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MEASURING THE SECONDARY IMPACT OF THE LEFT BANK OUTFALL DRAIN ON THE ECONOMY OF SINDH*

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This paper provides an evaluation of the secondary effects of a major irrigation and drainage project being implemented in the province of Sindh, Pakistan. To allow the empirical magnitude of these effects to be estimated a simple model of the regional economy was developed. While this model reflects various resources and data constraints it incorporates the effects of all the major linkages in the local economy. It was found that the secondary effects of the project, once it is fully operational, will be quite large in relation to the direct benefits. This reflects the high degree of integration of agriculture with the local economy, through both backward and forward linkages.

Introduction

This paper provides an evaluation of the secondary effects of a major project in Pakistan designed to increase agricultural productivity. The project, the Left Bank Outfall Drain (LBOD), will provide drainage and irrigation for an area covering some 1.3 million acres in the province of Sindh, Pakistan. The aim of the project is to increase agricultural output in the catchment zone by increasing the cultivated area, and by increasing crop yields. Though the direct beneficiaries of the LBOD project will be agricultural producers in the districts in which the project is located, the nature and scale of the project are such as to ensure that, through backward and forward linkage effects, secondary impacts will be felt in a wide range of industries throughout the whole of Sindh. This paper provides

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some empirical estimates of these secondary impacts.

Information on the extent and nature of the secondary impact of major projects, such as the LBOD, can be of value both to planners who will have to take all of the consequences of such projects into account, and decision takers responsible for the evaluation of the project in the first place. Planners will be interested in the anticipated sectoral impact of the secondary effects as a first step in the identification of potential bottlenecks which might impede the development of forward and backward linkages. Planners are also likely to be concerned with the macroeconomic impact of any major project on regional income and employment levels. Additionally, the identification of the secondary effects is likely to be perceived as an essential step in the development of a comprehensive assessment of the distributive impact of a project.

Estimates of the potential secondary benefits of a project are also relevant for an economic appraisal of the project, although it is a well established proposition that the multiplier effects generated by a project are not directly relevant for the measurement of that project's net benefits [see Marglin (1967), and UNIDO (1972)]. The overall multiplier effects will result from either the employment of resources drawn from other uses or of resources previously unemployed: the former clearly does not constitute a net benefit, while some of the contribution of the latter, to the extent that they arise from consumption expenditure, could possibly have been secured by correcting any deficiency in aggregate demand that caused the unemployment in the first place. Nevertheless, estimates of multiplier effects and secondary benefits have a role to play in the economic evaluation of projects. For example, before a shadow wage rate can be calculated it is necessary to identify the full impact on consumption of employing an additional person. The multiplier effects are not explicitly included in the economic evaluation but their effects are embodied in the values derived for the projects direct inputs and outputs [see Bell et al. (1982), and Bell and Devarajan (1980)]. The analysis of secondary effects is also useful, by identifying the backward and forward linkages, in defining the economic as opposed to the administrative scope of a project.

The paper is divided into three sections. The first provides some background information on the economy of Sindh. This is necessary to appreciate the likely nature of the secondary effects. This section also has a brief description of the Left Bank Outfall Drain Project. The second section describes the methodology developed to measure the linkage multiplier effects, while the third section summarises the empirical results of the impact analysis.

I. The Economy of Sindh and the LBOD Project

According to the 1981 census the population of Sindh was 19 million and that of Pakistan 84 million. Over 56 per cent of Sindh's population in 1981 lived in rural areas, a reflection of the fact that agriculture is the predominant economic activity in the region. Manufacturing is primarily agro-based, especially in terms of industries processing agricultural produce as opposed to supplying agricultural inputs. However, Karachi, which is the capital city of Sindh, contains 'heavier' engineering and chemical industries; in particular, the city has Pakistan's only major oil refinery. Karachi also has a relatively high proportion of both regional and national employment in certain service sectors, especially business and financial services and transportation. The relative importance of Karachi as a national service centre is probably declining as these activities expand elsewhere in the country. An indication of the employment structure of Sindh, derived from a 1979 labour force survey, is given in Table 1.

