REPUBLIC OF AZERBAIJAN

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ABSTRACT

of the dissertation for the degree of Doctor of Philosophy

STUDY OF GENERAL EQUILIBRIUM MODEL BASED ON SOCIAL ACCOUNTING MATRIX

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ÜMUMİ ŞÖBƏ

GENERAL CHARACTERISTICS OF THE STUDY

Relevance of the topic and degree of elaboration. Evaluating the dynamics of key economic indicators over time is one of the fundamental issues in economics. For this purpose, economic-mathematical models are widely used. Unlike other sciences, in economics, it is risky to assess the effects of decisions or external shocks based on experiment or judgment; therefore, economic-mathematical modeling serves as a kind of 'laboratory' for economics. These models are broadly categorized into two main groups: partial and general equilibrium models. Partial equilibrium models typically estimate how a variable of interest depends on other influencing variables, assuming the rest of the economy remains constant. While such models allow for a deeper analysis of relationships among selected indicators, the assumption that other factors remain constant often does not reflect real-world conditions. General equilibrium models, in contrast, consider the economy as a whole and reflect the interactions among different agents in various markets. They make it possible to assess the effects of shocks on different variables as well as the outcomes of policy decisions. There are 3 main types of general equilibrium models: macroeconometric models, dynamic stochastic general equilibrium (DSGE) models, and computable general equilibrium (CGE) models. These models differ in terms of data requirements, assumptions, and the types of questions they can address. While such models are widely used in most developed countries, constructing them remains a focus in many developing economies.

In the context of Azerbaijan, developing these models is also of great significance. Thus, it is essential to assess the impacts of various decisions on the national economy and to ensure that oil revenues are allocated in a way that supports comprehensive development of the country. Moreover, the country's approved strategic roadmaps set forth goals such as reducing dependence on oil, promoting the development of the non-oil sector, increasing the production of quality export goods, diversifying the economy, enhancing competitiveness, and improving employment and living standards. Analyzing the challenges related to achieving these goals, determining the appropriate strategies, and evaluating the impact of decisions all underscore the importance of developing general equilibrium models.

Given the role of the Social Accounting Matrix (SAM) and general equilibrium models (GEMs), they have been widely investigated by international organizations, government agencies, research centers, and researchers. Institutions such as the United Nations, the World Bank, the International Monetary Fund, the Food and Agriculture Organization of the UN, and the International Food Policy Research Institute recommend the construction of SAMs, publish guidelines and recommendations for addressing potential challenges, and support SAM-based research projects in developing countries. Researchers such as R. Stone, G. Pyatt, C. Round, E. Thorbecke, and D. Roland-Holst have conducted studies on SAM, while scholars including L. Walras, K. Arrow, G. Debreu, H. Scarf, J. Shoven, J. Whalley, F. Klein, S. Devarajan, D. Jorgenson, S. Robinson, J. Bandera, among others, have carried out research on general equilibrium models.

In Azerbaijan, based on input-output tables, models such as input-output model, equilibrium price model, labor and capital balance models were developed by Y.Hasanli. In addition, scholars such as Q.Imanov, Y.Hasanli, F.Hasanov, F.Joutz and S.Huseynov have constructed the country's macroeconometric and dynamic-stochastic general equilibrium models. Later, with the support of the Asian Development Bank and in partnership with the EcoMod, SAMs for the years 2006 and 2011 were developed at the Institute for Scientific Research on Economic Reforms (now the Economic Scientific Research Institute), and a CGE model called AzMod was developed based on these matrices. Some of the results of this research have been reflected in articles and conference papers, and dissertations authored by V.Valiyev, M.Mehdiyev, and A. Suleymanov.

In these studies, analyses were carried out using a multiplier model based on the 2011 SAM, which allowed for simulations across 19 sectors. The AzMod model, on the other hand, was developed in the GAMS system, however, it is not open to updates. Moreover, the substitution elasticities used in the system of equations of the general equilibrium model were estimated based on certain assumptions, rather than empirical methods. In contrast, the present dissertation econometrically estimates the parameters of lon-linear functions (CES, Armington and CET) using the non-linear least squares method. It should also be noted that the input-output tables, which is the foundation for constructing a SAM, are compiled every five years in Azerbaijan. Since 2011, input-output tables for the Azerbaijani economy have been prepared for the years 2016 and 2021. These tables reflect structural changes in the national economy as well as technological transformations. In this regard, constructing a new SAM based on recent statistical data, as well as developing and improving models based on it, is of critical importance. Therefore, in this research SAM has been constructed based on the latest available data, and the number of sectors increased to 25.

The object of the research is the Azerbaijani economy, and its **subject** is the study of general equilibrium problems in the economy and their modeling based on the SAM.

Research goals and objectives. The main goal of the research is to develop general equilibrium models (GEMs) based on the Social accounting matrix (SAM) for the Azerbaijani economy.

