Estimating the economic impacts of the Padma bridge in Bangladesh

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EXECUTIVE SUMMARY

Construction of Padma Bridge is expected to generate welfare to the people of Bangladesh in general and the people of South West in particular. The benefits are expected to arise from the greater integration of regional markets within the Bangladeshi national economy. Moreover, given the interdependence of economic activities/sectors, the direct impacts of the Padma Bridge on individual sectors and factor markets are likely to induce a chain of changes in the rest of the sectors of the economy.

In this exercise, attempts have been made to quantify the economic as well as welfare implication of Padma Bridge using four different types of methodologies. Although strict comparisons of the outcomes of these models are not usually advocated, they have been used in this exercise to examine the robustness of the project benefit outcomes[3].

1. Although, it is customary to use 'traffic' models to estimate the benefits of transport project (e.g. Padma Bridge), reliance only on the traffic model may underestimate full benefits of the project since such model can only capture primary or direct benefits in the form of efficiency gains arising out of cost and time saved.

2. The secondary benefits of a transportation project are also substantial. The secondary effects may be generated due to multi-sectoral productivity gain through structural change occurring in the economy from improved productivity made possible by the bridge. The well known models for capturing secondary benefits are SAM based fixed price and CGE models.

3. Hence in addition to adopting the traffic model, both SAM based fixed price and CGE models are employed to estimate full benefits of the Padma Bridge project. In this context the full benefits would thus compose of efficiency gains of traffic model and the economy wide benefits of the SAM and CGE models.

4. Because of its location in the South West region of Bangladesh, Padma Bridge is expected to have larger impacts on this regions compared to the other parts of Bangladesh. A regional CGE model, although not an impossibility, has not been possible because of lack of required region specific parameters and elasticity values. However a regional SAM model was formulated to assess the impacts of Padma Bridge on the SW region of Bangladesh.

Social Accounting Matrix (SAM) constructed for Bangladesh economy as well as for the South West region served as the data bases for the above three economy wide models. Following simulations were carried out to examine the benefits of the Padma Bridge. More specifically, four simulations have been conducted for the SAM-Based Model. These are:

[3] All these models are stand alone model and hence their outcomes should be considered independent of each other. Strict comparison is not advocated in the literature. However, in this exercise road user benefit of the traffic model is combined with the outcome of the SAM model (i.e. considering it as a measure of economy wide secondary impacts due to the implementation of the project) to derive total benefit of the project.

I. Simulation 1A (National): Total investment cost of building Padma Bridge will be around $2.9 billion, out of which $2.1 billion will roughly be injected into the national economy.The rest of the total cost will consist of imported inputs, interest charges etc. $2.1 billion is expected to be injected into the economy in the following way: Construction sector $1.4 billion, utility $0.1 billion, trade $0.1 billion, transport and communication $0.15 billion, different kinds of services (professional, financial, public administration, social etc) $0.3 billion and food $0.05 billion. This total injection figure would exclude foreign imports, contingencies, IDC etc from the total cost of the bridge. All other exogenous elements remain unaltered.

II. Simulation 1B (Regional): In order to simulate the impact of the Padma Bridge within the Regional SW SAM model, we performed similar injection of $2.1 billion into the regional economy. We did two alternative scenarios for the regional economy—one scenario assumes that 100 percent of the investment stimulus will be felt in SW region and the other scenario is that 70 percent of the stimulus will be operative in south-west region. All other regional exogenous elements remain unaffected.

Operation of Jamuna Bridge suggests that additional demand may arise for consumer goods, energy and utility services and as well as transport services. These demand effects are due to bridge construction and associated services activities. Therefore, in line with the Jamuna Bridge impact analysis exercise, further simulations were carried out (i.e. 2A and 2B) to capture economic impacts of demand created by the investment stimulus of $2.1 billion. The simulation set ups are explained below:

III. Simulation 2A (National): Increase in sectoral demand of other crops by 10 percent, Fisheries by 10 percent, Utility by 5 percent and Transport by 20 percent at the national level:

IV. Simulation 2B (Regional): Increase in sectoral demand of other crops by 20 percent, Fisheries by 20 percent, Utility by 10 percent and Transport by 50 percent at the regional level:

Construction of Padma Bridge likely to lessen time needed to move goods leading to reduced transport margins. In line with the study on Jamuna Bridge a similar simulation is conducted under the CGE framework where sectoral transport margins are reduced and its impacts on resource re-allocation, sectoral output and consumption, poverty and income distribution situation of the representative household groups are examined. The simulation is as follow:

V. Simulation 3: In the CGE simulation base values of the sectoral transport margin rates are reduced by 50 percent. The base values of all other parameters are retained.

Although outcomes of all types of models are positive, the results show variations due to especially to size of shocks. The results are summarized below.

1. In the Traffic model, road users benefits are estimated based on the saving on vehicle operation costs (VOC) and savings in travel time cost (TTC). Total road user benefit is estimated to be about million 1,295,840 taka ($18,512 million) over the 31 year period.

2. As for economy-wide (secondary) benefits, use of national SAM with injection of $2.1 billion into the economy (i.e. Simulation 1A) produced economy wide (secondary benefits) in terms of value added of taka 453,670 million ($6481 million) over a period of 31 years, which represents 10.6 percent growth. This would give an annualized growth rate of 0.33 percent of national base GDP. This is obtained by dividing the total economy wide benefits by 31 to get an average annual incremental flow of value and dividing that figure by base GDP figure, we get this (0.33 percent) annual figure. If the WEB figure is added to with direct (traffic) benefits, the annual size of the benefits of the bridge, in relation to GDP, would be larger, as noted later.

3. Compared to national GDP the average annual increase in SW regional base GDP because of WEB alone will be 2.3 percent. This is on the assumption that a 100 percent of the shock will occur within the regional economy. However, if we assume that only 70 percent of the shock would be operative in the region (and not full 100 percent), the equivalent of annual rate of growth regional GDP would be roughly 1.66 percent. The annual equivalent rate of growth was calculated keeping in view the 31 years as the time taken to fully realize the impact of the bridge. If we took a shorter time horizon for fully realizing the benefit of growth, then the annual equivalent rates could be larger. Given that SAM based model assume excess capacity (which may be a reasonable assumption in a country like Bangladesh with under-utilized resources), the size of impacts vary with the size of injection or shock.

4. To sum up, using the Traffic model, road users benefit is found to be million 1,295,840 taka ($18512 million). We consider value added increase of million 453,670 taka ($6481 million) derived from the national SAM model (i.e. simulation 1A) as economy wide benefits of the project. Thus, total project benefit is estimated to be 1,749,510 million taka or $24993 million. The breakdown is: Total (1,749,510 million taka or $24993 million) = Road User Benefit (1,295,840 million taka or $18512 million) + WEB (453,670 million taka or $6481 million). This implies that total project benefit is 39 percent relative to the base national income (i.e. 4,468,549 million taka or $63836 million). Assuming the 31 year full realization timeframe, total project benefits per year is then 1.26 percent relative to the base national income. The base year GDP figure would not remain the same over 31 years. Assuming 5 percent GDP growth over (as experienced in recent years) the 31 period an alternative estimate of base year is arrived. The total project benefit (i.e. 1,749,510 million taka or $24993 million) is only 0.56 percent relative to the alternative base national income. Under certain assumptions, the relative size of annual increase of output for the SW region would be 1.66 percent considering the WEB alone. If the total benefits were taken into account, the relative size of annual flow of benefits in comparison to regional GDP would, of course, be larger and, would depend on how much of the traffic benefits would accrue to the south-west region.

5. Further assessment of the total project benefits (explained above) in terms of conventional project appraisal measures suggests that the project is economically viable. More specifically, the project is viable with:

- a net present value of US$ 1234 million;
- a benefit-cost ratio (BCR) of 2.01; and
- an economic internal rate of return (EIRR) of 19 percent.

6. The application of constrained optimization model such as CGE model outcomes also vindicates the findings of the traffic model and SAM based model. More specifically, 50 percent reduction in transport margins may lead to welfare increase by 0.78 percent compared to the base value.

7. Under certain assumptions (Simulation 1A), the construction of the Padma Bridge would lead to an annualised reduction in head-count poverty at the national level by 0.84 percent and at the regional level by 1.01 percent. Other simulations also indicated reduction in poverty in different magnitudes.

I. INTRODUCTION AND BACKGROUND

The Padma Bridge will be built to provide road and rail links between the relatively less-developed Southwest region (SWR) of the country and the more-developed eastern half that includes the capital of Dhaka and the port city of Chittagong. By facilitating transportation across the river, the bridge is expected to lead to a greater integration of regional markets within the Bangladeshi national economy. Given the interdependence of economic activities/sectors, the direct impacts of the Padma Bridge on individual sectors and factor markets are likely to induce a chain of changes in the rest of the sectors of the economy. This in turn is expected to result in subsequent feedback effects. These indirect and induced impacts can be estimated utilizing Social Accounting Matrix (SAM) and Computable General Equilibrium (CGE) models. Moreover, we use the results of the model simulations and feed them into the poverty module to estimate the impact of the bridge investment on national as well as regional poverty levels. Furthermore, the simulated income affects are also be included into the 'cost-benefit' analysis for a complete economic evaluation of the Padma Bridge.

It is expected that the Padma Bridge will have the most significant economic and poverty impacts in Khulna and Barisal Divisions – the southwest region of Bangladesh. Therefore, it is also imperative to conduct simulation of the Bridge's impact at the regional level utilizing an input-output table for the Southwest and a restructured SAM model that takes into account region-specific households (i.e. Southwest regional SAM based model). Incorporation of region-specific households within a SAM framework would surely provide additional avenues for a more comprehensive assessment of the impacts of the Bridge on sectors, household income-consumption and, hence, on the poverty situation at the regional level.

In order to assess the impacts of the Padma Bridge, a SAM based-fixed price model and a CGE based-flex price model are used in conjunction with the traffic model. Models based on regional SAM are not readily available and thus these models have been built to simulate the impacts at the regional level. The 2007 SAM for Bangladesh has been modified to incorporate regional dimension both in production and institutional accounts. The 2007

SAM is transformed[4] into a fixed price demand driven model to assess the impacts of additional demand (i.e. presumed to generate due to Padma Bridge) on the regional as well as on the national economy of Bangladesh. Also, a CGE model for the Bangladesh economy is used to explore the impact of reduction in transport margin.

Although, it is customary to use 'traffic' models to estimate the benefits of transport project (e.g. Padma Bridge), reliance only on the traffic model may underestimate full benefits of the project since such model can only capture primary or direct benefits in the form of efficiency gains arising out of cost and time saved. However, the secondary benefits of a transportation project are also substantial. The secondary effects may be generated due to multi-sectoral productivity gain through structural change occurring in the economy from improved productivity made possible by the bridge. The well known models for capturing secondary benefits are SAM based fixed price and CGE models. Hence in addition to using the traffic model, both SAM based fixed price and CGE models are employed to estimate full benefits of the Padma Bridge project.

A SAM is a square matrix with columns for expenditure and rows covering income accounts. It combines input-output data with national accounts data to reflect the circular flow of income at a particular point in time. In this context, its key use is to assess the economy wide effects of a particular exogenous impact (such as the completion of the Padma Bridge) that leads to different expenditure patterns. Two limitations of the SAM model are (i) fixed price ruling out reallocation of resources due to price changes and (ii) excess capacity ensuring supply due to demand increase. As a result of these limitations, a SAM may overestimate the impact of investment shocks, especially in a full-employment economy.

On the other hand, CGE analysis, allows for the assessment of the impacts of exogenous shocks (such as the completion of the Padma Bridge) within a constrained optimization framework (i.e. changes in quantity are restricted). At the core of the CGE model is a set of equations describing the behavior of various economic agents (such as firms and

[4] A Social Accounting Matrix is a macroeconomic data set consists of accounts such as activity; commodity; factors; households etc. SAM data set is transformed into a model by assigning some of the SAM accounts as endogenous and exogenous.

households) when faced with changes in relative prices. Furthermore, CGE models which invoke fully flexible prices and supply-side constraints usually underestimate the effect of investment or policy shocks. In order to examine these bounds, both SAM and CGE models are employed in this exercise.[5]

Furthermore, because of its location in the South West region of Bangladesh, Padma Bridge is expected to have larger impacts on this regions compared to the other parts of Bangladesh. A regional CGE model, although is not an impossibility, could not be used due to lack of required region specific parameters and elasticity values. So a regional SAM model was preferred over a regional CGE model to assess the impacts of Padma Bridge on the SW region of Bangladesh. A South West region SAM model was also used to assess Padma Bridge impact on the SW of Bangladesh.

II. JAMUNA BRIDGE STUDY[6]

Similar SAM based and CGE models were also used to estimate the economy wide benefits of the Jamuna Bridge (JB). The economy wide effects were estimated by applying conventional macroeconomic tools, making use of an improved version of Bangladesh's Social Accounting Matrix (SAM) model and a standard Computable General Equilibrium (CGE) model. Working with a national level SAM, however, restricts this type of analysis, in spite of the inclusion of region-specific household groups. This is because the size of change observed in any activity pertaining to a region is normally scaled down so that the size of the effect is small. The effect at the household level is further underestimated since the estimated total change through a national SAM is distributed across households in all regions. A second exercise was, therefore, carried out to supplement the findings of the first exercise by estimating changes at the regional level by using a regional SAM. A regional SAM was thus constructed to capture region-specific outcomes.

[5] These models are comparative static models showing before and after shock and are not projections showing growth paths. Only the traffic model used to estimate the direct benefit does the projection of only the traffic growth.

[6] For details please see Jamuna Bridge Impact Study, Final Report, prepared on behalf of: Asian Development Bank (TA No. BAN 3681), The Louis Berger Group, Inc. February 2003

In the SAM approach, the impact of the JB was demonstrated through enhancing the demand of other crops, electricity and transport services. Three simulations were carried out for **SAM model** are described below:

Table 1: Description of Simulations of the Jamuna Bridge Study

	Application of SAM	Increase in demand
Simulation	National	▪ Other crops—5%
		▪ Utility (Electricity) —5%
		▪ Transport—16%
Simulation 1	Regional	▪ Other crops—20%
		▪ Utility (Electricity) —10%
		▪ Transport—50%
Simulation 2	Regional	▪ Other crops—20%
		▪ Utility (Electricity) —10%
		▪ Transport—100%

The outcomes of the SAM models for the Jamuna study are presented below. Since there is no capacity constraints, matching outputs are always supplied (as a result of demand interventions), which resulted in higher factorial incomes and household consumption expenditure.

