# DISKUSSIONSSCHRIFTEN

## Measuring Welfare Effects on National and International Commodity Markets

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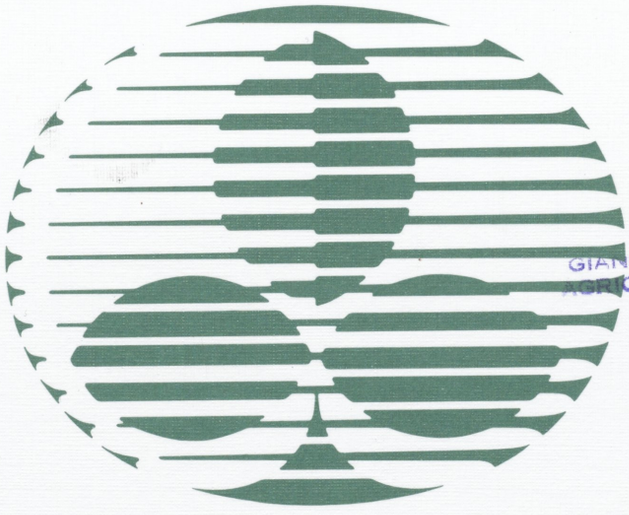



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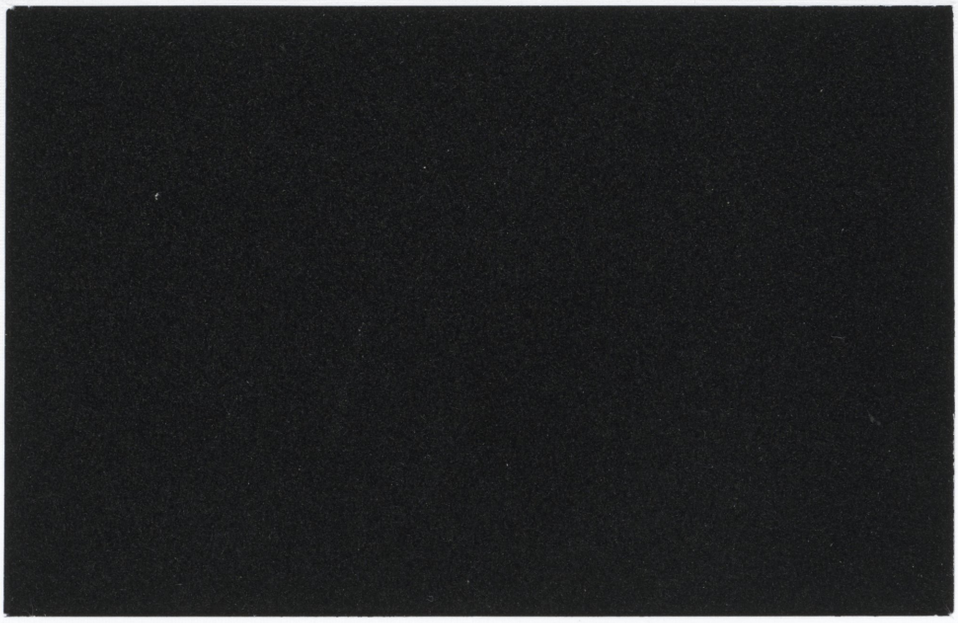

# Measuring Welfare Effects on National and International Commodity Markets

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September 1990 Nr. 19

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1. There seems to be large acceptance about the fact that it is possible to make adequate estimations on welfare effects proceeding from commodity markets by means of excess demand/supply functions (national welfare) and/or world supply and world demand functions (world welfare). In the following we would like to examine in how far this measuring concept meets cost-benefit analytical test criteria.

2. The first welfare measurements analysed are those at the national level. If the concept of economic rent is used, the above-mentioned procedures (now commonly in use) can often be reduced to the following approach:

$$(1)\quad \Delta W = -\int_1^2 (x_j - y_j^h)\, dp_j$$

$\Delta W$: Welfare change

$x_j$: Domestic consumption of good j

$y_j^h$: Domestic production of good j

$p_j$: Consumer price of good j

Numbers 1 and 2 denote the initial (1) and final (2) state of the economic system respectively.

