DEVELOPMENT POLICY SIMULATION USING MULTIREGIONAL INPUT-OUTPUT ANALYSIS: A CASE STUDY OF SRI LANKA[1]

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ABSTRACT Infrastructure investments in developing regions should lead to higher productivity and increased output. It would be extremely useful to planners to have a practical way of modelling the expected economic impacts. This paper describes the construction and implementation of a multiregional input-output (IO) model for policy simulation, based on a case study of Sri Lanka. The model is used to simulate impacts of alternative infrastructure investment policies that vary by region and industry. Only small differences in output are found at the national level, regardless of the location of investment. However there are substantial differences in the impacts on regional output, with the rural investment scenarios creating the most regionally equitable outcomes. It appears that there is no serious conflict between regional equity and national efficiency as far as the location of new infrastructure investment is concerned. The modelling technique seems promising as a means to broaden the applied analysis of public investment programs.

1. INTRODUCTION

Planners are faced with the problem of the spatial allocation of infrastructure investments in order to optimise multiple objectives, including regional output. Increased investment in roads, power supplies, telephones, and water and sanitation systems should lead to higher productivity and increased output. However, regions respond differently to investments in each type of infrastructure, depending on their existing stocks of public capital and levels of development. It would be extremely useful to planners to have a practical way of modelling the expected economic impacts of various investments. This paper develops such a technique using multiregional input-output analysis and illustrates it through a case study of Sri Lanka.

Although theories of development give some general guidance for aggregate levels of investment, the mechanisms by which the provision of various types of infrastructure impact growth and development at the regional level have not been thoroughly explored. An improved understanding of this topic could give planners useful tools to influence firm and household location decisions, target projects intended to boost regional growth and social welfare, and improve urban/rural and

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interregional linkages. The multiregional input-output model developed in this paper provides a tool for simulating regional and sectoral impacts, in effect making possible policy experiments that can inform the development planning process.

Sri Lanka makes a good case study for a number of reasons. The country has been widely studied and there is a large literature of empirical work that describes development trends, in some cases going back 50 years. There is a wealth of data available at a fairly small geographic level that allows cross-sectional analysis of regions, and wide regional variation in economic activity and infrastructure stocks that make this cross-sectional analysis meaningful.[2] The analysis in this study is carried out on the nine provinces (hereafter referred to as regions) shown in Figure 1.

National development plans in Sri Lanka rely heavily on expansion of garment export production in every region, and line ministries are expected to provide infrastructure to support a regionally dispersed industry. However, it is an open question whether this dispersed development plan would in fact maximise national output and minimise regional economic inequities, as more remote locations could well be more expensive or less efficient.

This paper describes the construction and implementation of a multiregional input-output model for policy simulation. The second section presents an overview of the methodology in three parts: the national input-output table and its multipliers are described, the multiregional model is derived, and a simulation method is developed. Following descriptions of the methodology, several possible policy scenarios are simulated. In the third section, the model is used to simulate regional industrial policy. An expansion of garment production is assumed and the resulting impacts on regional and sectoral output are analysed. In the fourth section, the model is used to simulate the impacts of infrastructure policies. Investments in transportation, communications, and energy infrastructure are implemented and the regional and sectoral impacts are analysed. In the simulations, comparisons are made between investments that are evenly dispersed across the country, focused only on rural regions, and focused on the capital district. The paper concludes with observations on possible extensions of these analyses.

2. OVERVIEW OF MULTIREGIONAL INPUT-OUTPUT ANALYSIS

Multiregional input-output (MRIO) analysis allows the separation of an economy by region and by industry so that relationships may be simultaneously analysed both sectorally and spatially. The goal of its use in this study is knowledge of how industrial and regional output respond to developments such as infrastructure improvements. The results of such an analysis should have clear

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[2] A serious reservation stems from the long-running civil war in the Northern and Eastern provinces. As the regional economies are in a shambles and the data are questionable, results for those two areas are unreliable.

