



# Impacts on Output and Welfare of Tax Reforms in the Multi-sector Multi-household Dynamic CGE Model of the Nepalese Economy, 2020-2040

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## Article History

Received : 04 January 2025

Revised : 12 February 2025

Accepted : 18 February 2025

Published : 30 May 2025

## To cite this article

Bhattacharai, K., & Pandit, B. (2025). Impacts on Output and Welfare of Tax Reforms in the Multi-sector Multi-household Dynamic CGE Model of the Nepalese Economy, 2020-2040. *Journal of Development Economics and Finance*, Vol. 6, No. 1, pp. 19-41. <https://DOI:10.47509/JDEF.2025.v06i01.02>

**Abstract:** A dynamic Computable General Equilibrium (CGE) model is constructed to measure the impacts of tax reforms on the Nepalese economy, benchmarked on micro-consistent data set created from the input output table of Nepal for 2017 (ADB, 2017). Impacts of tax reforms on welfare of households and output levels of industries are very positive. The model also shows a dynamic process of economic growth with redistribution.

All households get a welfare increase, but rich households get more than poor households in our analysis. This gap means policy should promote equitable economic growth to increase overall welfare of households. Analysis of dynamic CGE model results from 2020 to 2040 show possibility of targeting redistribution adequately ensuring economic growth across all sectors of the economy.

**Keywords:** Dynamic CGE model of Nepal, tax policy, economic growth

**JEL Classification:** C6, D6, E2 and O21

## Introduction to the Dynamic CGE Model of Nepal

A general equilibrium model is a framework of economic analysis where quantities and prices are determined by the interaction of demand and supply in goods and factor markets. Government plays a significant role in shaping market outcomes by introducing distortions in prices through taxes and transfers, and thus affecting the investment and growth rates of different sectors. We have constructed a dynamic Computable General Equilibrium (CGE) model for the Nepalese economy with

multiple households and production sectors. It considers labour-leisure choice within a framework where the labour supply of households and employment of firms are key determinants of growth rates of output, capital and investment levels. In essence, economic growth and redistributions are outcomes of optimisation problems of households, firms and traders in the economy. The model allows policy simulations and identification of policies that can achieve optimal utility and welfare for households (Bhattarai, 2020, 2008). General description of preferences, production technology, trade and public policy is as follows.

### *Preferences*

On the preference side, there are various utility functions that aggregate the well-being of a household from consuming goods, services and leisure in the economy. Time separable Constant Elasticity of Substitution (CES) utility function is one such representation that captures intra-period and intertemporal substitution between consumption and leisure. This is dependent on relative prices and wage rates in the economy. To make it numerical, this function can be hierarchically nested at multiple levels (Perroni & Rutherford, 1998). First aggregation is done at the level of goods and services, then at the level of goods and leisure and finally at the level of an entire lifetime of an individual household. This study uses this approach.

### *Production Technology*

Production technology is the conversion of inputs into outputs. In this context, inputs are labour (human effort in the production process), capital (man-made means of production such as buildings, structures, highways, communication networks, education, health and environmental systems) and natural resources (clean air, water, minerals and energy products). The intensity of using these factors in a particular industry or firm is captured by a production function. Among various types of production functions, Constant Elasticity of Substitution (CES) is widely used in economic literature. We do so because it can capture cross-price elasticity better than other production function models.

### *Trade Arrangements*

Trade benefits economies by exporting where they are best and importing where they are worst. Volume of trade is influenced by household and firm preferences

for domestic and foreign goods. Implicit in these preferences are the values that determine the substitution between domestic and foreign goods in our model.

### ***Government Sector Balances***

The government collects revenue from direct and indirect taxes and tariffs. These play key roles in determining the marginal conditions of consumption, production and trade. These taxes affect both the demand and supply sides of the economy. The government can have different policy options, from a balanced budget to a deficit budget to a cyclically balanced budget. The level of debt can also be tied to a certain percentage of GDP, as per conventions like the Maastricht Treaty among EU economies. Determining the optimal source of revenue and the efficiency of different tax instruments in raising revenue and promoting growth is an important question. Also, understanding the degree of freedom government has in determining its size, which reflects the aggregate economic activities of the economy, is an important institutional issue (Acemoglu & Robinson, 2008; Adams & Higgs, 1990).

### ***Definition of Equilibrium for a Growing Economy***

Equilibrium, defined as a point where opposing forces are in balance, is a central concept in economic modelling. Theoretical work has focused on whether equilibrium exists, is unique or is stable. Uniqueness is ensured by properties like continuity, concavity or convexity in preferences, technology and trade. Analytical solutions are often not feasible for large models, so numerical methods are used in applied policy work. In a general equilibrium model, equilibrium is a system of prices for commodities and services and factors of production where demand and supply balance for each period and over the model horizon. Proper calibration to micro-consistent data sets ensures that these prices reflect the scarcity of goods in the economy (Shoven & Whalley, 1984). Imperfections in goods and input markets are common; there are monopolies or oligopolies, and these imperfections can be represented by designing appropriate mark-up schemes, which may be sensitive to strategic interaction between different economic agents.

### ***Nature of Policy Experiments***

A small policy change can have a big impact on welfare and growth over time if it addresses the bigger economic issues and removes the distortions in prices of output,

employment and investment. For instance, effective pollution abatement policies, for example, not only reduce environmental damage but also create an environment conducive to human entrepreneurship. Policies that mitigate negative externalities and enhance positive externalities create a productive and creative environment for overall economic growth. Distortions can affect efficiency in all markets and need to be removed.