National import demand ($x_j - y_j^h < 0$) and export supply ($x_j - y_j^h > 0$) functions are most frequently estimated as excess demand and/or excess supply functions. When estimation problems are neglected, equation (1) may also be written in the following form:

$$(2)\quad \Delta W = -\int_1^2 x_j\, dp_j + \int_1^2 y_j^h\, dp_j$$

The first term on the right-hand side of equation (2) is known as the change in MARSHALLian consumer surplus; the second term, on the other hand, describes the change in producer surplus.

3. In order to check the approach described by equation (2) we use a welfare criterion that can be derived from the usual assumptions of traditional cost-benefit analysis (GANS and MARGGRAF, 1990a, p. 55):

$$(3)\quad \Delta W = -\sum_i \int_1^2 \tilde{x}_i \, dp_i + \sum_i \int_1^2 y_i^h \, dq_i + \Delta T$$

$\tilde{x}_i$: Domestic consumption of good i, derived from a compensated (HICKSian) demand function

$q_i$: Marginal economic cost of good i

$\Delta T$: Welfare change induced by market distortions

The welfare effect ($\Delta T$) due to market distortions is measured as follows (ibid.):

$$(4)\quad \Delta T = \sum_i (p_i^2 - q_i^2)\, x_i^2 - \sum_i (p_i^1 - q_i^1)\, x_i^1$$

The market distortions of the initial and final state of the economic system ($p_i^1 - q_i^1$) and ($p_i^2 - q_i^2$), respectively, are defined as the difference of consumer price ($p_i^k$) and marginal economic cost ($q_i^k$). We use the symbol $t_i^k$ to describe this difference:

$$(5)\quad t_i^k = p_i^k - q_i^k \qquad i = 1,\ldots, n; \qquad k = 1,2$$

4. Comparing equation (2) with equation (3) makes clear under which (sufficient) conditions approach (2) can be accepted as an adequate welfare measure:

- Functions $x_j\ (p_j)$ and $\tilde{x}\ (p_j)$ do not deviate from each other; ordinary and compensated demand curves coincide.
- $dp_i = 0$ for all $i \neq j$.
- $p_i^k = q_i^k$ for all i and for k = 1,2, i.e. there are no market distortions; term $\Delta T$ disappears.
  (A partial analysis exclusively directed towards market j is justified, if $dp_i = 0$ and $p_i^k = q_i^k$ for all $i \neq j$)

The question of whether approach (2) is an adequate measuring device cannot be answered generally (theoretically). Thus, we will try, through the use of empirical studies of our own research programme (GANS, 1990a and 1990b; GANS and MARGGRAF, 1990a and 1990b; KLÜMPER, 1990a and 1990b; KRAMER, 1988 and 1989; OBERLÄNDER, 1985 and 1986), to obtain indications as to how far the above-mentioned conditions are of real importance.

Before we introduce the most important results of the empirical analyses, let us briefly discuss in how far the described sufficient conditions are also to be considered necessary.

5. Of central importance in this respect is the second condition. If this condition is satisfied, then there is no need for an ordinary demand curve and a compensated demand curve to always coincide (condition 1). In case of a single price change for example ($dp_j \neq 0$ and $dp_i = 0$ for all $i \neq j$), the change in MARSHALLian consumer surplus (the integral) is unique; there is no path-dependency problem. On the other hand, the consumer surplus measured in this way cannot be given a definite utility interpretation in the sense of the HICKSian equivalent or compensating variation. Thus there are difficulties in aggregating the consumer and the producer surplus; for only the change in the producer surplus "provides an exact measure of both the compensating and equivalent variations" (JUST, HUETH, SCHMITZ; 1982, p. 53).