To achieve this goal, the following objectives have been set:

1. To investigate the theoretical and methodological foundations of SAM.
2. To study the principles of constructing SAM using the System of National Accounts (SNA) and input-output tables.
3. To explore the theoretical and methodological foundations of general equilibrium models.
4. To study methods for evaluating the key parameters used in CGE models (such as production and trade elasticities).
5. To construct SAMs for the Azerbaijani economy at both the sectoral and macro levels and adapt them for use in the computable general equilibrium model.
6. To evaluate the multiplicative effects of changes in exogenous demand on the economy through multiplier models based on SAM and input-output tables, and to conduct comparative analysis of the results.
7. To analyze the impact of changes in exogenous costs on price levels using equilibrium price model based on SAM and input-output tables.
8. To empirically estimate the production and trade elasticities of the Azerbaijani economy within the CGE model.

9. To build and apply a CGE model based on SAM for the Azerbaijani economy.

Research methods. The research process utilizes economic-mathematical modeling, including methods such as balance analysis, optimization, econometric modeling, logical generalization, statistical and comparative analysis.

The main provisions of the defense:

1. A 59-dimensional SAM was developed based on the latest data for Azerbaijan's 25 production sectors, 25 commodity and service groups, as well as households, production factors, enterprises, the government, investment/savings, and the rest of the world accounts.
2. A simulation model has been developed based on the constructed SAM, which allows the evaluation of the multiplicative effects of changes in exogenous demand for the products of each commodity and service group on other sectors, also on households and enterprise incomes.
3. Using the SAM based multiplier model and input-output model, the effects of investments in education and construction on various sectors of the national economy have been assessed. Additionally, the overall economic impacts of investments directed toward all sectors were evaluated and compared.
4. Based on the constructed SAM, an equilibrium price model was developed. This model enables the assessment of how changes in the share of exogenous costs in total spending—across each commodity and service group, as well as production sectors—affect producer and consumer prices at both the sectoral and national levels, as well as household expenditures. Furthermore, the model has been applied to evaluate the impact of changes in the share of exogenous costs in total expenditures within the machinery, equipment, and furniture production sector on prices and household spending.
5. A CGE model has been developed, covering the oil, non-oil, and service sectors, which allows the evaluation of the changes caused by exogenous variables. This model allows for the assessment of the effects of changes in variables such as the price of export and import goods in foreign currency, the supply of labor and capital in the country, net lending/net borrowing, direct and indirect tax rates and import duties on endogenous variables (sectoral production volume, labor and capital

factors, intermediate consumption, household and government consumption of various commodity and service groups, exports, imports, prices, etc.).

6. The parameters of the CES, Armington, and CET functions for the oil, non-oil, and service sectors were estimated using the non-linear least squares method. The corresponding substitution elasticities were then calculated and interpreted.

Scientific novelty of the research: The dissertation develops a 59-dimensional SAM based on the most recent 2021 input-output tables, enabling simulation across 25 sectors of the Azerbaijani economy.

A comparative analysis of the results of the multiplier models developed based on the SAM and input-output model has been carried out, identifying the most effective investment expenditure directions for the sectors of the economy.

Furthermore, a CGE model based on the SAM has been developed. This model allows for the identification of changes in macroeconomic indicators as a result of changes in other macroeconomic variables.

Theoretical and practical significance of the research: The research explores the theoretical and methodological foundations of constructing a SAM and developing general equilibrium models, which can serve as a theoretical and methodological foundation for future studies in this field. The SAM-based multiplier model and CGE model developed in the study can be used by government authorities and researchers to assess the impacts of various economic shocks as well as the results of different scenarios. Additionally, the models’ findings on the specific features of the national economy can be useful in decision-making processes.

Approbation and Application: The main results of the dissertation have been published in various scientific journals in the form of articles and have been presented at the following national and international scientific conferences:

- 55th International Scientific Conference on Economic and Social Development - "Socio Economic Problems of Sustainable Development. June 24, 2020. Baku, Azerbaijan.
- The 7th International Conference on Control and Optimization with Industrial Applications, August 26-28, 2020, Baku, Azerbaijan

- 70th International Scientific Conference on Economic and Social Development, June 25-26, 2021, Baku, Azerbaijan
- "Economy of Azerbaijan in the years of independence" Republican Conference, October 15, 2021, Baku, Azerbaijan
- 2nd International Modern Scientific Research Congress. December 23-25, 2021, Istanbul, Turkey
- The 8th International Conference on Control and Optimization with Industrial Applications (COIA), 24-26 August 2022, Baku, Azerbaijan
- International Scientific Conference of Economics and Management Researchers (ISCEMR-2023), 6/6/2023, Baku, Azerbaijan
- 5th International Conference on Problems of Cybernetics and Informatics (PCI 2023), August 28-30, 2023, Baku, Azerbaijan
- International Scientific Research Congress, September 26-27, 2023, Igdir University, Igdir, Turkey
- 28th FAI International Conference on Digitalization and Artificial Intelligence Revolution in Business Management, April 18-20, 2024, Baku, Azerbaijan
- 3rd International Conference on Problems of Logistics, Management and Operation in the East-West Transport Corridor (PLMO 2024), May 15-17, 2024, Baku, Azerbaijan

Name of the institution where the dissertation was conducted: The dissertation work was carried out at the Scientific-Research Institute of Economic Studies under Azerbaijan State University of Economics.

