Transport in the Input-Output System

ESRA BENNATHAN AND MARK JOHNSON

The links between the transport industry and other economic sectors of production or demand are examined for Côte d'Ivoire, India, Mexico, Philippines, and the United States, on the basis of recent input-output (I-O) tables of those countries. The extent to which the cost of transport services is affected by the prices of other goods and services that are required as inputs in the production of transport is indicated. The extent of the effects of prices and productivity of the labor and capital employed directly by the industry are also indicated. Effects of different tax systems on the cost of transport services are examined. Dependence of transport on industrial (intermediate) demand and on demand generated by private and government consumption, investment, and exports (final demand) and the extent to which the demand for transport reacts to changes in aggregate output are discussed. Further, realistic examples are used to demonstrate the ways in which I-O tables can be used to predict input requirements of the transport industry and of the demand for its output. The precautions necessary in such exercises and in international comparisons and the meaning of different concepts of the relative total size of a country's transport industry are discussed. In addition, the main features of I-O accounting and its relation to national income accounting are reviewed. Usually, national accounts are constructed with the help of relations discovered in I-O accounts so that the same qualifications apply to inferences drawn from either. Input-output accounts rarely attempt to credit transport with the output of own-account (i.e., self-operated) transport operations. Therefore, value added in transport and total output of transport are typically understatements of the true value of a country's total transport activity. Further, the transport cost component of a transaction between two industries could be debited to either the buyer or the seller as a purchase from transport. Different conventions are followed in this matter and the differences affect the apparent transport requirements of various industries.

Structural analysis of industries in terms of their input-output (I-O) relations may seem rather an old-fashioned pursuit but so far it has not been done for the transport industries of developing countries. Input-output tables are used essentially for descriptive purposes and the small number of countries covered make this study a modest attempt in this direction. The links between transport and other sectors of the economy are described as they appear from the I-O tables of five countries: Côte d'Ivoire, India, Philippines, Mexico, and the United States. Figure 1 presents the underlying accounting framework of I-O analysis. Essentials of the method become clear by thinking of a closed economy without foreign trade and, moreover, one in which the output of an industry can be unambiguously identified with one well-defined commodity or service.

The World Bank, 1818 H Street, N.W., Washington, D.C. 20433.

TRANSPORT AS A USER OF RESOURCES

Differences between the five countries in the share of intermediate inputs within the total value of transport output are partly explained by differences in prices, including the cost of labor per unit of output.

As a broad generalization, the gross output of the transport industry is about 1.8 times the value added by transport. The share of value added (the value of labor and capital services employed directly by the industry) in the cost of total output is typically greater for the transport industry than for the average of all industries. A relatively light share of intermediate inputs in the cost of producing transport services tends to insulate transport from movements in the prices of traded goods in the economy and thus from the effect of competitive forces or of technical progress acting on those prices.

Transport is less sensitive than other industries to the cascading effect of turnover taxes. Users and the transport industry should therefore be less affected and benefit less than other industries from the trend towards value-added taxation.

DEMAND FOR TRANSPORT

The average share of transport cost in the total output value of industries is found to be close to 2 percent in all countries. Although the average direct transport input coefficients of industries is similar, this is not true of the total coefficient, which represents the shares of different inputs required per unit dollar increase, in each industry's sales to the final demand sector. In the case of the required transport inputs the total demand coefficients are significantly higher than the direct coefficients that measure input requirements for the prevailing output levels.

In order to sustain a unit increase of each industry's sales to final demand, transport has to increase its output by more than the average industry. Demand for transport is thus more sensitive to a general increase (or decrease) in general production than the average industry.

INDICATORS OF THE RELATIVE SIZE OF TRANSPORT ACTIVITY

Different measures of the relative size or importance of transport in the national economy are value added, gross output, final demand, and the index of sensitivity to general output changes. Each measure provides an answer to a different question.

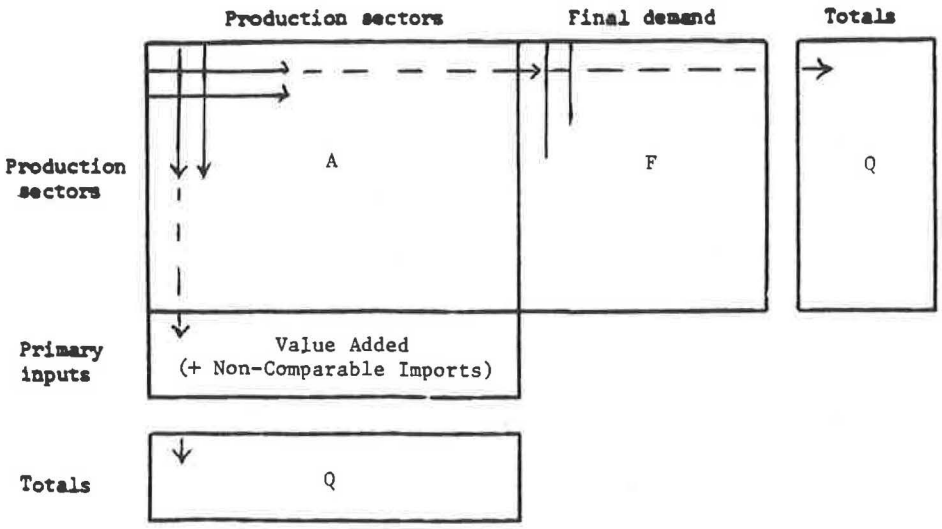

FIGURE 1 Accounting framework of I-O analysis.

Matrix **A** at the upper left corner of the scheme (Figure 1) records the flows of intermediate goods and services traded between different production units, called industries. The scheme can be a commodity-by-commodity matrix (commodity *i* as an input into commodity *j*), a commodity-by-industry matrix (commodity *i* into the production of industry *j*), an industry by commodity matrix, or an industry-by-industry matrix. Concentration here is on this last type in which each industry has a row and a column arrayed in either direction in the same sequence. The crucial convention on dimension is that each industry distributes its output along its row to other producers within matrix **A**, and to final demand sectors **F**. In the absence of foreign trade, final demand consists essentially of private and government consumption and investment.

Industry sales are elements in the rows and columns record inputs for each industry. Inputs consist of intermediate goods and services (recorded in **A**) and of primary inputs. Primary inputs consist of the industry's own resources which contribute its value added (wages and gross profits) and of indirect taxes that make up the difference between value to the producer and value to the buyer.