6. Empirical Test of Condition 1.

The relationship between ordinary and compensated demand functions can be described by means of the SLUTSKY equation:

$$(5) \quad \frac{\delta x_i}{\delta p_j} = \frac{\delta \tilde{x}_i}{\delta p_j} - x_j \frac{\delta x_i}{\delta y}$$

y: Nominal income

It is useful to apply the elasticity notation:

$$(6) \quad \varepsilon_{ij} = \overset{*}{\varepsilon}_{ij} - b_j \cdot \eta_i$$

$\varepsilon_{ij}$: Price elasticity of demand for the ordinary demand function for good i (COURNOT elasticity)

$\overset{*}{\varepsilon}_{ij}$: Price elasticity of demand for the compensated demand function for good i (SLUTSKY elasticity)

$b_j$: Budget share of good j

$\eta_i$: Income elasticity of good i

The smaller the budget share of good j and/or the smaller the income elasticity of good j, the less the own-price COURNOT elasticity corresponding to the MARSHALLian demand function ($\varepsilon_{jj}$) deviates from the compensated price elasticity.

In order to illustrate the relative magnitudes of compensated and non-compensated price elasticities, we refer to an econometric study of the Indonesian food sector. This study is based on an AIDS (Almost Ideal Demand System) approach and on a sample size of n = 50,000 (households) (KLÜMPER, 1990a, p. 223 ff.). Nine of the altogether 18 products and/or product groups have been selected; besides, we limit our investigation to the case "Indonesia - total sample survey" (ibid, p.300).

Table 1: Compensated and Uncompensated Own-price Elasticities of Demand (Indonesia 1981)

| Basic food products and sugar | (1) Income elasticity $\eta_j$ | (2) Budget shares $b_j$ | (3) Uncompens. price elast. $\varepsilon_{jj}$ | (4) Compens. price el. $\varepsilon^*_{jj}$ |
|---|---|---|---|---|
| Rice | 0,51 | 0,2262 | - 0,66 | - 0,54 |
| Corn | - 0,60 | 0,0180 | - 0,51 | - 0,52 |
| Wheat | 1,19 | 0,0007 | - 0,97 | - 0,97 |
| Cassava | - 0,35 | 0,0083 | - 0,54 | - 0,54 |
| Sweet pot. | 0,53 | 0,0019 | - 1,61 | - 1,61 |
| Peanuts | 1,24 | 0,0017 | - 1,31 | - 1,31 |
| Soybeans | 0,79 | 0,0179 | - 0,98 | - 0,96 |
| Other BFP | 0,90 | 0,0052 | - 1,67 | - 1,67 |
| Sugar | 0,84 | 0,0364 | - 0,73 | - 0,70 |

Source: KLÜMPER, 1990a and 1990b
(1) KLÜMPER, 1990a, p. 297
(2) KLÜMPER, 1990b, p. 54
(3) KLÜMPER, 1990a, p. 301
(4) KLÜMPER, 1990a, p. 300
(4) = (3) + (1) X (2)

Table 1 shows that in most cases the compensated and the uncompensated price elasticities only reveal minor differences. Table 1, however, also shows that the deviations should not be ignored, if - even in the case of unelastic demand with respect to income - a relatively large portion of income is spent on one good (as is the case with rice).

One should keep in mind that elasticity differences are only the starting-point of the propagation of error within a cost-benefit framework. For further reference see the "classic" article by WILLIG (WILLIG, 1976).

## 7. Empirical test of condition 2.

Condition 2 can be regarded as almost satisfied when partial and equilibrium elasticities of an economic system do not show any major deviations.

Through the use of a computable general equilibrium model (food sector) reactions of the essential economic variables to exogenous price changes are estimated in the Indonesia study. Relating the endogenous demand and output reactions to the exogenous price changes, we directly obtain the equilibrium elasticities required. In tables 2 and 3 we compare them with the partial elasticities.

