ECONOMIC APPRAISAL OF THE ASWAN HIGH DAM*
A NEW APPROACH

Dr. GERHARD TINTNER
Department of Economics University of Southern California, California

Dr. ABDEL-FATTAH M. KANDEEL
Faculty of Econ. and Pol. Science Cairo University, Cairo

In this essay the authors attempt an economic evaluation of the Aswan High Dam, using the concept of consumers' and producers' surplus.[1] A comprehensive treatment of our subject would no doubt require the inclusion of both the agricultural and industrial sectors of the UAR economy. We were unable to treat our problem in this way, however, for several reasons. Aside from the fact that the full range of the project's effects on the industrial sector cannot be totally conceived of at this stage, the inavailability of the necessary data, from that sector, was the major obstacle. Faced with these problems, we decided to limit the scope of our study to the agricultural sector.

Data and Methodology :

In its comprehensive survey and study conducted diring the period 1954—1956, the International Bank for Reconstruction and Development estimated the cost of the project at L.E. 465 million (at the 1956 rate of exchange L.E. 1.00 = $ 2.78). Figures published by the UAR Information Departument indicate that L.E. 77.5 million of the cost are being devoted to hydroelectric machine construction, transmitting electric power, and building several stations for that purpose. The rest of the cost, i.e., L.E. 387.5 million, can therefore be assumed to represent the share of agriculture in the total cost of the Dam.

The set of data used for estimating domestic demand and supply functions for agricultural producs was not available in the form necessary

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1 G. Tintner, *The Econometrics of Development and Planning* (First Draft, 1964), 1964), pp. 500 — 505.

for the present study. The figures we use are taken from several sources. Several of the time series for some variables were incomplete in the original form, thus making it necessary to fill in the gaps (some for a peiod of several years), by statistical estimation.

Our study is performed with only nineteen observations (i.e., 1946-1964). The price variable is composed of price indices of a few main crops, together with a price index of an aggregate variable named ,,other crops,'' with each index's contribution to the general price index weighted by the share of the value of each variable in the total value of agricultural output. Steps were taken to obtain figures for domestic supply-and-demand of agricultural produts in terms of an aggregate unit, and adjustments for stocks and for foreign trade were performed.

The methodology consists of estimating domestic supply and demand equations for agricultural products. Integration is used to obtain the initial value of the area between the two curves. We determine the degree of shifts of the supply and demand curves as a result of the project-over the period 1960—1977. Finally, we calculate the ensuing increase in the value of consumer's and producers' surplus. Eighteen separate values of the area between the two curves are obtained for the eighteen years covered, and the difference between each two successive years is estimated. After properly discounting over time, these values are added, and the total is then compared with the relevant cost, similarly dicounted. If the surplus turns out to be greater than costs, then the project will be economically justified on the basis of its benefits from the agricultural sector alone.

The two structural equations are assumed to be of the form :

Demand : $X_{1(t)} = K_0 + K_2 K_{2(t)} + K_3 X_{3(t)}$ .. (1)

Supply : $X_{1(t)} = L_0 + L_2 X_{2(t-1)} + L_4 X_{4(t)}$ .. (2)

where $X_{1(t)}$ is the quantity of agricultural product at time t

$X_{2(t)}$ is the price of agricultural product at time t

$X_{2(t-1)}$ is the price of agricultural product at one year earlier

$X_{3(t)}$ is the national income at time t

$X_{4(t)}$ is the cultivated area at time t

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2 UAR Publications : National Bank of Egypt : *Economic Bulletin*; Memos of Institute of National Planning.

The model has two endogenous variables, i.e. $X_{1(t)}$, $X_{2(t)}$. and three predetermined variables, i. e., $X_{2(t-1)}$, $X_{3(t)}$, $X_{4(t)}$. Since both equations are thus overidentified[3], we use the twostage least squares method[4] to estimate the coefficiets K_0, K_2, K_3, L_0, L_2, and L_4.

In the first stage we estimate the reduced form equations,

$$\hat{X}_{1(t)} = a_0 + a_2 X_{2(t-1)} + a_4 X_{4(t)} \qquad (3)$$

$$\hat{X}_{2(t)} = b_0 + b_2 X_{2(t-1)} + b_3 X_{3(t)} + b_4 X_{4(t)} \qquad (4)$$

and obtain the following values :

$$\hat{a}_0 = -32325.379 \qquad \hat{b}_0 = +1053.991$$

$$\hat{a}_2 = +\ 0.540 \qquad \hat{b}_2 = +0.115742$$

$$\hat{a}_4 = +\ 6.014 \qquad \hat{b}_3 = +0.053397$$

$$\hat{b}_4 = -0.176999$$

Using equations(3) and (4), we generate a series of estimates $\hat{X}_{1t}$ and $\hat{X}_{2t}$ for the nineteen observations.