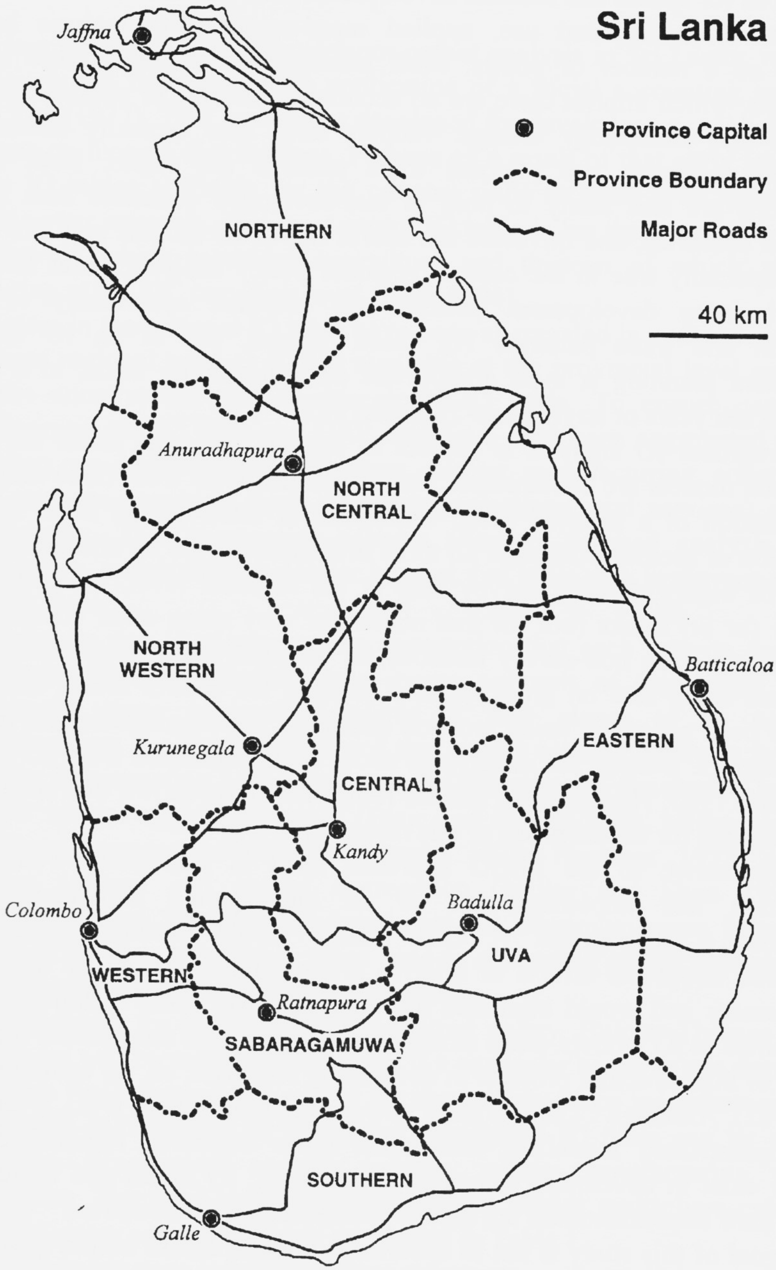

Figure 1. Provinces of Sri Lanka

implications for spatial and sectoral development policies.

Despite its widespread use, applied input-output (IO) analysis has been criticised on a number of points. Most models have assumed fixed technical coefficients, which implies there are no economies of scale or substitution effects as prices and technology change. Models have also typically assumed that production structures and regional trade patterns are stable. Both of these assumptions are less likely to hold in less-developed countries than in more-developed countries, and therefore the useful life of IO models may not be long. This is especially true in the case of regional policy analysis, notes Richardson (1985), because development policies are intended specifically to change production and trade patterns. For these reasons, use of an IO model for development planning is most appropriate on a short-term basis, to a planning horizon of ten years or so (Bulmer-Thomas 1982).

Multiregional IO analysis is subject to further criticisms about the ways in which such models are constructed. The difficulties stem from three main issues: regionalisation of a national table, estimation of interregional trade flows, and aggregation of sectors. Although all three difficulties could be eliminated through the use of highly detailed survey data at the regional level, no such data are available for Sri Lanka (nor for that matter for very many other countries). This study has relied on non-survey methods for all three tasks. Regionalisation was carried out using data on gross regional product for control totals, interregional trade has been estimated using location quotients, and aggregation has been from 24 to 8 sectors. Despite the misgivings about such techniques from IO specialists (e.g. Round 1983, Hewings and Jensen 1986), it will be shown that such methods are appropriate for the purposes of this research.

An alternative to the MRIO approach used in this study would be the construction and implementation of an interregional computable general equilibrium (CGE) model. A CGE model would produce more accurate information about the effects of relative price changes caused by infrastructure improvements and would eliminate the concerns over fixed technical and trade relationships in IO models. Such models have in fact been constructed for regional analysis of infrastructure projects in developing countries, as, for example, by Bell *et al* (1982). Although CGE is a more powerful approach than is IO, it requires far more sophisticated modelling and much more extensive regional data than typically exist in developing countries. In contrast, IO tables and basic regional data for their implementation are readily available in most countries.

The goal of this study is not to accurately forecast future output quantities but rather to compare in a practical way the effects of policy proposals under a constant set of assumptions. The attraction of the MRIO approach is that it can be implemented with very modest resources using data that are typically available at the regional level. The limitations of the MRIO model can be mitigated through its use for short to medium term analysis and for relative comparisons. Since it is the differences between alternatives that are of interest, rather than ultimate output levels, the MRIO approach is appropriate.