The total volume of the dissertation in characters, indicating the volume of the structural sections of the dissertation separately. The dissertation consists of an introduction (10235 characters), 3 chapters (Chapter I – 67202 characters; Chapter II – 46615 characters; Chapter III – 71913 characters), conclusion (5470 characters) and a list of 150 references. In total, the volume of the dissertation is 290170 characters.

SUMMARY OF THE DISSERTATION

The introduction of the dissertation discusses the degree of development of the topic, justifies its relevance, and provides information about the objectives and tasks of the research, the subject and object of the study, and the scientific novelty of the work.

In the first chapter of the dissertation, titled **"Theoretical and Methodological Foundations of Social Accounting Matrix and General Equilibrium Models",** detailed information about SAM is provided. The principles of its construction based on SNA and other sources are examined. At the same time, this chapter discusses the classification of GEM and explores the methodological foundations for constructing multiplier models and CGE model based on SAM.

SAM is a square matrix that captures the economic and social structure of a country or region using statistical data for a specific period (usually one year). Its construction not only provides an overall description of the economy by depicting the processes in a table but also represents the initial equilibrium state of the economy. Therefore, using various multiplier models and CGE models, the SAM allows to evaluate the new equilibrium state that arises from exogenous shocks[1].

The input-output model allows assessing the impact of changes in the final demand of sectors on the output of this sector itself, of other sectors and on the overall output of the country. The main simulation equation of this model is expressed as follows[2]:

$$\Delta X = B\Delta Y \quad (1)$$

Where, ΔX denotes the change in total output, ΔY represents the change in final demand, and B is the matrix of total input coefficients.

In addition to the production relationships in the input-output model, the simulation equation of the multiplier model based on SAM, which takes

[1] *Mainar-Causapé, A. J., Ferrari, E., & McDonald, S. (2018). Social accounting matrices: basic aspects and main steps for estimation. Publications Office of the European Union: Luxembourg.*

[2] *Hasanli, Y., 2011. Modelling of the intersectoral relationships of Azerbaijan economy. Baku: Elm.*

into account the effects of income flows and import-export operations as well, is as follows[3]:

$$\Delta Z = M_A \Delta Y \quad (2)$$

Here, ΔZ represents the vector of changes in incomes of the accounts, ΔY denotes the changes in exogenous demand, and M_A is the SAM multiplier matrix. It is evident that these multiplier effects also manifest themselves in terms of expenditures. The changes in exogenous expenditures of each sector — reflected in the price changes within the sector itself and in other sectors, as well as their impact on household spending — are evaluated using the equilibrium price model based on SAM[4]:

$$\Delta P = (E - A^t)^{-1} \Delta B \quad (3)$$

Here, **P** is the price vector, representing producer prices for the production activities account, consumer prices for the group of goods and services, and the cost-of-living index for the household account. **E** denotes the unit matrix, $\mathbf{A^t}$ is the transposed matrix of technical coefficients, and **B** is the vector indicating the share of exogenous payments in the expenditures of endogenous accounts.

More comprehensive models based on SAM are CGE models. In these models, relationships are not only linear but are also modeled using various non-linear functions. This allows for the incorporation of changes in the behavior of economic agents in response to price changes. In a CGE model, the entire process of a country's economy—from production to the consumption of the produced goods—is represented[5]. Here, the primary factors of production, namely labor and capital, are first combined using a CES (Constant Elasticity of Substitution) production function to produce a composite factor.

$$Y_j = b_j(\beta k_j K_j^{-\rho_j} + \beta l_j L_j^{-\rho_j})^{-\frac{1}{\rho_j}} \quad (4)$$

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[3] *Round J., Social accounting matrices and SAM-based multiplier analysis //The impact of economic policies on poverty and income distribution: Evaluation techniques and tools -2003, 14, -p. 261-276.*

[4] *Roland-Holst, D.W. and Sancho, F., 1995. Modeling prices in a SAM structure. The review of economics and statistics, p.361-371.*

[5] *Hosoe N., Gasawa K., Hashimoto H., Hesablanabilir Genel Denge Modellemesi: GAMS uygulamaları ve simülasyonlar // Türkcə tərcümə (Recep Tarı, Ferhat Pehlivanoğlu, Muhammet Rıdvan İnce). Ekin Basım yayın - 2021*