Table 2: Total and Annualized Economic Impacts of Simulations of the Jamuna Bridge Study

(Percentage Change from Base Values)

	National SAM Based		Regional SAM: Simulation 1		Regional SAM: Simulation 2	
Increase in:	Total	Annualized	Total	Annualized	Total	Annualized
Output	29.73	1.19	37.2	1.49	45.65	1.83
Factor Income	28.97	1.16	35.23	1.41	44.29	1.77
Household Income	28.03	1.12	35.72	1.43	44.15	1.77
Poverty Reduction	30.17	1.21	39.92	1.60	47.47	1.90

Note: Poverty reduction rate is reported to have been 1.1 percent per year during 1991-2000.

On the other hand, in the CGE case the simulation was performed by reducing the transport margin rates. The base values of the sectoral transport margin rates are halved (i.e., reduced by 50 percent) to examine their implication on variables both at sectoral and macro levels[7]. The base values of all other parameters are retained.

The changes in transport rates alter the relative price situation in the economy, which then led to the reallocation of existing resources to various producing activities. The gains are obtained by reducing existing distortions and hence they are small. Since supplies of primary factors were fixed there is no scope of generating extra income by employing additional factors (as was the case in the SAM approach).

[7] The sectoral transport rates are derived as proportions of sectoral total domestic sales values.

Aggregate consumption expenditure, domestic sales, exports and imports are found to be enhanced by 1.05, 1.10, 1.37 and 0.89 percent compared to their base values. However as expected the most impressive gains have been found for the general price index which declined by 3.4 percent. The positive growth of the economy and moderate fall of general price index led to the enhancement of national welfare by 0.51 percent of base value of household income.

III. TRAFFIC MODEL[8]

Road users benefits, estimated based on the saving on vehicle operation costs (VOC) and savings in travel time cost (TTC). Vehicle operating cost (VOC) is used to provide economic value in distance savings covering various factors such as fuel, tiers and maintenance etc. For economic valuation unit VOC was derived from the "Road Users Cost Report, 2004-05", RHD. Total VOC was disaggregated into fuel and non-fuel components, which were then escalated to 2009 values by the increase in average petroleum spot price (IMF, 2009b) and Consumer Price Index (BBS, 2009a). A measure of Value of Time (VOT) is used to convert travel time savings into a monetary value. Savings in travel time costs account for 23% of total benefits estimated by Design Consultant. Unit travel time costs for passengers and crew were sourced from RHD (2005) and for freight in transit from STUP (2007). These were then escalated to 2009 using prices by estimated increase in General Wage Rate Index from BBS (2008) and ADB (2009). These constitute a major part of the quantifiable benefits. Total road user benefit is estimated to be about million 1,295,840 taka over the 31 year period.

Table 3: Road User Benefit from the Traffic Model

Year End June	VOC	TTC	Sub-total
2011			0
2012			0
2013			0
2014			0
2015	19	31	50
2016	37	50	88
2017	61	75	137
2018	74	87	161
2019	84	97	182
2020	93	106	199
2021	111	124	235
2022	131	145	276
2023	153	168	321
2024	176	193	369
2025	202	221	423

[8] The traffic benefits were estimated by Design Consultants and revised by the World Bank team.

Year End June	VOC	TTC	Sub-total
2026	231	243	473
2027	260	266	526
2028	290	291	581
2029	322	316	637
2030	354	342	696
2031	370	351	721
2032	386	360	746
2033	401	370	771
2034	417	378	795
2035	431	388	820
2036	447	397	844
2037	462	407	869
2038	477	417	895
2039	493	427	919
2040	508	437	945
2041	513	438	951
2042	518	439	957
2043	521	440	962
2044	525	441	966
2045	542	455	997
Total (Mill USD)	9609	8900	18512
Total (Mill Taka)	672630	623000	1295840

IV. BANGLADESH SAM 2006/07

In a narrower sense, a SAM is a systematic database and an organized, consistent classification system. As a data framework, the SAM is a snapshot, which explicitly incorporates various crucial transaction links among variables, such as the mapping of factorial income distribution from the structure of production and the mapping of the household income distribution from the factorial income distribution, among others. In a broader sense, in addition to providing a consistent classification scheme, it can be conceived as a modular analytical framework for a set of interconnected subsystems which specifies the major relationships among variables within and among these systems (see Pyatt and Thorbecke, 1976).

For the purpose of this exercise, a SAM for 2006/07 for Bangladesh has been constructed. SAM 2006/07 is composed of 109 accounts. The distributions of 109 accounts are: (i) 41 activities; (ii) 41 commodities; (iii) 4 factors of production; (iv) 11 current institutions; and (v) 2 capital institutions. Data on various components of the demand side have been collected from Bangladesh Bureau of Statistics (BBS). In particular, data on public consumption by 41 commodities, gross fixed capital formation by 41 commodities, and private consumption by 41 commodities have been obtained from BBS. The vector of private consumption data is further distributed among the eight representative household groups using the unit record data of Household Income and Expenditure Survey (HIES) of 2005. Data on exports of goods and services are collected from the Export Promotion Bureau and Bangladesh Bank (i.e. the central bank of Bangladesh). Supply side composed of value added and imports of goods and services. We used disaggregated BBS data to derive the value added vector for the 41 activities. Data on imports of goods and services are collected from Bangladesh Bank and National Board of Revenue. Information on direct and indirect taxes and subsidies has been collected from National Board of Revenue and the Finance division, Ministry of Finance. Input-output flow matrix for 2006/07 has been derived by using newly conducted surveys for few selected activities and updating the previous technology vectors using secondary information. More specifically, out of the 41 activities, technology vectors of five important activities such as paddy, livestock, poultry, pharmaceuticals and information technology (ICT) have been derived using the field survey data. The technology vectors of the remaining 36 activities are updated using secondary information.

Due to data limitation, constructing a Southwest specific regional was a difficult task. Several data sources and information have been consulted to derive the SW regional SAM. Information of IFPRI regional SAM for Bangladesh for 2005 has been used in addition to the information/data collected from the secondary sources to derive a SW regional SAM. More specifically, following data sets have been used along with the information contained in IFPRI regional SAM to generate the value added vector:

- Provisional Estimates of Gross Regional Product 1995-96 to 1999-2000, published by the Bangladesh Bureau of Statistics (BBS) in May 2002.
- Employment data from the 2005 Labor Force Survey published by the Bangladesh Bureau of Statistics (BBS) in 2006.
- Output shares of major sub-sectors within manufacturing from the 2005-06 Report on Bangladesh’s Survey of Manufacturing Industries (SMI).

Furthermore, input-output coefficients for the Southwest region have been based on the input-output coefficients used in the IFRPI SAM for the Southwest region. After adjusting the I-O coefficients for the 41 activities and commodities, the regional SAM was appropriately balanced so that the base scenario reflected the current situation (i.e. 2007) in Khulna and Barisal divisions as closely as possible[9].

The 2006/07 SAM identifies the economic relations through *four types of accounts*: (i) production activity and commodity accounts for 41 sectors; (ii) 4 factors of productions with 2 different types of labour and 2 types of capital; (iii) current account transactions between 4 main institutional agents; household-members and unincorporated capital, corporation, government and the rest of the world; and (iv) two consolidated capital accounts distinguished by public and private origins to capture the flows of savings and investment. The disaggregation of activities, commodities, factors and institutions in the SAM is given in Table 4.

Table 4: Disaggregation and Description of Bangladesh SAM Accounts

Accounts	Description of Elements
Activities (41)	
Agriculture (12)	Paddy Cultivation, Grains, Jute Cultivation, Sugarcane Cultivation, Vegetables, Commercial Crops, Other Crop Cultivation, Livestock Rearing, Poultry Rearing, Shrimp Farming, Fishing, and Forestry
Manufacturing (20)	Rice Milling, Grain Milling, Fish Process, Oil Industry, Sweetener Industry, Food, Leather, Jute, Clothing, RMG, Tobacco, Wood, Chemical, Fertilizer, Petroleum, Clay Products, Cement, Steel, Machinery, and Miscellaneous
Construction (1)	Construction
Services (8)	Utility, Trade, Transport, Social Services, Financial services, Public Administration and Defense, Professional Services, and Other Services
Commodities (41)	
Agriculture (12)	Paddy Cultivation, Grains, Jute Cultivation, Sugarcane Cultivation, Vegetables, Commercial Crops, Other Crop Cultivation, Livestock Rearing, Poultry Rearing, Shrimp Farming, Fishing, and Forestry
Manufacturing (20)	Rice Milling, Grain Milling, Fish Process, Oil Industry, Sweetener Industry, Food, Leather, Jute, Clothing, RMG, Tobacco, Wood, Chemical, Fertilizer, Petroleum, Clay Products, Cement, Steel, Machinery, and Miscellaneous
Construction (1)	Construction
Services (8)	Utility, Trade, Transport, Social Services, Financial services, Public Administration and Defense, Professional Services, and Other Services

[9] Detailed National and Regional SAMs are available in Excel.

Accounts	**Description of Elements**
Factors of Production (4)	
Labour (2)	Labour Unskilled, and Labour Skilled
Capital (2)	Capital and Land
Current Institutions (11)	
Households (8)	Rural: landless, Agricultural marginal, Agricultural small, Agricultural large, Non-farm poor and Non-farm non poor Urban: Households with low educated heads, and households with high educated heads
Others (3)	Government, Corporation and Rest of the World
Capital Institutions (2)	
Public Capital	Public Capital
Private Capital	Private Capital

In that context the Bangladesh SAM 06/07 captures:

- The sources of income and expenditure destination of all accounts.
- Breakdown of sectoral GDP (value addition) by labour and capital factors.
- Income generation and distribution of the institutions in general and household groups in particular.
- Patterns of expenditure by institutions including Household groups.
- The inter-dependence between activities and institutions with respect to income generation and final demand creation.
- Inter-dependence among institutions regarding transfer receipts and transfer payments.
- Role of institutions in capital formation.
- Relationship of the domestic economy with the Rest of the World or external sector.

V. THE SAM MULTIPLIER MODULE

5.1. Derivation of the SAM Multiplier[10]

The move from a SAM data framework to a SAM model or multiplier framework requires decomposing the SAM accounts into "exogenous" and "endogenous" as well as to introduce

[10] Detailed analysis is provided in Annex 1.

a set of assumptions pertaining to the Generalized Leontief Model[11]. Generally accounts intended to be used as policy instruments (e.g. government expenditure, investment, exports) are made exogenous and accounts a priory specified as objectives or targets must be made endogenous (e.g. activity, commodity demand, factor return and household income).

For any given injection into the exogenous accounts (i.e. instruments) of the SAM, influence is transmitted through the interdependent SAM system among the endogenous accounts. The interwoven nature of the system implies that the incomes of factors, households and production are all derived from exogenous injections into the economy via a multiplier process. The multiplier process is developed here on the assumption that when an endogenous income account receives an exogenous expenditure injection, it spends it in the same proportions as shown in the matrix of average propensities to spend (APS). The elements of the APS matrix is calculated by dividing each cell by its corresponding column sum totals.

The multiplier analysis using the SAM framework helps to understand the linkages between the different sectors and the institutional agents at work within the economy. Accounting multipliers have been calculated according to the standard formula for accounting (impact) multipliers, as follows:

$\mathbf{Y} = A\,Y + \mathbf{X} = (I - A)^{-1}\,\mathbf{X} = M_a\,\mathbf{X}$

Where:

Y is a vector of incomes of endogenous variables

X is a vector of expenditures of exogenous variables

A is the matrix of average expenditure propensities for endogenous accounts

$M_a = (I - A)^{-1}$ is a matrix of aggregate accounting multipliers (generalized Leontief inverse).

[11] ALARCON, J.V. (2002): Social Accounting Matrix-Based Modelling: Extension to Wellbeing and Environment and Computable General Equilibrium Models: Applications using the 1975 and 1980 Ecuador and Bolivian 1989 and 1997 SAMs, Institute of Social Studies, The Hague, The Netherlands, pp. 13-15.

Variations in any one of the exogenous account (i.e. in this case ΔX) will produce total impacts (ΔY) of endogenous entries via the multipliers. More specifically they are expressed as:

$\Delta Y = M_a \times \Delta X$.

The economy wide effect is thus equal to $\Delta Y = M_a \times \Delta X$. Thus ΔY captures the economy wide impacts on the four endogenous accounts namely: (i) gross output; (ii) commodity demand; (iii) factor returns and (iv) household. Table 5 provides the description of the endogenous and exogenous accounts and multiplier effects.

Table 5: Description of the Endogenous and Exogenous Accounts and Multiplier Affects

Endogenous (y)	Exogenous (x)
The activity (gross output multipliers), indicates the total effect on the sectoral gross output of a unit-income increase in a given account *i* in the SAM, and is obtained via the association with the commodity production activity account *i*.	
The consumption commodity multipliers, which indicates the total effect on the sectoral commodity output of a unit-income increase in a given account *i* in the SAM, is obtained by adding the associated commodity elements in the matrix along the column for account *i*.	Intervention into through activities (x = i + g + e), where i= GFC + ST (GFCF) Exports (e) Government Expenditure (g) Investment Demand (i) Inventory Demand (i)
The value added or GDP multiplier, giving the total increase in GDP resulting from the same unit-income injection, is derived by summing up the factor-payment elements along account *i*'s column.	
Household income multiplier shows the total effect on household and enterprise income, and is obtained by adding the elements for the household groups along the account i column.	Intervention via households (x = r + gt + ct), where Remittance (r) Government Transfers (gt) Corporation Transfers (ct)

The economy-wide impacts of the Padma Bridge are examined by changing the total exogenous injection vector, especially Government Expenditure (g), and Investment demand (investment in construction, infrastructure, machinery and equipment). More specifically, the total exogenous account is manipulated to estimate their effects on output (through an output multiplier), value-added or GDP (through the GDP multiplier), and household income (through household income multiplier) and commodity demand (via commodity multipliers). The calculated multipliers are provided in Annex 3.