TABLE 1

Employment Structure of Sindh, 1979

Industry	Percentage of employed persons over 10 years in: Sindh	Sindh Urban	Sindh Rural	Location Quotient
Agriculture, forestry, fishing	55.82	4.25	83.99	1.06
Mining and quarrying	0.01	0.03	0.00	0.07
Manufacturing	11.91	26.71	3.83	0.82
Utilities	0.86	1.75	0.37	1.16
Construction	3.97	7.23	2.19	0.81
Distributive trades, restaurants, hotels	10.58	23.11	3.75	0.96
Transport/communications	5.11	11.44	1.65	1.08
Finance, business, insurance	1.30	3.60	0.04	1.53
Community, social, personal	10.05	21.38	3.86	1.00
Not adequately defined	0.38	0.49	0.32	–
Total	100.00	100.00	100.00	

Defined as LQ_i = percentage of Sindh total employment in industry i/percentage of Pakistan total employment in industry i.

Source: Labour Force Survey 1978-79, Federal Bureau of Statistics, Government of Pakistan, 1982.

For Sindh as a whole, agriculture was the main source of employment (56 per cent of total) followed by services (28 per cent) and manufacturing (12 per cent). Not surprisingly, there were substantial differences in the industrial employment structures in urban and rural areas of the province. The location quotients (LQ's) in the final column in Table 1 indicate that, compared with Pakistan as a whole, Sindh was relatively specialised (i.e., industries with LQ values greater than unity) in agriculture, utilities, transport and business services.

In the agricultural sector the main crops grown are cotton and rice in the summer, wheat in the winter, and perennial sugar-cane. The estimated values of crop production in 1981-82 are shown in Table 2, which indicates that these four crops accounted for some 85 per cent of total Sindh crop revenue in that year. Livestock products (mainly from cattle, sheep and goats) are also an important source of agricultural revenue in Sindh, and accounted for an estimated 24 per cent of net farm income in 1981-82.

Agricultural production in Sindh is almost entirely dependent on water obtained by irrigation from the river Indus. Construction and improvement of the inundation canal system has taken place since the latter half

TABLE 2

Estimated Agricultural Revenue and Income in Sindh 1981-82

Item	Rs. million (current prices)
Rice	3,763
Wheat	3,627
Cotton	4,291
Sugar-cane	1,004
All other crops	2,462
Total gross value:	15,147
Of which, value added	12,990
Livestock value added	4,178
Total sectoral value added	17,168

Source: Estimates from agricultural census data and national accounts statistics.

of the nineteenth century and in 1932 barrage commanded irrigation was introduced with the construction of the Sukkur Barrage system. Two other barrages, Kotri (1955) and Guddu (1962) completed the system as it is at present. The Left Bank Outfall Drain project is concerned with the left bank of the Sukkur Barrage.

Given the climatic and geological conditions prevalent in Sindh, continued application of irrigation water without adequate drainage inevitably leads to waterlogging and salinity which in turn lead to lower crop yields and loss of cultivable land. Crop damage due to storm flooding is also increased. These problems are especially acute in the left bank districts of Nawabshah, Sanghar and Mirpurkhas. In 1982, 75 per cent of these areas had water tables less than five feet deep.

The LBOD Stage 1 project (which is the subject of the present paper) is designed to provide surface drainage and priority sub-surface drainage for 1.3 million acres in these three districts. Additionally, since improved drainage will permit the beneficial use of more irrigation water, the project package also includes components (canal remodelling, etc.,) designed to increase available water supply. From commencement, the project will take an estimated eight years to completion and the projected total cost is $650 million (1983 prices).