Y_j − denotes the volume of composite factor produced in sector j; L_j and K_j represent the quantities of labor and capital inputs, respectively. βl_j and βk_j indicate the shares of these factors in the production of the composite input. b_j is the intensity parameter in the CES function, and ρ_j is the parameter used to calculate the elasticity of substitution. Using ρ_j the elasticity of substitution between labor and capital is calculated as follows:

$$\sigma_i = \frac{1}{1+\rho_j}$$

At this stage, the firm seeks to maximize its profit subject to the constraints of the production technology represented by the CES function. Given the prices of labor, capital, and the composite factor, this objective is formulated as an optimization problem. Solving this problem using the method of Lagrange multipliers yields the optimal quantities of labor and capital inputs used in the production process, as follows:

$$L_j = Y_j \left(\frac{p_j^y \cdot b_j^{-\rho_j} \cdot \beta l_j}{Pl}\right)^{\frac{1}{1+\rho_j}} \tag{5}$$

$$K_j = Y_j \left(\frac{p_j^y \cdot b_j^{-\rho_j} \cdot \beta k_j}{Pk}\right)^{\frac{1}{1+\rho_j}} \tag{6}$$

Here, p_j^y – denotes the price of the composite factor, while Pl and Pk represent the prices of labor and capital, respectively. Subsequently, in each production sector, the composite factor and intermediate consumption goods are combined using a Leontief production function to ensure the production process can take place. Within this constraint, the sector aims to maximize its profit given the prices of its output, the composite factor, and the intermediate inputs acquired from other sectors. Solving this optimization problem yields the following equations, which determine the quantities of the composite factor and intermediate goods used in the production process, as well as the price of the final output:

$$X_{i,j} = ax_{i,j} \cdot Z_j \tag{7}$$

$$Y_j = a\gamma_j \cdot Z_j \tag{8}$$

$$p_j^z = a\gamma_j \cdot p_j^y + \sum_i ax_{i,j} p_i^q \tag{9}$$

Here, $X_{i,j}$ denotes the volume of intermediate inputs from sector *i* required to produce the output of sector *j*; Z_j is the total output of sector *j*; $ax_{i,j}$ represents the quantity of intermediate input from sector *i* required to produce one unit of output in sector *j*; P_j^z is the price per unit of output in sector *j*; Y_j is the composite factor required for the production in sector *j*; $a\gamma_j$ indicates the amount of the composite factor required to produce one unit of output in sector *j*; p_j^y is the price of one unit of the composite factor used in sector *j*; and p_i^q represents the unit price of the product supplied by sector *i* as intermediate consumption to other sectors.

In this model, the government gets revenue by collecting direct taxes (T^d), as well as production taxes (T_j^z) and tariffs (T_j^m).

$$T^d = \tau^d(Pl \cdot Ls + Pk \cdot Ks) \quad (10)$$

$$T_j^z = \tau_j^z p_j^z Z_j \quad (11)$$

$$T_i^m = \tau_i^m p_i^m M_i \quad (12)$$

Direct taxes represent a fixed proportion (τ^d) of the income generated from the use of labor (Ls) and capital (Ks) across the economy. Production taxes are calculated as a fixed share (τ_j^z) of the production value ($p_j^z Z_j$), while tariffs correspond to a fixed proportion (τ_i^m) of the import value ($p_i^m M_i$).

$$\mathrm{S^g = ss^g(T^d + \textstyle\sum_j T_j^z + \sum_j T_j^m)} \quad (13)$$

Here, $\mathrm{ss^g}$ denotes the fixed share of government revenue that is saved, and $\mathrm{S^g}$ represents total government savings. The remaining government revenue is allocated to the purchase of various goods and services (X_i^g) according to specific expenditure shares (μ_i).

$$X_i^g = \frac{\mu_i}{p_i^q}(T^d + \textstyle\sum_j T_j^z + \sum_j T_j^m - S^g) \quad (14)$$

Household income is formed from the payments for the use of labor and capital factors in the economy. A fixed proportion $\mathrm{ss^p}$ of this income is saved, with households saving $\mathrm{S^p}$. The remaining income is allocated to the purchase of various goods and services (X_i^p) according to the shares (a_i) that maximize utility, expressed by a Cobb-Douglas utility function.

$$\mathrm{S^p = ss^p(Pl \cdot Ls + Pk \cdot Ks)} \quad (15)$$

$$X_i^p = \frac{a_i}{p_i^q}(Pl \cdot Ls + Pk \cdot Ks - S^p - T^d) \quad (16)$$

In the model, savings are allocated according to shares (λ_i) that maximize utility under a Cobb-Douglas utility function. These shares are then distributed across different commodity and service groups as investment expenditures (X_i^v):

$$X_i^v = \frac{\lambda_i}{p_i^q}(S^p + S^g + \varepsilon S^f) \qquad (17)$$

In modeling foreign trade, export and import prices expressed in foreign currency are considered exogenous, and it is assumed that the economy operates under an equilibrium defined by these export and import prices.

$$P_i^e = \varepsilon P_i^{we} \qquad (18)$$

$$P_i^m = \varepsilon P_i^{wm} \qquad (19)$$

$$\sum_i P_i^{we} E_i + S^f = \sum_i P_i^{wm} M_i \qquad (20)$$

Here, P_i^{we} represents the world market price of a unit of exported product or service for the i-th commodity and service group; P_i^e is the price received by domestic producers per unit sold in that group; P_i^{wm} denotes the world market price of the imported product or service; and P_i^m is the domestic market price of the imported product or service. The symbol ε indicates the exchange rate. The term $\sum_i P_i^{we} E_i$ reflects the value of exports, i.e., from selling the exported quantity E_i of each commodity and service group. Similarly, $\sum_i P_i^{wm} M_i$ represents the expenditure for importing a quantity M_i of goods and services across various groups. S^f stands for the net lending/borowing and includes variables that ensure the balance between the domestic economy and the rest of the world.