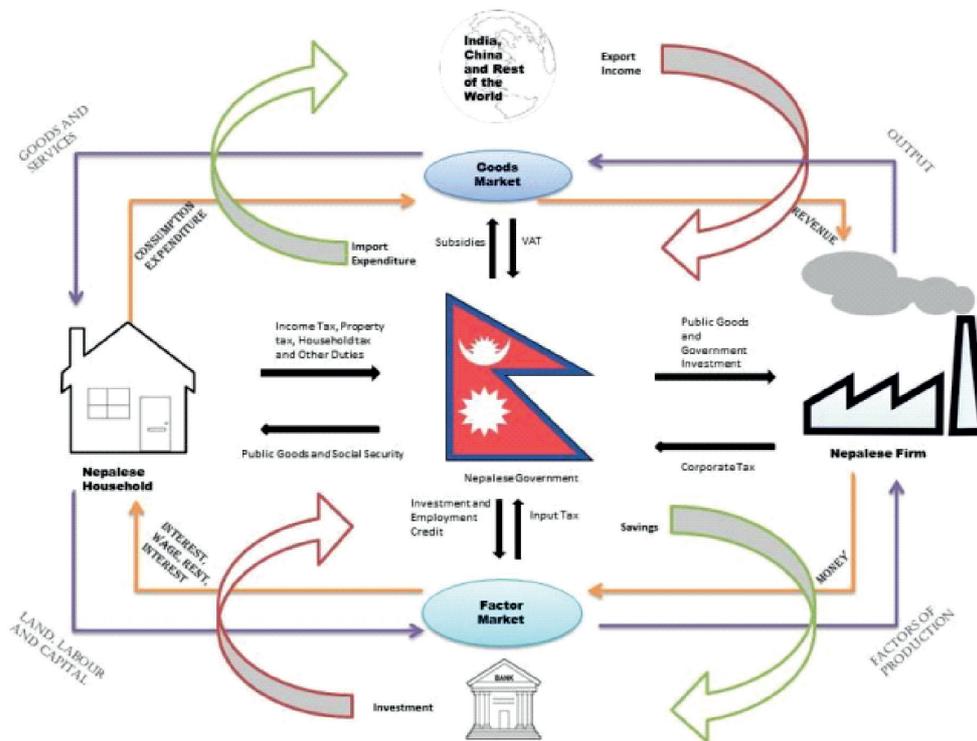


Figure 1: Circular flow of income in Nepal

Figure 1 represents the circular flow of income in Nepal. A circular flow of income is a representation of the cyclical movement of money between households, firms, the government, the financial and foreign sectors. This shows the flow of money in exchange for different goods and services among the different sectors. The circular flow of income shows five major economic agents or sectors in the dynamic Nepalese economy. First, there are firms or businesses. Nepalese firms produce goods and services which are consumed by domestic as well as foreign consumers. The firms pay wages to their employees (household) in exchange for

the labour they provide. Firms also pay various taxes to the government, for which the government responds with business-related policies for its firms and public goods and investments in national infrastructure. The financial sector is involved in providing the business sector with loans for investment when required, as well as maintaining savings for the business.

The household sector works for the firms in exchange for wages. The wages they earn are spent on the consumption of domestic and foreign products as well. Part of their income is paid to the government as taxes. Various taxes like income tax, property tax, VAT, labour tax, etc, are levied on the household in exchange for public goods and social security that the government provides. The household is also involved with the financial sector by taking loans to finance their consumption, mortgage their houses, while extra disposable income is saved with the banks. The government sector collects taxes from various sectors like income tax, VAT, labour tax, capital tax, corporate tax, import and export taxes (customs duties). These taxes are part of the government revenue, which the government uses to finance public infrastructure in the whole country as well as to provide public goods and security. The government aims to utilise various fiscal, monetary and trade policies to grow national output to maximise the benefits and utility for its citizens.

The foreign sector involves the exchange of goods and services for money among different countries. All excess goods are exported, while goods required but not produced in the country are imported. As it is almost impossible to produce all goods required by a country, countries tend to maximise their interests by producing goods in which they specialise or have a competitive advantage. Finally, the financial sector is involved in the model to help borrowers and lenders. They loan money to all other sectors in exchange for the interest they earn while providing savings services to the various sectors for which they pay interest. The model introduces various counterfactual scenarios or shocks to the economy, resulting in various changes to the economic variables of the economy. The shocks are spread over various variables like output, investment, capital stock, employment, wage and welfare.

Output constitutes the total GDP of the country, which represents the total consumption, investment, government expenditure and net trade of all agents of the economy. Investment represents all money that households, firms, and the government spend to build capital for their benefit. Households may invest their savings in shares, bonds, gold, currency, and real estate. Business invests in

increasing capital goods or business infrastructure to expand their production, and the government invests in public infrastructure. All fixed assets used in the economy's production that are still in use, such as homes, vehicles and intellectual property like software, are represented by capital stocks. Total employment signifies the total labour that the households supply to other sectors in exchange for wages. Consumption represents goods and services consumed (domestic and foreign) by all economic agents in the economy. Welfare represents the total utility derived by the household or citizens for its consumption of goods and services as well as leisure.

### **Application of the Dynamic CGE Model of Nepal**

The computations of the Dynamic Computable General Equilibrium (CGE) Model for Nepal provide a platform to analyse many policy questions. We will apply it to assess the impacts of tax and trade policies on growth, employment, investment, capital formation and technological progress over the next 20 years. The scope of analysis includes pension and social security challenges through a multi-household dynamic general equilibrium modelling of the welfare system of the economy. The model also provides a basis to analyse the relationship between fiscal policy and economic growth. The 17-sector general equilibrium model developed for Nepal in this study can be further refined and used to see how Nepal can transform its economy in the coming decades.

The model is not limited to domestic production only, it will be used to analyse trade arrangements and foreign direct investment strategies with the rest of the world, particularly with India, that is bordering Nepal to the East, South and West. By doing so it will provide valuable insights to optimise Nepal's economic engagement in the global economy.

