CHAPTER VII

EFFECTIVENESS OF INSTRUMENTS; RELIABILITY OF RESULTS

1. The central question of economic policy is the question of the *effectiveness* of its various instruments. In fact the controversial issues in practical and scientific discussions all center around that problem. This even applies to a much wider area than that of quantitative economic policy, viz. to qualitative economic policy as well. The sponsors of new economic systems maintain that these systems are a more efficient means to obtain the targets of general welfare and those who defend existing systems or older ones are of the opposite opinion. Within the more modest, and more reliable, realm of quantitative policy the same problem is essential. The true controversies are whether e.g. prices are or are not efficient regulators of market stability; whether wage rates, or interest rates, or exchange rates are effective in regulating various aspects of the economy.

In principle, the concept of effectiveness is a quantitative concept: it has, in one way or another, to measure the ratio between the quantitative effect and the quantitative effort made. In the simplest case with one instrumental variable z and one target variable y there is no ambiguity; the natural measure being dy/dz.

There arises a certain ambiguity, however, in the more complicated multidimensional cases where the general interdependency of policies manifests itself. The problem may be set in two ways, following the traditional or the "inverted" approach. The traditional approach considers the target values y_k as functions of the values z_l of the political parameters. Here the natural concept of the effectiveness of z_l with regard to y_k is

$$\frac{\partial y_k}{\partial z_l}$$

where the y_k are considered as functions of the z_l, and all (i.e. all other *instruments*) other z's than the one under consideration are assumed constant.

The inverted setting of the problem sees the desired values of the instrument variables z_l as functions of the given values of the target variables y_k and here a logical measure of the same effectiveness would seem to be:

$$\frac{1}{\dfrac{\partial z_l}{\partial y_k}}$$

This means that if $\partial z_l/\partial y_k$ is very large the effectiveness of z_l with regard to y_k is small. Here all the y's except the one considered (i.e. all other *targets*) are assumed to be constant.

It is evident that these two measures are not identical; both are functions of all or some of the structural coefficients, but they are not the same functions. Using the general notation of chapter III, § 2 and chapter IV, § 1 and 2 we find:

$$\frac{\partial y_k}{\partial z_k} = \eta^z_{kl} = \frac{\sum^m \Delta_{mk}\, \varepsilon_{ml}}{|\Delta|}$$

$$\frac{1}{\dfrac{\delta z_l}{\partial y_k}} = \frac{1}{\zeta^y_{lk}} = \frac{|E|}{\sum^m E_{ml}\, \delta_{mk}}.$$

The two expressions may be illustrated by their explicit values in the case of a two-instruments-two-targets problem where we have (omitting u's):

$$\delta_{11}y_1 + \delta_{12}y_2 = \varepsilon_{11}z_1 + \varepsilon_{12}z_2$$
$$\delta_{21}y_1 + \delta_{22}y_2 = \varepsilon_{21}z_1 + \varepsilon_{22}z_2$$

As an example we calculate the effectiveness of z_2 with respect to y_1:

$$\frac{\partial y_1}{\partial z_2} = \frac{\sum^m \Delta_{m1}\, \varepsilon_{m2}}{|\Delta|} = \frac{\Delta_{11}\, \varepsilon_{12} + \Delta_{21}\, \varepsilon_{22}}{\delta_{11}\, \delta_{22} - \delta_{12}\, \delta_{21}} = \frac{\delta_{22}\, \varepsilon_{12} - \delta_{12}\, \varepsilon_{22}}{\delta_{11}\, \delta_{22} - \delta_{12}\, \delta_{21}}$$

$$\frac{1}{\dfrac{\partial z_2}{\partial y_1}} = \frac{\varepsilon_{11}\, \varepsilon_{22} - \varepsilon_{12}\, \varepsilon_{21}}{\varepsilon_{11}\, \delta_{21} - \varepsilon_{21}\, \delta_{11}}.$$

In the case where the system is partitioned and z_2 only influences y_1 whereas y_1 is only influenced by z_2, the two expressions are the same, as they should. In that case $\delta_{12} = \varepsilon_{11} = \delta_{12} = \varepsilon_{22} = 0$ and both expressions are equal to $\varepsilon_{12}/\delta_{11}$.