2.1 The National Input-Output Table

There is a well-known history of input-output analysis in Sri Lanka, including most famously the first large-scale application of a social accounting matrix by Pyatt and Roe (1977). That model was developed for development policy analysis, with a focus on income distributions. Perhaps as a result of that early start, there have been IO tables available for the country since at least 1970, produced at roughly five-year intervals. The most recent IO table is for the year 1991 with 24 sectors, five of which represent agriculture and thirteen of which represent manufacturing at the SIC two-digit level (DNP 1996).

The sectors in the national IO table have been aggregated in order to match the data on gross regional product (GRP) available at the provincial level and make possible the construction of a multiregional IO table. To ensure compatible sectoral coverage, the IO table and GRP data have each been aggregated to eight sectors: seven one-digit sectors (agriculture, mining, manufacturing, construction, electricity and gas, transport trade and communications, and services) plus the garment industry. This aggregation scheme allows a focused analysis of the garment industry, which is of particular interest due to its role in current regional development plans.

Aggregation to this level requires an assumption that each activity forming a one-digit sector should have the same inputs per unit of aggregated output. Although such severe aggregation seems at first glance to be an over-simplification, there is empirical evidence that such a scheme need not introduce serious errors in estimating aggregate impacts. This general conclusion has been validated for spatial aggregation only (Blair and Miller 1983, Miller and Blair 1981), sectoral aggregation only (Morimoto 1970, Hewings 1972) and for simultaneous sectoral and spatial aggregation (Miller and Shao 1990). In particular, Miller and Shao (1990) found that the maximum error between an aggregated and disaggregated table when used in estimating output impacts was 8 per cent when aggregating to as few as 5 sectors.

Most importantly for simulations of industrial policy, Bulmer-Thomas (1982) shows that there will be no aggregation bias if a particular sector is not aggregated and changes in final demand occur only for that sector. Since manufacturing was disaggregated in the original IO table, the aggregated IO table can be used to conduct policy experiments on any industry within manufacturing without introducing bias. The total input requirements and output multipliers calculated from the eight-sector aggregated table are shown in Table 1.

These multipliers are quite low. They suggest that inter-industry linkages are weak in Sri Lanka, and that most industries rely more heavily on imported inputs than is the case in more developed countries. The data in the original IO table lend support to this hypothesis. The share of manufacturing gross output represented by imports ranges from about 15 per cent to a high of over 60 per cent. The relatively high multiplier of 1.7 for the garment industry confirms its central importance to the Sri Lanka economy

Table 1. National Direct and Indirect Input Coefficients

	1	2	3	4	5	6	7	8
1 Agriculture	1.035	0.004	0.174	0.021	0.061	0.005	0.006	[illegible]
2 Mining	0.001	1.000	0.003	0.002	0.024	0.000	0.001	[illegible]
3 Manufacturing	0.074	0.011	1.067	0.082	0.205	0.008	0.020	[illegible]
4 Garments & Textiles	0.010	0.003	0.049	1.076	0.098	0.006	0.024	[illegible]
5 Construction	0.033	0.005	0.025	0.062	1.024	0.008	0.060	[illegible]
6 Electricity & Gas	0.048	0.012	0.055	0.126	0.044	1.057	0.045	[illegible]
7 Trade, Transport, & Communication	0.040	0.021	0.136	0.207	0.153	0.052	1.035	[illegible]
8 Services	0.045	0.042	0.040	0.150	0.080	0.088	0.047	[illegible]
Sum (Multipliers)	1.286	1.099	1.550	1.725	1.689	1.225	1.237	[illegible]

2.2 Construction of the Multiregional Input-Output Table

There are two steps to the creation of the multiregional model. First, the national input-output table must be regionalised in recognition of the fact that some regions are not self-sufficient in some sectors. This step produces a multiregional technical coefficients matrix in which the coefficients reflect intraregional inputs only. Second, interconnections between regions are modelled using trade coefficients. This step produces a multiregional trade matrix in which the coefficients reflect (estimated) trade flows. The two matrices are then employed in the solution to the input-output system, but in contrast to a national IO model, the solution to the MRIO model produces information on the *regional* impacts of changes in final demand.

The national input-output table for 1991 has been regionalised using data on gross regional product for 1990 as the sectoral control totals (DNP 1995). The GRP data matched the gross sectoral product reported in the IO table fairly closely (with the exception of the mining and electricity/gas sectors, which may be due to different definitions of those sectors between the two sources).[3]

The regional technical coefficients have been calculated using location quotients. Although there are other non-survey techniques that could be used given the available data (e.g. cross-industry or purchase-only location quotients), simple location quotients have been shown to be at least as good as any of the other quotient methods (Sawyer and Miller 1983).