### **Model Structure**

The paper introduces the general equilibrium model, a tool to analyse the overall impact of tax policies on the economy. The specifications of the structure of this model are presented along with the data used to calibrate the parameters of the model.

A general equilibrium model shows equilibrium through price adjustments, balancing supply and demand across different markets. It implicitly analyses the impact of monetary policy changes on capital, output, investment and employment,

focusing on the supply side. It also analyses the shifts in consumer preferences on the demand side and how economic agents coordinate their decisions across markets.

Based on Bhattarai (2008) this study uses the general equilibrium model for Nepal. The model has a representative household, 17 producers, government and international linkages. The household is a supplier of factor inputs in labour and capital markets and a consumer maximising utility on demand side. Producers are autonomous and maximise profit with constant returns to scale using Cobb-Douglas and CES production functions. The government collects taxes and allocates funds through transfers to households or public services.

### **Household Problem**

The model uses a standard Ramsey-type time-separable constant elasticity of substitution (CES) utility function to calculate household welfare for each period. Households optimise their consumption and leisure choices based on relative prices, wage rates, tax rates and public spending, and substitute between consumption and leisure both within and across periods. All commodities are aggregated into a single composite good, which is then combined with leisure to get utility (U). Lifetime utility for each household is calculated by summing up the utilities over time.

According to the budget constraint, the cost of goods and leisure must be equal to the income earned. Tax rates on consumption, wages and capital income are set by the policymakers who aim to be optimal and revenue-neutral in tax reform, including transfers. Solving the model requires solving the Euler conditions for each household with infinite lifetime and labour-leisure trade-offs.

The real rate of return from investment across sectors is based on the marginal product of capital until the net of business tax returns matches the cost of capital across sectors. Each household's wage rate is equal to the marginal product of its labour.

Households maximise utility consumption and leisure.

$$U_t^h = \sum_{t=0}^{\infty} \beta_t^h U_t^h(C_t^h, l_t^h) \text{ where } 0 < \beta^h < 1 \quad (1)$$

subject to an inter-temporal budget constraint:

$$[\sum_{t=0}^{\infty} P_{i,t} (1 + tc_i^h) c_i^h + w_{j,t}^h (1 - tw_i^h) l_i^h] \leq [\sum_{t=0}^{\infty} w_{i,t}^h (1 - tw_i^h) \bar{L}_{i,t}^h + r_{j,t} (1 - tk_i) K_{i,t}^h + TR_i^h] \quad (2)$$

### Producers' Problem

$$\Pi_{i,t} = \left[ (1 - \psi_i) PD_{i,t}^{\frac{\sigma_y - 1}{\sigma_y}} + \psi_i PE_{i,t}^{\frac{\sigma_y - 1}{\sigma_y}} \right]^{\frac{1}{\sigma_y - 1}} - \theta_i PY_{i,t} - \theta_i^d \sum_{t=0}^{\infty} a_{i,t} P_{i,t} \quad (3)$$

subject to production technology,

$$Y_{j,t} = \Omega_{i,t} \left[ (1 - \delta_i) K_{i,t}^{\frac{\sigma_p - 1}{\sigma_p}} + \delta_i L_{i,t}^{\frac{\sigma_p - 1}{\sigma_p}} \right]^{\frac{1}{\sigma_p - 1 / \sigma_p}} \quad (4)$$

and the sector-specific capital accumulation

$$Y_{j,t} = K_{i,t} - (1 - \Delta) K_{i,t-1} \quad (5)$$

Each firm in the model has a unit profit function. This is in terms of prices of commodities- the composite of prices of domestic sales ( $PD_{i,t}$ ) and exports ( $PE_{i,t}$ ), and prices of primary inputs ( $PY_{i,t}$ ) and intermediate inputs ( $a_{i,t} P_{i,t}$ ).

1.  $\Psi$  (Psi) and  $\theta$  (theta) are share parameters
2.  $\sigma_y$  (sigma) = elasticity of substitution in trade between imported and domestic goods
3.  $\sigma_p$  (sigma) = elasticity of substitution in production
4.  $\delta$  (small delta) = is share of labour input
5.  $\Omega$  (omega) is total factor productivity (total output/ total input or total output/ weighted average of inputs)

The third equation shows Investment, which is capital stock- capital stock of last year after depreciation, and here  $\Delta$  (Delta) is depreciation. Also, capital of a sector cannot be transferred and used in another sector.

#### Trade Arrangement

The model is an open economy model, so it is open to trade. It can be presented under two different equations.

The first equation is the representation of total goods supplied in the economy.

$$A_{i,t} = \left[ \theta_i^d D_{i,t}^{\frac{\sigma_m - 1}{\sigma_m}} + (1 - \theta_i^d) M_{i,t}^{\frac{\sigma_m - 1}{\sigma_m}} \right]^{\frac{\sigma_m}{\sigma_y - 1}} \quad (6)$$

Here,  $A_{i,t}$  is the total supply to the market,  $\sigma_m$  (sigma) is the elasticity of substitution between domestic and imported goods,  $\sigma_Y$  (sigma) is the elasticity of substitution of trade and  $\theta_d$  (theta) are the share parameters of the domestic supply.