5.2. Simulation Design: SAM-Based Model

Simulation 1A (National): Total investment cost of building Padma Bridge will be around \$2.9 billion, out of which \$2.1 billion is estimated as the amount that will be injected into the economy. It is further assumed that \$2.1 would be injected into the economy in the following way: Construction sector \$1.4 billion, utility \$0.1 billion, trade \$0.1 billion, transport and communication \$0.15 billion, different kinds of services (professional, financial, public administration, social etc) \$0.3 billion and food \$0.05 billion. This total injection excludes foreign imports, contingencies, IDC etc from total cost. All other exogenous elements remain unaltered.

Simulation 1B (Regional): In order to simulate the impact of the Padma Bridge within the Regional SW SAM model, we performed similar injection of \$2.1 billion into the regional economy. All other regional exogenous elements remain unaffected. In tracing the impact on the regional economy, two alternatives were reviewed. First, it was assumed that the entire injection would accrue to the region. Second, it was assumed that 70 percent of injection would accrue to the region.

Operation of Jamuna Bridge suggests that additional demand may arise for consumer goods, energy and utility services and as well as transport services. These demand effects are in addition to impacts generated due to bridge construction and associated services activities. Therefore, in line with the Jamuna Bridge impact analysis exercise, further simulations were carried out (i.e. 2A and 2B) to capture economic impacts of demand. The simulation set ups are explained below:

Simulation 2A (National): Increase in sectoral demand at the national level: Other crops by 10 percent, Fisheries by 10 percent, Utility by 5 percent and Transport by 20 percent.

Simulation 2B (Regional): Increase in sectoral demand at the regional level: Other crops by 20 percent, Fisheries by 20 percent, Utility by 10 percent and Transport by 50 percent.

5.3. SAM Based Simulation Results

Impacts simulations using the 'National' and the 'Regional' SAM models are reported in terms of gross output, commodity demand, value added by factors and household consumption. Moreover, output and commodity demand outcomes are reported using intermediate classifications of activity (i.e. 17 activities aggregated from the 41 activities), commodity (i.e. 17 activities aggregated from the 41 commodities), value-added (i.e. 4 factors of production) and household groups (i.e. 8 representative households) as well according to final classification (i.e. Activity-5, commodity-5, value-added-3 and household groups-3). The mapping is shown in Annex 2.

5.3.1. Results of Simulation 1A

Simulated outcomes by four endogenous accounts according to the national level 'intermediate classification' are reported in Table 6. As a result of the $2.1 billion injection, the gross output of the economy would increase by 10.56 percent compared to the base year value. The largest increase of 29 percent has been reported for the construction activity (i.e. due to increase in construction commodity demand) followed by linked activities such as forestry (19 percent), utility (17 percent), other industries (14 percent) and machinery (13.5 percent). The effects on other sectors are determined by the sectoral interlinkages as can be understood from the estimates of the SAM multipliers reported in Annex 3.

Table 6: Simulation 1A: Economic Wide Benefit of Intervention

Using the National SAM Model-Intermediate Classification

(In million taka unless otherwise specified)

	Endogenous SAM Accounts (Intermediate Classification)	Base Value	Simulation	% Change over Base
1	Cereal Crops	614209	55060	8.97
2	Commercial Crops	199811	13050	6.53
3	Livestock-Poultry-fishing	764211	62889	8.23
4	Forestry	210295	40473	19.24
5	Other Agriculture	159683	14046	8.80
6	Other Food	1156780	103912	8.98
7	Leather Products	64680	2574	3.97
8	Cloth	274245	12582	4.58
9	Readymade Garments	734635	7323	0.99
10	Chemical-Fertilizer	96050	10558	11.00
11	Machinery	338400	45821	13.54
12	Petroleum Products	45849	4312	9.41
13	Other Industries	318938	44561	13.98
14	Construction	895119	260071	29.06
15	Transport	556137	46726	8.40
16	Utility	200010	34176	17.08
17	Other Services	2746118	231270	8.43
	Gross Output	**9375170**	**989400**	**10.56**
1	Cereal Crops	647473	58089	8.97
2	Commercial Crops	281463	18706	6.64
3	Livestock-Poultry-fishing	769744	63383	8.23
4	Forestry	210295	40473	19.24
5	Other Agriculture	178805	15733	8.80
6	Other Food	1302387	116817	8.97
7	Leather Products	65167	2594	3.97
8	Cloth	357348	16784	4.70
9	Readymade Garments	748044	7456	0.99
10	Chemical-Fertilizer	220509	23653	10.73
11	Machinery	676932	71475	10.56
12	Petroleum Products	247631	23289	9.41
13	Other Industries	539253	64169	11.90
14	Construction	895119	260071	29.06
15	Transport	654329	54976	8.40
16	Utility	208034	35547	17.08
17	Other Services	2790890	234088	8.39
	Total Commodity Demand	**10793425**	**1107304**	**10.26**
18	VA Labour Unskilled	1107767	116069	10.47
19	VA Labour Skilled	1130936	97308	8.60
20	VA Capital	1941427	216344	11.14
21	VA Land	288419	23950	8.30
	Value added	**4468549**	**453670**	**10.16**

	Endogenous SAM Accounts (Intermediate Classification)	Base Value	Simulation	% Change over Base
22	Rural Landless	300256	27482	9.15
23	Rural Marginal Farmers	283097	25634	9.05
24	Rural Small Farmers	549961	47406	8.63
25	Rural Large Farmers	341538	28974	8.49
26	Rural Non Farm Poor	433473	35822	8.26
27	Rural Non Farm Non Poor	1156862	114049	9.86
28	Urban Low Education	490267	42807	8.73
29	Urban High Education	1168683	101617	8.70
	Household income	**4724136**	**423793**	**8.97**
	National (Output + Commodity + Factor + Household)	**29361280**	**2974168**	**10.13**

Note: Gross output = intermediate use + factor payments; Total commodity demand = commodity demanded by households; Value added = factor payments; Household income = Incomes of different household categories

Value-added or gross domestic product of the Bangladesh is expected to increase by more than 10 percent compared to the base case implying that annual addition to GDP over 31 years between 2014 and 2044[12] is 0.33 percent. Largest return would accrue to the capital factor (11.14 percent) followed closely by unskilled labour (10.47 percent).

As mentioned above, economy wide benefit is added to the road users benefits of the traffic model to derive the total project benefit[13]. Road users benefit is estimated to be million 1,295,840 taka. We consider value added increase of million 453,670 taka as economy wide benefits of the project. Thus, total project benefit is estimated to be 1,749,510 million taka [i.e. Total (1,749,510) = Road User Benefit (=1,295,840) + WEB (=453,670)]. This implies that total project benefit is 39 percent relative to the base national income (i.e. 4,468,549 million taka). Assuming the 31 year full realization timeframe, total project benefits per year is then 1.26 percent relative to the base national income. Alternatively, assuming 5 percent GDP growth over the 31 period an alternative estimate of base year is arrived. The total project benefit (i.e. 1,749,510 million taka) is only 0.6 percent relative to the alternative base national income.

Due to leakages of different types (e.g. savings and direct taxes), increase in household consumption is 1.19 percent less than the increase in value-added or GDP. More specifically,

[12] The 31 years time period is selected to maintain consistency with the reference period used in the Traffic Model.

[13] It should be noted that, outcomes of these three models independently suggest that the project is economically viable.

total household consumption would increase by 8.97 percent compared to the base case over the 31 years between 2014 and 2044. Among the household groups, largest increase is found for the non-farm non poor household group (9.86 percent) followed by landless (9.15 percent) and marginal farmers (9.05 percent).

Simulated outcomes are further aggregated following the classification involving 5 activities, 5 commodities, 3 factors and 3 household groups. Simulated outcomes according to the final classification are reported in Table 7.

Table 7: Simulation 1A: Economy Wide Benefit of Intervention

Using the National SAM Model-Final Classification

(In million taka unless otherwise specified)

	Endogenous SAM Accounts (Final Classification)	Base Value	Simulation	% Change over Base
1	Agriculture	1948209	185517	9.52
2	Manufacturing	3229588	265816	8.23
3	Construction	895119	260071	29.06
4	Transport	556137	46726	8.40
5	Services	2746118	231270	8.43
	Gross Output	**9375170**	**989400**	**10.56**
1	Agriculture	2087781	196384	9.41
2	Manufacturing	4365306	361785	8.29
3	Construction	895119	260071	29.06
4	Transport	654329	54976	8.40
5	Services	2790890	234088	8.39
	Total Commodity Demand	**10793425**	**1107304**	**10.26**
1	Labour	2238703	213377	9.54
2	Capital	1941427	216344	11.14
3	Land	288419	23950	8.30
	Value added	**4468549**	**453670**	**10.16**
1	Rural Land Based	1474851	129498	8.78
2	Rural Non-farm	1590335	149871	9.42
3	Urban	1658950	144425	8.71
	Household Income	**4724136**	**423793**	**8.97**
	National (Output + Commodity + Factor + Household)	**29361280**	**2974168**	**10.13**

Note: Gross output = intermediate use + factor payments; Total commodity demand = commodity demanded by households; Value added = factor payments; Household income = Incomes of different household categories

As mentioned above, due to the intervention gross output would increase by 10.56 percent compared to the base case. Among the 5 activities, largest increase of 29.06 percent is found for the construction activity followed by agriculture (9.52 percent) since forestry is included in broad agriculture activity classification. Increases in output of the other three activities would be more than 8 percent.

Income generation has been reported by three types of factors-labour, capital and land. Largest increase of 11.14 percent is found for the capital factor followed by labour factor (9.54 percent). Lowest income generation has been reported for land factor (i.e. 8.30 percent).

Among three categories of household groups, largest gain is reported for the rural household engaged in non-farm activities (9.42 percent) followed almost equally by rural land based household (8.71 percent) and urban household (8.78 percent).

5.3.2. Results of Simulation 1B

As mentioned in previous sections, the Padma Bridge is expected to have large impact on the economy and poverty situation of Khulna and Barisal Divisions, since the Bridge links this region to the generally more prosperous markets of the eastern part of Bangladesh. However, the previous simulation exercise fails to capture the benefits that may potentially accrue to the people (households) in the Southwest. There may be two reasons for this. *First,* it is necessary to adjust downward the magnitude of the regional impacts of the Bridge within the national models that was utilized to account for the fractional share of the Southwest in the whole of Bangladesh. *Second,* all benefits resulting from the simulations are distributed to households across all regions so that the pie received by the people in the southwest is likely to be underestimated. Thus, we also conducted simulations of the Bridge's impact at the regional level utilizing a SW regional SAM model that takes into account region-specific households.

Simulated outcomes of injection of $2.1 billion using the 'Regional' SAM model is reported in this section again in terms of output supply, commodity demand, value added by factors and household consumption. The outcomes are reported following the 'intermediate' and 'final' endogenous account classification.

Table 8: Simulation 1B: Economy Wide Benefit of Intervention

Using the Regional SAM Model-Intermediate Classification

(In million taka unless otherwise specified)

	Endogenous SAM Accounts (Intermediate Classification)	Base Value	Simulation	% Change
1	Cereal Crops	82010	49316	60.13
2	Commercial Crops	43145	23194	53.76
3	Livestock-Poultry-fishing	193480	68146	35.22
4	Forestry	36272	38976	107.45
5	Other Agriculture	26570	16262	61.21
6	Other Food	165149	105160	63.68
7	Leather Products	3129	1785	57.03
8	Cloth	20522	14198	69.19
9	Readymade Garments	14024	8976	64.01
10	Chemical-Fertilizer	23363	9678	41.43
11	Machinery	76982	69954	90.87
12	Petroleum Products	6613	6536	98.83
13	Other Industries	62503	85623	136.98
14	Construction	87508	139738	159.69
15	Transport	78228	56557	72.29
16	Utility	27155	27751	102.19
17	Other Services	386929	257047	66.43
	Gross Output	**1333583**	**978900**	**73.40**
1	Cereal Crops	82119	49384	60.13
2	Commercial Crops	44943	24290	54.05
3	Livestock-Poultry-fishing	193508	68165	35.23
4	Forestry	36272	38976	107.45
5	Other Agriculture	26786	16393	61.20
6	Other Food	165628	105478	63.68
7	Leather Products	3130	1785	57.03
8	Cloth	20943	14503	69.24
9	Readymade Garments	14282	9141	64.01
10	Chemical-Fertilizer	23424	9704	41.43
11	Machinery	80617	71807	89.07
12	Petroleum Products	6626	6548	98.83
13	Other Industries	63590	86446	135.95
14	Construction	87508	139738	159.69
15	Transport	78382	56667	72.29
16	Utility	27206	27804	102.19
17	Other Services	387554	257368	66.41
	Total Commodity Demand	**1342515**	**984197**	**73.32**
18	VA Labour Unskilled	132408	98133	74.11

	Endogenous SAM Accounts (Intermediate Classification)	Base Value	Simulation	% Change
19	VA Labour Skilled	152721	105493	69.07
20	VA Capital	293265	216977	73.98
21	VA Land	64424	37961	58.93
	Value added	**642818**	**458562**	**71.34**
22	Rural Landless	41451	28922	69.78
23	Rural Marginal Farmers	41598	27468	66.04
24	Rural Small Farmers	75323	50692	67.30
25	Rural Large Farmers	96441	65962	68.39
26	Rural Non Farm Poor	62621	42482	67.84
27	Rural Non Farm Non Poor	204405	140637	68.80
28	Urban Low Education	56472	39021	69.10
29	Urban High Education	61593	40813	66.26
	Household Income	**639904**	**435997**	**68.14**
	South West Bangladesh (Output + Commodity + Factor + Household)	**3958820.9**	**2857658**	**72.18**

Note: Gross output = intermediate use + factor payments; Total commodity demand = commodity demanded by households; Value added = factor payments; Household income = Incomes of different household categories

Injection impacts on four endogenous accounts of the Regional SAM (i.e. activity, commodity, factor and household) have been reported in Table 6. As mentioned above, injection of $2.1 billion into the 'Southwest' (SW) Bangladesh would translate 159.69 percent increase in construction demand compared to the regional base value. *It is important to note that the estimated increase of 159.69 percent of construction demand is almost 5.5 times larger than the estimated increase of 29 percent at the national Level[14]l.* Due to this large injection, the impacts on the four endogenous accounts are also large compared to the impacts found under the National SAM model.