II. Impact Methodology

The LBOD represents a major injection of activity into the economy of Sindh. This injection may be divided into three distinct components: (i) activity associated with the construction of LBOD facilities, (ii) activity associated with the actual operation of LBOD, and (iii) increased on-farm activity arising from the operation of the LBOD scheme. All of these injection components are included as direct effects of the LBOD and, while they may in fact overlap in calendar time, in modelling terms it is desirable to treat them separately since the size and direction of their secondary impacts may differ significantly.

These direct injections stimulate further secondary activity in the region, initially through their own interactions with local sectors and, subsequently, through the more general interactions which take place between agents in the regional economy as a whole. Two elements of secondary impact are considered in the present study as follows:

(a) Backward Linkage Impact

This refers to the impact which the new activity has on the regional

economy as a purchaser of local goods and services, including local labour services. For example, to produce more crops, farmers will increase their demands for production inputs such as fertiliser, seeds, etc. To meet these new demands, local suppliers will increase their own outputs which in turn means they will demand more production inputs from their suppliers . . . . . and so on. Furthermore, the increase in agricultural output will increase the incomes of farmers and farm workers, who will then demand more consumer goods and services. This in turn increases the incomes of workers in the consumer goods industries . . . . . etc.

The total increment to regional activity arising from these increases in demands for local goods and services is known as the backward linkage impact.

(b) Forward Linkage Impact

This refers to the impact which the new activity has on the local economy as a supplier of goods and services to other local sectors. For example, the increased availability of agricultural products in Sindh may increase production in the agro-processing industries which use such products as raw materials. To the extent that agro-processing activity does expand, there will be further beneficial effects on the regional economy through the backward linkage interaction described above. In the present study, forward linkage is defined to be the increase in agro-processing activity plus any increase in local activity which this induces through backward linkage effects.

The aim of a secondary impact study is to develop an applied model which 'captures' all these backward and forward linkage impacts in a comprehensive, consistent and detailed fashion. In practice, however, the development of the model will be constrained by time, resource and data availabilities, and inevitably such constraints imply compromises. Reality, therefore, is the creation of a cost-effective model which gives 'good' results within the resource limitations.

In the present study, it was immediately clear that, given available resources, any multiplier model of Sindh would have to be derived entirely from published information and pre-existing data sources. After extensive examination of such sources,[1] a general model framework was developed as described mathematically in Appendix I.[2] Here, it is sufficient to

[1] Described in detail in McNicoll (1983).

[2] In the construction of a model for secondary impact evaluation in a developing country, a frequent preliminary step is the construction of a Social Accounting Matrix (SAM) for the area under study for some specific year, or a series of years. A very good and relevant example of

summarise some of the main features and limitations of the model. These can usefully be subsumed under two major headings as follows:

(i) Coverage of the Secondary Impact

Inspection and Appendix I reveals that the model includes a complete household income/expenditure backward linkage loop. It also allows for multiplier interaction between provincial government tax revenue and expenditure though, in practice, the absolute magnitude of flows through this loop is rather small. It will be seen that the model does not include an interindustry purchases backward linkage loop (also known as indirect multiplier effects). To include this backward linkage in the model would have required data on industry purchases which were not available. This omission is unfortunate as it is equivalent in effect to assuming that all industrial inputs are imported into the Sindh province. Clearly this is not the case for all industrial inputs, some of which would be available from firms located in cities such as Karachi and Hyderabad. But this omission may not be too damaging to the final results. There are indications from previous research that the failure to include the backward linkage loop may not have a major impact on the final results of a study such as the one reported here, i.e., the understatement of the secondary effects is likely to have been quite limited. Both Bell, et al. (1982) and Round (1979), for example, have demonstrated that income/expenditure multiplier effects are much more important than interindustry multiplier effects in developing countries. Indeed, Bell, et al. (1982) argue that this is particularly true in analysing the impact of an agricultural project in an agro-based economy, as in the case with the LBOD project in Sindh. There are two distinct reasons why local interindustry linkages may be small in a region such as Sindh: first, industry technologies in use are likely to