Similarly, the second equation is an equation for the long run, which shows trade is balanced over time in value terms, such as:

$$\sum_{t=0}^{\infty} PE_{i,t} E_{i,t} = \sum_{t=0}^{\infty} PM_{i,t} M_{i,t} \quad (7)$$

### Government Sector

The government receives revenue from direct and indirect taxes and tariffs, as shown in the equation. These taxes are distortionary and affect the marginal conditions of allocation in consumption, production and trade, causing shifts in the demand and supply functions of commodities. The government can be either a balanced budget, a deficit budget, balanced budget or simply peg the deficit to a fixed debt/GDP ratio. The structure of taxes depends on the state of the economy, policy debates and rules based on conventions and international commitments made in treaties or agreements.

$$\begin{aligned} Rev_t = \sum_{h=1}^H \sum_{i=1}^N t c_i^h P_{i,t} C_{i,t}^h + \sum_{h=1}^H \sum_{i=1}^N t w_i^h w_{i,t}^h L S_{i,t}^h + \sum_{i=1}^N t k_i^h r_{i,t}^h K_{i,t}^h \leq GovSpent_t = \\ \sum_{i=1}^N (P_{i,t} g_{i,t}) + \sum_{h=1}^H TR_t^h \end{aligned} \quad (8)$$

### General Equilibrium

First of all, for the DCGE model to be solved, all three market-clearing conditions must be met. The left-hand sides (LHS) and right-hand sides (RHS) of these equations contain first-order Euler conditions resulting from the dynamic optimisation by consumers and producers with respect to relevant commodities or inputs. In each period, the empirical version of the model solved here contains ten Euler equations of household demand for multiple commodities, then the first-order conditions of all equations for each labour and sector-specific capital. Also export and import demand functions for tradable sectors, and revenue and spending equations for the public sector in each period.

Goods Market

$$Y_{i,t} = \sum_{h=1}^H C_{i,t}^h + I_{i,t} + E_{i,t} + g_{i,t} \quad (9)$$

Labour Market

$$\bar{L}_t^h = LS_t^h + l_t^h; LS_t^h = \sum_{h=1}^H LS_{i,t}^h \quad (10)$$

Capital Market

$$K_t = \sum_{i=1}^N K_{i,t} = \sum_{i=1}^N [(1 - \Delta)K_{i,t-1} + I_{i,t}] \quad (11)$$

### Four Ingredients of this Dynamic CGE Model

The general equilibrium path of the economy is a stable and dynamically efficient long-run series of prices and quantities given by the balance of demand and supply across all markets in each period and over the entire model horizon in the equation, which is called market clearing, as seen in the previous section. The dynamically efficient allocations result from the system of relative prices of commodities and services, wage rates and interest rates for each period that guarantee market clearing. Their numerical values entirely depend on the parameters of preferences and technology, showing the behavioural responses of consumers and producers in the economy, as in the equation.

When a model is calibrated to the benchmark micro-consistent data set, relative prices in equilibrium are Pareto optimal allocation of resources in the economy. A computable model like this can answer key policy questions for the benevolent government that can choose policies that generate the most equal distribution of welfare across households to maximise the social welfare function of the economy.

### The Price System

The relative price system is determined by over twenty-five categories of parameters in the larger model.

$$\{P\}_t^T = [\Theta]_t^T \quad (12)$$

Where  $\Theta$  represents all parameters that explain behaviour in consumption, production, trade and economic policies, endowments of households as clearly represented by Bhattarai (2008) as

$$\{P\}_t^T = p \begin{bmatrix} \beta^h & \alpha_c^h & \sigma_c^h & & \sigma_l^h & \sigma_u^h & \delta_c^h & & \delta_l^h & \delta_u^h & \sigma_{ucl}^h \\ & & \sigma_y^h & & \psi_i & \theta_i & \theta_i^d & & & & a_{i,t} \\ & & & & \sigma_p & \delta_i^p & \delta_i & & & & \\ & & & & \delta_i^d & \delta_i^m & \delta_m & & & & \\ & & & & tc_i^h & tw_i^h & tk_i^h & TR_i^h & & & \\ & & & & g_i & \Delta_i & r_i & & & & \\ & & & & \bar{L}_{i,t}^h & K_{i,t} & & & & & \end{bmatrix}$$

Thus, the relative price system in equilibrium depends on:

1. Share and elasticity substitution parameters of household preference on the demand side,
2. Elasticity of substitution and input share parameters for firms,
3. Share and Substitution elasticity parameters for international trade,
4. Tax transfer policy parameters,
5. Rate of growth and depreciation, and cost of capital across sectors for benchmarking the steady state, and
6. Initial factor endowment.

The vector of price includes

$$P : \{P_{i,t}, PY_{i,t}, PD_{i,t}, PE_{i,t}, w_{j,t}^h, r_i, R_{i,t}, PM_{i,t}\}_t^T \quad (13)$$

Equation for quantity

$$\{Q\}_t^T : ED_{i,t} = D\{P\}_{i,t}^T - S\{P\}_{i,t}^T = 0 \quad (14)$$

### Equations for Quantity

The model can be solved for equilibrium quantities once the price vector is obtained by solving for zero excess demand across all sectors. Efficiency in allocations can be ascertained once the system of relative prices is known in the model. Welfare to households can be known after the quantities of households, producers and fiscal variables are known, as shown below:

$$\text{Household:} \quad \{C_t^h, I_t^h, C_{i,t}^h, LS_{i,t}^h\}_t^T$$

$$\text{Producers:} \quad \{K_{j,t}, L_{j,t}, I_{i,t}, D_{i,t}, E_{i,t}, M_{i,t}, D_{i,t}, A_{i,t}\}_t^T$$

Government:  $\{Rev_t, GovSpen_t\}_t^T$

Equation to Welfare:

$$(W = W(U_1, U_2, \dots, U_{10}))_t^T \quad (15)$$

The household quantity vector includes optimal consumption-leisure and labour supply choices of the household to maximise lifetime utility. Producers choose to maximise profit through optimal capital and labour input choices. The government chooses a sequence of revenue and spending streams to maximise social welfare. The government is not only collecting taxes but is also responsible for infrastructure development, which is the basis of economic development. The banking sector is responsible for supervising and maintaining monetary matters. The Central Bank creates monetary policy and also supervises commercial banks to control the money supply in the economy. The country trades with the rest of the world by exporting its specialisation and excess, while importing things in short supply as well.