The location quotient compares the regional share of a given industrial sector to the national share of that sector to determine exporting regions. The location quotients were calculated as shown in Equation 1, where the superscripts refer to the region or the nation, the subscript refers to a particular sector, and X is gross output.

[3] All output data are expressed in terms of constant 1993 rupees in this study.

$$LQ_i^R = \frac{X_i^R / X^R}{X_i^N / X^N} \quad (1)$$

Regional status as a net exporter or importer is determined by the location quotients. An *LQ* greater than 1 means that the region has a higher proportion of its output in a given sector compared to the national proportion. The region is assumed to produce a surplus in that sector; all regional demand is met locally and the surplus is exported to other regions. If the *LQ* is less than 1, the region is assumed to be a net importer in the sector.

The location quotients are used to construct the multiregional model as follows. The matrix of technical coefficients is generated from the national table, using the information on industry concentration embodied in the location quotients. For regions that are net exporters from a sector, the regional direct input coefficients for that sector are assumed equal to the national technical coefficients. For regions that are net importers, the regional direct input coefficients are obtained by multiplying each row of the national coefficients by the location quotient for that sector, thereby reducing the coefficients to account for the proportions of inputs that are not supplied locally. The multiregional technical coefficient matrix **A** is then constructed as a diagonal matrix of the regional matrices. Each regional table is an 8x8 matrix, and there are 9 regions, so the multiregional table is a 72x72 matrix. The process is summarised below in Equations 2 through 5 (where matrices are symbolised by bold-faced capital letters):

$$d_{ij}^R = d_{ij}^N \ \ if \ LQ_i^R \geq 1 \quad (2)$$

$$d_{ij}^R = d_{ij}^N (LQ_i^R) \ if \ LQ_i^R < 1 \quad (3)$$

$$\mathbf{A}^R = \begin{bmatrix} a_{11}^R & \dots & a_{1j}^R \\ \vdots & \vdots & \vdots \\ a_{i1}^R & \dots & a_{ij}^R \end{bmatrix} \quad (4)$$

$$\mathbf{A} = \begin{bmatrix} \mathbf{A}^1 & 0 & \dots & 0 \\ 0 & \mathbf{A}^2 & \dots & 0 \\ \vdots & \vdots & \vdots & \vdots \\ 0 & 0 & \dots & \mathbf{A}^n \end{bmatrix} \quad (5)$$

Once the multiregional technical coefficient matrix **A** is created, construction of a trade table is necessary to model the interconnections between regions. This requires the estimation of trade flows by sector between each pair of regions. Though there are several useful techniques for the estimation of interregional trade when actual flows are unknown, the necessary data to apply them are not typically available in developing countries. But given data on GRP by industry, as are available for Sri Lanka, quotient methods may be readily applied. Therefore a trade matrix is constructed using a modified location quotient method that simulates trade flows.

For a given sector i, regions are assumed to export "surplus" output if the industry is relatively more concentrated locally than nationally (that is, with a location quotient greater than 1). Regional exports E_i^R and total interregional exports E_i^N are calculated as shown in Equations 6 through 8:

$$\text{if } LQ_i^R > 1, E_i^R = \left(\frac{LQ_i^R - 1}{LQ_i^R} \right) \cdot X_i^R \quad (6)$$

$$\text{if } LQ < 1, \ E_i^R = 0 \quad (7)$$

$$E_i^N = \sum E_i^R \quad (8)$$

Trade between regions is estimated from these exports. For a given sector i, regions are assumed to import if the sector is relatively less concentrated locally than nationally (that is, with a location quotient less than 1). Interregional trade coefficients c are defined as the ratio of imports of input i from region R_1 to region R_2 compared to total imports of input i to region R_2. Since data on actual interregional trade are not available, it is assumed that regions import in proportion to the exports defined above, as shown in Equation 9:

$$c_i^{R_1 R_2} = \frac{E_i^{R_1}}{E_i^N} \quad (9)$$

Then for every pair of regions R_1 and R_2, a trade vector for a set of n inputs is defined by Equation 10.

$$\mathbf{C}^{R_1 R_2} = \begin{bmatrix} c_1^{R_1 R_2} \\ \vdots \\ c_n^{R_1 R_2} \end{bmatrix} \quad (10)$$

The trade vectors are converted to regional trade matrices for computational purposes, as shown in Equation 11, so that they may be used to modify the technical coefficients as explained below.

$$\hat{\mathbf{C}}^{R_1 R_2} = \begin{bmatrix} c_1^{R_1 R_2} & 0 & \dots & 0 \\ 0 & c_2^{R_1 R_2} & \dots & 0 \\ \vdots & \vdots & \vdots & \vdots \\ 0 & 0 & \dots & c_n^{R_1 R_2} \end{bmatrix} \quad (11)$$