The domestically supplied goods and services (D_i) and imported goods and services (M_i) jointly form the total demand (Q_i) in the country, which is modeled using the Armington function:

$$Q_i = \gamma_i(\delta m_i M_i^{\eta_i} + \delta d_i D_i^{\eta_i})^{\frac{1}{\eta_i}} \qquad (21)$$

Here, γ_i is a parameter indicating the effectiveness of the substitution between imported and domestic products for the i-th goods and services group, δm_i and δd_i are distribution parameters, η_i is the parameter used to calculate the elasticity of substitution between imported and domestic products. Thus, within the constraint expressed by the Armington function, solving the maximization problem of the difference between the total expenditure on the overall demand and the sum of the expenditures on domestically purchased and imported goods and services allows for determining the volume of imports and domestic products in the economy as follows:

$$M_i = Q_i \left[\frac{\gamma_i^{\eta_i} \delta m_i p_i^q}{(1+\tau_i^m) p_i^m}\right]^{\frac{1}{1-\eta_i}} \tag{22}$$

$$D_i = Q_i \left[\frac{\gamma_i^{\eta_i} \delta d_i p_i^q}{p_i^d}\right]^{\frac{1}{1-\eta_i}} \tag{23}$$

A portion of the products produced within the country is sold in the domestic market, while the remaining portion is exported. The decision of producers on how much of the product to export and how much to sell in the domestic market is represented as a combination of the volumes sold in the domestic and foreign markets, expressed through the Constant Elasticity of Transformation (CET) function.

$$Z_i = \theta_i (\xi e_i E_i^{\varphi_i} + \xi d_i D_i^{\varphi_i})^{\frac{1}{\varphi_i}} \tag{24}$$

Here, θ_i is a parameter that indicates the efficiency of substitution between the quantities of goods sold in the export and domestic markets for the *i*-th production sector; ξe_i and ξd_i are the CET (Constant Elasticity of Transformation) distribution parameters; and φ_i is the parameter used to calculate the elasticity of transformation between goods sold in the export and domestic markets.

The producer's CET function expresses a constraint within which, given the prices, the overall production quantity is divided between the export and local markets. By solving the profit maximization problem, the volumes of the produced goods sold in foreign and domestic markets are determined:

$$E_i = Z_i \left[\frac{\theta_i^{\varphi_i} \xi e_i (1+\tau_i^z) p_i^z}{p_i^e}\right]^{\frac{1}{1-\varphi_i}} \tag{25}$$

$$D_i = Z_i \left[\frac{\theta_i^{\varphi_i} \xi d_i (1+\tau_i^z) p_i^z}{p_i^d}\right]^{\frac{1}{1-\varphi_i}} \tag{26}$$

As the final equilibrium conditions, the Armington composite good (a combination of domestically produced goods sold in the local market and imported goods) is assumed to be equal to the sum of household consumption expenditures, government consumption expenditures, investment demand, and intermediate inputs for the respective commodity group. So, market equilibrium in the goods and services market is expressed as follows:

$$Q_i = X_i^p + X_i^g + X_i^v + \sum_j X_{i,j} \tag{27}$$

The equilibrium condition in the factor markets states that the total amount of labor and capital factors used across different sectors is equal to the total supply of labor and capital in the country. This condition is expressed by the following equalities:

$$Ls = \sum_i L_i \tag{28}$$

$$Ks = \sum_i K_i \tag{29}$$

Thus, within the framework of the general equilibrium model, the processes occurring in the economy are modeled. Considering that the system consists of 26 equations from (4) to (29) and that the model involves three sectors, we obtain a system of 72 equations. There are 88 variables in total, of which 16 are exogenous. The exogenous variables include the foreign market prices for imports and exports for each sector, import tariffs, production tax rates, direct tax rates, net lending/borrowing, and the supply of production factors. The remaining variables are endogenous, and their values are determined within the model framework. First, using the initial values of the endogenous and exogenous variables, the parameters characterizing the economy are estimated through mathematical calculations and econometric modeling. Then, simulations are conducted to assess the changes in the exogenous variables, and the new equilibrium values of the endogenous variables are determined.

The second chapter of the dissertation, titled **"Issues in Constructing the Social Accounting Matrix for Azerbaijan"** discusses the construction of a macro-SAM based on the indicators of the national accounts system and other statistical indicators. It also covers the disaggregation of the production and goods and services accounts into sectors and commodity groups, using the input-output tables, resulting in the sectoral SAM. Additionally, it considers the construction of the SAM as the database for the CGE model. In this framework, the organization of the production process of the economy’s sectors is reflected in the production account, while the demand for goods and services is considered in the goods and services account. Production factors—labor and capital—are classified, and economic agents such as the government, households, and enterprises are identified. The investment account is divided into investment and changes in the stocks of physical capital. To reflect foreign relations, the rest of the world account is also included. Moreover, to ensure the equality of row and column sums during the construction of the SAM, rows and columns that represent these sums for each account are added. Thus, a macro SAM structure is determined, and its elements are filled using relevant statistical indicators (Table 1).