In the second stage. the structural equations ate estimated. Using the series $\hat{X}_2$ —instead of $\hat{X}_2$ — in equatin (1), the demand equation is estimated as :

$$\hat{X}_{1(t)} = 2508.952 - 19.380 X_{2(t)} + 1.812 \hat{X}_{3(t)}$$

The supply equation (2) is already in a reduced form, and the values of L_0, L_2, and L_4 are identical to those of $\hat{a}_0$, $\hat{a}_2$, and $\hat{a}_4$. Equation (2) is thus equal to :

$$X_{1(t)} = -32325.379 + 0.540 X_{2(t)} + 6.104 X_{4(t)}$$

The following table shows the significance of the regression coefficients.

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3. T. C. Koopmans, "Identification Problems in Economic Model Construtions," *Econometrica*, April 1949; G. Tintner, *The Econometrics of Develoment and Planning*, Draft, p. 143.

4 H. Theil, *Economic Forecast and Policy* (Amsterdam 1965), Revised Ed., pp. 228—240; G. Tintner, *The Economics of Development and Planning* pp. 162 — 169.

Table 1.

Parameter	Value	Stand. Error	Statisticst	Significant Level
K_2	—19.380	1.398595	13.856763	1%
K_3	+1.812	0.518140	3.497124	2%
L_2	+0.540	0.813700	0.663635	Not Significant
L_4	+6.014	3.386610	1.775876	10%

Putting the exogenous variables X_3 and X_4 at their mean values, we obtain the following valus for equations (1) and (2) :

Demand : $X_{1(t)} = 4382.781 - 19.380\ X_{2(t)}$

Supply : $X_{1(t)} = 2473.519 + 0.450\ X_{2(t-1)}$

and the equilibrium value of $X_1 = 2525.276$.

Assuming that the two equations represent the situation in 1959, i.e., immediately before construction work on the project began, we proceed to calculate the initial consumers' and producers' surplus. For the integration process, we transform the two equations into the form :

Demand : $X_2 = 226.149 - 0.0516\ X_1$

Supply : $X_2 = 4580.591 + 1.851\ X_1$

and the area between these two curves is equal to

$$\int_0^{2525.276} (226.149 - 0.0516X_1)\,dx_1 - \int_{2473.519}^{2525.276} (-4580.591 + 1.851X_1)\,dx_1$$

$$= 404\ 191.406$$

Since the figures of X_1 used in this tudy are in thousand units, the initial consumers' and producers' surplus is : L.E. 404, 191, 406,

As a result of the project, both the supply and semand curves are expected to shift, The following are the assumptions on the bais of which these shifts are estimated :

1. For estimating the shifts in demand, we abstract from any increase in national income, other than what would result from local expenditures on the project and the multiplier effect.

5R. El-Mallakh, "Some Economic Aspects of the Aswan High Dam Project in Egypt," *Land Economics* (February 1959), p. 21.

2. Local expenditures on the progect are estimated at L.E. 20 million for each construction year,[5] i.e., total of L.E. 200 million.

3. The marginal propensity to consume is estimated for the period at 0.8265.[6]

4. Shifts in demand would take place over the period 1960—1969.

5. Shifts in the supply curve are assumed to result only from the addition of 1.3 million acres of cultivable land. Increased productivity of the old land is not considered in this study.

6. It is expected that about 100, 000 acres of new land would be added annually for 13 years .

7. Officials estimate that the lower productivity of the new land — during the first 20 years — is such that 100,000 acres would equal only 62,000 acres of the old land in terms of yield.

8. Until 1964 the published figures did not show any addition of new land. Would. We therefore assume that the first 100,000 acres would have been added during 1965; the thirteen years of shift in supply will then end in 1977

9. The total period during which shifts of either of the curves or both are estimated, is 1960 to 1977 inclusive.

After having determined the values of the two equations for each year, and that of equilibrium X_1, the differences in the value of the int >-gral were dicounted over time by the proper $1/(1+r)^t$ (r = rate of interest). We used, for this process, two altrnative calues of r, i.e., 3% and 6%. Results are listed in Table II.

Table II indicates that there is a substantial increase in the surplus at either one of the discount rates. In order to evaluate the results, the surplus must be compared with costs. Out of the relevant cost (to agriclture) of L.E. 387.5 million, L.E. 200 million is to be spent over the ten-year period of construction, and discounting over time is to be appliod of construction, and discounting over time is to be applied to this protion as well.