### Sources of Data

The 61-sector input-output table was reduced to 17 17-sector databases given in Table 1 to simplify the model by combining similar sectors. Total output and total consumption were added to make sure there is no imbalance in the data. ADB data does not have wage and capital division of Value added, which basically uses the share of an input-output table (2012, CBS). A wage-to-value-added ratio of 60-plus sectors was used to calculate the average value of the wage data when combining into a 17-sector model. This ratio was then used in the 2017 (ADB) database.

As shown in Table 1, the value of each 17 sectors undertaken for this study represents a different segment of the economy. These sectors are Agric (Agriculture, hunting, forestry, and fishing, plus mining and quarrying), Food (Food, beverages, and tobacco), Cloth (Textiles, textile products, leather, leather products, and footwear), Raw (Wood products, cork, pulp, paper, chemicals, petroleum, nuclear fuel, non-metallic minerals, rubber, plastics, basic metals), Equip (Machinery, electrical equipment, transport equipment), Manuf (Manufacturing, recycling), Utili (Electricity, gas, water supply), Const (Construction), Trade (Motor vehicle sales, fuel retail, wholesale and commission trade), Hotel (Hotels, restaurants), Trans (Transport activities, travel agencies), Commu (Post, telecommunications), Finan

Table 1: Input-Output Table

	Agric	Food	Cloth	Raw	Equip	Manuf	Utili	Const	Trade	Hotel	Trans	Commu	Finan	Public	Educat	Health	Others
Agric	774.27	1003.89	48.44	157.37	0.01	25.43	44.83	119.25	0.01	396.45	0.00	163.77	0.23	30.22	128.62	0.00	0.00
Food	502.15	374.71	15.06	29.70	0.48	2.57	12.39	9.34	3.42	172.94	16.33	102.28	31.32	53.69	9.83	3.53	10.27
Cloth	19.17	2.90	36.28	4.87	0.35	1.58	4.16	2.50	0.91	10.37	4.63	5.34	17.20	3.21	1.04	0.90	3.39
Raw	471.86	72.84	56.06	1140.98	29.81	164.42	53.19	1502.22	21.40	12.78	820.17	11.42	65.23	7.22	11.72	123.55	29.52
Equip	2.60	0.35	0.33	2.23	10.31	0.66	88.78	113.66	0.14	0.18	25.07	0.33	101.48	0.08	0.18	0.28	16.49
Manuf	63.25	6.83	8.63	54.72	0.90	11.01	7.70	26.36	2.11	3.12	5.86	3.18	19.13	1.16	1.85	1.77	7.22
Utili	51.85	8.46	7.77	89.01	1.02	2.46	47.01	79.04	52.62	124.15	13.24	88.65	44.88	5.64	14.03	7.20	26.00
Const	11.60	3.53	0.73	8.33	0.23	0.55	6.29	1.81	2.16	0.16	4.10	0.47	374.98	1.78	1.91	2.65	5.70
Trade	252.82	200.90	26.98	179.67	4.68	14.88	14.42	196.74	14.55	80.65	139.15	46.03	45.73	17.33	18.13	19.12	6.61
Hotel	6.05	9.24	3.53	8.09	0.31	0.87	8.99	5.23	1.47	76.52	49.56	50.37	78.13	0.84	23.57	1.09	78.11
Trans	145.69	96.98	10.47	89.48	3.00	8.22	41.44	73.84	328.53	48.79	207.79	111.97	127.27	18.26	57.24	20.77	124.70
Commu	11.70	6.98	2.32	7.64	0.48	1.38	10.88	11.23	78.85	44.02	57.74	35.13	105.85	2.12	15.13	4.72	46.53
Finan	357.11	27.12	7.87	43.25	2.93	11.69	84.17	76.99	143.18	38.89	139.50	38.84	344.22	12.19	33.95	63.07	141.25
Public	0.46	0.03	0.05	0.05	0.00	0.03	1.74	0.35	0.74	0.07	1.41	0.16	0.85	0.74	0.66	1.12	13.28
Educat	0.27	0.22	0.05	0.22	0.01	0.03	4.95	0.28	0.11	0.10	4.44	0.08	36.88	1.53	6.89	9.27	21.37
Health	17.34	1.56	0.21	1.49	0.04	0.17	0.13	1.93	0.99	1.46	1.38	1.01	8.19	0.19	0.26	5.02	9.89
Others	10.23	0.66	0.44	2.73	0.10	0.51	28.93	10.26	25.67	4.98	26.08	5.68	22.52	12.69	11.35	18.68	49.65

(Financial intermediation, real estate, renting, business activities), Public (Public administration, defence, social security), Educat (Education), Health (Health, social work), Others (Community, social services, households).

### **Assumptions and Scenario Development**

Modelling is a very complex procedure, especially for dynamic models, as it is almost impossible to set exact values for various variables; thus, assumptions are required when calculating and calibrating the model. In constructing economic models or economic analysis, economists often use simple beliefs in forming assumptions. Under these assumptions, we can better understand the behaviour of consumers and their market and how they adjust to dynamic changes. The primary goal of making any assumption is to control variables and eliminate variables that have no effect on the forecasts or predictions of the model. This will simplify the problem without affecting the answers. These assumptions are a necessary requirement to decompose real-world complex scenarios and make them more understandable in the study. Although assumptions can help us to simplify economic events, we should remember that assumptions may not capture all reality.

For the CGE model, we have also made several assumptions for smooth calibration and prediction of the model. First and foremost, it is assumed that all economic agents in the model are maximising their gains; consumers and producers are maximising their utility and profits, respectively. This is considered rational behaviour. It is also assumed that the market is at perfect equilibrium, which means there is no excess demand (Bhattarai et al., 2016).