In the absence of imports, row totals must equal column totals for each industry (in **Q**)—the value of an industry's sales (rows) equals the total value of its output (columns).

The simplicity of this rudimentary scheme is destroyed by the existence of foreign trade and by the heterogeneity of most industries' output. Different I-O tables deal with imports in different ways and this affects the comparability of different tables across countries. The problem of heterogeneous output is relevant because many industries besides transport produce transport services for their own account.

Exports do not present a problem because they are usually and simply treated as a final demand sector with a separate column into which each industry (in an industry by industry scheme) contributes the value of its exports. However, imports infiltrate both the interindustry exchanges in matrix **A** (as intermediate goods and services) and the final demand sectors. Imports are subject to very different treatment in different I-O tables. A widely, but by no means universally adopted, procedure is to split imports between (a) comparable (or competitive) imports—goods or services similar in nature to domestic production and (b) noncomparable (or noncompetitive) imports. Noncomparable imports are then treated as a special industry with its own row (distributing to intermediate uses and final demand) but not corresponding column. On the other hand, comparable imports are merged with the outputs of similar (comparable) domestic industries, which distribute their product, domestic or foreign, along their rows. However, this method is not generally used. In some tables noncomparable imports are classified as a primary input, whereas in others they are treated as an industry (i.e., left in matrix **A** of Figure 1). In still others, the distinction between the two classes of imports is not drawn or drawn on principles unlike those followed elsewhere. These differences limit the comparability of tables because it is sometimes not clear what method was followed.

One further aspect of the treatment of imports in I-O tables is relevant to the connection between I-O and national accounting. In the method previously described, imports are treated as a sector (i.e., a column) of final demand with negative entries. Thus, imports are deducted from each industry's sale of its product and row totals are clear of imports. In the columns of the interindustry exchanges of matrix **A**, however, no deduction is made for imported inputs because column totals represent the total value of industry output, including the value of all inputs, imported or otherwise. Not all tables follow this scheme—some have no imports column in final demand (see Figure 2). Whether imports are deducted from total sales value, the presence of imports breaks the equality between row and column totals. Some industries buy more imports than they sell along with their own comparable product, whereas others distribute more imports than they absorb.

I-O ACCOUNTS AND NATIONAL ACCOUNTING

In most national accounts the analysis of gross domestic product (GDP) is done according to its industrial origin. This

Gross National Product

In the National Income and Product Accounts

Compensation of Employees	Personal Consumption Expenditures
Proprietors' Income	Gross Private Domestic Investment
Rental Income of Persons	Net Exports
Corporate Profits	Government Purchases
Net Interest	
Business Transfer Payments	
Indirect Business Taxes	
Less: Subsidies Less Current Surplus of Government Enterprises	
Capital Consumption Allowances	
CHARGES AGAINST GNP	**GNP**

In an Input-Output Format

	PRODUCERS	FINAL DEMAND				
PRODUCERS		Personal Consumption Expenditures	Gross Private Domestic Investment	Net Exports	Government Purchases	GNP
VALUE ADDED	Compensation of Employees					
	Profit-Type Income*, Net Interest, & Capital Consumption Allowances					
	Indirect Business Taxes					
	Charges Against GNP					

Consists of proprietors' income, rental income of persons, corporate profits, and business transfer payments, less: subsidies less current surplus of government enterprises.

U.S. Department of Commerce, Bureau of Economic Analysis

84-5-4

Input-Output Use Table

		INDUSTRIES									FINAL DEMAND (GNP)				TOTAL COMMODITY OUTPUT
		Agriculture	Mining	Construction	Manufacturing	Transportation	Trade	Finance	Services	Other	Personal Consumption Expenditures	Gross Private Domestic Investment	Net Exports	Government Purchases	
COMMODITIES	Agricultural Products														
	Minerals														
	Construction														
	Manufactured Commodities														
	Transportation														
	Trade														
	Finance														
	Services														
	Other														
VALUE ADDED (Charges against GNP)	Compensation of Employees														
	Profit-Type Income*, Net Interest, & Capital Consumption Allowances														
	Indirect Business Taxes														
TOTAL INDUSTRY OUTPUT															

* Consists of proprietors' income, rental income of persons, corporate profits, and business transfer payments, less: subsidies less current surplus of government enterprises.

U.S. Department of Commerce, Bureau of Economic Analysis

84-5-6

FIGURE 2 Relationship between gross national product and the I-O account.

method uses a readily available statistic and the simplest measure of the relative contribution of a sector to national product (though not a measure of total resources devoted to the production of that sector's output). In terms of accuracy or completeness, however, this measure is subject to the same qualifications that are attached to I-O totals of industry output or value added—industrial origin analysis in the national accounts is typically based on the results of I-O accounts.

In broadest terms, the relationship between I-O accounts and national accounts is

GDP = value added by industries

= final demand − imports

The GDP of the national accounts is identical (in principle) to the total of value added in the I-O account. The industrial origin analysis is the same in each. Figure 2, which reflects U.S. methodology, demonstrates this relationship (*1*).

THREE BASIC TABLES IN I-O ACCOUNTING

I-O accounting subjects data to essentially three different treatments, each giving rise to a basic table.

Transactions Matrix

This matrix of interindustry exchanges records the absolute values of goods and services flowing between industries in the accounting period (one year). It is bordered by the blocks for final demand, primary input, and the two totals (Figure 1). Sources of these data are censuses of production, the less common censuses of distribution, special studies, fiscal records, and special estimating efforts.

Several major decisions have been made when constructing this table. First, the way in which industries, commodities, or producing units are aggregated affects the results and meaning of any analysis based on the table. In an industry by industry scheme, changing the method of aggregation will change the gross output of industry just as would vertical integration of industries (e.g., sugar refineries integrating with sugar plantations). It is quite common for transport to be aggregated (in I-O as well as national accounting) with warehousing and frequently also with communications. The result is a loss of information on transport throughout the (output) rows and the (input) columns of the aggregate industry. A nuisance of special significance arises at the crossing of a row and column in the cell (the diagonal element) that records intraindustry transactions. The size of the entry in this cell is particularly sensitive to purely organizational features of an industry. For example, whether a railway contracts with independent road haulers or merges with them, payments arise in the former case and vanish in the latter. Because such features of an industry, and changes in them, do not have any necessary technological or economic meaning these entries may be removed at the row-and-column crossing from the table for purposes of analysis. This method was used for the empirical part of this study. If warehousing and communications are combined with transport, however, the contents of the diagonal cell refer partly to the result of otherwise irrelevant organizational peculiarities of the transport industry and partly to relevant exchanges between essentially different activities (e.g., road haulage under contract for the post office).