The gross output of the regional SW economy would increase by 73.4 percent compared to the base regional gross output. As expected the largest increase of 159.69 percent has been reported for the construction activity (i.e. due to increase in construction commodity demand) followed by linked activities such as other industries (135.95 percent), forestry (107.45 percent), utility (102.19), and machinery (90.87 percent).

[14] According to 2007 estimates, regional SW GDP is around 15 percent of national income.

Value-added or gross domestic product of the SW Bangladesh is expected to increase by more than 71 percent compared to the base GDP of SW Bangladesh implying that annual addition to SW GDP over 31 years between 2014 and 2044 would be around 2.3 percent. Unlike the national case, the largest return would accrue to unskilled labour (74.11 percent) followed closely by the capital factor (73.98 percent) reflecting regional structure of production, factorial income generation and their ultimate distribution among the region specific representative household groups.

Total consumption of the household of SW Bangladesh would increase by 68.14 percent compared to the their base consumption envisaging that annual addition to household consumption over 31 years between 2014 and 2044 would be around 2.2 percent. Among the household groups, the largest increase is found for the landless (69.78 percent), followed by urban low educated household group (69.1 percent) and non-farm non-poor household groups (68.8 percent).

Simulated outcomes are further aggregated following the final classification involving 5 activities, 5 commodities, 3 factors and 3 household groups. Simulated outcomes according to the final classification are reported in Table 9.

Table 9: Simulation 1B: Economy Wide Benefit of Intervention Using the Regional SAM Model-Final Classification

(In million taka unless otherwise specified)

	Endogenous SAM Accounts (Final Classification)	Base Value	Simulation	% Change
1	Agriculture	381477	195896	51.35
2	Manufacturing	399441	329662	82.52
3	Construction	87508	139738	159.69
4	Transport	78228	56557	72.29
5	Services	386929	257047	66.43
	Gross Output	**1333583**	**978900**	**73.40**
1	Agriculture	383628	197209	51.41
2	Manufacturing	405444	333214	82.18
3	Construction	87508	139738	159.69
4	Transport	78382	56667	72.29
5	Services	387554	257368	66.41
	Total Commodity Demand	**1342515**	**984197**	**73.32**
1	Labour	285129	203625	71.41

	Endogenous SAM Accounts (Final Classification)	Base Value	Simulation	% Change
2	Capital	293265	216977	73.98
3	Land	64424	37960	58.93
	Value added	**642818**	**458562**	**71.34**
1	Rural Land Based	254814	173044	67.91
2	Rural Non-farm	267026	183120	68.58
3	Urban	118065	79834	67.61
	Household Income	**639904**	**435997**	**68.14**
	South West Bangladesh (Output + Commodity + Factor + Household)	**3958820.9**	**2857658**	**72.18**

Note: Gross output = intermediate use + factor payments; Total commodity demand = commodity demanded by households; Value added = factor payments; Household income = Incomes of different household categories

As mentioned above, due to the intervention regional gross output would increase by 73.4 percent compared to the base case. Among the 5 activities, the largest increase of 159.69 percent is found for the construction activity followed by manufacturing (82.52 percent) and Transport (72.29 percent).

Income generation has been reported by three types of factors-labour, capital and land. The largest increase of around 74 percent is found for the capital factor followed by labour factor (71.41 percent). Lowest income generation has been reported for land factor (i.e. 58.93 percent).

Among three categories of household groups, largest gain is reported for the rural household engaged in non-farm activities (68.58 percent) followed almost equally by rural land based household (67.91 percent) and urban household (67.61 percent).

5.3.3: Results of Simulation 2A

The impacts of the rise in sectoral demand on the national economy using the national SAM-intermediate classification are presented in Table 10. The gross output increases by 9.2 percent. The largest rise is for the transport sector (27.45 percent) followed by livestock-poultry-fishing (18.23 percent), utility (16.68 percent), other agriculture (14.78 percent) and other food (11.02 percent). The total commodity demand increases by 9.08 percent and value-added by 8.99 percent. The largest rise is for the capital (9.92 percent). Household consumption increases by 8.06 percent, and the largest rise is observed for the rural non-farm non poor household.

Table 10: Simulation 2A: Economy Wide Benefit of Intervention

Using the National SAM Model-Intermediate Classification

(In million taka unless otherwise specified)

	Endogenous SAM Accounts (Intermediate Classification)	Base Value	Simulation	% Change over Base
1	Cereal Crops	614209	49260	8.02
2	Commercial Crops	199811	28973	14.5
3	Livestock-Poultry-fishing	764211	139316	18.23
4	Forestry	210295	19389	9.22
5	Other Agriculture	159683	23601	14.78
6	Other Food	1156780	127477	11.02
7	Leather Products	64680	3247	5.02
8	Cloth	274245	11902	4.34
9	Readymade Garments	734635	6832	0.93
10	Chemical-Fertilizer	96050	7895	8.22
11	Machinery	338400	12013	3.55
12	Petroleum Products	45849	3838	8.37
13	Other Industries	318938	15819	4.96
14	Construction	895119	23989	2.68
15	Transport	556137	152660	27.45
16	Utility	200010	33362	16.68
17	Other Services	2746118	202664	7.38
	Gross Output	**9375170**	**862236**	**9.20**
1	Cereal Crops	647473	51927	8.02
2	Commercial Crops	281463	40812	14.50
3	Livestock-Poultry-fishing	769744	138043	17.93
4	Forestry	210295	19389	9.22
5	Other Agriculture	178805	26427	14.78
6	Other Food	1302387	143523	11.02
7	Leather Products	65167	3271	5.02
8	Cloth	357348	15509	4.34
9	Readymade Garments	748044	6957	0.93
10	Chemical-Fertilizer	220509	18126	8.22
11	Machinery	676932	24031	3.55
12	Petroleum Products	247631	20727	8.37
13	Other Industries	539253	26747	4.96
14	Construction	895119	23989	2.68
15	Transport	654329	179613	27.45
16	Utility	208034	34700	16.68
17	Other Services	2790890	205968	7.38
	Total Commodity Demand	**10793425**	**979760**	**9.08**
18	VA Labour Unskilled	1107767	92659	8.37

	Endogenous SAM Accounts (Intermediate Classification)	Base Value	Simulation	% Change over Base
19	VA Labour Skilled	1130936	95604	8.37
20	VA Capital	1941427	192510	9.92
21	VA Land	288419	23560	8.06
	Value added	**4468549**	**404333**	**8.99**
22	Rural Landless	300256	23994	8.06
23	Rural Marginal Farmers	283097	22506	8.06
24	Rural Small Farmers	549961	41881	7.75
25	Rural Large Farmers	341538	25947	7.75
26	Rural Non Farm Poor	433473	31403	7.44
27	Rural Non Farm Non Poor	1156862	101122	8.68
28	Urban Low Education	490267	35836	7.44
29	Urban High Education	1168683	95015	8.06
	Household Income	**4724136**	**377766**	**8.06**
	National (Output + Commodity + Factor + Household)	**29361280**	**2542155**	**8.68**

Note: Gross output = intermediate use + factor payments; Total commodity demand = commodity demanded by households; Value added = factor payments; Household income = Incomes of different household categories

Simulated outcomes are further aggregated following the classification involving 5 activities, 5 commodities, 3 factors and 3 household groups. Simulated outcomes according to the final classification are reported in Table 11.

Table 11: Simulation 2A: Economy Wide Benefit of Intervention

Using the National SAM Model-Final Classification

(In million taka unless otherwise specified)

	Endogenous SAM Accounts (Final Classification)	Base Value	Simulation	% Change over Base
1	Agriculture	1948209	260538	13.37
2	Manufacturing	3229588	222385	6.89
3	Construction	895119	23989	2.68
4	Transport	556137	152660	27.45
5	Services	2746118	202664	7.38
	Gross Output	**9375170**	**862236**	**9.20**
1	Agriculture	2087781	276599	13.25
2	Manufacturing	4365306	293591	6.73
3	Construction	895119	23989	2.68
4	Transport	654329	179613	27.45
5	Services	2790890	205968	7.38
	Total Commodity Demand	**10793425**	**979760**	**9.08**
1	Labour	2238703	188263	8.41
2	Capital	1941427	192510	9.92
3	Land	288419	23560	8.17
	Value added	**4468549**	**404333**	**8.99**

1	Rural Land Based	1474851	114328	7.75
2	Rural Non-farm	1590335	132525	8.33
3	Urban	1658950	130851	7.89
	Household Income	**4724136**	**377766**	**8.06**
	National (Output + Commodity + Factor + Household)	**29361280**	**2542155**	**8.68**

Note: Gross output = intermediate use + factor payments; Total commodity demand = commodity demanded by households; Value added = factor payments; Household income = Incomes of different household categories

5.3.4. Results of Simulation 2B

The economic impacts on the Southwest region due to rise in sectoral demand are presented in Table 12 based on the regional SAM-intermediate classification.

Table 12: Simulation 2B: Economy Wide Benefit of Intervention

Using the Regional SAM Model-Intermediate Classification

(In million taka unless otherwise specified)

	Endogenous SAM Accounts (Intermediate Classification)	Base Value	Simulation	% Change over Base
1	Cereal Crops	82010	44117	8.02
2	Commercial Crops	43145	41963	97.26
3	Livestock-Poultry-fishing	193480	236587	122.28
4	Forestry	36272	22432	61.84
5	Other Agriculture	26570	26341	99.14
6	Other Food	165149	122075	73.92
7	Leather Products	3129	1054	33.67
8	Cloth	20522	5974	29.11
9	Readymade Garments	14024	875	6.24
10	Chemical-Fertilizer	23363	12882	55.14
11	Machinery	76982	18331	23.81
12	Petroleum Products	6613	3713	56.14
13	Other Industries	62503	20795	33.27
14	Construction	87508	15731	17.98
15	Transport	78228	144036	184.12
16	Utility	27155	30382	111.88
17	Other Services	386929	191538	49.50
	Gross Output	**1333583**	**938825**	**70.40**
1	Cereal Crops	82119	6586	8.02
2	Commercial Crops	44943	43712	97.26
3	Livestock-Poultry-fishing	193508	236621	122.28
4	Forestry	36272	22432	61.84
5	Other Agriculture	26786	26555	99.14

	Endogenous SAM Accounts (Intermediate Classification)	Base Value	Simulation	% Change over Base
6	Other Food	165628	122429	73.92
7	Leather Products	3130	1054	33.67
8	Cloth	20943	6097	29.11
9	Readymade Garments	14282	891	6.24
10	Chemical-Fertilizer	23424	12915	55.14
11	Machinery	80617	19197	23.81
12	Petroleum Products	6626	3720	56.14
13	Other Industries	63590	21156	33.27
14	Construction	87508	2345	2.68
15	Transport	78382	144320	184.12
16	Utility	27206	30439	111.88
17	Other Services	387554	191848	49.50
	Total Commodity Demand	**1342515**	**892316**	**66.47**
18	VA Labour Unskilled	132408	92659	63.24
19	VA Labour Skilled	152721	95604	65.41
20	VA Capital	293265	192510	62
21	VA Land	64424	23560	51.77
	Value added	**642818**	**404333**	**62**
22	Rural Landless	41451	23994	60.76
23	Rural Marginal Farmers	41598	22506	57.04
24	Rural Small Farmers	75323	41881	58.28
25	Rural Large Farmers	96441	25947	58.59
26	Rural Non Farm Poor	62621	31403	60.14
27	Rural Non Farm Non Poor	204405	101122	59.83
28	Urban Low Education	56472	35836	60.14
29	Urban High Education	61593	95015	59.21
	Household Income	**639904**	**377766**	**59.52**
	South West Bangladesh (Output + Commodity + Factor + Household)	**3958820.9**	**2542155**	**61.07**

Note: Gross output = intermediate use + factor payments; Total commodity demand = commodity demanded by households; Value added = factor payments; Household income = Incomes of different household categories

Simulated outcomes are further aggregated following the classification involving 5 activities, 5 commodities, 3 factors and 3 household groups. Simulated outcomes according to the final classification are reported in Table 13.

Table 13: Simulation 2B: Economy Wide Benefit of Intervention

Using the Regional SAM Model-Final Classification

(In million taka unless otherwise specified)

	Endogenous SAM Accounts (Final Classification)	Base Value	Simulation	% Change over Base
1	Agriculture	1948209	371440	97.37
2	Manufacturing	3229588	216079	54.10
3	Construction	895119	15731	17.98
4	Transport	556137	144036	184.12
5	Services	2746118	191538	49.50
	Gross Output	**9375170**	**938825**	**70.40**
1	Agriculture	2087781	335906	87.56
2	Manufacturing	4365306	217897	53.74
3	Construction	895119	2345	2.68
4	Transport	654329	144320	184.12
5	Services	2790890	191848	49.50
	Total Commodity Demand	**10793425**	**892316**	**66.47**
1	Labour	2238703	183675	64.42
2	Capital	1941427	182001	62.06
3	Land	288419	33263	51.63
	Value added	**4468549**	**404333**	**62**
1	Rural Land Based	1474851	149513	58.68
2	Rural Non-farm	1590335	160084	59.95
3	Urban	1658950	70463	59.68
	Household Income	**4724136**	**377766**	**59.52**
	South West Bangladesh (Output + Commodity + Factor + Household)	**3958820.9**	**2542155**	**61.07**

Note: Gross output = intermediate use + factor payments; Total commodity demand = commodity demanded by households; Value added = factor payments; Household income = Incomes of different household categories

5.3.5 Assessment of Annual Effects

The pace at which the Padma Bridge is expected to impact upon output, income and subsequent reduction in poverty level, would depend mainly on the extent to which the bridge's capacity will be used. In line with traffic model estimation, one may assume that it will take roughly 31 years for full realization of the estimated simulation results from SAM analysis. Accordingly, the total effects are converted into annual effects and the estimates are presented in Table 14. It is important to note that the simulation exercises were meant to trace the impacts of a particular intervention, assuming that all other things remained constant.