Subsequently, considering the use of the SAM grouped at different sectoral levels in the modeling process, the SAM was also constructed at the sectoral level. For this purpose, the production activities and goods and services accounts were grouped into 25 sectors. To achieve this, the intersectoral balance table, initially consisting of 96 sectors, was aggregated and reduced to 25 sectors.

Thus, in the dissertation, a 59x59 dimensioned SAM was constructed, taking into account 25 production sectors, 25 commodity and service groups, 2 production factors, 3 domestic economic agents, changes in investment and physical capital stocks, the rest of the world, and accounts showing the row and column sums. This constructed matrix was used as the database for the multiplier models based on the SAM.

Since the database for the CGE model to be constructed in the dissertation is somewhat different, a 12x12 dimensioned SAM was also constructed in this chapter. This matrix includes 3 production sectors, labor, capital, taxes, tariffs, households, government, investment/savings, the rest of the world accounts, and accounts showing the row and column sums.

In the third chapter of the dissertation, titled **"Development of General Equilibrium Models for Azerbaijan"** the multiplier models based on the 59-dimensional SAM constructed in the second chapter and the 25-sector input-output table were developed, and results of two models were compared. Additionally, a CGE model was developed based on the 12x12 dimensional SAM consisting of 3 sectors.

The multiplier model based on the constructed SAM allows for the evaluation of the impact of a change in exogenous demand for each sector's goods and services, on total demand within that sector, other sectors, and the overall country. It also assesses which portion of this demand is met through domestic production and which portion is satisfied through imports.

Additionally, the model makes it possible to evaluate changes in factor incomes, and consequently, the incomes of households and enterprises.

Using this model, the effects of investments allocated for construction in the liberated territories in 2023 were assessed. In 2023, 2.254 billion manat were invested in the Karabakh economic region, with 2.204 billion manat directed toward construction and installation works[6]. The results of the assessment indicated that the 2.3 billion manat investment in construction generated demand for products amounting to approximately 4.3 billion manat through production linkages and approximately 5 billion manat through the SAM effect (Table 2).

A detailed analysis by sectors reveals that the SAM effect of construction is larger in some sectors and smaller in others compared to the production effect. In sectors where the SAM effect is greater than the production effect, the value-added or export effect is dominant. Conversely, in sectors where the SAM effect is smaller than the input-output effect, the import effect outweighs the other two effects.

Table 2. Multiplier effects of investments allocated to Construction sector in liberated teritories in 2023, mln manat

Sectors	Change of output basen on input-output model	Change in total demand based on SAM	The ratio of domestic production in total demand, %
Agriculture, forestry and fishing	0.78	207.92	88.05
Mining industry	167.96	122.11	97.94
Production of food, drinks and tobacco	2.44	155.49	72.02
Production of non-metallic products and base metals	**524.41**	**554.30**	51.13
Production of machinery, equipment and furniture	106.38	136.41	19.83
Electricity, gas, and steam production	27.31	58.68	97.65
Water supply	2.88	6.48	96.45
Waste treatment and disposal	4.01	4.57	80.74
Construction	**2607.03**	**2561.1**	76.87
Trade: repair of transport means	198.37	350.92	93.96
Transportation and storage	**244.88**	**277.75**	69.91

[6] *https://banker.az/isgaldan-azad-edilmis-%C9%99razil%C9%99rd%C9%99-tikinti-qurasdirma-isl%C9%99rin%C9%99-investisiyalar-53-artib/*

Accommodation and food service activities	14.12	52.08	63.67
Information and communication	19.37	39.79	90.63
Financial and insurance activities	56.69	65.71	96.76
Real estate services	34.59	75.67	98.77
Research and development	28.02	17.39	14.78
Professional and technical activities	**279.11**	**228.15**	81.91
Administrative and support service activities	18.19	22.29	89.23
Public administration and defense	0.25	0.68	95.59
Education	0.39	13.70	99.20
Healthcare	0.39	19.33	97.83
Social services	0.20	0.77	97.40
Library, archive, museum and other cultural services	0.51	2.02	99.50
Arts, entertainment and rest	0.05	9.95	96.48
Other services	4.39	26.38	97.92
Total	**4342.71**	**5009.4**	**75.32**

Source: *Author's calculations based on input-output model and SAM multiplier model*

Using the equilibrium price model based on the constructed SAM in the dissertation, the effect of a 10% increase in the share of exogenous costs (imports, import duties, and product taxes) in total costs on the “Production of machinery, equipment and furniture” was evaluated. This analysis assessed the impact on prices in this sector itself, other sectors, and the overall country, as well as the effect on household expenditures (Table 3).