Table 2: Partial (Compensated) vs. Equilibrium Demand Elasticities

| Elasticities / Products | (1) Partial own-price elasticity | (2) Equilibrium own-price elasticity |
|---|---|---|
| Rice | -0,54 | -0,53* |
| Corn | -0,52 | -0,55 |
| Wheat | -0,97 | -1,18 |
| Cassava | -0,54 | -0,46 |
| Peanuts | -1,31 | -1,14 |
| Soybeans | -0,96 | -0,93 |
| Sugar | -0,70 | -0,73* |

(1) See table 1

(2) Calculated on the basis of KLÜMPER's estimates (KLÜMPER 1990b, p. 84ff.)

* Changes in consumer prices with producer prices remaining constant

Table 3: Partial vs. Equilibrium Supply Elasticities (1)

| Elasticities / Products | (2) Partial own-price elasticity | (3) Equilibrium own-price elasticity |
|---|---|---|
| Rice | 0,18 | 0,16* |
| Corn | 0,33 | 0,26 |
| Cassava | 0,25 | 0,23 |
| Peanuts | 0,80 | 0,79 |
| Soybeans | 1,41 | 1,41 |

(1) Derived from a production model based on the profit function approach
(2) KLÜMPER 1990a, p. 347
(3) Calculated on the basis of KLÜMPER's estimates (KLÜMPER 1990b, p. 84ff.)
* Change in producer price with consumer price remaining constant

These results are similar to those obtained when dealing with the question of the empirical relevance of compensated own-price demand elasticities. Indeed, in most cases there are only minor differences between partial and equilibrium elasticities. However, this result should not be rashly generalized. A considerable disadvantage in this respect is the fact that there is no simple (a priori) test procedure available such as the SLUTSKY equation. Yet there are also warning signals advising us to be cautious: these are non-zero cross-price elasticities, as well as the existence of domestic markets not having any direct contact to the world market.

## 8. Empirical Test of Condition 3.

On the basis of a research study on the welfare effects of the Thai rice price policy (OBERLÄNDER, 1985 and 1986) we would like to demonstrate the importance of distortions due to protection. We confine ourselves to the production side here, i.e. we only calculate differences between economic and private costs incurred by changes in production. The approach to start from is the following:

$$(7)\quad D_j = |y_j^2 - y_j^1| \frac{p_j^1 + p_j^2}{2} \left[\alpha_{Fj} \left(1 - \frac{1}{NPC}\right) + \beta_j \left(1 - \frac{1}{EPC_g}\right)\right]$$

$D_j$: Difference between private and economic costs incurred by a change in production amounting to $|y_j^2 - y_j^1|$

$\alpha_{Fj}$: Input coefficient of "tradable inputs" (aggregate)

$\beta_j$: Relative share of value added in the gross output of good j

NPC: Nominal protection coefficient of the internationally traded input goods used by sector j

$EPC_g$: Effective protection coefficient of the industrial sector

Table 4 shows some results.

Table 4: Welfare Effects Resulting from a Reduction in the Thai Taxation of Rice Exports (in mill. Bath)

| | Alternative 1 | Alternative 2 | Alternative 3 | Alternative 4 |
|---|---|---|---|---|
| Welfare effect/ no distortions | 1536 | 3033 | 1702 | 4420 |
| Welfare effect of an increase in factor prices due to protection | 1342 | 4092 | 1393 | 4652 |
| Welfare effect of input protection | 63 | 193 | 66 | 219 |

Source: OBERLÄNDER, 1985, p. 256

Alternative 1: $\varepsilon_D = 0$; $\varepsilon_S = 0{,}3$; $\varepsilon_{DW} = -50$
Alternative 2: $\varepsilon_D = 0$; $\varepsilon_S = 1{,}0$; $\varepsilon_{DW} = -50$
Alternative 3: $\varepsilon_D = 0$; $\varepsilon_S = 0{,}3$; $\varepsilon_{DW} = \infty$
Alternative 4: $\varepsilon_D = 0$; $\varepsilon_S = 1{,}0$; $\varepsilon_{DW} = \infty$

$\varepsilon_D$: Own-price elasticity of the domestic demand for rice (equilibrium elasticity)