If, however, the system is partitioned in such a way that z_2 only influences y_2 and y_2 is only influenced by z_2, all "mixed" coefficients (i.e. coefficients with two different subscripts) vanish and we find 0 for the first expression as against ∞ for the second.

2. The concepts proposed may now be exemplified with numerical results for one of our two standard examples. For *example* (1) we found, in ch. IV, § 3:

$$\begin{aligned} \xi_1 y + D &= (\xi_3 - \xi_2\lambda)\, l' + \xi_0 \\ -\mu y + D &= \delta\lambda l' \end{aligned}$$

Here, D and y are the targets and l' and ξ_0 the instruments. Numerically these equations are:

$$\begin{aligned} 0.135\, y + D &= 0.0153\, l' + \xi_0 \\ -0.44\ \ y + D &= 0.366\, l' \end{aligned}$$

The solutions for y and D are:

$$\begin{aligned} y &= -0.61\, l' + 1.74\, \xi_0 \\ D &= \quad 0.10\, l' + 0.77\, \xi_0 \end{aligned}$$

Those for l' and ξ_0 are:

$$l' = -1.20\,y + 2.73\,D$$
$$\xi_0 = 0.15\,y + 0.96\,D$$

From these formulae we see that the following measures for the four effectiveness figures are obtained with the two concepts discussed:

	Effectiveness of			
	Wage rate		Public expenditure	
	with respect to			
	Balance of paym. defic.	Volume of production	Balance of paym. defic.	Volume of production
First concept $\left(\frac{\partial y_k}{\partial z_l}\right)$	0.10	−0.61	0.77	1.74
Second concept $\left(\frac{1}{\frac{\partial z_l}{\partial y_k}}\right)$	0.37	−0.83	1.04	6.7

It appears that a considerable difference occurs in the last column: a unit increase in public expenditure with constant wage rate causes an increase in production by 1.74; in order, however, to obtain an increase in production by 6.7, with constant balance of payments deficit, likewise only one unit increase in public expenditure would be necessary.

Or, to put it in more familiar terms: in this case the first concept represents the well-known multiplier for an "open" country where important parts of the additional expenditure "leak away" and increases the balance of payments deficit. In fact, the figure of about 1.7 is an estimate often quoted for this multiplier. Behind the second concept there is, broadly speaking, the problem of the multiplier in a "closed" country: by a wage and price reduction the equilibrium in the balance of payments is maintained and hence no leakage occurs. This explains, to a large extent, the much higher value of the co-efficient. There is a small complication arising from the autonomous effect of the wage rate on the propensity to spend.

Example (2) may be treated in the same way. Here we have the equations:

$$
\begin{array}{lllll}
-0.7\,h & -0.215\,l & +0.915\,\tau & & = -x+0.865\,a-0.05\,l^R \\
-0.44\,h & -0.53\,l & +0.53\,\tau & & = -D+0.44\,a-0.53\,l^R \\
+0.175\,h & +0.7\,l & -\tau & -\pi_0 & = +0.125a+l^R \\
h & +0.27\,l & -0.27\,\tau & & = -D+x-a+0.27\,l^R
\end{array}
$$

The two effectiveness concepts for each of the sixteen pairs of one target and one instrument variable are:

	Targets							
Instru-	D		x		a		l^R	
ments:	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
h	—0.11	—0.52	—0.10	0.78	—0.91	—1.00	0.29	∞
l	0.11	0.38	0.10	—0.65	—0.09	4.25	0.71	0.81
τ	—0.66	—1.15	—1.99	—2.13	—1.29	4.25	—0.84	4.25
π_0	—0.04	0.42	—0.93	—2.61	—1.12	—2.70	—0.86	—2.70

Here too, there are considerable differences between the two yardsticks; both order of magnitude and algebraic sign are different in a number of cases. When considering the figures each for themselves one should not, of course, overlook the fact that they are not elasticities and that a unit change in e.g. τ is a much higher relative change for that instrument than a unit change in h or l. Generally the difference between the first and the second column may be interpreted as follows. The first column gives the effectiveness of the instrument considered with respect to the target considered, *all other instruments remaining constant;* the second column gives the effectiveness with *all other targets kept equal.*