Table 3. The effects of a 10% increase in the share of exogenous costs in total costs in “Production of machinery, equipment and furniture”, %

	Sectors	**Producer prices**	**Consumer prices**
1	Agriculture, forestry and fishing	0.76	0.67
2	Mining industry	0.35	0.35
3	Production of food, drinks and tobacco	0.61	0.44
4	Production of non-metallic products and base metals	0.47	0.24
5	Production of machinery, equipment and furniture	**1.75**	**8.36**
6	Electricity, gas, and steam production	**1.01**	0.98
7	Water supply	**0.96**	0.93
8	Waste treatment and disposal	**1.07**	0.87
9	Construction	0.63	0.48
10	Trade: repair of transport means	0.60	0.56
11	Transportation and storage	0.83	0.58
12	Accommodation and food service activities	0.59	0.38

13	Information and communication	**0.90**	0.82
14	Financial and insurance activities	0.54	0.52
15	Real estate services	0.63	0.62
16	Research and development	0.84	0.12
17	Professional and technical activities	**0.99**	0.81
18	Administrative and support service activities	**1.01**	0.90
19	Public administration and defense	0.76	0.72
20	Education	0.73	0.73
21	Healthcare	0.72	0.70
22	Social services	0.64	0.62
23	Library, archive, museum and other cultural services	0.62	0.62
24	Arts, entertainment and rest	0.68	0.66
25	Other services	0.85	0.83
Total price change in the country		0.61	**0.91**

Source: *Author's calculations based on SAM equilibrium price model*

The results show that the increase in exogenous costs causes the greatest changes within the sector itself. Specifically, producer prices in the “Production of machinery, equipment and furniture” sector increase by approximately 1.75%. Due to the existing interconnections, changes have also been observed in other sectors depending on the volume of intermediate products used from this sector.

When comparing producer and consumer prices, we observe that the largest difference is observed in this sector itself (8.36%), with consumer prices in this sector increasing more than producer prices. This indicates that the increase in exogenous costs for this sector mainly occurs through the import of final consumption goods, and the value-added and import duties in this sector lead to an increase in consumer prices. In other sectors, after the increase in consumer prices due to the use of intermediate products from this sector, some of the taxes are offset, leading to a relatively smaller increase in consumer prices.

Additionally, a 10% increase in the share of exogenous costs in total costs within the "Machinery, Equipment and Furniture Production" sector results in price changes across various sectors, leading to a 0.6% increase in producer prices and a 0.9% increase in consumer prices at the national level. According to the model’s results, these changes cause a 0.72% increase in household expenditures.

Subsequently, in the study, to identify the key investment expenditure directions in the country, the total effects of the unit investment allocated to each sector on the country were assessed using the input-output and SAM multiplier models, and the results were analyzed comparatively (Table 4).

According to the results of the input-output model, the sectors with the greatest multiplicative effects are "Production of food, drinks, and tobacco" "Production of machinery, equipment and furniture" "Social services," and "Construction". The lowest multiplicative effects through production links are observed in the "Mining industry". The low production effect in this sector can be explained by the fact that it acquires very few intermediate products from the country's production sectors during its activity.

When examining the results of the multiplier model based on the SAM, we can observe that an increase in exogenous demand generates more demand across the country compared to the results of the input-output model for most sectors. The largest differences are observed in the sectors of "Education," "Library, archive, museum, and other cultural services," "Waste treatment and disposal" and "Other services." In these sectors, the multiplicative effect based on the SAM exceeds that of the input-output model. The main reason for this is that, within the SAM, factor (labor and capital) incomes create additional demand for different goods and services.

Table 4. Total multiplier effects of 1 million additional exogenous demand per sector based on SAM, in thousand manats

	Sectors	Change of output based on input-output model	Change of total demand based on SAM	Difference between the results of two models	Total change in domestic production based on SAM	The ratio of domestic production in total demand, %
1	Agriculture, forestry and fishing	1749.3	2231.9	482.6	1823.5	81.7
2	Mining industry	1146.2	1842.5	696.3	1624.2	88.2
3	Production of food, drinks and tobacco	**2163.0**	2273.7	110.8	1700.7	74.8
4	Production of non-metallic products and base metals	1783.9	1739.9	-44.0	1082.9	62.2
5	Production of machinery, equipment and furniture	**2064.8**	1319.5	-745.4	411.1	31.2
6	Electricity, gas, and steam	1862.2	2490.0	627.8	2130.2	85.6
7	Water supply	1760.9	**2754.6**	993.6	2349.1	85.3
8	Waste treatment and disp.	1677.5	**2843.3**	**1165.7**	2200.8	77.4
9	Construction	**1926.3**	2217.1	290.8	1669.9	75.3