Second, a decision has to be made on the treatment of an industry's secondary products. Industries are normally defined by their products but many firms produce a variety, including some that are the principal products of other industries. Coke from gasworks is the usual textbook example. But an equally important example is the production of transport services by firms outside the transport industry for their own-account transport. The general treatment of secondary production varies between I-O accounts of different countries. The recommended method is to define principal products for an industry then split off secondary products and redefine them together with the corresponding inputs for the industry that has them for its principal product. But the principle differs between countries and the practice is likely to differ even more. Comparability between different tables is especially affected in the case of transport because the principle adopted in a country for the treatment of secondary production is not necessarily extended to own-account transport. United Kingdom statisticians seek to transfer own-account transport operations to the transport industry, whereas the U.S. Commerce Department does not. In the empirical part of this study, the U.S. method prevails in the various tables. An immediate consequence of this omission is that the value added in transport and its gross output as recorded in the tables underestimate the total value of transport activities in the natural (not the organizational) sense of the word. Furthermore, the use of transport service by different industries will be underestimated whenever they operate own-account transport.

Third, a decision has to be made about the prices at which transactions are valued: net indirect taxes (basic prices), producer prices (including tax), or at purchaser's prices (including taxes, trade, and transport profits). Most of the tables examined use producer prices.

Fourth, the treatment of transport costs in the sale or purchase price requires yet another decision. The principle most widely adopted and followed so far as feasible is to debit the cost of transport to the buyer of the product as a separate purchase made from transport (the f.o.b. method). Thus, it is assumed that the costs transferred are solely those of transport purchased from the transport industry as defined in the I-O classification.

Direct Coefficient Matrix

This matrix, derived from the transactions matrix, records in its columns the inputs that the industry receives from other industries, each expressed as a proportion of the receiving industry's gross output. These figures are the industry's direct input coefficients—its direct intermediate requirements per unit of its own gross production, in practice, per dollar of its gross output.

Total Coefficient Matrix

This matrix is constructed from the direct coefficient matrix by matrix inversion through solution of the simultaneous

equations underlying the I-O account. The coefficients that result in any one industry column express the inputs from each sector per dollar of that industry's gross output for given final demands and account for direct as well as indirect inputs (the fuel absorbed by transport to carry the fuel, etc.).

USES AND BASIC ASSUMPTIONS

I-O analysis has developed significantly since Leontief (*2,3*) and has become a central tool in planning, forecasting, and many types of policy analysis. Its use in international comparisons of the structure of production and the study of development was largely pioneered by Chenery (*4,5*).

Use of I-O accounting for any of these purposes, and even for the descriptive purpose of this study, is conditional on certain assumptions. Without these assumptions the coefficients in the tables cannot be thought of as requirements and as requirements of specific inputs. The first, homogeneity of industry output, has to be accepted if the entries in I-O tables are to be treated as technical coefficients rather than as coefficients thrown up by mere commercial arrangements or industrial organization. Second, the proportion of inputs to outputs is assumed to be linear. Each input into a particular sector is assumed to vary in direct proportion with that sector's output. It is known that such strict proportionality characterizes only a limited class of production processes. The more usual assumption in economics is that inputs are substitutable (so that the unit cost of an output is a strictly concave function of the price of any one input). In addition, constant returns cannot be accepted as an empirically valid condition of production in general. It follows that the expected error in projections of input requirements for a specified level of output, based on a given set of I-O coefficients, will be greater the larger the specified change in final demands or the greater the possible change in relative prices. Major abuses of I-O analysis become possible when this caveat is ignored or forgotten. For example, a study in the 1970s using fixed I-O coefficients obtained results with truly alarming consequences for U.S. production and employment from a 15 percent reduction of the output of the U.S. maritime industry.

RELEVANT QUESTIONS FOR TRANSPORT IN THE ECONOMY

In order to throw light on the role of transport in the economy input-output data will be used to answer the following questions:

1. What are the input requirements of transport, the sources of inputs, and the balance between intermediate inputs and primary inputs? The answers should point to some of the major determinants of the cost and efficiency of the activity and the impact of different tax systems on transport; and
2. What are the destinations of transport services, the sources of demand for transport, and the balance between intermediate and final demand? The answers are relevant to the relative degree of sensitivity of the demand for transport to variations in national output.

The establishment of these requirements will be attempted with the help of relatively simple tools of industrial structure analysis formulated mainly by Chenery (*4,5*) some 30 years ago. More sophisticated and complex experiments would be needed to explore the consequences for transport of technological change or general economic growth. For this study, more data would be needed than are available in the tables for the five different countries. The countries are heterogeneous and although one strives to find reasons for differences among data of the different countries, such rationalizations have to be viewed with caution.

CASE STUDIES

Five sets of input-output tables were reviewed, one table for each country in the study. Information obtained from each I-O table was based on the following: the year of reference, the definition of the sector, the share of transport in GDP (gross national product) from the national accounts, the number of sectors distinguished in the interindustry matrix, the definition of the prices used for valuing the flows of inputs or outputs, and special features of the tables. For each case study country the I-O table information was based on

- United States (*6–8*)
  - —Year: 1977.
  - —Sector definition: transport and warehousing.
  - —GDP share of transport and communications: 6.4 percent at market prices.
  - —Number of sectors distinguished: 85.
  - —Valuation: at market prices (including tax on inputs).
  - —Value added: includes taxes on sector output.
- Philippines (*9*)
  - —Year: 1974, updated to 1981.
  - —Sector definition: distinguishes five transport subsectors (busline, other public passenger transport, land freight, water, and air).
  - —GDP share of transport and communications: 5.4 percent at market prices.
  - —Number of sectors distinguished: 31.
  - —Valuation: at market prices including tax on inputs.
  - —Value added: includes taxes on sector output.
  - —Special feature: the object of the table was the analysis of energy requirements. Energy (and fuels) and transport sectors were therefore analyzed in considerable detail.
- India (*10,11*)
  - —Year: 1968-1969, updated to 1979-1980 prices.
  - —Sector definition: distinguishes subsectors: rail, other.
  - —GDP share of transport and communications: 6.1 percent at factor cost.
  - —Number of sectors distinguished: 89.
  - —Valuation: at factor cost; indirect taxes included in primary inputs (with value added).
  - —Special features: high level of disaggregation of agricultural sector.
- Côte d'Ivoire (*12*)
  - —Year: 1987.
  - —Sector definition: transport and communications.
  - —GDP share of transport and communications: 7.5 percent at market prices.