Finally the multiregional trade matrix **C** is constructed by splicing together the individual regional trade matrices, which again results in a 72x72 matrix:

$$\mathbf{C}=\begin{bmatrix} \hat{\mathbf{C}}^{R_1R_1} & \hat{\mathbf{C}}^{R_1R_2} & \dots & \hat{\mathbf{C}}^{R_1R_j} \\ \hat{\mathbf{C}}^{R_2R_1} & \hat{\mathbf{C}}^{R_2R_2} & \dots & \hat{\mathbf{C}}^{R_2R_j} \\ \dots & \dots & \dots & \dots \\ \hat{\mathbf{C}}^{R_iR_1} & \hat{\mathbf{C}}^{R_iR_2} & \dots & \hat{\mathbf{C}}^{R_iR_j} \end{bmatrix} \qquad (12)$$

Once constructed, implementation of the multiregional model is similar to a single-region IO model. The multiregional trade matrix **C** is used in conjunction with the multiregional technical coefficients matrix **A** to simulate trade between regions. By converting the trade vectors into diagonal matrices and pre-multiplying, each row of the technical coefficients matrix is uniformly multiplied by the multiregional trade coefficients. This follows from the strong assumption that each sector in importing regions obtains its inputs proportionally from exporting districts. Similarly to the standard solution of a single region IO system, the multiregional system is solved as shown in Equation 13,

$$\mathbf{X} = (\mathbf{I} - \mathbf{CA})^{-1}\,\mathbf{Y} \qquad (13)$$

where **X** is the vector of *regional* outputs, **I** is the identity matrix, **C** is the multiregional trade matrix, **A** is the multiregional technical coefficient matrix, and **Y** is the vector of *regional* final demands.

The MRIO as constructed produces results that are close to those of the national IO model. Outputs of the two industries that are the foci of the simulations to follow, garments and transportation, are estimated to within 3% of their known levels. Other industries are within 5%, with the exception of mining and energy, probably due to inconsistent sectoral definitions between data sources. Multipliers calculated from the MRIO (shown below in Table 2) are in general smaller than expected, averaging 92% of the multipliers calculated from the national IO table. Because of these differences, two further refinements to this methodology would be desirable.

This first refinement would be to balance the model so that the sum of regional outputs exactly equal national output. Several alternative approaches might be suitable, including the well-known RAS technique. However, such adjustment is problematical for multiregional tables, as there is no unique way to apportion the adjustment dictated by control totals to more than 2 regions (Round, 1983). The second refinement would be to estimate the trade coefficients in a way that more accurately reflects actual net flows. A common criticism of the location quotient approach is that it underestimates trade, and therefore tables constructed in this way tend to underestimate impacts. There seems to be a consensus that gravity methods.are the best of the non-survey alternatives (Hewings and Jensen, 1986). Unfortunately the data to implement these methods (specifically regional estimates of intermediate sales and consumption) do not exist for Sri Lanka.

Table 2. Output Multipliers for Regional Impacts

Change in Demand	Impact	1	2	3	4	5	6	7	8
Western	Regional	1.123	1.041	1.187	1.348	1.357	1.098	1.100	1.126
	ROSL	0.108	0.045	0.163	0.297	0.243	0.102	0.097	0.092
Central	Regional	1.027	1.010	1.049	1.061	1.052	1.020	1.022	1.024
	ROSL	0.215	0.077	0.402	0.510	0.463	0.169	0.164	0.189
Southern	Regional	1.021	1.009	1.043	1.054	1.036	1.021	1.019	1.018
	ROSL	0.206	0.079	0.406	0.538	0.416	0.190	0.183	0.189
Northern	Regional	1.010	1.004	1.019	1.027	1.013	1.011	1.010	1.008
	ROSL	0.196	0.081	0.389	0.512	0.308	0.200	0.180	0.157
Eastern	Regional	1.008	1.002	1.037	1.012	1.012	1.005	1.005	1.011
	ROSL	0.122	0.050	0.277	0.300	0.201	0.116	0.107	0.108
N. West	Regional	1.014	1.005	1.050	1.034	1.025	1.013	1.010	1.016
	ROSL	0.152	0.064	0.338	0.416	0.300	0.152	0.135	0.139
N. Central	Regional	1.009	1.004	1.018	1.019	1.013	1.008	1.009	1.009
	ROSL	0.174	0.071	0.344	0.416	0.318	0.158	0.155	0.153
Uva	Regional	1.009	1.004	1.022	1.019	1.016	1.008	1.007	1.008
	ROSL	0.201	0.076	0.369	0.460	0.375	0.167	0.160	0.163
Sabara.	Regional	1.015	1.006	1.030	1.032	1.034	1.011	1.010	1.013
	ROSL	0.202	0.075	0.379	0.452	0.449	0.153	0.146	0.170

Despite the absence of these refinements, the MRIO constructed here produces results that are acceptably close for present purposes. Furthermore, the expected bias in this model is to underestimate impacts, so that the analysis to follow can be interpreted as providing a lower bound on any positive impacts that are identified. Since it is the impact of investments in roads and telephones that are of interest, exactly the kind of investment that should increase interregional trade, it is reasonable to expect that the true impacts could be larger and are probably not smaller.