Table 14: Total and Annualized Economy Wide Benefit of Simulations

(Percentage Change from Base Values)

	Simulation 1A: National SAM Based		Simulation 1B: Regional SAM Based				Simulation 2A: National SAM Based		Simulation 2B: Regional SAM Based	
Increase in:	Total (1)	Annualized (2)	Total (3)	Annualized (4)	Total* (5)	Annualized (6)	Total (7)	Annualized (8)	Total (9)	Annualized (10)
Gross Output	10.56	0.34	73.40	2.37	51.4	1.66	9.20	0.30	70.40	2.27
Commodity	10.26	0.33	73.32	2.37	51.3	1.66	9.08	0.29	66.47	2.14
Factor Return	10.16	0.33	71.34	2.30	49.9	1.61	8.99	0.29	62.00	2.00
Household Income	8.97	0.29	68.14	2.20	47.7	1.54	8.06	0.26	59.52	1.92

Note: *Annual equivalent rates of growth were calculated keeping in view the 31 years as the time taken to fully realize the impact of the bridge. If we took a shorter time horizon for fully realizing the benefit of growth, then the annual equivalent rates could be larger. The annualized equivalent rate would be 0.33 percent for national GDP (compared to the national base GDP) and 2.3 percent for SW region (compared to the SW base GDP) assuming 100 percent confinement of shock to the regional economy. If we assume that if 70 percent of the shock would be operative in the region, the equivalent of annual rate of growth regional GDP would be roughly 1.66 percent (please see column 5 and 6 respectively for revised WEB under 70 percent injections. Given that SAM based model assume excess capacity (which may be a reasonable assumption in a country like Bangladesh with under-utilized resources), the size of impacts vary with the size of injection or shock.

5.3.6. Economic Cost-Benefit Analysis of Simulations 1A and 2A

The quantifiable cost and benefits of the Padma Bridge carried out by AECOM New Zealand Limited in their study "Padma Multipurpose Bridge Design Project: Detailed Economic and Financial Analysis", has been modified to reassess the economic viability of the Padma Bridge. The major features of the cost-benefit analysis are:

1. The values of the project costs are obtained from the AECOM report.
2. Instead of using the road users benefits based on additional traffic, road users' benefits are based on existing traffic. The benefit estimates are taken from AECOM report.
3. Non-road users' benefits are derived from the simulated outcome of the National SAM model exercise.
4. The cost-benefit analysis was undertaken over a thirty one -year period following opening of the bridge. A real discount rate of 12% was used, reflecting the economic opportunity cost of capital in Bangladesh. All costs and benefits were expressed in 2009

prices, and 2009/10 was adopted as the discount year. Residual value was allowed for in the last year of the evaluation period (2045).

The estimated outcomes of cost-benefit analysis for the Simulations 1A and 2A in terms of Net Present Value (NPV), Benefit-Cost Ratio (BCR), and Internal Economic Rate of Return (IERR) are provided in Tables 15 and 16 respectively.

Table 15 shows that, based on the quantified benefits of Simulation 1A, the project is economically viable, with a net present value of US$ 1234 million, a benefit-cost ratio (BCR) of 2.01 and an economic internal rate of return (EIRR) of 19 percent. Also, from Table 16 it appears that based on the benefits of Simulation 2A, the project's net present value is US$ 1184, the benefit-cost ratio is 1.97 and the economic internal rate of return (EIRR) is 18 percent. The EIRRs from these two simulations are well in excess of the economic opportunity cost of capital of 12 percent.

Table 15: Economic Evaluation Results Based on Simulation 1A

(US$ million in 2009 prices, US$ 1 = 70 Taka)

	Cost			Project Benefits								Net
Year	Capital	O&M	Total	Road User Benefits			Non Road User Benefits				Total	Economic
End June	Cost		Cost	VOC	TTC	Sub-total	Ferry	Land	Utilities	WEB	Benefits	Benefits
2011	60		60			0					0	-60
2012	500		500			0					0	-500
2013	500		500			0					0	-500
2014	500		500			0					0	-500
2015	324	0	324	19	31	50	0	384	271	0	705	381
2016		13	13	37	50	88	0			0	87	74
2017		25	25	61	75	137	0			23	161	136
2018		25	25	74	87	161	0			36	197	172
2019		25	25	84	97	182	0			57	242	217
2020		25	25	93	106	199	0			73	272	247
2021		25	25	111	124	235	0			87	322	297
2022		25	25	131	145	276	0		0	102	378	353
2023		15	15	153	168	321	0		0	117	438	423
2024		15	15	176	193	369	0			134	503	488
2025		15	15	202	221	423	0			162	585	570
2026		15	15	231	243	473	0			190	717	702
2027		15	15	260	266	526	0			218	744	729
2028		15	15	290	291	581	0			250	831	816

	Cost			Project Benefits								Net
Year	**Capital**	**O&M**	**Total**	**Road User Benefits**			**Non Road User Benefits**				**Total**	**Economic**
End June	**Cost**		**Cost**	**VOC**	**TTC**	**Sub-total**	**Ferry**	**Land**	**Utilities**	**WEB**	**Benefits**	**Benefits**
2029		15	15	322	316	637	0			296	957	942
2030		15	15	354	342	696	0			296	992	977
2031		15	15	370	351	721	0			296	1017	1002
2032		15	15	386	360	746	0			296	1042	1027
2033		15	15	401	370	771	0			296	1067	1052
2034		15	15	417	378	795	0			296	1091	1076
2035		15	15	431	388	820	0			296	1206	1191
2036		15	15	447	397	844	0			296	1140	1125
2037		15	15	462	407	869	0			296	1165	1150
2038		15	15	477	417	895	0			296	1281	1266
2039		15	15	493	427	919	0			296	1307	1292
2040		15	15	508	437	945	0			296	1241	1226
2041		15	15	513	438	951	0			296	1247	1232
2042		15	15	518	439	957	0			296	1253	1238
2043		15	15	521	440	962	0			296	1348	1333
2044		15	15	525	441	966	0			296	1262	1247
2045		15	15	542	455	997	0			296	1293	1278
Total	1,884	508	2392	9609	8900	18512	0	384	271	6481	26091	23699
NPV (12%)	**$1,310**	**$139**	**$1,398**	**$1,291**	**$1,321**	**$1,660**	**$0**	**$343**	**$242**	**$902**	**$2,632**	**$1,234**
											ERR	**19%**
											NPV	**$1,234**
											B/C	**2.01**

Table 16: Economic Evaluation Results Based on Simulation 2A

(US$ million in 2009 prices, US$ 1 = 70 Taka)

	Cost			Project Benefits								Net
Year	**Capital**	**O&M**	**Total**	**Road User Benefits**			**Non Road User Benefits**				**Total**	**Economic**
End June	**Cost**		**Cost**	**VOC**	**TTC**	**Sub-total**	**Ferry**	**Land**	**Utilities**	**WEB**	**Benefits**	**Benefits**
2011	60		60			0					0	-60
2012	500		500			0					0	-500
2013	500		500			0					0	-500
2014	500		500			0					0	-500
2015	324	0	324	19	31	50	0	384	271	0	705	381
2016		13	13	37	50	88	0			0	87	74
2017		25	25	61	75	137	0			20	161	136
2018		25	25	74	87	161	0			32	193	168
2019		25	25	84	97	182	0			50	242	217
2020		25	25	93	106	199	0			64	263	238
2021		25	25	111	124	235	0			77	312	287
2022		25	25	131	145	276	0		0	90	366	341

	Cost			Project Benefits								Net
Year	**Capital**	**O&M**	**Total**	**Road User Benefits**			**Non Road User Benefits**				**Total**	**Economic**
End June	**Cost**		**Cost**	**VOC**	**TTC**	**Sub-total**	**Ferry**	**Land**	**Utilities**	**WEB**	**Benefits**	**Benefits**
2023		15	15	153	168	321	0		0	103	424	409
2024		15	15	176	193	369	0			118	487	472
2025		15	15	202	221	423	0			143	566	551
2026		15	15	231	243	473	0			168	717	702
2027		15	15	260	266	526	0			192	718	703
2028		15	15	290	291	581	0			221	801	786
2029		15	15	322	316	637	0			261	957	942
2030		15	15	354	342	696	0			261	957	942
2031		15	15	370	351	721	0			261	982	967
2032		15	15	386	360	746	0			261	1007	992
2033		15	15	401	370	771	0			261	1032	1017
2034		15	15	417	378	795	0			261	1056	1041
2035		15	15	431	388	820	0			261	1206	1191
2036		15	15	447	397	844	0			261	1105	1090
2037		15	15	462	407	869	0			261	1130	1115
2038		15	15	477	417	895	0			261	1281	1266
2039		15	15	493	427	919	0			261	1307	1292
2040		15	15	508	437	945	0			261	1206	1191
2041		15	15	513	438	951	0			261	1213	1198
2042		15	15	518	439	957	0			261	1218	1203
2043		15	15	521	440	962	0			261	1348	1333
2044		15	15	525	441	966	0			261	1227	1212
2045		15	15	542	455	997	0			261	1258	1243
Total	1,884	508	2392	9609	8900	18512	0	384	271	5715	25532	23140
NPV (12%)	**$1,310**	**$139**	**$1,398**	**$1,291**	**$1,321**	**$1,660**	**$0**	**$343**	**$242**	**$796**	**$2,582**	**$1,184**
											ERR	**18%**
											NPV	**$1,184**
											B/C	**1.97**

VI. THE IMPACTS OF THE PADMA BRIDGE: A COMPUTABLE GENERAL EQUILIBRIUM ANALYSIS

So far, we have analysed the indirect impacts of the Padma Bridge using the SAM-model, which is a fixed-price demand driven approach. As understood from the study on Jamuna Bridge, one of the major effects of the construction of Padma Bridge would be the reduction in the transport margin across the sectors. In line with the study on Jamuna Bridge this study also undertakes a simulation exercise considering a cut in the transport margins. An alternative method of undertaking this exercise is to run this simulation in a Computable General Equilibrium (CGE) framework, whose advantage is that it traces the price effects of the exogenous shock. In an increasingly market oriented economy, the variations in prices may be the most important sources of re-allocation of resources among competing activities which then may alter the factorial income and hence personal income distribution. Changes in personal income distribution of household groups and consumer price indices may have different implications on the welfare and poverty situations of the distinct household groups. Application of computable general equilibrium analysis allows us to assess the impacts of exogenous shocks primarily through changing prices. A SAM prepared for the year 2006-07 serves as the consistent and comprehensive database for the above-mentioned exercises.

The variations in the sectoral prices will reallocate resources across the producing activities, thereby altering factoral income generation. As a consequence, the personal income of the household group will also be altered. Implied price, income and consumption effects will have implications for the household welfare situation and poverty incidence. Welfare situation is measured by the well-known equivalent variation.

6.1. The CGE Model for Bangladesh Economy

A CGE model examines the consequences of policy reforms within a constrained optimization framework. Computable general equilibrium models capture the detailed accounts of the circular flows of receipts and outlays in an economy. It satisfies general equilibrium conditions in various markets simultaneously. Such models are useful to analyse associations between various agents of the economy.

In line with most of CGE models, the model has been solved in comparative static mode and provides an instrument for controlled policy simulations and experiments. Solution of each simulation presents complete sets of socio-economic, meso and macro level indicators such as activity/commodity prices, household incomes and expenditures, factor demand and supplies, gross domestic products, exports and imports, and household poverty situation. The model is calibrated to the SAM to exactly reproduce the base year values[15]. The equations of the CGE model are presented in Annex 4.

Activities

On the production side it is assumed that in each sector there is a representative firm that generates value added by combining labour and capital. A nested structure for production is adopted. Sectoral output is a Leontief function of value added and total intermediate consumption. Value added is in turn represented by a CES function of capital and composite labour. The latter is also represented by a CES function of two labour categories: skilled labour and unskilled labour. Both labour categories are assumed to be fully mobile in the model. In the different production activities we assume that a representative firm remunerates factors of production and pays dividends to households.

Households

Households earn their income from production factors: labour, land and capital. They also receive dividends, government transfers and remittances. They pay direct income tax to the government. Household savings are a fixed proportion of total disposable income. Household demand is derived from a Cobb-Douglas (C-D) utility function.

Foreign Trade

It is assumed that foreign and domestic goods are imperfect substitutes. This geographical differentiation is introduced by the standard Armington assumption with a constant

[15] In calibration procedure, most of the model parameters are estimated endogenously keeping the various elasticity values fixed.

elasticity of substitution function (CES) between imports and domestic goods. On the supply side, producers make an optimal distribution of their production between exports and domestic sales according to a constant elasticity of transformation (CET) function. Furthermore, a finite elasticity export demand function is assumed. Even if it is assumed that the international terms of trade are given, the small country assumption for Bangladesh is rejected, and assumed that foreign demand for Bangladeshi exports is less than infinite. In order to increase their exports, local producers must decrease their free on board (FOB) prices.

Government

The government receives direct tax revenue from households and firms and indirect tax revenue on domestic and imported goods. Its expenditure is allocated between the consumption of goods and services (including public wages) and transfers. The model accounts for indirect or direct tax compensation in the case of a tariff cut.

System Constraints and Equilibrium Conditions

There are four constraints in the system. The real constraint refers to domestic commodity and factor market; the nominal constraint represents two macro balances: the current account balance of the rest of the world and the savings-investment balance.

Sectoral supply is a composite of imports and output sold in the domestic market. Composite demand, on the other hand, includes final demands (i.e. private and public consumption expenditure and investment) and intermediate input demand. Variations in the sectoral prices assure equilibrium between sectoral supply and demand.

In the case of factor market, it is assumed that total quantities of factors supply are fixed. This specification also implies full mobility of labour factors across producing activities and variations in their returns (e.g. wages) assures equilibrium in the factor market.

The inflows (transfers to and from domestic institutions) are fixed but imports and exports are determined endogenously in the model. Foreign savings is fixed in this model and nominal exchange rate acts as numeraire.

Finally, for the savings-investment equilibrium, the model treats the investment decision as given and hence savings has to adjust to ensure the equality to the fixed value of investment. The basic approach is to allow the savings propensity of one of the domestic institution to vary.

6.2. Simulation Design

In CGE models since demands (which are usually assumed exogenous in SAM models) are endogenous along with supply, injection via demand variations are ruled out in CGE models. Since construction of Padma Bridge likely to lessen time needed to move goods leading to reduced transport margins, in CGE exercise one simulation is conducted where sectoral transport margins are reduced and its impacts on resource re-allocation, sectoral output and consumption, poverty and income distribution situation of the representative household groups are examined. Following simulation is conducted:

Simulation 3: In this simulation base values of the sectoral transport margin rates are reduced by 50 percent[16]. The base values of all other parameters are retained.