—Number of sectors distinguished: 33.
—Valuation: market prices, including taxes on inputs.
—Value added: includes taxes on output.

- Mexico (*13*)

—Year: 1975, transaction matrix updated to 1978 prices.
—Sector definition: transport.
—GDP share of transport and communications: 6.3 percent at market prices.
—Number of sectors distinguished: 72.
—Valuation: basic prices (exclude taxes); indirect taxes included in primary inputs.

For each case study country, the data used were noted for that country's heterogeneity in

- Definition of the sector that included transport,
- Relation of the time to which the underlying production data refer and the date of the prices applied to them,
- Extent of disaggregation of the economy, and
- Rule for valuing goods and services.

In addition to these differences are the highly probable differences in the treatment of imports in the different tables.

To improve comparability, the data were subjected to uniform treatment in two respects:

1. Intrasectoral transactions (the diagonal cells of the interindustry exchange table, at the crossing of the rows and columns for transport) were eliminated from the tables.
2. When tables were identified noncomparable imports they were included in primary inputs with value added by the industry receiving these imports because two of the tables merged this class of imports with value added. In the case of Côte d'Ivoire, this procedure could not be followed because imports were not separated into comparable and noncomparable. Total imports, by industry, are given separately and when added into primary inputs were found to form an improbably large proportion of the sum. The alternative is to assign imports wholly to intermediate inputs and this was the course adopted.

TRANSPORT AS USER OF RESOURCES

Two simple measures indicate the dependence of transport on intermediate inputs (and thus, by implication on primary inputs measured by the complement of the percentage share of intermediates). For convenience, intermediate inputs were named U and D:

1. The proportion of direct intermediate inputs in the gross value of output by transport (U) is computed from the direct input coefficients and was formulated by Chenery and Watanabe (*3*) for purposes of comparative structural analysis of industry. It is known also as the backward linkage coefficient because it reflects the extent to which activity is a source of demand for the outputs of other activities (*14*).
2. The index of the power of dispersion (D) is computed from the total coefficient matrix as the ratio of the average of total input coefficients in the transport column (the production function of transport) to the average of all total input coefficients in the matrix. Therefore, it measures the relative input-dependence of transport allowing for all the circles of interindustry exchanges. If $D > 1$, transport is a relatively intensive user of intermediate inputs. If $D = 0.5$, a dollar increase in the country's final demand generates only half as much additional demand for intermediate inputs for transport as for the country's average industry.

Table 1 shows the U and D indexes for the transport sectors or subsectors identified in the tables. It also shows the index for each country's total industry (Column 2) and the weights (Column 1) signifying the relative importance of transport subsectors in the two countries (Philippines and India) for which no sector aggregate is available.

THE LEVEL OF INTERMEDIATE INPUT SHARES

If the average share of intermediate inputs in gross output value across all industries is considered first, a notable degree

TABLE 1 INTERMEDIATE INPUT REQUIREMENTS FOR ALL INDUSTRY AND FOR TRANSPORT

Country and Sector	Weights: % of Value Added by Specified Sector (1)	*U*-Share of Intermediate Inputs in Gross Output			*D*-Relative Total Dependence on Intermediate Inputs (5)
		All Industry (2)	Transport		
			Sector (3)	Subsector (4)	
United States, 1977		.4896			
Transport and warehousing	100		.3229		.8438
Philippines, 1981		.5125			
Land freight	51			.4523	.9514
Public transport	13			.5063	.9912
Water	17			.5403	1.0612
Air	13			.5084	1.0794
India, 1979–1980		.4948			
Other than rail	77			.4650	1.0112
Rail	23			.3602	.9245
Côte d'Ivoire, 1978		.4426[a]			
Transport and communications	100		.4525[a]		1.0406
Mexico, 1978		.3733			
Transport	100		.2773		.9183

[a]Imports are not separated into comparable and noncomparable (left wholly with intermediate inputs).

of similarity exists between countries with the exception of Mexico. Intermediate input shares in the first four countries are between 44 and 51 percent, about the level found in most industrial or industrializing economies.

However, there is much less agreement between the shares of intermediate input in the transport sectors because the values for the United States and Mexico are well below those of the Philippines, India, and Côte d'Ivoire.

ROLE OF RELATIVE PRICES

Some part of the contrast noted previously can be explained by differences in relative prices and, specifically, the relative prices of fuels and labor. Table 2 presents the fuel input coefficients of transport as recorded in the five countries with the prevailing prices for the main fuels. Two petroleum-rich countries stand out in terms of both low fuel input coefficients (per unit of transport output) and low domestic fuel prices, kept at the time of the I-O table below world prices. If the fuel input coefficient for Mexico (0.06063) is doubled, bringing it closer to the corresponding coefficients for the Philippines, India, or the Côte d'Ivoire, the share of intermediate inputs for the transport sector would increase from the 0.2773 in Table 2, to 0.3373. Mexico thus underestimates gross output from transport.

The relative price of labor is more of a structural fact than the relative price of diesel fuel and the low share of intermediate inputs in the gross output of U.S. transport (Table 1, Column 3) may be explained in part by relatively high U.S. labor costs. A low share of intermediate inputs implies a high share of primary inputs within which labor accounted for 67 percent in the United States. Average share of labor in primary inputs across all industries was only 59 percent. The labor cost element in the cost of U.S. transport is higher than in U.S. industry in general and this should raise the share of primary inputs and depress that of intermediate inputs in gross transport output. Thus, relatively high labor cost and low fuel prices should explain some (unknown) part of the comparatively low shares of intermediate inputs in U.S. and Mexican transport products. The 1979 I-O accounts of the United Kingdom, a country with relatively high labor cost but with much higher relative fuel prices, have a *U*-index value for transport of 0.53, close to values found for the Philippines, India, and Côte d'Ivoire (Table 1, Columns 3 and 4). On the other hand, the United Kingdom's *U*-index for all industry is practically the same as that of the United States: 0.48 versus 0.49, respectively.