2.3 Implementation for Policy Simulation

The final step in construction of the MRIO is to introduce a mechanism for simulating the price effects of infrastructure investments. A model in which trade coefficients and technical coefficients were responsive to price changes caused by infrastructure investments would be a significant advance. Attempts at incorporating the effects of infrastructure investments through endogenous variable prices in IO models were developed by Amano and Fujita (1970) and extended by Liew and Liew (1985). However, such models require much more extensive data than are available for Sri Lanka, so the simpler production cost approach is used here.

Better infrastructure is expected to lower production costs. To allow comparisons of policy alternatives, infrastructure investments are implemented as lump-sum subsidies to the receiving sectors in the IO model. The subsidies are assumed to reduce the price of output and be passed on in the form of lower prices.

Price changes are incorporated in the inter-industry relationships mechanically by adjusting the technical coefficients matrix in response to the implied price changes. As described by Ngo et al (1987) the technical coefficients can be decomposed into price and quantity components as shown in Equation 14:

$$a_{ij} = \frac{P_i x_{ij}}{P_j x_j} \tag{14}$$

where a_{ij} is a regional technical coefficient, x_{ij} is a regional intermediate input quantity, x_j is a regional output quantity, and P_i and P_j are the relative prices of a given sector's output[4] If these relative prices change, then the new regional technical coefficients a^* can be recalculated as shown in Equation 15:

$$a^*_{ij} = \frac{P^*_i}{P^*_j} \cdot a_{ij} \tag{15}$$

or in matrix notation as shown in Equation 16 (where as before the carat denotes a diagonal matrix that uniformly multiplies the rows of the technical coefficient matrix **A**):

$$\mathbf{A}^* = \hat{\mathbf{P}}^* \cdot \mathbf{A} \cdot (\hat{\mathbf{P}}^*)^{-1} \tag{16}$$

The impact of the investment can then be translated into final demand changes using the appropriate price elasticities of demand for low-income countries as reported by Lluch et al (1977). Those figures are 0.48 for agriculture; 0.46 for mining, manufacturing, garments, and construction; 0.46 for energy and other utilities; 0.53 for transport and communications; and 0.45 for services.

This approach requires three major assumptions about the impacts of marginal infrastructure investments. The first assumption is that price changes do not cause input substitution. This is a reasonable assumption in the case of transport improvements, since there is no real alternative to road transport in Sri Lanka. It may be less tenable in the case of the energy sector, since private investment in electricity generators is widespread but might become less so if the public supply improved. Though for long run analysis this assumption is not ideal, it is acceptable for the short term and for relatively modest investment amounts. Second, implementing investments as cost reductions implies that additional

4 Regional indices have been omitted from this equation for notational clarity but are implicit in the definition of the regional technical coefficient, input quantity, and output quantity.

investment improves service and does not simply create excess capacity. Though this has often been a problem in developing countries, anecdotal evidence in Sri Lanka suggests that congestion and poor quality are pervasive in the country's energy, communications, and transport facilities. The creation of excess capacity is not a likely outcome. Third, it must be assumed that production costs decrease equally for every firm that is affected by increased investments.

Finally, the change in output resulting from infrastructure investments is found from the standard solution to the MRIO model, but now using the new technical coefficients matrix as shown in Equation 17 (where the asterisk denotes matrices modified to reflect the change in relative prices):

$$\Delta X^* = (\mathbf{I} - \mathbf{CA}^*)^{-1} \cdot \Delta Y^* \qquad (17)$$

The following two sections employ this multiregional model to simulate sectoral and infrastructure investment policies. The policy questions revolve around the preferred industries for promotion, and the preferred location for infrastructure investments. The main comparisons are between metropolitan, rural, and national output changes.

3. IMPACTS OF SECTORAL DEVELOPMENT POLICIES

The MRIO model can be used to analyse the local impacts of changes in final demand on regional output and regional multipliers. Results from this analysis can lead to inferences about the effectiveness of sectoral and spatial polices on regional growth. They also provide a baseline comparison for infrastructure investment alternatives that are analysed in the next section of this chapter.

In the study of the Philippines by Ngo et al (1987), the interregional impacts of sectoral policies were analysed using a simple two-region IO model. Multipliers were calculated for each sector and region as the result of changes in final demand in Manila versus similar changes in final demand outside of Manila, and the impacts were disaggregated into interregional and intraregional components. The results showed that impacts in Manila from expansion outside the capital were sizeable, in some cases exceeding the impacts in the periphery from expansion in Manila. More importantly, intraregional impacts were by far the largest part of total impacts. Taken together these results imply that policies to encourage rural industry were not necessarily inefficient in the Philippines, and that the local impacts of rural investment could be as large as if the industry had been located in the capital.