this approach is given in Bell, et al. (1982). The construction of a SAM has many advantages: it disciplines the analyst to compile a comprehensive and consistent database; it assists in the identification of data deficiencies; it is sufficiently flexible to be adapted to many different specific situations and, finally, it provides an immediate data framework for the development of a variety of alternative models. Given these benefits, we therefore also decided to use a SAM type approach to data collection and organisation. It quickly became clear, however, that it would be impossible (or at least extremely difficult and resource-consuming) to construct and complete a consistent set of regional accounts for Sindh for a specific year. Indeed, certain key information (particularly on trade) was not available for any year. Therefore, while we used a SAM framework as a filling system for organisation of components of the database, we did not attempt to enforce mutual consistency among these components by constructing a set of flows accounts for Sindh for a particular year. However, the model itself is internally consistent and reflects our best estimate of the underlying structure of the Sindh economy. Thus though a detailed set of Sindh accounts would be desirable, it is not essential for the present study.

be relatively simple and labour-intensive, so that intermediate purchases will be a small proportion of the total cost, with value added predominant.[3] Second, such economies are frequently simple in industrial structure, with limited supply capabilities, and hence a high proportion of intermediate requirements have to be imported from elsewhere in the country or from abroad.

Furthermore, although interindustry effects are not included in the multiplier model, the first-round of these effects is included in the impact analysis by defining the direct effect of an increase in agricultural activity, say, to include increased operating expenditures made by the agricultural sector. That is, though no indirect impact is incorporated in the multiplier model, the first round of indirect impact is included in the multiplicand. The efficacy of this approximation in a regional context has been tested by McNicoll (1981), where it was found to perform reasonably well.[4]

Taken together, the probability that local interindustry linkages are limited plus the fact that first-round indirect effects are included in the estimates of impact suggest that, in the present study, the omission of interindustry interactions in the model can be partially justified on the grounds that second and subsequent round indirect effects are of 'second order importance' in the calculation of total impact.

The model employed in this study implicitly assumes that the capacity is available to meet the incremental demands generated by the forward and backward linkages. Unless there is a sufficient margin of under utilised capacity and unemployed resources it may not be possible to meet these demands without drawing resources from other activities. Should this be necessary the final and overall impact on the local economy will be quite different from that suggested by the estimates generated on the assumption of no capacity constraints. Nevertheless these estimates do provide valuable information for planning purposes. It is only by estimating the likely secondary effects of a project that planners are alerted to the overall consequences of implementing the project, and given the opportunity to identify the bottlenecks and constraints which may be associated with the anticipated forward and backward linkages.

[3] In subsequent estimation of the model, it was found that in ten out of twenty-two separately identified Sindh industries the value added/output ratio was greater than 50 per cent.

[4] Specifically, in a study of 17 industries, it was found that multipliers calculated using the method described in the text underestimated the multipliers which incorporated 'full' interindustry effects in every case, on average by 11 per cent. In 11 industries the degree of underestimation was less than 10 per cent.

(ii) Estimation of Model Parameters

Though most of the data needed to estimate the model outlined in Appendix 1 were available for at least one time period, a complete set of necessary information was not available for any single specific year. Thus, in deriving model parameters, it was generally assumed that current price value coefficients would be constant over time and equal to the value calculated for the most recent year for which the necessary data were available. Though there are technical arguments for and against this type of assumption, the main justification for its use is the pragmatic one that some such assumption is virtually unavoidable in cases such as the present one where primary data are only available for single years and adjustment data (relative prices, technological change, etc.,) are lacking. Essentially, it is argued that the value of a coefficient derived for a particular year is the 'best empirical approximator' of that coefficient in any other year in the absence of additional information.[5]

By accepting assumptions such as those described above, it was possible to estimate the regional multiplier model described in Appendix I for Sindh with twenty-two sectors separately identified. The model is truly multisectoral since expenditure in one industry can affect income earned in another, and vice-versa. This model was then used in conjunction with estimates of the direct effects of the LBOD Stage 1 project to provide estimates of the total impact of the project on Sindh. The results of this exercise are discussed in the next section.