A NUMERICAL CONCLUSION: THE TYPICAL VALUE OF *U*

On the basis of the previous discussion it can be concluded that the average share of intermediate inputs in the gross output of transport in developing countries is about 45 percent. It then follows that the gross output of transport is about 1.8 times the value of the primary inputs into transport. If the noncomparable imports component of primary inputs is ignored (see Table 3), transport gross output would be about 1.8 times the value added in transport, as ascertainable from national accounts.

INTERMEDIATE INPUTS VERSUS PRIMARY INPUTS INTO TRANSPORT

For the United States, the main transport subsectors of the Philippines, India, and Mexico the share of intermediate inputs in the gross output value of transport is below the national average of this share (Table 2, Columns 2–4). In these countries, transport is intensive in primary inputs. The exception is Côte d'Ivoire where the *U*-index of transport lies close to the average for all industries.

Transport is largely classed as a nontraded good or service. In most countries, transport services are not in competition (actually or potentially) with imported services of the same kind. Except in countries that serve as important transit routes to others, international trade in transport services is confined to air and some shipping services. Therefore, in general world levels of costs (or efficiency in production of transport services) exercise little constraint on the costs and efficiency of national transport industries. Although direct competitive pressure from the outside is negligible there could still be

TABLE 2 FUEL INPUT COEFFICIENTS FOR TRANSPORT AND FUEL PRICES (*15*)

Country and Sector	Fuels	Fuel Input as Proportion of Sector Gross Output Value	Price per Gallon in U.S. Cents	
			Diesel	Premium Gasoline
Philippines, 1981				
Land freight	Diesel, gasoline	.19915	120.4	225.8
Public transport	Diesel, gasoline, and other	.2591		
India, 1979–1980				
Other than rail	Petroleum products	.14111	72.0–111.0	205–257
Rail	Coal, petrol products	.09111		
Côte d'Ivoire, 1978				
Transport and communications	Petroleum	.12156	N.A.	N.A.
United States, 1977				
Transport and warehousing	Diesel, petroleum refining, electricity	.09014	54.3	71.9
Mexico, 1978				
Transportation	Petroleum refining	.06063	11.0	67.0

TABLE 3 COMPOSITION OF PRIMARY INPUTS

Country and Sector	Payment to Labor (%)	Property-Type Income (%)	Noncomparable Imports (%)
United States, 1977			
Transport and warehousing	67	23	4
All industry	59		
Philippines, 1981			
Transport and communications	40		
All industry	33		
Côte d'Ivoire, 1978			
Transport and communications	57	41	[a]
All industry	33		
Mexico, 1978			
Transport	37	60	2

NOTE: India's I-O accounts do not distinguish labor and property-type income in gross value added by industry.
[a]Noncomparable imports cannot be distinguished for Côte d'Ivoire. Total imports were assigned as intermediate inputs.

indirect external effects on domestic transport cost levels transmitted through the prices of traded goods required in the production of transport service. The relatively low share of such intermediate inputs (including imported intermediate goods) in the gross output value of transport reinforces the effect of an absence of importable substitutes for transport. The lack of importable substitutes helps to shelter the cost of domestic transport from international costs, prices, and changes in them that follow from technical progress and other productivity improvements. Even in open economies, therefore, the lower the value of the *U*-index the more will the relative cost of transport be governed by the levels of competition and efficiency within the industry and not least by wage costs per unit of output (Table 3).

EFFECTS OF THE TAX SYSTEM

Two classes of taxes on the production of goods and services are the cascading type—turnover taxes and value-added taxes. The distorting effect of the turnover tax is a major argument in favor of the value-added tax. Transport, however, tends to have a relatively gross output. Other things being equal, transport may be relatively favored by a cascading system and should in any case benefit less than other industry from the institution of a value-added tax system (*16*).

TOTAL INPUT REQUIREMENT OF TRANSPORT

Total input coefficients represent the input requirements in response to a unit change in final demand calculated through the sequence of rounds of inputs into inputs. Coefficients in any one column thus depend on all other coefficients in the table. Averaging these total coefficients in the transport column and comparing the average with that of all total coefficients in the matrix results in the *D*-index. Its values (Table 1, Column 5) confirm what appeared from comparisons between the direct input coefficients for transport and all industry except in the case of India. For Côte d'Ivoire, India (nonrail transport), and the two lesser transport subsectors of the Philippines, the demand response of transport to a unit increase in general output is more intensive for intermediate inputs than for industry in general. In all other cases, the demand generated by transport for the output of other activities is less than for industry as a whole in India. Therefore, the direct input coefficients are a less reliable base for predicting requirements than in the remaining four countries.

TRANSPORT AS SUPPLIER OF SERVICES: TRANSPORT DEMAND

Once again two summary measures are used to indicate the sectoral destination of transport output or sectoral sources of demand for transport services and the sensitivity of transport demand to changes in general output:

1. The proportion of gross transport output going to other industries as intermediate services (*W*). This ratio is computed from the direct input coefficients and, like the index, was defined by Chenery and Watanabe (*4*). It is also known as the forward linkage coefficient because it expresses the support that transport (or any given sector) supplies to other industries. A relatively high ratio denotes relative predominance of intermediate uses of transport services.
2. The index of sensitivity (*S*) is the ratio of the average of the transport row entries to the average of all coefficients in the matrix. It indicates the relative importance of a sector as a supplier of intermediate inputs to other sectors, the comparison being with the average of all industries. Therefore, it measures the dependence of transport on industrial demand for its output relative to that kind of dependence for the country's industry as a whole. When this index exceeds unity transport has to increase output relatively more than other sectors for a unit increase in final demand in every sector.

TRANSPORT REQUIREMENTS: DEMAND FOR TRANSPORT

The presumed omission of own-account transport from the transport account in the I-O tables is likely to have more of a distorting effect on the reported structure of demand for

transport than on its input composition. Totals for transport services sold (row totals) and for resource requirements for transport (column totals) will be affected to an equal degree. But there is less reason to expect differences in input structures between professional and own-account transport than in the structure of demand (or destination of output) for the two modes of operation. Own-account transport tends to be used to a greater extent than professional transport for industrial purposes as intermediate service. The true *W*-index is thus likely to be underestimated in Table 4 (Columns 3 and 4). The size of the necessary correction remains unknown.

The demand structure of transport seems less likely to be a structural fact of the industry than its input structure. Transport in the United States and Mexico is presented in Table 4 as depending more on final demand than does the industrial sector as a whole. In the transport sector of Côte d'Ivoire and the main transport subsectors of India and the Philippines transport services are intermediate goods to a greater extent than industrial output in general. This does not hold for rail in India or for public transport, water, or air transport. In addition, water and air transport in the Philippines depend more than the average industry on sales to final demand.