These results have obvious implications for Sri Lanka. The vigorous promotion of the garment industry has resulted in the location of export-oriented manufacturing firms in nearly every district outside of Colombo. This policy was instituted to create rural industry and jump-start the local development process, based on an implicit assumption of growth via cumulative causation. From a national perspective the important questions to ask of this policy would be whether total regional and national output have been promoted or retarded, and whether regional equity has been improved.

Using a multiregional regional approach, it is possible to examine the impacts of manufacturing expansion in any one region on the other eight. In this study, expansion of the garment industry is simulated to test the feasibility of the government's export promotion plans. It is also possible to examine whether a Colombo-centred development policy would have larger or smaller impacts on the regions than would a more dispersed strategy.

As a first step, the output multipliers for the existing structure of production are calculated from the multiregional Leontief inverse. The national output multipliers are the column sums of that inverse, the intraregional multipliers are the column sums of the intraregional sub-matrix, and the interregional multipliers (noted as ROSL for the Rest of Sri Lanka) are the differences between those first two multipliers. The results are shown in Table 2.

From a sectoral development perspective, there are several important points to note about these multipliers. First, in all of the regions the interregional impacts of changes in final demand in any sector are much smaller than the intraregional impacts, showing that local multiplier effects dominate. Second, Western province has the strongest intraregional linkages in all 8 aggregate sectors, which would be expected given the concentration of industry around the capital district and the free-trade zones. Third, the highest multiplier and the highest interregional impacts are for the garment industry.[5]

From a regional development perspective, it is also important to note that the Central and Southern provinces have the largest interregional multipliers, as their provincial capitals are widely assumed to be the only viable counter-magnets to continued growth in Colombo. The interregional multipliers are a measure of how much of an impact on the rest of Sri Lanka would be caused by an expansion in economic activity in those two regions. If new industry is to be located away from the capital, these two regions may be good candidates.

Taken together, these results suggest that the emphasis placed upon the garment industry in Sri Lanka's regional development plans may be warranted. In five of the nine regions, the largest marginal gains to provincial output would be produced by increasing final demand in the garment industry rather than an equivalent increase in any of the other seven aggregate sectors. This is consistent with the findings of Ngo et al (1987) which found the multiplier for garments to be larger than all other industries and close to the value found here. For these five regions, garment factories have a larger impact on national growth than any of the other aggregate sectors.

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[5] Although the aggregation of sectors could tend to obscure some variation, the garment industry also has the second-highest multiplier in the original 24-sector national IO table.

4. IMPACTS OF INFRASTRUCTURE INVESTMENT POLICIES

Infrastructure investments are commonly used to promote, and even initiate, regional development. The actual impacts of additional infrastructure investments on interregional and intraregional growth have usually been taken for granted, however. It is not always clear whether the investments have produced the desired benefits. To address the lack of specific empirical knowledge about the results of such investments, the impacts of infrastructure plans can be simulated using the MRIO approach.

Several infrastructure investment scenarios are simulated in this section. Incremental investments are considered in the transport and communications sector, the energy sector, or both sectors combined. For each sectoral investment, three spatial scenarios are analysed: investment across all regions, in Colombo only, or in all regions except the capital region. In accordance with regional development theory it is expected that the impacts will vary widely.

Annual investment amounts are reported in the most recent national five-year public investment plan (DNP 1994). This plan shows annual average levels of investment in transportation (roads and rail) of approximately Rs 10 billion, in energy of Rs 6 billion, and in telecommunications of Rs 2 billion. A large multilateral aid project in Sri Lanka can approach 50% of these amounts. The total investment subsidy is therefore set at approximately half of annual infrastructure spending or Rs 5,000 million, distributed proportionally to the size of the sector in each region receiving the investment.

The first three scenarios simulate investments in the transportation and communications sector. They represent alternately a nation-wide distribution, concentration on the Colombo metropolitan area, or concentration in all regions except the capital region. Table 3 compares the incremental regional output that would be expected as a result of each scenario.

Table 3. Total Impacts of Transportation Investment Scenarios (Incremental Output in Rs Million)

	National	Colombo only	Rural only
Western	1,257.2	2,195.1	321.6
Central	267.9	87.5	453.4
Southern	222.8	69.1	380.7
Northern	123.2	36.8	211.8
Eastern	99.9	29.2	172.3
North Western	210.6	53.7	371.1
North Central	87.7	35.3	142.0
Uva	94.5	29.7	161.0
Sabaragamuwa	156.2	45.8	269.3
Total	2,519.9	2,582.0	2,483.3

The three transportation scenarios compare closely in terms of total impact on national output, but vary considerably in terms of impacts in each region. The Colombo-only scenario produces the largest output gain, and the rural-only scenario results in the most equitable impacts across regions while sacrificing only a small amount of potential output. The biggest sectoral gain is in the subsidised transportation sector. In the Colombo-only scenario, both the garment industry and energy industry show sizeable increases in output: 40 per cent for garments and 20 per cent for energy. Other sectors remain fairly static, with output gains of less than 1 per cent.