6.3. Simulation Results

In order to capture the effects of changes in transport margins on sectoral prices and volumes of output, as well as on the household's welfare and poverty situation, the transport margins paid by each of the producing activities are deducted from their transaction values valued at purchaser prices. The derived sectoral transport margins are then added as a component in the formation of the domestic sales price. Variations in the transport margins affect the domestic sales price first and subsequently the changed domestic sales price will influence all other prices due to their interdependence. The base and simulation values of transport margin rates are presented in Table 17.

[16] The sectoral transport rates are derived as proportions of sectoral total domestic sales values.

Table 17: Rates of Transport Margin by Sectors under Base and Simulation Scenarios

	Sectors	Base rate	New rate under simulation 3
1	Paddy Cultivation	3.69	1.85
2	Grains	4.16	2.08
3	Jute Cultivation	4.71	2.36
4	Sugarcane Cultivation	3.74	1.87
5	Vegetables	4.93	2.47
6	Commercial Crops	3.07	1.54
7	Other Crop Cultivation	1.22	0.61
8	Livestock Rearing	1.14	0.57
9	Poultry Rearing	1.12	0.56
10	Shrimp Farming	1.33	0.66
11	Fishing	1.18	0.59
12	Forestry	1.03	0.52
13	Rice Milling	1.25	0.62
14	Grain Milling	1.46	0.73
15	Fish Process	1.49	0.75
16	Oil Industry	1.13	0.57
17	Sweetener Industry	1.40	0.70

6.3.1. Macroeconomic Effects

The macro impacts of the fall in transport margins on major macro variables are reported in Table 18. It is observed that the effects of the transport margin rate reduction on macro variables are positive. Under Simulation 3, real GDP rises by 1.14 percent. The general price index falls by 2.85 percent. Both exports and imports rise by 1.89 and 1.66 percent respectively. Domestic sales and consumption expenditure also rise by 2.05 percent and 1.95 percent respectively. The positive growth of the economy and moderate fall of general price index led to the enhancement of national welfare by 0.78 percent of base value of household income.

Table 18: Macroeconomic Effects (% change from base value)

Macro variables	Simulation 3
Real Gross Domestic Product	1.14
General Price Index	-2.85
Imports	1.89
Exports	1.66
Domestic Goods	2.05
Consumption Expenditure	0.95
Equivalent Variation	0.78

The reasons for obtaining different outcome magnitudes under the SAM and CGE approaches lie in the fact that the impact of the Padma Bridge intervention is explained differently under the two approaches. In the SAM approach, the impact was demonstrated via enhancing the sectoral demand. Since there is no capacity constraints, matching outputs are always supplied, which resulted in higher factorial incomes and household consumption expenditure. In the CGE case, the simulation was performed by reducing the transport margin rates. The changes in transport rates alter the relative price situation in the economy, which then led to the reallocation of existing resources to various producing activities. The gains are obtained by reducing existing distortions and hence they are small. Since supplies of primary factors were fixed there is no scope of generating extra income by employing additional factors (as was the case in the SAM approach)[17].

6.3.2. Price Effects

The fall of transport margin rates affects the sectoral domestic sales price first. The changes in domestic sales prices then influence other prices, allocation of resources, incomes and consumption expenditures. The price effects of reduction in transport margin rate for 41 sectors are presented in Table 19.

[17] The CGE results under Padma exercise are largely similar to those under the Jamuna exercise. However, the differences between SAM and CGE outcomes under the Padma exercise are wider than that found for the Jamuna exercise. The probable reasons mat include: (i) changed inter-industry structure reflecting larger multipliers; and (ii) relatively larger size of the demand intervention.

Under Simulation 3, the fall in prices of domestic sales in general is higher for the agricultural sectors compared to the manufacturing and services sector. Since the base of rates of transport margins for agriculture are higher than manufacturing and services, these sectors would experience the larger price fall. The fall in the price of domestic sales is the highest for forestry sector. The fall in consumer and producer prices help reduce the general price index. The fall in FOB export prices results in rise in the competitiveness of the sectors. As a result of the fall in domestic sales prices (which dominates the consumer price formation), the prices faced by final consumers are also reduced. The reduction in the domestic price of manufacturing product imports led to a further decline of consumer prices of manufacturing commodities. Due to the interdependence of price formation, imports-exports and producer prices have also been affected by the fall of domestic sales prices.

Table 19: Sectoral Price Effects (Percentage change from base value)

		Simulation 3			
	Sectors	**Domestic Sales**	**Consumer**	**Producer**	**Export_ FOB**
1	Cereal Crops	-2.38	-2.28	-2.24	0.00
2	Commercial Crops	-2.78	-2.74	-2.65	-1.76
3	Livestock-Poultry-fishing	-2.44	-2.26	-2.50	-2.71
4	Forestry	-2.92	-2.62	-2.49	0.00
5	Other Agriculture	-2.46	-2.27	-2.17	-2.01
6	Other Food	-2.34	-2.31	-2.19	-1.42
7	Leather Products	-0.95	-0.92	-0.87	-0.79
8	Cloth	-1.41	-1.35	-1.24	-1.04
9	Readymade Garments	-1.26	-1.25	-1.24	-1.23
10	Chemical-Fertilizer	-1.50	-1.35	-1.24	-1.23
11	Machinery	-1.42	-1.69	-1.60	-1.63
12	Petroleum Products	-1.48	-1.31	-1.17	-1.02
13	Other Industries	-1.45	-1.41	-1.42	-1.21
14	Construction	-1.67	-1.29	-1.92	0.00
15	Transport	-1.34	-1.27	-1.20	-1.07
16	Utility	-1.09	-1.76	-1.46	0.00
17	Other Services	-1.24	-1.12	-1.66	-1.33

Simulated outcomes for 5 aggregated sectors are reported in Table 20. The fall of prices of domestic sales is reported to be the highest for agriculture, followed by manufacturing and construction activities.

Table 20: Price Impacts of Intervention Using the National Level 5 Activity Classification

(Percentage change from base value)

		Simulation 3			
	Sectors	Domestic Sales	Consumer	Producer	Export_FOB
1	Agriculture	-2.55	-2.42	-2.48	-2.30
2	Manufacturing	-1.52	-1.50	-1.48	-1.29
3	Construction	-1.67	-1.29	-1.92	
4	Transport	-1.34	-1.27	-1.20	-1.07
5	Services	-1.27	-1.25	-1.54	-1.50

6.3.3. Volume Effects

Under Simulation 3, the decline in sectoral prices leads to rise in sectoral domestic sales, consumption, imports, exports and outputs. Consistent with the price decline pattern, the gains are found to be the highest for agricultural sectors. Fishing sector would experience the largest rise in output. Export from sectors like other crop, vegetables, poultry, rice and food rise by more than 5 percent.

Table 21: Sectoral Effects of Simulation (Percentage change from base value)

		Simulation 3				
	Sectors	Output	Imports	Exports	Domestic Sales	Consum-ption
1	Cereal Crops	2.58	1.89	0.00	2.45	0.00
2	Commercial Crops	3.56	2.04	2.08	3.17	1.53
3	Livestock-Poultry-fishing	4.44	2.28	3.34	4.23	1.90
4	Forestry	3.52	0.00	0.00	3.76	1.48
5	Other Agriculture	4.62	2.49	5.28	4.38	1.91
6	Other Food	3.85	2.21	3.36	3.48	1.59
7	Leather Products	1.84	0.99	2.38	1.69	0.76
8	Cloth	2.47	1.47	0.10	2.50	1.13
9	Readymade Garments	0.54	0.29	0.60	0.46	0.21
10	Chemical-Fertilizer	3.06	2.96	4.32	3.56	1.52
11	Machinery	2.75	1.14	1.85	2.37	0.77
12	Petroleum Products	4.65	2.51	3.64	3.42	1.94
13	Other Industries	3.83	2.05	3.73	4.63	1.57
14	Construction	3.38	0.00	0.00	3.66	1.14
15	Transport	3.53	2.44	3.03	3.16	1.37
16	Utility	2.91	2.27	0.00	2.27	1.31
17	Other Services	4.19	1.75	1.41	3.74	1.58

Simulated outcomes for 5 aggregated sectors are reported in Table 22. Output in the agricultural sector as a whole rises by 3.84 percent, which is the highest among the five broad sectors. Also, exports and domestic sales in agriculture experience the largest rise.

Table 22: Volume Impacts of Intervention Using the National Level 5 Activity Classification (Percentage change from base value)

	Sectors	Simulation 3				
		Output	Imports	Exports	Domestic Sales	Consum-ption
1	Agriculture	3.84	2.30	4.39	3.60	1.55
2	Manufacturing	3.22	2.10	3.38	3.12	1.41
3	Construction	3.38	0.00	0.00	3.66	1.14
4	Transport	3.53	2.44	3.03	3.16	1.37
5	Services	3.54	2.20	3.15	3.14	1.43

6.3.4. Factor Movements and Value-Added Effects

Under a general equilibrium framework, any shock into the system would lead to reallocation of resources from existing less productive sectors to relatively more productive sectors. The resultant primary factor movements and changes in value added are reported in Table 23. Under Simulation 3, in general, resources move out of some manufacturing and services activities and are absorbed in the agricultural and some manufacturing leading to the positive value added growth of agriculture and manufacturing activities. On the other hand, reduced availability of primary factors manifested in negative value added growth for many services activities.

Table 23: Effects on Value Added and Factor Movements (Percentage change from base value)

	Sectors	Simulation 3				
		Value-Added	Labour unskilled	Labor skilled	Capital	Land
1	Cereal Crops	1.03	0.87	0.84	0.00	1.07
2	Commercial Crops	1.41	1.12	1.09	0.00	1.49
3	Livestock-Poultry-fishing	1.78	1.52	1.48	1.95	0.00

		Simulation 3				
	Sectors	Value-Added	Labour unskilled	Labor skilled	Capital	Land
4	Forestry	1.41	1.20	1.15	1.55	0.00
5	Other Agriculture	1.85	1.57	1.51	0.00	1.91
6	Other Food	1.51	1.59	1.62	1.43	0.00
7	Leather Products	0.74	0.76	0.77	0.66	0.00
8	Cloth	0.98	1.03	1.05	0.93	0.00
9	Readymade Garments	0.22	0.22	0.23	0.19	0.00
10	Chemical-Fertilizer	-0.99	-1.11	-1.14	-0.86	0.00
11	Machinery	-0.35	-0.30	-0.30	-0.36	0.00
12	Petroleum Products	-1.86	-1.99	-2.03	-1.67	0.00
13	Other Industries	-0.72	-0.90	-0.92	-0.56	0.00
14	Construction	1.75	1.52	1.55	1.58	0.00
15	Transport	0.91	0.86	0.88	0.82	0.00
16	Utility	-0.76	-0.66	-0.68	-0.69	0.00
17	Other Services	0.57	-0.23	0.27	0.84	0.00

Simulated outcomes for 5 aggregated sectors are reported in Table 24. Under Simulation 3, value-added in the agricultural sector would rise by 1.54 percent while that of manufacturing would rise by only 0.34 percent. Construction and transport sector would experience positive gain in value added while the value added in the services sector decline by 0.43 percent.

Table 24: Volume Impacts of Intervention Using the National Level 5 Activity Classification (Percentage change from base value)

		Simulation 3				
	Sectors	Value-Added	Labour unskilled	Labor skilled	Capital	Land
1	Agriculture	1.54	1.31	1.26	0.75	0.88
2	Manufacturing	0.34	0.36	0.37	0.31	-
3	Construction	1.75	1.52	1.55	1.58	-
4	Transport	0.91	0.86	0.88	0.82	-
5	Services	-0.43	-0.40	-0.40	-0.38	-

6.3.5. Welfare Effects

Most CGE modellers use these models to assess the impacts of given shocks or policies on a specific economy. While it is quite straightforward to measure impacts on aggregate nominal production and consumption levels, relative prices, nominal income and savings, it is less obvious to quantitatively evaluate how much better or worse off the households are. As direct and indirect utility functions are purely ordinal in nature, we can only analyse the direction of change. An interesting alternative is provided by using the money metric utility function, which measures the nominal income the consumer needs at one set of prices in order to be as well of at an alternative set of prices and nominal income. As such, it can be used to obtain monetary measures of the welfare effects of different policy scenarios. The most common of these measures is equivalent variations (EV).

Table 25 presets the change in consumer price index, income and EV of the eight representative households in the model. Under both the scenarios, all the households experience fall in CPIs and rise in income which leads to rise in real consumption and welfare of the households. The largest rise in EV is for the small and marginal farmers. In general the rural households experience larger rise in real consumption and welfare.

Table 25: Welfare effects (Percentage change from base value)

	Simulation 3		
Households	**CPI**	**Income**	**EV**
Landless	-2.65	1.19	0.86
Marginal farmers	-2.68	1.45	0.89
Small farmers	-2.58	1.67	0.89
Large farmers	-2.56	1.14	0.76
Rural non-farm poor	-2.52	1.26	0.72
Rural non-farm non poor	-2.22	1.14	0.68
Urban low education	-2.48	1.20	0.78
Urban high education	-2.36	1.11	0.65

VII. POVERTY ESTIMATES UNDER DIFFERENT SIMULATIONS

It can be mentioned that under the SAM model, which is a fixed price model, the changes in household incomes are judged against a pre-determined poverty line income. However, under the CGE framework, there is an initial distribution of income for different representative household groups. Now, for any policy shock, the incomes of different household groups change. Also, the poverty line income is adjusted for the change in consumer price index. Now, the simulated income of the household is compared with the new adjusted poverty line income. If the income is above the poverty line income, the household is non-poor and if it is below the household is poor. The annualised headcount poverty impacts under different scenarios are presented in Table 26.

Table 26: Annualised Reduction in Aggregate Head-count Poverty Estimates under different Simulations (% change from base value)

Type of Model	Simulation 1A (National)	Simulation 1B (Regional)	Simulation 2A (National)	Simulation 2B (Regional)	Simulation 3 (National)
SAM Multiplier Model	-0.84	-1.01	-0.63	-0.81	X
CGE Model	X	X	X	X	-0.08

Note: The annualised figures are derived by dividing the total effects by 31 years

It appears from Table 26 that under the SAM multiplier model, Simulation 1A would generate the highest reduction in annualised head-count poverty at the national level (-0.84 percent) and Simulation 1B would generate the highest fall in head-count poverty at the regional level (-1.01 percent). The annual fall in head-count poverty under Simulation 3 (CGE framework) would be 0.08 percent.