DIRECT AND TOTAL TRANSPORT REQUIREMENTS

Although the distribution of total transport output between intermediate use and final demand differs a good deal between the countries there is striking similarity in the average direct transport input coefficients of their industries (Table 5). These coefficients are sensitive to the varying degrees of aggregation in the different tables with the means of the direct coefficients clustering around 2 percent. In four of the five countries, the dispersion of coefficients around the mean is also quite similar. Therefore, the average impact of changes in transport prices on industrial costs seems to be broadly similar in these different countries. Less uniformity exists in the total transport coefficients, which are highly sensitive to aggregation differences. Predictions of future demand for transport on the basis of direct input coefficients will be biased downwards. Table 5 indicates that the errors will be significant. When all repercussions have been taken into account, the average transport input coefficient is doubled in three of the five countries and raised by one-third in the other two.

Table 5 also presents the average of direct transport input coefficients for the groups of most intensive users—producers most sensitive to changes in productivity and prices of the transport industry. Identifying this group of main users may be difficult, but in terms more readily known they are the industries on whose activity and development transport operators depend most heavily. In principle, the two groups need not overlap, either fully or partially. Main users may be industries with transport input coefficients well below the national average, but have a high total output value relative for the total interindustry sales of the transport industry. A main user who is not also a most intensive user will have a larger total output value than the least intensive among the most intensive users. This relationship is illustrated by comparing the five most intensive users of land freight transport in the Philippines with the top five main users (Table 6). Using commodity producing sectors, three of five Philippine industries figure in either group. If trade is included in the 5 main users—an industry for which forecasts may be more difficult than for commodity sectors—the overlap shrinks to two in five. Excluding trade the two most important users of this major branch of Philippines transport, with a combined share of 40 percent of transport services provided to intermediate users, are not among the most intensive users. However, in a comparison with all industry all of the top 5 main users (whether trade is included or not) have transport coefficients above the general average. This result is the norm in the 4 I-O tables that permit the comparison of average direct transport coefficients for all industry and for the group of main users. For the practical purpose of determining required volumes of transport service, the average of industry coefficients is not usually relevant because coefficients for individual industries are expected to increase or decrease more than the average.

TABLE 4 SHARE AND INTENSITY OF INTERMEDIATE DEMAND FOR THE OUTPUT OF ALL INDUSTRY AND OF TRANSPORT

County and Sector	Weights: Value Added by Specified Sector (%)	Proportion of Gross Output for Intermediate Use (*W*)			Relative Total Dependence on Demand for Intermediate Use (*S*)
		All Industry	Transport		
			Sector	Subsector	
United States, 1977		.5619			
Transport and warehousing	100		.5268		2.3029
Philippines, 1981		.5969			
Land freight	51			.7280	1.1531
Public transport	13			.0657	.5383
Water	17			.6930	.7732
Air	13			.0958	.5427
India, 1979–1980		.5539			
Other than rail	77			.5833	2.7900
Rail	23			.4648	1.1235
Cote d'Ivoire, 1978		.4048			
Transport and communications	100		.4495		1.4035
Mexico, 1978		.4276			
Transportation	100		.3263		2.0088

TABLE 5 AVERAGE TRANSPORT REQUIREMENT PER UNIT DOLLARS OF OUTPUT

Country and Sector	Total in I-O Table	Direct Requirements: Mean Coefficient (%)	Direct Requirements: SD (%)	Direct Requirements: CV	Total Requirement: Mean Coefficient (%)	Total Requirement: SD (%)	Total Requirement: CV
United States, 1977							
Transport and warehousing							
Sectors	78	2.04	1.43	0.7	4.3	1.7	0.4
Most intensive users	10	5.1	1.51	0.3	7.3	1.3	0.2
Philippines, 1981							
Land freight transport							
Sectors	29	2.1	1.2	0.6	4.0	1.6	0.4
Most intensive users	5	3.8	0.8	0.2	5.3	1.2	0.2
India, 1979–1980							
Rail							
Sectors	88	0.6	1.2	2.0	1.2	1.3	1.04
Other than rail							
Sectors	88	2.5	1.8	0.73	4.7	2.6	0.56
Most intensive users	10	5.7	0.7	0.13	9.0	1.5	0.16
Côte d'Ivoire, 1978							
Transport and communications							
Sectors	30	2.0	3.4	1.7	3.3	3.5	1.06
Most intensive users	5	7.0	5.6	0.8	7.7	6.4	0.83
Mexico, 1978							
Transportation							
Sectors	71	2.0	1.2	0.6	2.9	1.4	0.5
Most intensive users	10	3.8	1.8	0.5	4.8	1.7	0.35

NOTE: SD – Standard Deviation
CV – Coefficient of Variation

TABLE 6 COMPARISON OF USERS OF PHILIPPINES LAND FREIGHT TRANSPORT

	A	A′	B
Five most intensive users			
Basic metals	5.2	7.3	4.8
Paper, publishing	3.6	5.1	2.0
Chemicals	3.6	5.1	5.0
Forest, wood production	3.5	4.7	5.0
Textiles	3.2	4.4	5.3
Subtotal			22.1
Top five main users			
Food products (1)	2.7	3.8	23
Construction (2)	2.5	4.5	12
Textiles (3)	3.2	4.4	5.3
Forest, wood production (4)	3.6	4.7	5.0
Basic metals (5)	5.2	7.3	4.8
Subtotal (1–5)			50.1
[Trade] (6)	[2.4]	[2.9]	[17]
Total (1–4, 6)			[62.3]

NOTE: **A** – Direct transport input coefficient.
A′ – Total transport input coefficient.
B – Share of total transport services delivered to industries.

TABLE 7 RELATIVE INTENSITY OF TRANSPORT USE BY DIFFERENT PRODUCER GROUPS

Country	A (%)	B (%)
United States		
All industry	2.04	
10 main users	4.01	40
Omitting Trade	3.96	32
India (excluding rail transport)		
All industry	2.5	
10 main users	4.0	47
Omitting Trade	3.0	34
Philippines (land freight)		
All industry	2.1	
5 main users	2.9	62.3
Omitting Trade	3.4	50.1
Côte d'Ivoire		
All industry	2.0	
5 main users	7.0	57
Omitting Trade	5.2	18

Averages are used for a quick characterization of the relative intensity of transport use by different producer groups (Table 7). For this table, *A* and *B* have the same meaning as in Table 6. The comparisons suggest that the main users of transport are transport-intensive industries relative to the average of the producing sector. Other things being equal, changes in the efficiency and unit price of transport (cost of the service to its user) should affect their costs and profits more than the effect on industry at large. Because transport-intensive industries are the main source of demand for transport their reaction will, in turn, have a relatively strong effect on transport. Trade and construction are in all cases among the main users of transport.