$\varepsilon_S$: Own-price elasticity of the domestic supply of rice

$\varepsilon_{DW}$: Own-price elasticity of world demand for Thai rice

Main results :

- the cost "correction" (sum of lines 2 and 3) caused by the distortions of factor and input prices can weigh heavier than the total welfare effect which is determined on the condition that the factor prices are undistorted (alternatives 2 and 4);
- as the supply elasticity increases, so does the "correction" factor; it increases even more than the welfare effect (alternative 1 vs. alternative 2; alternative 3 vs. alternative 4);
- the increase in the elasticity of world demand has a greater influence on the welfare effect than on the "correction" factor (alternative 1 vs. alternative 3; alternative 2 vs. alternative 4).

The first statement is of crucial importance. It may be regarded as typical of agricultural sectors in developing countries in so far as, given a relatively high level of protection of non-agricultural sectors, there is always the danger of overestimating the opportunity cost resulting from an increase in agricultural production (KRAMER, 1988 and 1989). Neglecting the corrections entails fatal consequences if the result of a cost-benefit analysis is incorrect even in terms of direction. This is the case, when the welfare effect, calculated on the condition that the economic environment is "undistorted", is negative, while the positive correction effect overcompensates this welfare effect. A "good" measure would obviously be considered "bad". Most simple second-best considerations may already give the empirically working analyst a warning signal: if we, for example by introducing a tariff, depart from the world market price level, this measure may well have a positive allocation effect, if the other markets are distorted (for example in the form of positive protection rates).

What we do not want to withhold in this repect is that the estimations of table 4 cannot be completely satisfactory either; one reason for this is the existence of very wide elasticity intervals. Nevertheless, this fact can hardly raise an objection to our argumentation since the welfare effect and "errors" due to distortions (table 4) tend into the same direction. In addition, it should be pointed out that table 4 refers only to a subset of structural distortions.

9. In order to obtain an adjusted estimation method, it seems to be useful to substitute a "quantity-oriented" method (integration via the quantity axis) for the "price-oriented" approach applied so far (integration via the price axis: equations (1) and (3)). Equation (1) exactly corresponds to the method described by equation (8):

$$(8)\quad \Delta W = \int_1^2 p_j \, dx_j - \int_1^2 p_j \, dy_j^h$$

$$- \; p_j^2 \, \Delta x_j + p_j^2 \, \Delta y_j^h$$

$$- \; (x_j^1 - y_j^{h1}) \, \Delta p_j$$

$y_j^h$: Domestic production of good j

On the other hand, equation (3) corresponds to the following procedure (see ANNEX), if activities on other markets are neglected:

$$(9)\quad \Delta W = \int_1^2 p_j \, d\tilde{x}_j - \int_1^2 q_j^S \, dy_j^h$$

$$- \; q_j^{w2} \, \Delta x_j + q_j^{w2} \, \Delta y_j^h$$

$$- \; (x_j^1 - y_j^{h1}) \, \Delta q_j^w$$

$q_j^S$: Marginal economic cost of the domestic production of good j

$q_j^w$: Marginal economic cost/revenue of imports ($x_j > y_j^h$) /exports ($x_j < y_j^h$) of good j

The relations between approaches (8) and (9) are exactly those which exist between approaches (1) and (3). Indeed, approach (8) can be transformed into approach (9) and vice versa, if the (sufficient) conditions described in section 4 are satisfied.

Thus, we have, at least generally, clarified the way in which approach (8) is to be corrected in order to lead us to the same result as equation (9):

I: Term 1

The MARSHALLian demand curve $p_j = p_j(x_j)$ is to be transformed into a HICKSian demand curve $p_j = p_j(\tilde{x}_j)$. Equation (6) describes such a transformation technique.

II: Term 2

The supply function $p_j = p_j(y_j^h)$ has to be transformed in such a way as to describe the marginal economic cost ($q_j^s$) as a function of domestic production ($y_j^h$).

III: Terms 3, 4 and 5

The marginal economic cost/revenue of the imports/exports ($q_j^w$) are to be derived from the consumer price $p_j$.