Now, using the Foster-Greer-Thorbecke (FGT) class of poverty measures (Foster, et al, 1984) we can also derive other two measures of poverty: poverty gap index and squared poverty gap index for different household categories under different simulations. The poverty gap index, measures the depth of poverty, and it estimates the average distance separating the income of the poor from the poverty line as a proportion of the income indicated by the line. The squared poverty gap index, also measures the severity of poverty, quantifies the aversion of the society towards poverty. Table 27 provides the annualised estimates of impact on poverty indices for different household groups under the three national simulations. It appears that the poorer household groups are likely to experience higher reduction in poverty indices compared to their non-poor counterparts under all those three simulations.

Table 27: Annualised Impacts on Poverty Indices for different Household Groups under different Simulations (% change from base value)

	Simulation 1A			Simulation 2A			Simulation 3		
Households	Head-count (P0)	Poverty gap (P1)	Squared poverty gap (P2)	Head-count (P0)	Poverty gap (P1)	Squared poverty gap (P2)	Head-count (P0)	Poverty gap (P1)	Squared poverty gap (P2)
Landless	-0.99	-1.21	-1.38	-0.74	-0.95	-1.19	-0.09	-0.12	-0.15
Marginal farmers	-0.86	-1.13	-1.19	-0.64	-0.89	-1.03	-0.08	-0.11	-0.13
Small farmers	-1.06	-1.33	-1.38	-0.80	-1.04	-1.19	-0.10	-0.13	-0.15
Large farmers	-0.54	-0.70	-0.83	-0.40	-0.55	-0.71	-0.05	-0.07	-0.09
Rural non-farm poor	-0.43	-0.51	-0.64	-0.32	-0.40	-0.55	-0.04	-0.05	-0.07
Rural non-farm non-poor	-0.32	-0.40	-0.46	-0.24	-0.32	-0.40	-0.03	-0.04	-0.05
Urban low education	-0.95	-1.22	-1.38	-0.72	-0.96	-1.19	-0.09	-0.12	-0.15
Urban high education	-0.66	-0.91	-0.73	-0.49	-0.72	-0.63	-0.06	-0.09	-0.08
National	-0.84	-0.99	-1.10	-0.63	-0.78	-0.95	-0.08	-0.10	-0.12

Note: The annualised figures are derived by dividing the total effects by 31 years

VIII. CONCLUDING OBSERVATIONS

By facilitating transportation across the river, the Padma Bridge is expected lead to the greater integration of regional markets within the Bangladeshi national economy. On the basis of their suitability of capture primary and secondary economic impacts of construction project, three different types of economy wide models are employed in addition to traditional traffic model to capture the total and economy wide impacts of Padma Bridge.

Although outcomes of all types of models are positive, the results show variations due to especially to size of shocks. The results are summarized below.

1. In the Traffic model, road users benefits are estimated based on the saving on vehicle operation costs (VOC) and savings in travel time cost (TTC). Total road user benefit is estimated to be about million 1,295,840 taka over the 31 year period.

2. Out of the total cost of the project ($2.9 billion), it was estimated that about $2.1 billion would be injected into the economy and the rest consists of imports, IDC etc. Injection of $2.1 billion into the economy using national SAM model envisaged value added increase of 453,670 million taka. This increase implies that annualized equivalent rate for national GDP would be 0.33 percent compared to the national base GDP (i.e. 4,468,549 million

taka). Annual equivalent rates of growth were calculated keeping in view the 31 years as the time taken to fully realize the impact of the bridge. If we took a shorter time horizon for fully realizing the benefit of growth, then the annual equivalent rates could be larger.

3. On the other hand, injection of $2.1 billion into the regional economy using the regional SAM model envisaged that annualized equivalent rate for regional GDP would be 2.3 percent compared to the regional base GDP. However, if it assumed that only 70 percent of the shock would be operative in the region (against full 100 percent or $2.1 billion), the annualized equivalent rate for regional GDP would be roughly 1.66 percent of the regional base GDP. Given that the SAM model assume excess capacity (which may be a reasonable assumption in a country like Bangladesh with under-utilized resources), the size of impacts vary with the size of injection or shock.

4. Using the Traffic mode, road users benefit is found to be million 1,295,840 taka. We consider value added increase of million 453,670 taka derived from the national SAM model (i.e. simulation 1A) as economy wide benefits of the project. Thus, total project benefit is estimated to be 1,749,510 million taka (i.e. Total (1,749,510) = Road User Benefit (=1,295,840) + WEB (=453,670). This implies that total project benefit is 39 percent relative to the base national income (i.e. 4,468,549). Assuming the 31 year full realization timeframe, total project benefits per year is then 1.26 percent relative to the base national income. The base GDP figure would change over 31 years. Assuming 5 percent GDP growth over the 31 period an alternative estimate of base year is arrived. The total project benefit (i.e. 1,749,510) is only 0.56 percent relative to the alternative base national income (average GDP during that period).

5. Further assessment of the total project benefits (explained above) in terms of conventional project appraisal measures suggests that the project is economically viable. More specifically, the project is viable with:
    - **a net present value of US$ 1234 million;**
    - **a benefit-cost ratio (BCR) of 2.01; and**
    - **an economic internal rate of return (EIRR) of 19 percent.**

6. The application of constrained optimization model such as CGE model outcomes also vindicates the findings of the traffic model and SAM based model. More specifically, 50 percent reduction in transport margins may lead to welfare increase by 0.78 percent compared to the base value.

7. Under certain assumptions (Simulation 1A), the construction of the Padma Bridge would lead to an annualised reduction in head-count poverty at the national level by 0.84 percent and at the regional level by 1.01 percent. Other simulations also indicated reduction in poverty in different magnitudes.

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Annex 1: SAM Multiplier Modules

The shift from a 'data' SAM structure to a SAM Multiplier Module requires the introduction of assumptions and the separation of the SAM accounts into 'exogenous' and 'endogenous' components[18].

Table A1: General SAM Modular Structure

		1a-PA	1b-CM	2-FP	3a-HH-OI	4-KHH-OI	5-ROW	TDD
1a	PA		$T_{1a, 1b}$		0			$\mathbf{Y_{1a}}$
1b	CM	$T_{1b, 1a}$			$T_{1b, 3}$	$T_{1b, 4}$	$T_{1b, 5}$	$\mathbf{Y_{1b}}$
2	FP	$T_{2, 1a}$					$T_{2, 5}$	$\mathbf{Y_{2}}$
3	HH-IO	$T_{3, 1a}$	$T_{3, 1b}$	$T_{3, 2}$	$T_{3, 3}$		$T_{3, 5}$	$\mathbf{Y_{3}}$
4	KHH-OI	$T_{4, 1a}$			$T_{4, 3a}$		$T_{4, 5}$	$\mathbf{Y_{4}}$
5	ROW		$T_{5, 1b}$	$T_{5\ 2}$	$T_{5, 3}$	0	0	$\mathbf{Y_{5}}$
	TSS	$\mathbf{E_{1a}}$	$\mathbf{E_{1b}}$	$\mathbf{E_{2}}$	$\mathbf{E_{3}}$	$\mathbf{E_{4}}$	$\mathbf{E_{5}}$	

Where: by definition $Y_i = E_j$ and **1 Production (1a PA** = Production Activities and **1b CM** = Commodities); **2 FP** = Factors of Production; **3 HH-IO** = Households and Other Institutions (incl. Government); **4 KHH-OI** = Capital Account Households and Other Institutions (incl. government); **5 ROW** = Rest of the World (Current and capital account). **Blank entries** indicate that there are no transactions by definition.

The separation is needed to gain entry into the system, allowing some variables within the SAM structure to be manipulated exogenously (via injection instruments) to assess the subsequent impacts on the endogenous accounts as well as on the exogenous accounts.

Generally, accounts intended to be used as policy instruments are classified as exogenous and accounts specified *a priory* as objectives (or targets) are classified as endogenous.

Three accounts are designated as endogenous accounts: *(1) Production (Production Activities and Commodities) account, (2) Factors of Production account, (3a) Households and Other Institutions (excl. the Government)*.

The exogenous accounts comprises *3a Government (expenditure, transfer, remittances); 4 Capital account of institutions (savings and demand for houses, investment demand, infrastructure and*

[18] The methodology and symbology follows Pyatt, G. and Jeffrey Round, (1977) Pyatt, G. and Jeffrey Round, (1979) and Pyatt, G. and Roe, A. (1987) (eds), while the lay out follows Alarcón, J. V., E. Delabastida and R. Vos, (1984), Alarcon, J. V., S. Keuning, J. van Heemst, W. de Ruyter and R. Vos, (1991).

machinery and equipment); and 5 ROW *transfers, remittances, export demand and capital.* The SAM Flows and the categorization into endogenous and exogenous accounts are shown below.

Table A2: Endogenous and Exogenous Accounts

		1a-PA	1b-CM	2-FP	3a-HH-OI	3b-Gov	4-KHH-OI	5-ROW	TDD
1a	PA		$T_{1a, 1b}$		0				$\mathbf{Y_{1a}}$
1b	CM	$T_{1b, 1a}$			$T_{1b, 3a}$	$T_{1b, 3b}$	$T_{1b, 4}$	$T_{1b,5}$	$\mathbf{Y_{1b}}$
2	FP	$T_{2, 1a}$						$T_{2, 5}$	$\mathbf{Y_2}$
3a	HH-OI			$T_{3a, 2}$	$T_{3a, 3a}$	$T_{3a, 3b}$		$T_{2, 5}$	$\mathbf{Y_3}$
3b	Gov	$T_{3b, 1a}$	$T_{3b, 1b}$		$T_{3b, 3a}$	$T_{3b, 3b}$		$T_{3a, 5}$	
4	KHH-OI	$T_{4, 1a}$			$T_{4, 3}$			$T_{4, 5}$	$\mathbf{Y_4}$
5	ROW		$T_{5, 1b}$	$T_{5, 2}$	$T_{5, 3a}$	$T_{5, 3b}$	$T_{5, 4}$	0	$\mathbf{Y_5}$
	TSS	$\mathbf{E_{1a}}$	$\mathbf{E_{1b}}$	$\mathbf{E_2}$	$\mathbf{E_{3a}}$	$\mathbf{E_{3b}}$	$\mathbf{E_4}$	$\mathbf{E_5}$	

Where Endogenous: **1 Production (1a PA** = Production Activities and **1b CM** = Commodities); **2 FP** = Factors of Production; **3a HH** = Households and Other Institutions (excl. Government); Where Exogenous: **3b** Government; **4 KHH-OI** = Capital Account of Households and of Other Institutions (incl. government); **5 ROW** = Rest of the World (Current and capital account). **Blank** entries indicate that there are no transactions by definition.

Table A3: Endogenous and Components of Exogenous Accounts

	PA	CM	FP	3a HH&OI	EXO	INCOME	Exogenous Accounts (EXO) used as injections Column Vectors
1a PA		$T_{1a\ 1b}$		0	X_{1a}	$\mathbf{Y_{1a}}$	$X_{1a} = 0$
1b CM	$T_{1b\ 1a}$			$T_{1b\ 3a}$	X_{1b}	$\mathbf{Y_{1b}}$	X_{1b} = Government Consumption Subsidies -Taxes + Exports + Gov. Investment (capital formation in infrastructure and machinery and equipment) + Gross Capital Stock formation
2 FP	$T_{2\ 1a}$				X_2	$\mathbf{Y_2}$	X_2 =Factor Remittances from ROW
3a HH&OI			$T_{3a\ 2}$	$T_{3a\ 3a}$	X_{3a}	$\mathbf{Y_{3a}}$	X_{3a} = Factor Remittances from ROW
3b-5 Leaks	L_{1a}	L_{1b}	L_2	L_{3a}	$L_{3b\text{-}5} = X_{3b\text{-}5}$	$Y_{3b\text{-}5}$	3b =Aid to Government from ROW
EXPN	$\mathbf{E_{1a}}$	$\mathbf{E_{1b}}$	$\mathbf{E_2}$	$\mathbf{E_{3a}}$	$\mathbf{E_{3b\text{-}5}}$		Where $\mathbf{E_i = Y_j}$
L_{1a} = Activity Tax					L_{3a} = Income Tax + Household Savings + Corporate Savings		

L_{1b} = Commodity Tax + Import Duty + Imports	$L_{3b\text{-}5}$ $X_{3b\text{-}5}$ and $Y_{3b\text{-}5}$ falls out of the model
L_2 = Factor Remittances to ROW	Blank entries indicate that there are no transactions by definition.

Note on Injection: For any given injection into the exogenous accounts X_i (i.e. instruments) of the SAM, influence is transmitted through the interdependent SAM system among the endogenous accounts. The interwoven nature of the system implies that the incomes of factors, institutions and production are all derived from exogenous injections into the economy via a multiplier process. Multiplier models may also be built on the input-output frameworks. The main shortcoming of the IO model is that the feedback between factor income generation (value added) and demand by private institutions (households) does not exist. In this case the circular economic flow is truncated. The problem can be partly tackled by endogenising household consumption within the I-O framework; this is typically referred to as a 'closed I-O model'. In this case, the circular economic flow is only partially truncated. A better solution is to extend the I-O to a SAM framework which captures the full circular economic flow.

SAM coefficient (Aij) are derived from payments flows by endogenous accounts to themselves (Tij) and other endogenous accounts as to the corresponding outlays (Ei = Yj); similarly, the leak coefficients (Bij) derived from flows reflecting payments from endogenous accounts to exogenous accounts. They are derived below.