Sensitivity of Transport Demand to Changes in Production

The index of sensitivity *S* shown in the final column of Table 4 is computed using the rows of the total requirements table. Entries in the transport row of those tables show the production of transport services required, directly and indirectly, per dollar of output delivered to final demand by the respec-

tive column industries. The index then compares the average of these required transport inputs to other industries (per dollar of additional final demand for their products) with the average of total input coefficients in the table. Therefore, it measures the average effect on transport of equal increases in sales to final demand by all sectors relative to the corresponding average demand effect on all sectors. (Because of the use of total coefficients, all intermediate demands for inputs to support such a final demand expansion are, of course, brought into consideration.

The sensitivity index for the transport sectors of the United States, India, Côte d'Ivoire, and Mexico, and for the land-freight subsector of the Philippines, is always well above unity (Table 4). Therefore, in terms of the index, transport is distinctly more sensitive to general output expansion than the average industry because it has to expand output by more than the average industry to support this type of output expansion. It is unlikely that final demand will ever expand in this particular fashion, by equal amounts for each industry's output. When the entire pattern of incremental demands is specified (a standard step in planning exercises) in sensitivity planning exercises, the index seems as good a measure as any other for determining the relative effect of general marginal output expansion on the demand for the output of specific sectors. The magnitudes of the transport sensitivity index reported in Table 4 are such that it may be concluded that relatively high output sensitivity of transport demand will hold even for moderately uneven distributions of increments to final demand.

Size of the Transport Sector

Different summary indicators of the total size of an industry are usually answers to different questions. Therefore, in considering alternatives it is essential to be clear about the meaning of the indicator and the use to which it is to be put. Most uses require that the indicator permit logically valid comparisons with other aggregates.

Value added by transport is usually the most available indicator because it is part of the standard presentation of national accounts. Value added is the sector's contribution to GDP or gross national product and can be expressed as a percentage of them. Like other indicators drawn from national statistics, value added is safer to use for comparisons over time in the same country than for international comparisons. Interpreting the difference between the percentages of value added from transport in Côte d'Ivoire (9.6 percent in 1978) and the United States (6.4 percent in 1977) is difficult because the sector definitions are different. For example, in Côte d'Ivoire the definition includes communications with transport whereas in the United States warehousing is included. Furthermore, in the former, value added is at factor cost and in the latter, at market prices. In addition, U.S. national accounts include the value added by trade or public administration and defense whereas these are omitted in Côte d'Ivoire (or so it appears), yielding a smaller result. A more general objection to the value added measure is that in most countries it excludes the value added in own-account transport operations. This objection is no less valid for any other measure that does not include a deliberate correction for this omission. Although the computation of value added by transport will be done with different degrees of perfection in different countries, the concept is clear—the value (at local prices) of the annual product is the gross of capital consumption but net of all intermediate inputs (labor and capital) employed in what is defined as the transport industry.

Because the industry's labor and capital do not produce transport services unaided by supplies from other industries, value added is not a measure of the total resources devoted to the production of transport services. Gross output may seem to be the right answer to this question because it is the sum of value added plus intermediate inputs in transport. For a given technology, industrial organization, and differential productivity gross output in transport is not quite twice value added. Unfortunately, gross output is useless as a measure of the relative size of the transport sector because it cannot be related to the other aggregates such as GDP, which is net of intermediate inputs, nor to a grand total of gross outputs, which involves double-counting (the gross output of petroleum refining also being partly counted in the gross output of transport, and so forth). Therefore, the concept has limited uses. Planners may use it as the base from which to project or plan changes in the supply of transport to all uses. Because gross output measures industry turnover, it can be used in estimating the return to changes in turnover taxes. Also, the comparative movement over time of value added and gross output (the time path of the index) can serve as an indicator of differential productivity change. This use is safest done in the course of projecting because in ex post facto studies the problem of having to control for irrelevant changes in industrial organization or statistical aggregation must be faced. For example, India's seventh 5-year plan expects gross value added in transport to rise annually at 7.1 percent and gross output value at 8 percent, between 1984-1985 and 1989-1990 (*17*).

None of these indices of the total size of the transport sector cover the country's transport activity exhaustively. The gap consists of own-account, industrial, and personal transport. Most input-output accounts known do not attempt to reclassify the outputs and the corresponding inputs of industrial own-account transport operation to the transport industry. The overall importance of this omission (in terms of the proportion of the country's total freight transport cost excluded from the account of the transport industry) should be the larger. The smaller is the share of rail, water, and air in freight transport. A rough calculation for the United States suggests that the value added by personal consumption expenditure (and government consumption) accounts for final demand. In developed countries, the category of own-account transport operations constitutes a sizeable component of the transport output in the broadest sense. In the United States, personal consumption absorbs 26 percent of the total output of transport industry services. Even without government consumption (partly also personal transport) personal consumption is thus more than half of that consumed by intermediate uses of transport (Table 8). But personal consumption expenditure on petroleum refinery products (used partly for other household purposes) and automobile repairs amounts to almost twice as much as personal expenditure on services bought from the transport industry. In 1977, personal expenditure on

TABLE 8 PERSONAL CONSUMPTION OF TRANSPORT OUTPUT

From Industry	Delivered to: Intermediate Users[a] (all industry)	Delivered to: Personal Consumption	Delivered to: Government Consumption
United States (1977)			
Transport and Warehousing			
$ millions	58,805	33,210	7,194
Percent	100	56	12
Percent		100	
Petroleum Refining			
$ millions	49,561	38,595	5,831
Percent	100	78	12
Percent		116	
Automobile Repair and Services			
$ millions	16,997	25,437	775
Percent	100	150	8
Percent		77	
Motor Vehicles and Equipment			
$ millions	38,896[b]	46,124	3,026
Percent	100	119	8
India			
Railways			
Rs millions	9,247	6,751	2,629
Percent	100	73	28
Other Transport			
Rs millions	45,513	23,527	5,390
Percent	100	52	12
Petroleum Products			
Rs millions	25,933	10,852	1,525
Percent	100	42	6
Motor Vehicles and Repair			
Rs millions	8,611[b]	1,614	3,672
Percent	100	19	43
Motorcycles, Bicycles, and Repair			
Rs millions	2,890[b]	1,706	334
Percent	100	59	12