IV: Terms 1 and 2

The demand and supply functions are to be estimated as equilibrium functions. Such a procedure has been referred to in section 7.

As we already know the estimation methods corresponding to positions I and IV, we will now turn to the question of how it is possible to transform consumer prices into marginal economic cost/revenue (positions II and III).

10. Let us first of all look at the marginal economic cost/revenue of imports/exports ($q_j^w$). If the domestic willingness to pay is chosen as numéraire, we obtain:

(10) $q_j^w = p_j^w\ (\$) \cdot DW\ (DM/\$)$

$q_j^w(\$)$: Marginal economic cost/revenue measured in foreign exchange foregone/gained

DW (DM/$): "Value" of one unit of foreign exchange, measured as the domestic willingnes to pay

The value of one unit of foreign exchange is identical to the shadow exchange rate well-known from literature.

Moreover, we can use equation

(11) $q_j^w\ (\$) = p_j^w\ (\$)$,

if the world market price of good j can be regarded as independent from the consumption and production decisions taken in the country considered. Substituting equation (11) into equation (10), we obtain

(12) $q_j^W = p_j^W \text{ (\$)} \cdot DW \text{ (DM/\$)}$

$q_j^W$ is the factor of valuation used in the adequate procedure (9).

In procedure (8), however, domestic prices ($p_j$) are taken for valuation. Under competitive conditions these prices are determined as follows:

(13) $p_j = p_j^W \text{ (\$)} \cdot W \text{ (DM/\$)} \cdot (1+t_j^\circ)$

W (DM/\$) : Actual exchange rate

$(1 + t_j^\circ)$ : Relation between domestic price and world market price (both of them expressed in domestic currency) due to protection; $t_j^\circ$, for example, is a non-redundant tariff rate of good j.

The factors of valuation $q_j^W$ (procedure (9)) and $p_j$ (procedure (8)) are obviously identical if:

(14) $DW \text{ (DM/\$)} = W \text{ (DM/\$)} (1 + t_j^\circ)$

This condition is satisfied

- in the case of free trade

or

- if the degree of the domestic currency appreciation due to protection (measured by DW/W) exactly corresponds to good j's price increase due to protection (measured by $1 + t_j^\circ$).

Thus, the factor of valuation generally to be used is $q_j^W$ (see equation (12)). This procedure requires both, the determination of the world market price $p_j^W$ (\$) and the estimation of DW (DM/\$) by means of appropriate techniques.

11. In the following we are going to consider the marginal economic cost of domestic production ($q_j^S$). In analogy to equation (10) in section (10), we start with a definitional equation:

(15) $q_j^S = q_j^S \text{ (\$)} \cdot DW \text{ (DM/\$)}$

The marginal economic cost of domestic production, expressed in foreign currency ($q_j^s$ ($)), are determined, like the marginal economic cost of imports, as foreign exchange foregone:

(16) $q_j^s\ (\$) = p_m^w(\$)\ (-\ dy_m^s/dy_j^s)o$

$p_m^w$ ($): World market price of a commodity bundle (m) - except good j - representative for the economy

$(-\ dy_m^s/dy_j^s)o$: Marginal rate of transformation regarding goods m and j

We do not know the marginal rate of transformation (being inter alia technically determined). We thus estimate it with the help of market data using the following relationship:

$$(17)\ (-\ dy_m^s/dy_j^s)o = \frac{p_j/p_m}{p_j} = \frac{p_j}{p_m^w\ (\$)\ \cdot\ (1+t_m^\circ)\ \cdot\ W\ (DM/\$)}$$

$t_m^\circ$: "Average" tariff rate of commodity bundle m

Substitutions into equation (15) yield:

$$(18)\ q_j^s = \frac{p_j}{(1+t_m^\circ)\ \cdot\ W\ (DM/\$)}\ \cdot\ DW\ (DM/\$)$$

This equation describes the necessary transformation of (domestic) market prices ($p_j$) into economic (marginal) opportunity cost ($q_j^s$). This transformation can be omitted

- in the case of free trade ($t_m^\circ = 0$; $DW = W$)

or

- if the degree of the domestic currency appreciation due to protection (measured by DW/W) corresponds to the average degree of protection (measured by $1+t_m^\circ$).