Any excess is assumed to not exist as outputs are either assumed to be consumed, go to other sectors as inputs or exported. The small country assumption suggests that changes in Nepalese exports and imports have no effect on terms of trade in the model as Nepal is considered as a minor player compared to the world. Export demand and import supply functions are horizontal, meaning international prices are exogenous in foreign currency terms.

The elasticity of substitution between labour and capital for the model is assumed to be a non-nested CES production function with 1.5. The interest rate in the model is assumed to be 5%, the growth rate of output is 5% and the depreciation rate is 15%. Consumption and Income for household deciles are presented in Table 2. According to Living Standard Survey Data 2017, the decile of HH in each higher

group is having higher share of both consumption and income. It is consistent with the finding that the higher the household decile, the higher the consumption and income will be as well.

**Table 2: Consumption and Income for Household Decile**

<i>Household</i>	<i>Consumption</i>	<i>HH Income</i>	<i>Share of Income</i>	<i>Share of Consumption</i>	<i>Income Adjustment</i>
HH1	562.39	342.53	0.0350	0.0428	-2482.086
HH2	678.80	471.72	0.0482	0.0516	-2995.857
HH3	800.05	549.03	0.0561	0.0609	-3531.018
HH4	839.31	636.13	0.0650	0.0638	-3704.289
HH5	919.95	739.87	0.0756	0.0700	-4060.174
HH6	1040.73	846.55	0.0865	0.0792	-4593.221
HH7	1176.26	979.65	0.1001	0.0895	-5191.398
HH8	1388.23	1158.74	0.1184	0.1056	-6126.913
HH9	1786.91	1477.78	0.1510	0.1359	-7886.515
HH10	3952.93	2584.66	0.2641	0.3007	-1.745E+4

To predict the various outputs of the economy, a CGE model is to be developed, which helps in forecasting the outcomes due to various shocks in the economy. For the development of the model, various raw data are collected. For this CGE model, various raw data such as input-output table, national accounting data, tax, trade and household surveys are collected, which is then adjusted to a benchmark data set, which is a micro-consistent dataset (Bhattarai et al., 2019). Using this dataset, a benchmark model is constructed based on the various datasets and assumptions we make for the model. The model is optimised with the help of GAMS software and is involved in a calibration check and replication. The first calculation and calibration for optimisation bring out the benchmark results for the model. Later, various shocks are introduced in the model, which results in re-computation, recalibration and re-optimisation, resulting in a new equilibrium. This new equilibrium can be compared to the benchmark data, which helps us to analyse the impact of shocks (Bhattarai & Benjasak, 2021).

These shocks (tax shocks for this model) are referred to as various scenarios of the economy. For the sake of the model, 10 various scenarios or counter shocks are introduced. In a different scenario, different adjustments are made, which are presented in Table 3.

**Table 3: Different Scenarios Developed for the Model**

<i>Scenario</i>	<i>Tax on labour (txl)</i>	<i>Tax on capital (txk)</i>	<i>VAT</i>	<i>HH income tax</i>
Benchmark	sector wise	sector wise	0.13	0.20
All zero tax	0.00	0.00	0.00	0.00
Uniform Tax	0.30	0.20	0.13	0.20
Zero Labour tax	0.00	0.20	0.13	0.20
Zero capital tax	0.30	0.00	0.13	0.20
zero hhinctax	0.30	0.20	0.13	0.00
Low HH Income Tax and Uniform Tax	0.30	0.20	0.13	0.10
High HH Income Tax and Uniform Tax	0.30	0.20	0.13	0.30
zero vat	0.30	0.20	0.00	0.20
Low VAT and Uniform Tax	0.30	0.20	0.07	0.20
High VAT and Uniform Tax	0.30	0.20	0.20	0.20

The rates for the benchmark scenarios are based on the actual Nepalese economy (NPC, 2024). Taxes on labour and capital are different based on various sectors. While VAT is 13% and household income tax is 20%. HH income tax is the average household taxes across various deciles of the household (i.e richest and poorest households). As various sectors are inconsistent in taxes on labour and capital, we later assume a standard consistent tax of 30% and 20% in labour and capital, respectively, across all sectors. Counter shocks of increase and decrease in taxes are applied across all sectors in a proportional manner. i.e. if HH income taxes are increased by 10% in one scenario, it is decreased by 10% as well in the next scenario, which represents a similar proportional increase or decrease. The sector-wise tax set on the benchmark model under tax on labour and tax on capital is presented in Table 4.

**Table 4: Sector-wise Tax**

<i>S.N.</i>	<i>Sector</i>	<i>Labour Input Tax</i>	<i>Capital Tax</i>
1	Agriculture	0.023	0.274
2	Food	0.313	1.074
3	Clothing	0.291	0.868
4	Raw Materials	0.134	1.292
5	Equipment	0.352	0.959
6	Manufacturing	0.323	1.109
7	Utility	0.120	0.951
8	Construction	0.241	1.142

S.N.	Sector	Labour Input Tax	Capital Tax
9	Trade	0.288	0.245
10	Hotel and Restaurant	0.139	0.915
11	Transport	0.142	0.584
12	Communication	0.257	0.743
13	Finance and Real Estate	0.450	0.252
14	Public Sector and Defence	0.130	0.355
15	Education	0.009	2.815
16	Health	0.007	5.122
17	Others	0.323	0.446

As mentioned above, the main objective of this study is to analyse the impact of tax reform in the Nepalese Economy with the application of 17 17-sector Dynamic CGE model. At the macro level, the focus was to assess the impacts of different counterfactual scenarios on selected macroeconomic variables such as different types of taxes that includes uniform tax, labour tax, capital tax, income tax and VAT; efficiency and redistribution impacts of tax reform for various households in Nepal; and to identify who gain more through these tax reforms. How much of the gain accrues to richer households and how much to poorer households? Each scenario is developed and based on model solutions.