Comparison of surplus and cost shows that there would be a sizeable net gain of L.E. 145, 367 and L.E. 86,740, at 3 and 6 per cent, respectively. Results of the 3 per cent interest, however, are far more

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6M. M. El-Imam, Models Used in Drafting the 20-Years Plan)1959—1978) nstitute of National Planning, Memo., No., 255 (Dec. 1962), Cairo, p. 11.

Table II

Year	Number	(1) Δ Surplus	(2) (1) Discounted by 1/(1+0.03)t	(3) (1) Discounted by 1/ (1+0.0.06)t
1960	0	+27 255.112	+27 255.112	+27 255.112
1961	1	+27 318.582	+26 526.243	+25 761.423
1962	2	+27 379.677	+25 819.035	+24 367.913
1963	3	+27 438.175	+25 105.930	+23 048.067
1964	4	+27 501.763	+24 421.566	+21 781.396
1965	5	+83 686.537	+72 221.481	+62 513.483
1966	6	+84 536.613	+70 757.145	+59 598.312
1967	7	+85 384.284	+69 417.423	+56 780.549
1968	8	+89 366.119	+70 509.868	+56 032.557
1969	9	+83 949.824	+64 298.671	+49 692.968
1970	10	+36 402.131	+27 083.185	+20 313.289
1971	11	+29 303.130	+21 156.860	+15 442.479
1972	12	+22 204.212	+15 555.153	+11 036.493
1973	13	+15 105.236	+10 286.666	+ 7 084.356
1974	14	+ 8 006.287	+ 5 292.156	+ 3 538.779
1975	15	+ 940.947	+ 604.088	+ 390.375
1976	16	— 5 963.768	— 3 713.427	— 2 349.725
1977	17	—12 864.043	— 7 782.746	— 4 792.560
Total		+656 941.818	+517 567.397	+430 260884

favorable; the net gain amounting nearly to one-half of the cost, while at 6 percent it is barely a quarter of the cost. Moreouver, the difference between the two values of the surplus at the two discount rates isfour and one-half times the difference between the two alues of cost at the corresponding discount rates.

Essential for acceping the conclusion for this criterion, however, is that equilibrium prices of the initial and terminal positions are appro-

Table III.

Year	Number	Value to be in Million L.E.	Discouted Discounted By $(1/(1+0.03)_t$	Discounted by $(1/1+0.06)_t$
1960	0	20.000	20.000	20.000
1961	1	20.000	19.420	18.860
1962	2	20.000	18.860	17.800
1963	3	20.000	18.300	16.800
1964	4	20.000	17.760	15.840
1965	5	20.000	17.260	14.940
1966	6	20.000	16.740	14.100
1967	7	20.000	16.260	13.300
1968	8	20.000	15.780	12.540
1969	9	20.000	15.320	11.840
Total		200.000	10.750	175.700
Undiscounted Part of Cost		187.500	187.500	187.500
Total Cost		387.500	363.200	343.520

approximately equal. Results of our study fare poorly in this regard, and the sum total of the increased suprlus may be considered overestimated.[7] Not only does the equilibrium price of the terminal position fall far below that of the initial position, but it even falls below the horizontal axis and attains a negative value. Table IV lists equilibrium values of X_1 and X_2 over eighteen years.

We therefore suggest that we consider for the moment, only the gain in surplus from the year 1960 until a future year is reached where equilibrium value of price ($X2$) is approximately equal to that of 1959 (i.e., 95.845). Two such years are examined as alternative cut-off points, as ndicated in Table V.

7For more details on this point, the reader is referred to A. M. Kandeel, "The urplus Approach for Project Appraisal," a Doctoral disertation, University of outhern California, 1966, Chapter III.

Table IV.

Year	Equilibrium Value of X_1	Equilibrium Value of X_2
1959	2 525.276	95.845
1960	2 530.937	106.330
1961	2 536.599	116.814
1962	2 542260	127.299
1963	2 547.922	137783
1964	2 553.384	148.268
1965	2 924.931	129.883
1966	3 269.278	131.498
1967	3 667.625	123114
1968	4 038.973	114729
1969	4 410.320	106.444
1970	4 776.005	87.475
1969	5 141.691	68.608
1972	5 507.377	49.737
1973	5 873.377	90.862
1974	6 238.740	11.899
1975	6 604.433	— 6.871
1976	6 970.177	—25.740
1977	7 335.805	—44.610

Table V.

Border line year	Equilibrium X_2	Net gain in suprlus until the border line L.E. at 3%	L.E. at 6%
1969	106.344	113 132 574	63 312 140
1970	87.475	140 215 759	83 624 529

It should be observed that one of the X_2 values in Table V lies above the equilibrium X_2 of the initial situation, while the other lies below it, and either of them oould be considered approximately qual to it.