As is well-known, the second condition is satisfied when all goods show the same degree of protection. In real economic terms, this, in turn, corresponds to the state of free trade.

Equation (7) in section 8 describes a possible estimation procedure to determine

$$p_j / (1 + t_m^\circ)$$

in equation (18). As an estimator the following term is to be used:

$$D_j / | y_j^2 - y_j^1 |$$

12. From the explanations made so far, we can draw the following conclusions: Measuring welfare effects at the level of domestic commodity markets may, in view of doubtful data quality (especially in developing countries) and statistic-econometric estimation errors, dispense with corrections of type I (MARSHALL vs. HICKS concept) and IV (partial vs. equilibrium elasticities). This assumption is supported by the empirical analyses of sections 6 and 7. Corrections of types II and III, however, seem to be indispensable. Market distortions (such as import protection) induced by economic policy often assume such proportions that neglecting them may lead to completely useless results. This statement is supported by section 8.

At the level of international commodity markets, the measuring difficulties are increasing considerably - even if we leave out statistic-econometric estimation problems. For illustration purposes we will first of all turn to the world supply curve.

A world supply curve describes a relationship between a world market price and world supply. What we need, however, is a relationship between (marginal) opportunity cost of production on the one hand and supply on the other. This deficiency could be remedied if world market prices could be transformed into opportunity cost (similarly to section 11). Such transformation first of all requires information from all supply countries included in the world supply curve:

- information about the protection of good j, so that a relationship between the world market price and the domestic price can be established;
- information about the protection of the commodity bundle m, so that from the domestic price of good j we can derive the opportunity cost of production of good j.

But even if we were successful in obtaining such information (which would be very time-consuming), this would be of little help. For in order to

estimate the world opportunity cost incurred by a change in world supply we would have to know,

- which countries, to what extent, contribute to supply adjustment.

This question cannot be answered by a world supply curve!

On the other hand, a world demand curve (secondly) describes the relationship between a world market price and the corresponding world demand. What we need, however, is a relationship between (marginal) willingness to pay for good j on the one hand, and demand on the other. It is true that it is easy to transform market prices into willingness to pay (domestic prices) but we are faced with a problem here, similar to that concerning supply adjustment:

- we do not know (and cannot know) which countries to what extent contribute to demand adjustment.

Thirdly, we would have to carry out conversions because we have determined the opportunity cost at $ world market prices, and willingness to pay, on the other hand, at domestic prices. Thus, it would be necessary

- to calculate a shadow exchange rate (foreign exchange value) for each demand country

so that we could convert the willingness to pay into foreign exchange equivalents.

Fourthly, we have not yet taken into account that world supply and world demand curves reflect only the domestic excess supply and/or demand. This means that sellers (buyers) on the world market, in general, also buy (sell) the respective good on the domestic market. As we now know that supply and demand factors are subject to completely different revaluation procedures, the world supply and demand curves would have to be constructed according to a gross concept instead of the net (excess) concept.

In summary, we can state that it is almost impossible to apply satisfactory revaluation procedures at the world market level if considerable market distortions are in existence. This means that if one intends to make valuations at world market level, these should always be preceded by analyses of market distortions. In our estimation, therefore, if market prices strongly deviate from marginal economic cost, cost-benefit analyses are useless.

ANNEX: Derivation of the "quantity-oriented" from the "price-oriented" method (GANS and MARGGRAF, 1990a, p. 56 ff.)