III. Estimated Impact of the LBOD Project

The impact analysis concentrated on developing 'with' and 'without' project scenarios for two years: the 'maximum construction' year (expected to be 1988-89 in calendar time) and a 'long-run operational' year (e.g., 2008-09 in calendar time). The impact of the LBOD project is the difference between the 'with' and 'without' scenario activity measures in each selected year. In the main, the activity measure chosen to assess impact in the present study was local value added (i.e., wages, profit, interest and rent retained within Sindh), since this was felt to provide a reasonable indication of the project's contribution to the region's real economic welfare. However, industry employment/value added coefficients were derived and, hence, the project's impact on local employment could also be estimated.

[5] For further discussion of this point see McNicoll and Rees (1982).

Data on the direct increase in local activity arising from the construction and operation of the LBOD scheme itself were derived from engineering studies undertaken by other members of the project team. Similarly, projections of 'with' and 'without' project levels of agricultural activity were provided by agro-economic studies undertaken by the project team. Generally, the information obtained from both these sources had to be adapted in terms of definition, classification, etc., for use in the impact study, though overall consistency was maintained.

In estimating increases in agro-processing activities, only the most important of these associated with the most important crops were considered. Specifically, attempts were made to estimate the following: (i) increased cotton ginning activity arising from increased cotton production, (ii) the increase in sugar refining associated with higher sugar-cane production, (iii) increased rice milling arising from higher rice production, (iv) the expansion of grain milling as a result of higher wheat production.

For each of these four sectors, the ratio of output to raw material input was calculated from the Pakistan Input-Output Tables (1975-76). LVA/output ratios were obtained from the main Sindh model. On the assumption that 100 per cent of the local crop passes through the appropriate local processing sector, the local value added (LVA) created in each processing sector can be calculated as:

$$\text{Sectoral LVA} = \frac{\text{Output}}{\text{Material Input}} \times \frac{\text{LVA}}{\text{Output}} \times \text{Crop Value}$$

In terms of applying the model, the above elements comprise the direct effect of the LBOD project (i.e., the multiplicand).[6] These direct effects attributable to LBOD in both scenario years are shown in Table 3.

Applying the matrix multiplier to these direct effects gives the estimated total impact of the LBOD on the economy of Sindh. A summary of the results in terms of LVA is given in Table 4.

As the table shows, the LBOD project is predicted to generate a real increase in Sindh LVA of some Rs. 1.3 billion in 1988-89 and of Rs. 4.8 billion in 2008-09.[7] As might be expected, in the peak construction year, a large proportion of the total impact (59 per cent) is attributable to the

[6] In economic terms, of course, the increase in agro-processing activity is part of the forward linkage impact.

[7] For comparative purposes, Sindh Gross Domestic Product in 1980-81 is estimated to have been about Rs. 56.7 billion (current prices). This estimate was derived from a variety of data sources as is discussed in some detail in McNicoll (1983). Details are available from the authors on request.

TABLE 3

Direct Effects* on Sindh LVA of LBOD Project

Item	Rs. million (1983 prices)	
	1988-89	2008-09
(i) Agriculture sector	+ 207.3	+ 1,966.4
(ii) First round indirect effects of increased agriculture	+ 49.3	+ 336.7
(iii) Increased agro-processing	+ 119.0	+ 935.1
(iv) LBOD construction/operation	+ 535.1	+ 141.9
Total direct effects	910.7	3,380.1

* As discussed in the text, these are 'direct' effects in modelling terms; items (ii) and (iii) are secondary effects in economic terms.