## Analysis of Model Results

### *Benchmark Dataset*

In a CGE model, the benchmark dataset is the foundation of the economy at a certain point in time, usually the base year, representing the economy's equilibrium (Adams & Higgs, 1990). It includes sectoral outputs, consumption, investment, government expenditure and trade which are the core inputs of the model (Bhattarai, 2020) and also serves as a reference to set the initial condition of the CGE model and to assess the impact of policy changes across various scenarios (Bhattarai et al., 2017, 2019). By ensuring the model replicates the base year's economic conditions, the benchmark dataset maintains consistency and allows for simulation of policy impacts and economic scenarios (Burgess & Stern, 1993; Dixit, 2009; Dixon & Jorgenson, 2013). The benchmark dataset used in this study is the base year's economic equilibrium, and Table 5 shows the simulation results under the assumed parameters in the benchmark scenario.

**Table 5: Benchmark for Various Data**

Parameters	2020	2025	2030	2035	2040
Output	47702.6	60882	77702.6	99170.4	126569
Investment	12163.3	15523.7	19812.7	25286.6	32272.8
Capital Stock	60816.3	77618.7	99063.4	126433	161364
Wellbeing	9786.68	9786.68	9786.68	9786.68	9786.68
Employment	9786.68	12490.6	15941.5	20345.8	25967
Personal Consumption	27603.1	35229.3	44962.5	57384.8	73239.2
Labour Supply	7829.34	9992.45	12753.2	16276.6	20773.6

From the benchmark scenario, we can see: economic output increases from 47,702.6 in 2020 to 126,569 in 2040; investment grows from 12,163.3 in 2020 to 32,272.8 in 2040; capital stock rises from 60,816.3 in 2020 to 161,364 in 2040; employment grows from 9,786.68 in 2020 to 25,967 in 2040; personal consumption increases from 27,603.1 in 2020 to 73,239.2 in 2040; labour supply grows from 7,829.34 in 2020 to 20,773.6 in 2040; despite economic growth and investment, wage bill remains constant at 9,786.68 throughout the period, meaning it is stable over time.

**Table 6: Benchmark for HH Welfare over the Model Horizon**

	2020	2025	2030	2035	2040
HH1	1348.38	1720.91	2196.37	2803.18	3577.65
HH2	1627.48	2077.12	2651	3383.42	4318.19
HH3	1918.2	2448.17	3124.55	3987.81	5089.57
HH4	2012.33	2568.3	3277.88	4183.5	5339.32
HH5	2205.67	2815.05	3592.8	4585.42	5852.29
HH6	2495.24	3184.63	4064.48	5187.43	6620.62
HH7	2820.2	3599.36	4593.8	5862.99	7482.82
HH8	3328.41	4247.99	5421.63	6919.52	8831.26
HH9	4284.3	5467.98	6978.68	8906.76	11367.5
HH10	9477.53	12096	15437.9	19703.1	25146.7

From the benchmark scenario 2020 to 2040, we can see several trends in the economy. Economic output grows robustly, more than doubling from 2020 to 2040, meaning significant expansion and productivity growth. Investment grows steadily, meaning efforts to build future economic capacity. But capital stock growth,

while substantial, grows slower than output and investment, meaning potential inefficiency in capital allocation or infrastructure challenges (Bhattarai & Benjasak, 2021). Wage bill and employment remain constant throughout the period, meaning concerns on income distribution and potential structural unemployment despite overall economic growth. Personal consumption grows significantly, meaning improved living standards, but labour supply growth lags behind employment, meaning potential labour market constraints or skills and job demand mismatch. Addressing stagnant wage growth and labour supply dynamics will be key to sustainable development.

From the household welfare analysis of the benchmark scenario (2020-2040), we can see a varying degree of improvement across households. Household welfare, measured by income or other welfare indicators, shows a consistent growth for each household group over the years. For example, HH1 starts at 1348.38 in 2020 and grows to 3577.65 in 2040, meaning steady economic progress (See Table 6). Other households, like HH2 to HH10, also experience a significant increase in welfare metrics, meaning a broad-based improvement in living standards. The data shows a positive trend in household welfare, meaning economic policies or conditions are generally favourable for income growth across different income groups. But there may be disparities, as higher income households (e.g. HH10) show a bigger absolute increase compared to lower income households (e.g. HH1). Addressing these disparities may be key to more inclusive economic growth and overall household welfare.

## **Total Output**

Total output is the total of goods and services produced across all sectors of the economy over a period of time, usually a year. It is derived from the interaction of demand and supply within the model because of the behaviour of various economic agents/actors. Consumption, investment, government expenditure and net trade with the foreign sector are involved in the calculation of total output of the economy. Total output is the main indicator of an economy's health. An increase in output means economic growth, and a decrease means contraction, which means economic problems. Total output helps policymakers design policies, such as the introduction of spending during a recession. Output also helps businesses make strategic decisions, such as expansion or entry into a new market. Higher output generally

means a higher standard of living. Total output is affected by various factors such as labour supply, capital stock, natural resources, level of technology/innovation and government policies. The simulation result for output in the benchmark case when benchmark taxes on labour and capital are set as sector-wise tax and value added tax is 13%, and HH Income Tax is 20%, is shown in Table 7.