3. The formulae discussed represent what was called in chapter I "the relations between targets and quantitative values of instrument variables"; as was set out in that chapter, it is also the task of the theory of economic policy to investigate the connections between these relations and the structure of the economy. This structure evidently manifests itself in the value of the coefficients in the structural equations and a study of the connections just mentioned means expressing our effectiveness figures as functions of those coefficients. This may be exemplified by a general treatment of example (1) using the Greek symbols for the co-efficients instead of their numerical values. Written in this form the solutions for the instrument variables l' and ξ_0 are:

$$l' = \frac{-\mu}{\delta\lambda} y + \frac{1}{\delta\lambda} D$$

$$\xi_0 = \left\{ \xi_1 + \frac{\mu(\xi_3 - \xi_2\lambda)}{\delta\lambda} \right\} y + \left\{ 1 - \frac{\xi_3 - \xi_2\lambda}{\delta\lambda} \right\} D.$$

From these formulae the connection between structure of the economy and effectiveness of the policies considered may be found. It may be seen at once e.g. that if δ (i.e. sum of the elasticities of exports and imports with respect to prices) is large, both co-efficients in the expression for l' are small and wages are therefore effective regulators of both employment and the balance of payments. This is the traditional viewpoint, in respect to which certain doubts have come up since certain measurements of the elasticities just mentioned suggested that they might be low. A closer inspection of the co-efficients ξ_1, ξ_2 and ξ_3 shows that for $\sigma = 0$ (i.e. no tendency to hoard) the co-efficient of y in the second equation becomes very small and the co-efficient of D almost equal to 1. (If $\bar{x} = 1$, i.e. equilibrium in the balance of payments in the initial situation, they become exactly 0 and 1, respectively). This means that, under those circumstances, ξ_0 becomes almost equal to D and independent of y. This result could be called the "classical" (pre-Keynesian) view: it is equivalent to saying that the only way to eliminate a balance-of-payments deficit is in an equal reduction of autonomous national expenditure, whatever level of employment may be desired. The level of employment, then, may be regulated by changes in the wage (and price) level. The formulae show to what extent other results will be obtained if a different structure is assumed.

Similar discussions may be based on the formulae for example (2). Those are already much more complicated. Still more general discussions would be needed if account is to be taken of the terms in our basic model that have been neglected beforehand. It goes without saying that the foregoing considerations on the effectiveness of different economic policies have to be changed if the complications created by the boundary conditions are introduced. The reader will not find it too difficult to formulate these changes. A very simple example may be given on the basis of example (1). Suppose we introduce the boundary condition $l' = 0$ (no wage reduction); this comes to the reduction of the number of instruments to only one, viz. ξ_0, for which we now have the equations:

$$\begin{aligned} 0 &= -1.1\ y + 2.73\, D \\ \xi_0 &= 0.15\, y + 0.96\, D \end{aligned}$$

It follows that $y = 2.3\ D$ and $\xi_0 = 1.3\ D$, meaning that now a larger reduction in national expenditures is necessary to bridge the same gap in the balance of payments and that unemployment will be created equal to somewhat more than twice the gap, expressed as a percentage of national income.

4. More or less the statistical counterpart of the economic problem of effectiveness of policy is the problem of the *reliability of our results*. Both problems are variation problems. The effectivity problem presupposes variations in targets or in instrument variables. The reliability problem is a con-

sequence of possible variations in the constants; above all, however, not in the material sense but in a more virtual one. If the structural relations from which we start are not exactly known, what will the consequences be of possible errors?

According to the type of error that may occur, the problems that arise are of a different type. We shall only deal with some rather simple ones, leaving the more complicated unsolved.

In principle, errors may be involved (1) in the *numerical estimates of the coefficients* used and (2) in the *mathematical shape of the relations*: as to the latter type of error, it may be that the relations are not linear, but curvilinear. This again may happen at both sides of our equations, i.e. (2*a*) at the side of the target variables as well as (2*b*) at the side of the political parameters. In policy problems the usual additive errors are absent.