TABLE 4

The Impact of the LBOD Stage 1 Project on Local Value Added in Sindh

Impact component	Rs. million (1983 prices)	
	1988-89	2008-09
(1) Direct agriculture LVA	+ 207.3	+ 1,966.4
(2) Agriculture backward linkage production and household impact	+ 160.1	+ 1,327.1
(3) Agriculture, forward linkage impact	+ 165.0	+ 1,296.5
(4) Agriculture impact sub-total	+ 532.4	+ 4,590.0
(5) Direct LBOD construction/operation LVA	+ 535.1	+ 141.9
(6) LBOD backward linkage impact	+ 222.3	+ 38.3
(7) LBOD impact sub-total	+ 757.4	+ 180.2
(8) Total impact	+ 1,289.8	+ 4,770.2

construction and operation of the drainage/irrigation scheme itself. When the scheme is fully operation, almost all the impact (96 per cent of total) is attributable to the direct and secondary effects of increased on-farm activity.

If items (1) and (5) of Table 4 are taken as the direct project impact (in the economic sense) and the remainder as its secondary impact, then it can be seen that the latter represents an important component of the project's total contribution to the economy of Sindh: secondary impact is 42 per cent of total impact in 1988-89 and 56 per cent in 2008-09. Put another way the LBOD project has an LVA multiplier (total impact/ direct) of 1.74 in the peak construction year and 2.26 in the year of full operation.

It was indicated in the introduction that, while the direct impact of the fully-operational LBOD would be felt in the agricultural sector, the secondary impact would be spread over a wider range of industries. This is illustrated in Table 5. The table shows that, in terms of LVA, some 51 per cent of the total impact, or 92 per cent of the secondary impact, is realised in industries other than agriculture. Major gainers are food processing sectors (largely, though not wholly, through forward linkage effects) and distributive trades (largely, though not wholly, through backward household linkage effects). The fact that agriculture has a higher-than-average employment/output coefficient means that it retains a slightly larger share of total impact measured in employment terms. It would have been interesting to have been able to consider the implica-

TABLE 5

Industrial Incidence of Fully-operational LBOD Impact

Industry	LVA	(Rs. million 1983 prices) (%)	Employment	(Million man-hours) (%)
Agriculture	2,317.0	(48.6)	261.6	(53.3)
Food processing textiles	548.5	(11.5)	8.7	(1.8)
Other manufacturing	85.4	(9.2)	51.4	(10.5)
Construction	41.7	(8.7)	4.2	(0.9)
Distributive trades	785.1	(16.5)	85.8	(17.5)
All other industries	553.6	(11.6)	73.5	(15.0)
Total	4,770.2	(100.0)	491.1	(100.0)

tions of the industry impact of the project on the distribution of income.[8] Unfortunately, without access to social accounting data on household income distribution on an industry basis it was not feasible to pursue the distributive consequences at this level of detail.[9]

It was also suggested in the introduction that, while the LBOD scheme itself is restricted to certain districts of Sindh, the nature of secondary impact effects are such as to make it likely that ramifications of the project would be felt over a wider geographical area. An indicative estimate of the geographical dispersion of impact was derived from the following assumptions: (i) all the direct agricultural impact would be realised in the project districts and (ii) the project districts would obtain the same share of each other impact element as the share they had of Sindh's activity in that sector in some base year.[10] While the first assumption is descriptively accurate the second is likely to lead to some minor understatement of the secondary impact on the project districts.

These districts are likely to retain a higher proportion of induced industrial activity, much as that in the agro-processing industries, than their previous share of these industries in the Sindh economy would suggest. Geographical proximity is always likely to foster business links. The results of this analysis, in LVA terms, are given in Table 6.