The second three scenarios simulate investments in the energy (electricity and gas) sector. They again represent a nation-wide distribution, concentration on the Colombo metropolitan area, or concentration in all regions except the capital region. The total investment is again Rs 5,000 million in each scenario, distributed proportionally to the size of the sector in each region receiving the investment. Table 4 compares the incremental regional output that would be expected as a result of each scenario.

As in the transportation investment scenarios, the three energy investment scenarios compare closely on the size of the increase in national output, but again vary in terms of impacts in each region and sector. However in this case the regions-only scenario produces both the largest output gain, and the most equitable impacts across regions.

The third set of scenarios simulates simultaneous investments in both the transportation and energy sectors. The total investment is again Rs 5,000 million in each scenario, distributed proportionally to the size of the sector in each region receiving the investment. Table 5 compares the incremental regional output that would be expected as a result of each scenario.

Table 4. Total Impacts of Energy Investment Scenarios (Rs Million)
(Incremental Output in Rs Million)

	National	Colombo only	Rural only
Western	692.6	988.3	267.7
Central	105.1	59.2	189.2
Southern	126.6	54.3	252.4
Northern	64.9	27.2	130.2
Eastern	41.6	23.2	75.1
North Western	85.0	42.9	159.9
North Central	38.9	24.3	66.6
Uva	41.6	23.6	74.6
Sabaragamuwa	51.5	35.7	83.2
Total	1,247.7	1,278.7	1,298.9

Table 5. Total Impacts of Combined Investment Scenarios (Rs Million)
(Incremental Output In Rs Million)

	National	Colombo only	Rural only
Western	1,200.8	2,050.8	313.4
Central	251.8	83.4	432.2
Southern	213.1	66.6	370.0
Northern	117.3	35.2	205.2
Eastern	94.1	28.2	164.5
North Western	198.2	51.8	354.3
North Central	82.8	33.6	135.8
Uva	89.2	28.6	154.1
Sabaragamuwa	145.8	44.2	254.5
Total	2,393.1	2,422.4	2,384.0

Table 6. Comparison of Investment Scenarios
(Incremental National Output in Rs Million)

	National	Colombo only	Rural only
Transport and Communications	2,519.9	2,582.0	2,483.3
Energy	1,247.7	1,278.7	1,298.9
Combined Transport and Energy	2,393.1	2,422.4	2,384.0

In all three sets of scenarios, there is only a small difference in the total impact on national output, regardless of the location of the investment. Most of the difference in output between the scenarios is accounted for by the subsidised sector. The inter-industry impacts are fairly small, but consistently positive. However there are substantial differences in the impacts on regional output, with the rural-only scenarios creating the most regionally equitable outcomes. The spatial and sectoral development scenarios can be compared in terms of the total impact on national output as shown in Table 6.

There is very little difference in national output within a given investment scenario. Comparing between scenarios however it is obvious that subsidies to the transport and communications sectors would produce the largest gain in national output. Since output increases everywhere, regardless of the location of the investment, it also appears that regional investments can be used to jump-start regional output without negatively impacting national growth.

5. CONCLUSION

Based on these simulation exercises, it appears that there is no serious conflict between regional equity and national efficiency as far as the location of new infrastructure investment is concerned. The increments in national output from a provincial investment strategy, regardless of infrastructure sector, would nearly equal those from a strategy focused on the capital region.

These results are consistent with the development plans in place in Sri Lanka and in many other developing countries. However they should be interpreted cautiously when considering the transferability of such plans as there may be unique reasons for Sri Lanka's rural success. It is a small and very densely populated country, with an extensive road network that a truck can traverse in a day. It may be that the combination of density and proximity strengthens the linkages between rural and urban firms and allows rural firms to remain productive and make the most of additional infrastructure investments even when situated away from the main centres. The structure of production in the country is heavily oriented toward export goods that have a high import content. Both of these factors may make the potential gains from interregional trade relatively more important.

The goal of this simulation exercise has been to suggest a framework for determining the allocation of future infrastructure investments to promote regional growth, in light of existing output effects and spatial relationships. The multiregional IO model developed in this paper provides a tool for simulating regional and sectoral impacts, in effect making possible policy experiments that would inform the development planning process. The data requirements of the model are modest, relying as it does on tables that are readily available in many developing countries. The technique seems promising as a way to broaden and generalise analysis of the impacts of infrastructure investments.

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