We readily observe that the net gain in surplus for either year, and either dicount rate, is such that we could even diregard the rest of the gain in surplus (i.e., until 1977) for our pourpose. The net gain in surplus. up to this point (1969 or 1970), obviusly justifies the project economically on the basis of its contributions to agriculture alone, i.e., the first part of the surplus alone exceeding the cost by a very comfortable margin.

Waste of Potential Surplus

We have seen (Table II) that negative values of the surplus result in the last two yeas of the period; the supply curve shifts with a pace which takes it — in the years 1975, 1976, and 1977 — out of the range of the positive triangular area under a demand curve. which represents the situation in 1969, and remians unchanged thereafter. The negative values of the surplus are outcomes of the intersection of the two curves in the fourth quandrant.

Lest us relax our basic assumption — of abstracting from all other developments — and take into account the policy of UAR planners to double national income by 1969 (base year oncome,1959/1960), assuming first, that the target will be realized,and second, that no further increase in national income will take place. Our findings still give two negative values of equilibrium X_2 :

$$1976 : \quad X_2 = -13.678$$

$$1977 : \quad X_2 = -23.548$$

Although a negative value is implausible, this statistical finding has a meaningful economic interpretation : there is more potenital gain, from the project, which would be lost as a reslt of the slow shift in the domestic demand curve for agricultural products.

To recapture this part, the demand curve has to be pushed further to the right by a process of increasing national income. But there is an important requirement for achieving the desired result by the type of shift which we here suggest : the increase in national incime must be generated from outside the argicultural sector to avoid further losses in potential gain. Any further imrovement in this sector, at this stage, would result in a further shift in the supply curve to the right and more negative magintudes of the surplus would occur.

Further Considerations

It is estimated from our study that two years of growth (at an

annual rate of 7.2 per cent[8]) beyond the plan Target date of 1969 is required to bring X_2 to a value $\geqslant 0$.[9]

A value of $X_2 = 0$. however, is as implausible as a negative value. Agricultural products would be free goods. It is difficult to foresee the rate of growth in the UAR after 1969. Houwever, if the same growth of 7.2 will continue, there is no chance of X_2 falling below 80.

But even if only a mild 3 or 4 per cent rate takes place from 1969—1977, the theoretical negative values of X_2 will never occur in reality. Table VI lists these values.

Table VI.

Year	Equilibrium X_2 with 3% growth in N.I.	Equilibrium X_2 with 4% growth in N.I.
1970	106.551	108.889
1971	94.906	99.746
1972	83.476	90.993
1973	72.269	82.644
1974	61.292	74.716
1975	50.552	67.225
1976	40.055	60.190
1977	29.810	53.628

Conclusions

The fact that negative values of X_2 will not actually occur does not affect our basic conclusions :

1. That the Aswan High Dam is economically justified on its own metrits, even if we assume that the national income of the UAR does not increase beyond the multiplier effect on expenditures of the poject.

8This being the same as the Plan rate of groth which will double the National Income in ten years.

9Actually, a 7.2% rate lf grwoth annually for two years, beginning with the 1969 National Income (target) would result in equilibrium $X2 = 2.4$.

2. That there is a loss of potential surplus, due to the fact that shifts in supply outstrip shifts in demand to the effect that the two curves would intersect in the fourth quadrant.

3. The loss in potential surplus wold still occur when we take into account the taget of the UAR plan to double the natonal income by 1969. This conclusion, however, is on the assumption that no further growth in national income after 1969 is considered.

It is to be noted that conclusion (1) will be somewhat weakened and (2) and (3) would be strengthened if some – or all of the assumptoins underlying the shifts of the curves do not hold. This would occur — in the case based on the multiplier — if the actual annual local expenditure on the project is less than L.E. 20 million, or if the marginal propensity to consume is substantilly less than the estimated figure used in this study. Or — and this applies also to the case of doubling national income — if the productivity of the new land is not as low as estimated by the Institute of National Planning, or if improved drainage conditions — with considerable effect on productivity of the old land — is taken into account.

4. That an increase in national income – required for shifting the demand curve — as to be generated fromoutside the agricultural sector, in order to recapture the loss. The hydroelectric power,[10] that is to be created by the project, is now brought into effect. Industrialiation becomes a must, even if only to maximize the surplus from agriculture.

In other words, distragrding its contribution to industry, has serious effects on the project's maximum contribution to agriculture. The criterion applied in this study should be credited for bringing this conclusion into focus.

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10 For a mathematical model for a balance between the two uses, see H.A. Thomas, Jr. and R. Revelle. "On the Efficient Use of High Aswan Dam for Hydr-o power and Irigation. "*Management Science*, Vol.XII, No.8, (April 1966), pp. 296—311.

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