mobility or elasticity of labor supply. Indeed, some empirical works find very high labor supply elasticity for particular states or industries (see, for example, McGuire and Rapping (1968; 1970). Such high mobility implies that from the point of view of economic growth and an increase of tax revenue within the jurisdiction of a state or a local government, one jurisdiction cannot charge higher tax rates than its neighbors' one. Supply-side or incentives effects of tax policies, therefore, will be come more important a matter for a state or a local government than the federal one.

Notes

* This paper is a revised version in which a model designed in my previous article (1993) is mathematically simplified.
1) See, for example, Roberts (1978a; 1978b; 1982), Ture (1980a; 1980b; 1982). For further detailed discussion on this

point, for example, see Kobayashi (1986a, chaps. 5 and 6 ; 1989). And also, a full discussion and some meaningful listing of the literatures on supply-side economics and the supply-side debates, see Kobayashi (1986a).

2) Ture (1982), p. 11.

3) Canto, Joines, and Laffer (1983a), p. xv.

4) The model designed by Victor A. Canto, Douglas H. Joines, and Arthur B. Laffer is the most typical supply-side model. For a full discussion of their model, see Kobayashi (1986b). See also, for one about the major elements of their model in non-technical terms, Kobayashi (1989, pp. 23-9).

5) Each school in macroeconomics has their hypothesis or idea on the formulation mechanism of expectations. Accordingly, it needs to make a further discussion about how expected prices are formed and determined.

6) For the analysis of supply-side economics identifies the initial effects of government policy or their other action in terms of what it does to one or another relative price and seeks to describe and measure the responses of households and firms to such relative price changes. That is, in the supply-side analysis the initial effect of any changes in government policies are identified as a change in the actual or implied price of something relative to that of others. On this point, see, for example, Roberts (1978a ; 1978b ; 1982), Ture (1980a ; 1980b ; 1982), and Kobayashi (1986a, chaps. 5 and 6).

7) See also, Fullerton (1980, pp. 151-3 ; 1982, pp. 16-9).

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