(1) As to the consequences of possible errors in the *numerical values* assumed for the coefficients, a simple practical procedure is to indicate variation intervals for these coefficients and to solve the problems for different extreme values of these coefficients. Such calculations have been made for our example (1) and have been based on reasonable alternatives for the coefficients that are less certain. The alternatives are listed below:

Alternative No.	1	2	3	4	5	6
$1-\sigma$ marginal prop. to spend	0.7	*1.0*	*0.5*	0.7	0.7	*0.9*
ε^m price elasticity of imports	0.3	0.3	0.3	*0.5*	0.3	0.3
ε^e ,, ,, ,, exports	2.0	2.0	2.0	*3.0*	2.0	2.0
π_1 marginal wage quota . .	0.3	0.3	0.3	0.3	*0.5*	0.3

Alternative No 1 is the one chosen in our example sofar. For a justification of the choice of the figures the reader is referred to an earlier publication. [1])

[1]) J. Tinbergen, Econometrics, § 44 ff.

For the policy problem considered in ch. IV § 3, where a devaluation of 11 % is calculated for alternative 1, the same figure is found (since the result only depends on the coefficients μ, λ and the two ε's) for alternatives 2, 3, 5 and 6. For alternative 4, it is found to be 6 %. The values for ξ_0 are:

Alternative No.	1	2	3	4	5	6
$\xi_0 =$	—0.038	—0.037	—0.039	—0.038	—0.038	—0.038

Evidently the variance in ξ_0 is very small in this particular case, which is partly due to the special structure of the problem under discussion: the main remedy for balance of payments difficulties is in the adaptation of national expenditure to national income, particularly if the volume of production is to be kept constant. The variance in the degree of devaluation is larger.

(2*a*) As to possible errors in the mathematical shape of the relations we shall only deal with case (2*a*), case (2*b*) being far more complicated and in fact hardly soluble in a general way. If at the side of the target values the expressions used are not linear we may develop them in a power series, adding second, third, etc. degree members. Assuming that the changes in target values aimed at are small in comparison to the initial values, these further members will, as a rule, be small in comparison to the first degree members, which is the usual justification for using linear approximations. It may happen, however, that the coefficient before the first degree member, found in the solution appears to be of the same order as the change in the target value. Then the second-degree term will be of the same order as the first degree term and the latter will be a very inaccurate approximation. [1]) This may easily be tested.

[1]) I owe these remarks to Professor R. FRISCH.

The calculation may be illustrated with our examples. In example (1) the values of the target variables D and y are -0.04 and 0 respectively. From the figures just quoted we see that, since $l' = -0.11$ and $\xi_0 = -0.04$ are the results for the instrument variables, that the coefficients in these expressions are 2.75 and 1.0 respectively which is considerably above 0.04. The danger pointed out does not therefore exist in this case. Generally speaking one could say that already intuitively one would not write more decimal places for the values of l' and ξ_0 than for those of D and therefore avoid such suggestions of false accuracy; and a result of say $l' = -0.01$ would already have to be interpreted as: "practically no devaluation necessary".

Turning to example (2), of which the numerical results have been given in ch. IV, § 4, we find the same reassuring situation as to this point. The value of D is -0.02 and those found for h, l, π_0 and τ respectively are 0.04, -0.05, -0.09 and 0.02. All coefficients are therefore 1 or more and consequently of much higher order than D.

The same argument applies to the coefficients before the changes in data. These coefficients have been shown explicitly in the formulae just discussed; all of them are larger than 0.02 and most of them much larger; only in the formula for τ the co-efficients are of the same order. These are therefore not accurate in any sense and the result should be interpreted in about this way: a change in import and export conditions should not affect the necessary tax rate τ to an appreciable extent.

(2*b*) The possibility of an erroneous mathematical shape of the expressions in the instrument variables has not, however, been ruled out by this test and here serious sources of inaccuracy remain possible. The only general reassurance present here to be tested, however, in every individual case is that the scatters found in by far the most statistical investigations on economic subjects are practically linear.

After these simple illustrations the test discussed under (2*a*) may be expressed in the general notation. Evidently it relates to the coefficients of the general solution:

$$\zeta_{lk}^{y} = \frac{\sum^{m} E_{ml}\,\delta_{mk}}{|E|} \text{ and } \zeta_{li}^{u} = \frac{\sum^{m} E_{ml}\,\varphi_{mi}}{|E|}.$$

Their order of magnitude should be larger than the order of magnitude of the y_k or the u_i.