**Table 7: Total Output over the Model Horizon**

	2020	2025	2030	2035	2040
Scenario 1	47702.64	60882	77702.57	99170.36	126569.3
Scenario 2	57719.49	87777.12	123293.9	167925	226158.3
Scenario 3	53871.63	72090.07	92807.42	118232.4	149000.1
Scenario 4	51191.01	71708.29	93727.68	121540.1	157013.6
Scenario 5	55978.92	79513.08	106293.4	139449.8	181701.4
Scenario 6	51902.89	70822.6	90638.51	115876.1	148068.7
Scenario 7	51279.29	69716.39	89008.35	113623.8	145037.8
Scenario 8	49608.41	66795.09	84730.2	107733.4	137128.9
Scenario 9	50514.68	68419.04	87208.87	111539.8	145988.7
Scenario 10	51430.82	66756.01	85257.57	111349.3	139289.9
Scenario 11	50535.08	68401.88	87082.03	110970.7	141475

The analysis of total output across different scenarios (2020-2040) shows a varying trend of economic performance. Scenario 2 leads in total output throughout the period, starting at 57,719.49 in 2020 and growing to 226,158.3 in 2040, meaning robust economic growth and good policy conditions. Scenarios 5 and 11 also show strong growth, with total output increasing steadily over the years, meaning resilience and a good economic outcome. Scenario 8 starts lower at 49,608.41 in 2020 and grows more slowly, meaning a different economic trajectory, possibly due to less favourable conditions or policy assumptions. Overall, the analysis shows the importance of scenario planning and policy formulation in shaping economic outcomes, some scenarios outperform others because of initial conditions or policy settings. Understanding these variations can help policymakers make informed decisions to optimise economic growth and stability in the long run. The outcomes under different scenarios are presented in Figure 2.

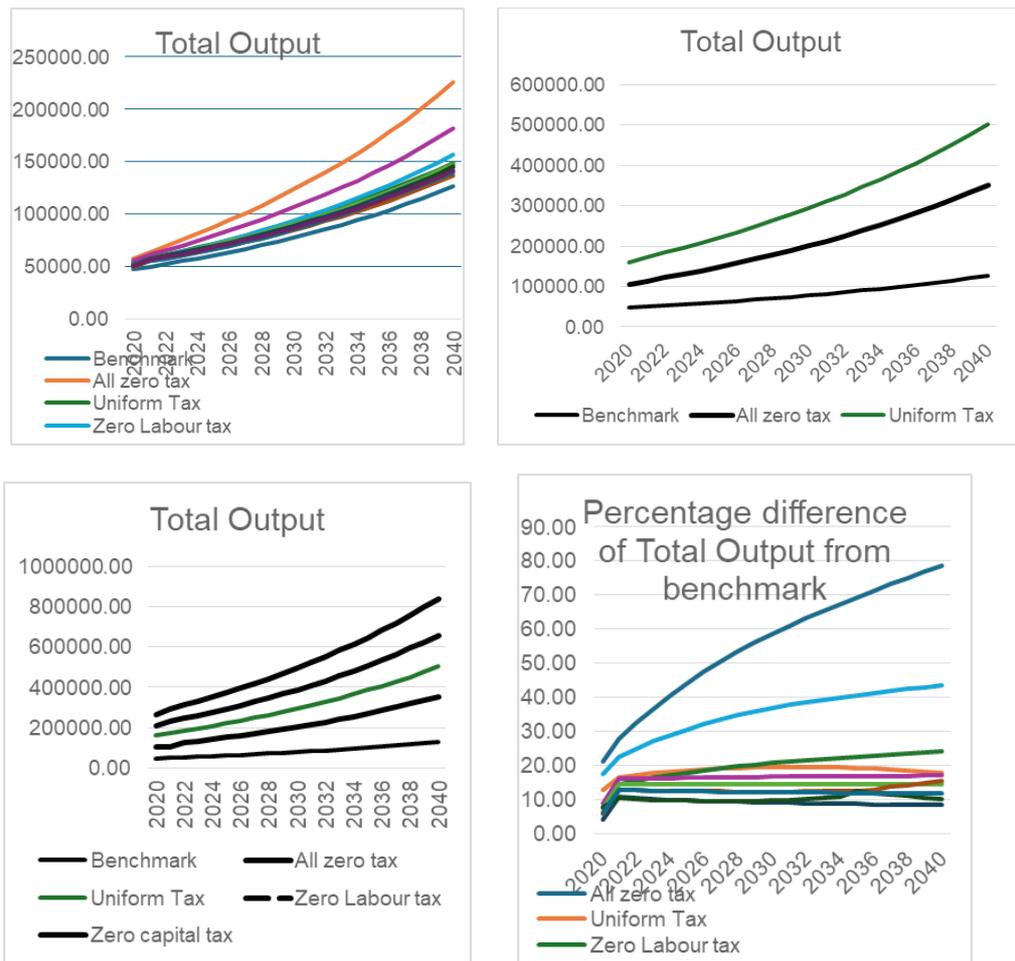


Figure 2: Total Output under Different Scenarios

The results presented above are a glimpse of the DCGE model analysis. It provides key features of the model and indicates to computations of scenarios under this model. More detailed analysis of results, including those under the equal-yield tax reforms from this model will be provided in forthcoming papers. We hope that this a short summary of the model results raises interests of a careful reader.

## Conclusions

Analysis of dynamic CGE model for Nepalese economy from 2020 to 2040 shows economic growth across all the sectors. Economic output, investment, capital

stock, employment, personal consumption and labour supply increase significantly. Labour cost is stable but gap between higher and lower income households persists means policy should promote equitable growth.

The model horizon covers 2020-2040. Model results show that the welfare of each household increases under the tax reform scenarios with less distorted steady state scenarios of the model economy. It shows the possibility of improving the living standard of people. All the households get a welfare increase, but the highest income households (e.g. HH10) gain a lot more than the lowest income households (e.g. HH1). This gap means that policies should target promoting equitable economic growth to sustain the economy in the long run.

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