Table A4: Coefficient Matrices and Vectors of the SAM Model

Account	1a - PA	1b – CM	2 – FP	3a - HH&OI	3b … 5 EXO	Income
1a – PA		$A_{1a,1b} = T_{1a,1b} / \mathbf{Y_{1b}}$			X_{1a}	$\mathbf{Y_{1a}}$
1b – CM	$A_{1b,1a} = T_{1b,1a} / \mathbf{Y_{1a}}$			$A_{1b,3a} = T_{1b,3a} / \mathbf{Y_{3a}}$	X_{1b}	$\mathbf{Y_{1b}}$
2 – FP	$A_{2,1a} = T_{2,1a} / \mathbf{Y_{1a}}$				X_2	$\mathbf{Y_2}$
3a - HH&OI			$A_{3a,2} = T_{3a,2} / \mathbf{Y_2}$	$A_{3a,3a} = T_{3a,3a} / \mathbf{Y_{3a}}$	X_{3a}	$\mathbf{Y_{3a}}$
3b … 5 Leaks	$B_{1a} = L_{1a} / \mathbf{Y_{1a}}$	$B_{1b} = L_{1b} / \mathbf{Y_{1b}}$	$B_2 = L_2 / \mathbf{Y_2}$	$B_{3a} = L_{3a} / \mathbf{Y_{3a}}$		
Expenditure	$\mathbf{E_{1a} = Y_{1a}}$	$\mathbf{E_{1b} = Y_{1b}}$	$\mathbf{E_2 = Y_2}$	$\mathbf{E_3 = Y_{3a}}$		

The multiplier analysis using the SAM framework helps to understand the linkages between the different sectors and the institutional agents at work within the economy. Accounting multipliers have been calculated according to the standard formula for accounting (impact) multipliers, as follows:

$\mathbf{Y} = A\,Y + \mathbf{X} = (I - A)^{-1}\mathbf{X} = M_a\,\mathbf{X}$

Where:

Y is a vector of incomes of endogenous variables

X is a vector of expenditures of exogenous variables

A is the matrix of average expenditure propensities for endogenous accounts

$M_a = (I - A)^{-1}$ is a matrix of aggregate accounting multipliers (generalized Leontief inverse).

Variations in any one of the exogenous account (i.e. in this case ΔX) will produce total impacts (ΔY) of endogenous entries via the multipliers. The total impact will be decomposed by direct and induced impacts for capturing the strengths of the transmission channel.

Table A6: Description of the Endogenous and Exogenous Accounts and Multiplier Affects

Endogenous (y)	Exogenous (x)
The activity (gross output multipliers), indicates the total effect on the sectoral gross output of a unit-income increase in a given account *i* in the SAM, and is obtained via the association with the commodity production activity account *i*.	
The consumption commodity multipliers, which indicates the total effect on the sectoral commodity output of a unit-income increase in a given account *i* in the SAM, is obtained by adding the associated commodity elements in the matrix along the column for account *i*.	Intervention into through activities (x = i + g + e), where i= GFC + ST (GFCF) Exports (e) Government Expenditure (g) Investment Demand (i) Inventory Demand (i)
The value added or GDP multiplier, giving the total increase in GDP resulting from the same unit-income injection, is derived by summing up the factor-payment elements along account *i*'s column.	Factor Income Remittances from RoW.
Household income shows the total effect on household and enterprise income, and is obtained by adding the elements for the household groups along the account i column.	Intervention via households (x = r + gt + ct), where Remittance (r) Government Transfers (gt) Corporation Transfers (ct)

The economy-wide impacts of infrastructure investments are examined by changing the total exogenous injection vector (especially Government Expenditure (g), Government Investment (expenditures on infrastructure, machinery and equipment) and Investment Demand (i). More specifically, the total exogenous account is manipulated to estimate their effects on output (through an output multiplier), value-added or GDP, (through the GDP multiplier), and household income (through household income multiplier).

Annex 2: Mapping and Classification Scheme

Table A7: Mapping

Activity-Commodity 17	Activity-Commodity 41
1. Cereal Crops	Paddy Cultivation and Grains Cultivation
2. Commercial Crops	Jute cultivation, Sugarcane Cultivation and Commercial Crops
3. Livestock-Poultry-fishing	Livestock Rearing, Poultry Rearing, Shrimp Farming and Fishing
4. Forestry	Forestry
5. Other Agriculture	Vegetable and Other Crop Cultivation
6. Other Food	Rice Milling, Grain Milling, Fish Process, Oil Industry, Sweetener Industry and Food
7. Leather Products	Leather
8. Cloth	Jute and Clothing
9. Readymade Garments	Ready Made Garment
10. Chemical-Fertilizer	Chemical and Fertilizer
11. Machinery	Steel and Machinery
12. Petroleum Products	Petroleum Products
13. Other Industries	Wood, Tobacco, Clay Products, Cement, and Miscellaneous
14. Construction	Construction
15. Transport	Transportation
16. Utility	Utility
17. Other Services	Trade, Social Services, Financial Services, Public Administration-Defense, Professional Services and Other Services
Activity-Commodity 5	**Activity-Commodity 17**
a. Agriculture	Cereal Crop, Commercial Crop, Livestock-Poultry-fishing, Forestry and Other Agriculture
b. Manufacturing	Other Food, Leather Products, Cloth, Readymade Garments, Chemical-Fertilizer, Machinery, Petroleum Products and Other Industries
c. Construction	Construction
d. Transport	Transport
e. Services	Other Services
Labour Factor 1	**Labour Factor 2**
• Labour	Labour Skilled and Labour Unskilled
Household 3	**Household 8**
• Rural Land Based	Landless, Marginal, Small, Large
• Rural Non-farm	Rural Non Farm Poor, and Rural Non Farm Non Poor
• Urban	Low Education and High Education

Annex 3: Multipliers of the SAM Modules

The multipliers derived using the National and Regional SAMs are reported here.

Table A8: Multipliers of the National and Regional SAMs

		National SAM	Regional SAM SW
1	a_Paddy Cultivation	11.66	11.33
2	a_Grains	9.55	11.85
3	a_Jute Cultivation	11.57	10.89
4	a_Sugarcane Cultivation	11.31	11.65
5	a_Vegetables	11.13	11.00
6	a_Commercial Crops	10.84	10.85
7	a_Other Crop Cultivation	11.82	11.98
8	a_Livestock Rearing	11.29	11.67
9	a_Poultry Rearing	10.92	13.95
10	a_Shrimp Farming	12.85	12.21
11	a_Fishing	11.08	10.79
12	a_Forestry	11.37	11.35
13	a_Rice Millling	12.53	11.96
14	a_Grain Milling	9.56	11.71
15	a_Fish Process	13.53	12.70
16	a_Oil Industry	8.56	11.27
17	a_Sweetener Industry	11.72	11.43
18	a_Food	9.88	11.53
19	a_Leather	12.02	11.77
20	a_Jute	12.53	11.45
21	a_Clothing	10.91	11.00
22	a_RMG	10.67	10.68
23	a_Tobacco	6.50	10.95
24	a_Wood	10.75	11.49
25	a_Chemical	9.07	11.01
26	a_Fertilizer	10.79	10.25
27	a_Petroleum	4.09	12.63
28	a_Clay Products	10.44	10.65
29	a_Cement	10.60	11.80
30	a_Steel	10.36	11.27
31	a_Machinery	9.98	10.39
32	a_Miscellaneous	10.38	10.27
33	a_Construction	10.50	11.12
34	a_Utility	10.11	9.99
35	a_Trade	9.93	9.27

		National SAM	Regional SAM SW
36	a_Transport	10.20	9.58
37	a_Social Servcies	10.22	9.12
38	a_Financial servcies	10.29	9.20
39	a_Public Administration and Defense	10.47	9.36
40	a_Professional Servcies	9.15	8.92
41	a_Other Services	10.80	10.50
42	c_Paddy	12.66	12.33
43	c_Grains	6.08	12.62
44	c_Jute	12.57	11.89
45	c_Sugarcane	12.31	12.65
46	c_Vegetables	10.83	11.87
47	c_Commercial Crops	8.08	11.13
48	c_Other Crop	12.11	12.96
49	c_Livestock Rearing	11.99	12.65
50	c_Poultry Rearing	11.87	14.94
51	c_Shrimp Farming	13.85	13.21
52	c_Fishing	12.08	11.79
53	c_Forestry	12.37	12.35
54	c_Rice	13.34	12.92
55	c_Grain	10.46	12.71
56	c_Fish Process	14.19	13.70
57	c_Oil Industry	4.86	11.88
58	c_Sweetener Industry	5.93	12.25
59	c_Food	10.30	12.50
60	c_Leather	12.93	12.77
61	c_Jute	13.43	12.45
62	c_Clothing	9.17	11.62
63	c_RMG	11.48	11.60
64	c_Tobacco	7.49	11.95
65	c_Wood	9.35	12.44
66	c_Chemical	5.23	11.60
67	c_Fertilizer	3.47	11.14
68	c_Petroleum	1.76	13.32
69	c_Clay Products	10.79	11.64
70	c_Cement	9.12	12.75
71	c_Steel	8.25	11.95
72	c_Machinery	4.56	10.02
73	c_Miscellaneous	4.43	10.22
74	c_Construction	11.50	12.12
75	c_Utility	10.72	10.92

		National SAM	Regional SAM SW
76	c_Trade	10.93	10.27
77	c_Transport	9.67	9.58
78	c_Social Servcies	11.22	10.12
79	c_Financial servcies	10.30	10.09
80	c_Public Administration and Defense	10.57	10.19
81	c_Professional Servcies	9.28	9.80
82	c_Other Services	11.80	11.50
83	VA Labour Unskilled	10.62	9.68
84	VA Labour Skilled	8.82	6.46
85	VA Capital	8.97	7.26
86	VA Land	9.75	9.25
87	Landless	11.34	8.81
88	Marginal	10.15	9.82
89	Small	9.92	9.17
90	Large	7.29	8.85
91	Rural Non Farm Poor	8.63	6.22
92	Rural Non Farm Non Poor	10.80	9.05
93	Low Education	9.60	9.44
94	High Education	5.98	2.44
	Total	**100.0**	**100.0**

Annex 4: Equations of the CGE Model

	Equations	Description
1.	*Price Block*	
2.	$PM_i = \overline{PWM_i} \cdot ER \cdot (1+tm_i+tv_i)$	Import Price
3.	$PE_i = PE\_FOB_i \cdot ER/(1+te)$	Export Price
4.	$P_i \cdot Q_i = PD_i \cdot D_i + PM_i \cdot M_i$	Composite Price
5.	$PX_i \cdot X_i = PD_i \cdot (1-td_i-tv_i) \cdot D_i + PE_i \cdot E_i$	Activity Price
6.	$PN_i = \sum_j \tau_{ji} \cdot P_j$	Input price
7.	$PV_i \cdot V_i = PX_i \cdot X_i - PN_i \cdot INT_i$	Value added price
8.	$PK_i = \sum_j \kappa_{ij} \cdot P_j$	Capital Price
	Production and Supply Block	
9.	$X_i = AX_i \cdot [\eta_i \cdot V_i^{-\phi_i} + (1-\eta_i) \cdot N_i^{-\phi_i}]^{-1/\phi_i}$	Gross Output (CES aggregate of value-added and intermediate input)
10.	$N_i = V_i \cdot \frac{PN_i \cdot (1-\eta_i)}{PV_i \cdot \eta_i}]^{\frac{1}{1+\phi_i}}$	Composite Intermediate
11.	$V_i = AV_i \cdot [\sum_f \alpha_{if} \cdot FD_{if}^{-\mu_i}]^{-\frac{1}{\mu_i}}$	Value added function
12.	$FD_{if} = V_i \cdot \left[\frac{\alpha_{if} \cdot PV_i}{AV_i^{\mu_i} \cdot W_f \cdot \varpi_{if}}\right]^{\frac{1}{1+\mu_i}}$	Factor Demand
13.	$FY_f = \sum_i W_f \cdot \varpi_{if} \cdot FD_{if}$	Factor Income
14.	$Q_i = AQ_i \cdot [\delta_i \cdot M_i^{-\rho_i} + (1-\delta_i) \cdot D_i^{-\rho_i}]^{-1/\rho_i}$	Composite Supply (Armington Function)
15.	$M_i = D_i \cdot [\frac{PD_i \cdot \delta_i}{PM_i \cdot (1-\delta_i)}]^{\frac{1}{1+\sigma_i}}$	Import-Domestic Demand Ratio
16.	$Q_i = M_i + D_i$	Composite commodity aggregation for perfect substitutes
17.	$Q_i = D_i$	Composite supply for Non-imported commodities
18.	$Q_i = M_i$	Composite supply for Non-produced imports
19.	$X_i = AT_i \cdot [\gamma_i \cdot E_i^{-\phi_i} + (1-\gamma_i) \cdot D_i^{-\phi_i}]^{1/\phi_i}$	Composite supply function

	Equations	Description
20.	$E_i = D_i \cdot [\frac{PE_i \cdot (1-\gamma_i)}{PD_i \cdot (1-td_i)}]^{\varphi_i}$	Export Supply
21.	$E_i = E_i^0 \cdot \left[\frac{PWE_i}{PE\_FOB_i}\right]^{e_i}$	Export Demand
	Institutional Income	
22.	$YF_h = \sum_f \varepsilon_{h,f} \cdot FY_f$	Household Factor Income
23.	$Y_h = \left[YF_h + \overline{RM_h}\right] \cdot (1 - th_h - s_h)$	Household Income
24.	$YG = \sum_h th_h \cdot Y_h + \sum_i tm_i \cdot \overline{PWM_i} \cdot M_i \cdot ER + \sum_i td_i \cdot X_i \cdot PD_i$	Government Income
25.	$CD_{ih} \cdot P_i = \beta_{ih} \cdot Y_h$	Consumption Demand
26.	$\overline{GD_i} = \beta_i^g \cdot \overline{GTOT}$	Government Demand
27.	$PK_i \cdot DK_i = \xi_i \cdot I$	Investment by Destination
28.	$ID_i = \sum_j \kappa_{ij} \cdot DK_j$	Investment by Origin
29.	$INT_i = \sum_j \tau_{ij} \cdot N_j$	Intermediate Demand
	Equilibrium Condition	
30.	$S = \sum_h SH_h + SG + SF$	Total Savings by Institutions
31.	$Q_i = INT_i + \sum_h CD_{ih} + GD_i + ID_i$	Product Market Balance: Supply equals Demand
32.	$\sum_i FD_{if} = FS_f$	Factor Market Balance: Demand plus unemployed factor equals Supply. (capital is fully employed, but labour is not)
33.	$\sum_i \overline{PWM_i} \cdot M_i - \sum_i PWE_i \cdot E_i - \sum_h \overline{RM_h} - SF = 0$	Current Account Balance: Receipts equal to Outlays
34.	$I = S = \sum_h SH_h + SG + SF$	Macro Balance: Investment equals Savings