Starting point is the "price-oriented" method:

$$(3)\quad \Delta W = -\sum_i \int_1^2 \tilde{x}_i \, dp_i + \sum_i \int_1^2 y_i^h \, dq_i + \Delta T$$

The sum of the last two terms on the right-hand side of equation (3) corresponds to the income change $\Delta E$ (GANS and MARGGRAF, 1989a, pp. 51 and 55). If the income restriction

$$(a)\quad dE = \sum_i p_i \, d\tilde{x}_i + \sum_i \tilde{x}_i \, dp_i$$

is taken into account, we obtain

$$(b)\quad \Delta E = \int_1^2 dE = \sum_i \int_1^2 p_i \, d\tilde{x}_i + \sum_i \int_1^2 \tilde{x}_i \, dp_i$$

Substitution of the two terms on the right-hand side of equation (b) into equation (3) yields:

$$(c)\quad \Delta W = \sum_i \int_1^2 p_i \, d\tilde{x}_i$$

This is the <u>basic equation</u> of the alternative ("quantity-oriented") method.

Assuming <u>market equilibrium</u> ($\tilde{x}_i = y_i^g$; $y_i^g$: aggregate supply) and using equation (5) ($t_i = p_i - q_i$), equation (c) yields:

$$(d)\quad \Delta W = \sum_i \int_1^2 t_i \, dy_i^g$$

Note: We use the following property of marginal economic cost:

$$(e)\quad \sum_i \int_1^2 q_i \, dy_i^g = 0$$

(GANS and MARGGRAF, 1989a, pp. 16 and 58)

If, subsequently, market j is separated from the other markets ($i \neq j$), equation (d) can be rewritten as:

$$(f)\quad \Delta W = \int_1^2 t_j \, dy_j^g + \sum_{i \neq j} \int_1^2 t_i \, dy_i^g$$

$$= \int_1^2 p_j \, d\tilde{x}_j - \int_1^2 q_j \, dy_j^g + \sum_{i \neq j} \int_1^2 t_i \, dy_i^g$$

If welfare effects caused by <u>distortions on other markets</u> ($t_i$; $i \neq j$) are neglected, we further obtain:

$$(g)\quad \Delta W = \int_1^2 p_j \, d\tilde{x}_j - \int_1^2 q_j \, dy_j^g$$

Moreover we will take into account that the aggregate supply of good j ($y_j^g$) consists of a domestic ($y_j^h$) and a foreign ($y_j^w$) component. Equation (g) can then be transformed into

$$(h)\quad \Delta W = \int_1^2 p_j \, d\tilde{x}_j - \int_1^2 q_j^s \, dy_j^h - \int_1^2 q_j^w \, dy_j^w$$

At a constant $q_j^w$ (determined by the "world market"), the third term on the right-hand side of equation (h) reads:

$$(i)\quad \int_1^2 q_j^w \, dy_j^w = q_j^w \, \Delta y_j^w$$

This is the change of $q_j^w \, y_j^w$ at a <u>constant $q_j^w$</u>.

If we further take into account that $q_j^w$ may also change (autonomously)($q_j^{w1} \neq q_j^{w2}$), a unique change $\Delta q_j$ yields:

$$(k)\ \Delta\ (q_j^w\ y_j^w) = q_j^{w1}\ \Delta y_j^w + y_j^{w1}\ \Delta q_j^w + \Delta y_j^w\ \Delta q_j^w$$
$$= q_j^{w2}\ \Delta y_j^w + y_j^{w1}\ \Delta q_j^w$$

Equation (h) can - if equation (k) is taken into account - be rewritten as:

$$(1)\ \Delta W = \int_1^2 p_j\ d\tilde{x}_j - \int_1^2 q_j^s\ dy_j^h$$
$$- q_j^{w2}\ \Delta y_j^w$$
$$- y_j^{w1}\ \Delta q_j^w$$

Equation (1) is identical to equation (9).

Note: Interdependencies arising in an economy can, to a limited extent, be accounted for by using this approach. For, as far as quantities and prices existing on market j are influenced by changes on other markets ($i \neq j$), this can be taken into account with the help of equilibrium functions. Nevertheless, those welfare effects caused by distortions on other markets remain unnoticed (cf. the transition of equation (f) to equation (g)).

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