The table shows that, on the assumptions made, only some 57 per cent of the total LVA impact in Sindh would accrue in the project areas. Equivalently, almost 75 per cent of the secondary impact would be realised in areas of Sindh outside the project districts. This is because the non-farm industrial and service sectors in the project areas are small and limited in scope and hence much of the increased purchasing and selling activity stimulated by the project would take place in areas of Sindh with larger and more comprehensive economic structures (e.g., Karachi). Of course,

[8] Lee et al. (1986), in a related study, have provided some initial estimates of the direct income effects of the project. It is estimated that under the prevailing share cropping system landlords and tenants would each receive an extra Rs. 1,950 per hectare. From this additional income the landlord would pay less than two per cent in extra water charges and taxes. But the government is considering the possibility of higher water charges following a review of the incomes generated by the project.

[9] However, by identifying the overall impact of the project on an industry by industry basis a study such as this prepares the way for a detailed consideration of its distributive impact.

[10] The impact on the districts is calculated as follows:
100 per cent of the district direct effect + x per cent of the overall secondary effect.
Where x is based on the district's share of the Sindh employment in the relevant industries.
The empirical basis of the derivation of base year project district shares as discussed in some detail in McNicoll (1983).

it is likely that, in practice, relevant economic activities would move into the project districts, increasing their share of total impact. Nevertheless, it is clear from Table 6 that, unless such movement took place on a very large scale, the rest of Sindh would still experience significant project-induced effects.

TABLE 6

Regional Incidence of Fully-operational LBOD Impact

Industry	Percentage of total impact on LVA in:	
	Project districts	Rest of Sindh
Agriculture	93.1	6.9
Food processing	48.9	51.1
Textiles	15.8	84.2
Other manufacturing	2.0	98.0
Construction	17.3	82.7
Distributive trades	16.8	83.2
All other industries	11.6	88.4
Total	56.6	43.4

The nature of the model employed in this study suggests that the estimated secondary effects are likely to be under rather than overstated. It employs the historical average input-output relationship to estimate the likely consequences of the project. But the impact at the margin may differ from that suggested by the past average relationships. A major project may be capable of generating structural changes. Associated industries, in the backward and forward chains, which in the past might not have been profitable to locate in the project area might now become viable. Such investments would not be identified by the model used here.

Conclusions

This paper has been concerned with assessing the impact of a large scale drainage and irrigation project on the economy of Sindh province in Pakistan.

In order to estimate the secondary effects of such a project it is necessary to develop a model of the regional economy which incorporates the various interactions which take place locally among economic agents. Given (inevitable) resource and data constraints, the construction of an operational quantitative model always involves compromises in scope, detail and accuracy. Thus the development of an empirical multiplier model of Sindh required the invoking of a number of limiting and simplifying assumptions as discussed in section II. Of course, different analysts may take different views on what are, or are not, reasonable assumptions in a given situation, which is why applied modelling is an 'art' as well as a 'science'.

The impact analysis itself revealed three main features: firstly, when fully operational the secondary impact of the LBOD would be large in absolute terms relative to the direct increase in agricultural production. This was also found by Bell, et al. (1982) in a study of an irrigation scheme in the Muda region of Malaysia. The significant secondary effects arise because, in regions such as Sindh and Muda, agriculture is highly integrated with the rest of the local economy through both backward and forward linkages (including household income/consumption linkages). Secondly, while the direct impact of the project is restricted to the farm sector, the multiplier processes ensure that effects will be felt in all Sindh industries, especially agro-processing and service sectors. Thirdly, the analysis indicated that, although the direct beneficiaries of the project would be restricted to a specific geographical area, secondary effects would be experienced throughout the whole of Sindh.