[a]Intra-industry transactions excluded.
[b]Value of output delivered to industries plus delivery to Gross Fixed Investment.

motor vehicles and equipment exceeded that of industry by almost one-fifth. For developing countries, ownership of the means of transport is less relevant. For example, in India (Table 8) the share of personal consumption in the total output of the transport industry (30 percent) and its share relative to that of intermediate industrial use are quite close to those in the United States. Personal expenditure on motor vehicles, motorcycles, bicycles, and repairs was only 28 percent of such purchases by classified industries. (Motorcycles and bicycles for intermediate use went to the other transport industry, which includes services by rickshaws of all kinds.) If government purchases are added the percentage rises but only to 64 percent of the purchases by industries. These quantities, besides confirming who are the passengers, are a better representation of the total personal transport output in developing rather than in developed countries, but are in no sense a full representation.

TRANSPORT AND ECONOMIC DEVELOPMENT: HYPOTHESES

Data for only five countries, each representing just 1 year, are not a sufficient basis for generalizations, but some hypotheses nevertheless emerge from even this small sample that are relevant to transport in the development process and also have a bearing on policy formation.

A Sheltered Industry

Inland transport is normally sheltered from foreign competition because professional transport depends less than the average industry upon intermediate inputs. Value added in transport accounts for a larger percentage of the value of transport services than is the case for other industries (Table 1). Therefore, technical progress in other parts of the economy will have a smaller effect on the cost of transport than it should have for the cost of the average industry. Sheltered by space and technology, transport efficiency and the control of costs and the level of prices depend critically on competition within the transport sector itself.

Growth-Sensitive Industry

Demand for transport as an intermediate input into production is sensitive, above the average for all industry, to variations in national output (Table 4). Because this conclusion is derived from I-O data, it is more likely to hold for small

rather than for large changes in national output (I-O analysis generally assumes that industries have an infinite elasticity of supply). Nevertheless, it points to a relatively high risk of transport acting as a bottleneck and a brake on growth.

A Wage-Intensive Industry

If gross domestic product per capita serves as a proxy for the national wage level, the data tell us that the share of value added in the value of national production tends to fall with the wage levels presented in Table 9. The corresponding share in the value of transport output in the sample is greater than the share for all industry and declines much more regularly with GDP per capita. The relatively high share of labor payments in value added (Table 3) hints that the transport industry, in national terms, is labor-intensive. More cautiously, transport is relatively wage-intensive and therefore sensitive above average to wage increases in the course of development.

In Poor Countries, A Producer's Good

Data in Tables 4 and 8 suggest that transport in poor countries is more of an intermediate product for use by other producers than is the output of the average national industry. Going down the income scale, the share of intermediate use of transport output tends to grow relative to the corresponding share for all industry. Taxes that fall on all transport (such as fuel tax rather than license fees that can distinguish trucks from cars) are therefore likely to interfere with the desirable object of productive efficiency, that is, the choices that producers would make in the absence of taxation. This interference seems to be stronger, the poorer the country.

TABLE 9 SHARE OF VALUE ADDED IN GROSS OUTPUT FOR ALL INDUSTRY AND FOR TRANSPORT PER CAPITA GROSS DOMESTIC PRODUCT

Country	1987 GDP ($U.S.)	Share of Value Added in Gross Output	
		All Industry	Transport
United States	18,530	.51	.68
Mexico	1,830	.63	.66
Côte d'Ivoire	740	.56	.55
Philippines	590	.49	.53
India	300	.50	.54

ACKNOWLEDGMENTS

The authors are grateful to colleagues at the World Bank, who helped them to gain access to I-O materials. Alan A. Armstrong of the University of Bristol and Claiborne M. Ball of the U.S. Department of Commerce provided information and advice.

REFERENCES

1. The Input-Output Structure of the U.S. Economy, 1977. *Survey of Current Business*, U.S. Department of Commerce, May 1984.
2. W. W. Leontief. *The Structure of the American Economy*. 2nd edition. Oxford University Press, New York, 1951.
3. W. W. Leontief. *Studies in the Structure of the American Economy*. Oxford University Press, New York, 1953.
4. H. B. Chenery and T. Watanabe. International Comparisons of the Structure of Production. *Econometrica*, Vol. 26, No. 4, 1958.
5. H. B. Chenery and P. G. Clark. *Interindustry Economics*. John Wiley & Sons, N.Y., 1959.
6. *The Detailed Input-Output Structure of the U.S. Economy*. Bureau of Economic Analysis, U.S. Department of Commerce, Vol. 1, 1977.
7. P. Ritz. *Definitions and Conventions of the 1972 Input-Output Study*. Bureau of Economic Analysis Staff Paper, U.S. Department of Commerce, July 1980.
8. G. Silverstein. New Structures and Equipment by Using Industries, 1977. *Survey of Current Business*, U.S. Department of Commerce, Nov. 1985.
9. *Philippine Statistical Yearbook, 1984*. National Economic and Development Authority, Manila, Republic of the Philippines, 1984.
10. *A Technical Note on the Sixth Plan of India*. Perspective Planning Division, Planning Commission, New Delhi, India, 1981.
11. M. R. Salvja. *Input-Output Tables for India: Concepts, Construction and Applications*. New Delhi, India (undated).
12. *Les Comptes de la Nation, 1978*. Ministère de l'Economie, des Finances et du Plan. Abidjan, République de Côte d'Ivoire, 1980.
13. *Matriz de Insumo-Producto, Ano 1978*. Secretaria de Programacion y Presupuesto, Mexico City, Mexico, 1978.
14. A. O. Hirschman. *The Strategy of Economic Development*. Yale University Press, New Haven, Conn., 1958.
15. G. A. Hughes and T. Tavana. *Petroleum Product Prices, 1970-1980*. World Bank Transportation Department, Washington, D.C., 1986.
16. J. A. Kay and E. H. Davis. *The VAT and Services*. World Bank, Development Research Department, Discussion Paper, Report DRD 245, Washington, D.C., 1987.
17. *The Seventh Five-Year Plan*. Planning Commission, New Delhi, India, Vol. 1, 1985.