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Appendix I

Mathematical Derivation of the Model used in the LBOD Impact Analysis

For each Sindh industry i, we have:

$$LVA_i = C_i^{\ell} v_i^{\ell} + P_i^{\ell} v_i^{\ell} + \sum_j X_{ij}^{\ell} v_i^{\ell} + E_i^{\ell} v_i^{\ell} \quad (1)$$

where: LVA_i is local value added in Sindh industry i. C_i^{ℓ} is expenditure by Sindh households on the products of Sindh industry i. P_i^{ℓ} is (endogenous) provincial government expenditure on local product i. X_{ij}^{ℓ} are sales from Sindh industry i to Sindh industry j. E_i^{ℓ} is the sum of all other sales made by Sindh industry i. E_i is assumed exogenous. v_i^{ℓ} is a local value added coefficient denoting the LVA earned per unit of sales in industry i. It is assumed that v_i is independent of the market in which the sale is made.

It is assumed:

$$X_{ij}^{\ell} = 0 \; V_{i,j} \quad (2)$$

$$C_i^{\ell} = c_i^{\ell} \; \delta \, Y^T \quad (3)$$

where: c_i^{ℓ} is the proportion of total Sindh household consumption spent on local good i. δ is the marginal propensity to consume out of gross household income. Y^T is gross Sindh household income.

$$Y^T = \beta + \sum_i y_i \, LVA_i \quad (4)$$

where β represents exogenous household receipts. y_i is a coefficient denoting the proportion of LVA in industry i which is paid as local household income.

$P_i^{\ell} = p_i^{\ell} P^{\ell}$ where p_i denotes the share of total local provincial government expenditure, P^{ℓ}, on local industry i. (5)

$$P^{\ell} = \theta + \lambda Y^T \quad (6)$$

where θ is exogenous local government revenue. λ is a scalar denoting the proportion of gross household income paid as taxes.

Substituting (2) – (6) into (1) gives:

$$LVA_i = c_i^{\ell}\,\delta\,v_i^{\ell}\,\beta + c_i^{\ell}\,\delta\,v_i^{\ell}\sum_i y_i\,LVA_i + p_i^{\ell}\,\theta\,v_i^{\ell} + p_i^{\ell}\,\theta\,v_i^{\ell} + p_i^{\ell}\,\lambda\,v_i^{\ell}\sum_i y_i\,LVA_i + E_i^{\ell}\,v_i^{\ell} \tag{7}$$

Now let,

$$c_i^{\ell}\,\delta\,v_i^{\ell}\,\beta + p_i^{\ell}\,\theta\,v_i^{\ell} + p_i^{\ell}\,\lambda\,\beta\,v_i^{\ell} = M_i^{\ell}\,v_i^{\ell} \tag{7a}$$

It will be noted that $M_i^{\ell}\,v_i^{\ell}$ is independent of the magnitude of LVA_i.

Substituting (7a) into (7) and solving for LVA_i,

$$LVA_i - c_i^{\ell}\,\delta\,v_i^{\ell}\sum_i y_i^{\ell}\,LVA_i - p_i^{\ell}\,\lambda\,v_i^{\ell}\sum_i y_i\,LVA_i = v_i^{\ell}\,(E_i^{\ell} + M_i^{\ell}) \tag{8}$$

or in matrix form,

$$LVA - \hat{v}^{\ell}\,c^{\ell}\,\delta\,y'\,LVA - \hat{v}^{\ell}\,p^{\ell}\,\lambda\,y'\,LVA = \hat{v}^{\ell}\,(E + M) \tag{9}$$

Thus,
$$[I - \hat{v}^{\ell}\,(c^{\ell}\,\delta + p^{\ell}\,\lambda)\,y']\,LVA = \hat{v}^{\ell}\,(E + M) \tag{10}$$

Therefore,
$$LVA = [I - \hat{v}^{\ell}\,(c^{\ell}\,\delta + p^{\ell}\,\lambda)\,y']^{-1}\,\hat{v}^{\ell}\,(E + M) \tag{11}$$

The multisectoral multiplier for a change in exogenous LVA is therefore,

$$[I - \hat{v}^{\ell}\,(c^{\ell}\,\delta + p^{\ell}\,\lambda)\,y']^{-1} \tag{12}$$