10	Trade: repair of trans. means	1461.2	2247.7	786.5	1901.7	84.6
11	Transportation and storage	1548.4	1859.6	311.2	1324.1	71.2
12	Accommodation and food service activities	1523.9	1887.0	363.1	1321.1	70.0
13	Information and commun.	1483.6	2193.8	710.2	1812.9	82.6
14	Financial and insurance	1348.4	2355.5	1007.1	2058.4	87.4
15	Real estate services	1306.5	2006.7	700.2	1772.7	88.3
16	R&D	1409.3	1242.5	-166.9	321.4	25.9
17	Professional and technical activities	1720.8	2417.5	696.7	1892.8	78.3
18	Administrative and support service activities	1535.0	2491.2	956.3	2029.9	81.5
19	Public administration and defense	1674.1	2584.8	910.8	2080.9	80.5
20	Education	1322.0	**2631.2**	**1309.2**	2251.7	85.6
21	Healthcare	1605.2	2521.2	916.1	2090.8	82.9
22	Social services	**1917.8**	**2758.3**	840.5	2353.0	85.3
23	Library, archive, museum and other cultural services	1201.2	2389.0	**1187.8**	2062.5	86.3
24	Arts, entertainment and rest	1753.6	**2698.9**	945.3	2274.3	84.3
25	Other services	1510.6	**2660.8**	**1150.2**	2256.5	84.8

Source: Author's calculations based on input-output model and SAM multiplier model

In the sectors of "Production of non-metallic products and base metals" and "Production of machinery, equipment and furniture " as well as in the sector of "Research and development" the SAM effect is smaller than the production effect. This is because, in the SAM-based multiplier model, imports are considered separately. As a result, part of the multiplicative effect in the input-output model is transferred abroad, which leads to a lower result in sectors with high imports in the SAM-based multiplier model. Additionally, a significant portion of the total demand in the final stage is met through imported products. Consequently, the creation of an additional 1 million exogenous demand in the "Production of machinery, equipment and furniture" sector increases the domestic production volume by only 0.4 million manat. In the "Research and development" sector, the result of an additional 1 million exogenous demand in the SAM multiplier model creates an additional demand of 1.2 million manat for various goods and services in the country. Of this, only 25.9%, or 0.3 million manat, is met by domestic production. However, for the sectors such as "Real estate services", "Financial and insurance activities", "Library, archive, museum, and other cultural services," and "Mining industry" more than 86% of the created demand for the products of various goods and service groups is met by domestic production.

In the research, the CGE model for the Azerbaijani economy has been realized. For this purpose, after the system of equations for the model is established, the first step is to estimate its parameters. After that, exogenous and endogenous variables must be separated. Then, it is possible to evaluate the changes in the endogenous variables caused by any change in the exogenous variables in the system of equations. A widely used method for estimating the parameters of the general equilibrium model is the calibration method. Using this method, it is possible to estimate as many parameters as the number of equations in the system of equations (72). The parameters for the CES, CET, and Armington functions must be exogenously incorporated into the model.

The parameters of the CES, CET, and Armington functions have been estimated in the Mathcad program using the Marquardt method using nonlinear least squares. It should be noted that these parameters, being input variables in the CGE model, provide essential information regarding the behavior of producers and consumers with respect to choices between imports and local products; between sale in local and foreign market and between production factors in the local market.

The results of estimating the CES function for the three sectors are as follows:

$$Y_{oil} = 1.26 \cdot (0.88 \cdot K_{oil}^{-5.4} + 0.12 \cdot L_{oil}^{-5.4})^{-0.19}$$
$$Y_{non-oil} = 1.22 \cdot (0.88 \cdot K_{non-oil}^{-2.27} + 0.12 \cdot L_{non-oil}^{-2.27})^{-0.44}$$
$$Y_{services} = 1.5 \cdot (0.98 \cdot K_{services}^{-2.36} + 0.02 \cdot L_{services}^{-2.36})^{-0.42}$$

Here, **Y** represents the GDP of the sectors; **K** represents the value of fixed capital, and **L** represents labor input.

The results of estimating the Armington function, which reflects the dependence of total demand in the economy on the volume of imports and local production for the oil, non-oil, and services sectors, are as follows:

$$Q_{oil} = 1.06 \cdot (0.58 \cdot M_{oil}^{-0.00007} + 0.42 \cdot D_{oil}^{-0.00007})^{-15243}$$
$$Q_{non-oil} = 1.002 \cdot (0.24 \cdot M_{non-oil}^{0.7} + 0.76 \cdot D_{non-oil}^{0.7})^{1.4}$$
$$Q_{services} = 0.98 \cdot (0.25 \cdot M_{services}^{-0.00003} + 0.75 \cdot D_{services}^{-0.00003})^{-40563}$$

The import of sectors is denoted by **M**, the value of locally sold domestic products in the domestic market is denoted by **D**, and the total demand for commodities and services in the country for each sector is represented by **Q**.

The results of estimating the CET function parameters, which express the relationship between the volume of domestic production and the portion sold in the local and domestic markets, are as follows:

$$Y_{oil} = 0.97 \cdot (0.92 \cdot E_{oil}^{0.14} + 0.08 \cdot D_{oil}^{0.14})^{6.9}$$

$$Y_{non-oil} = 1.001 \cdot (0.06 \cdot E_{non-oil}^{0.4} + 0.94 \cdot D_{non-oil}^{0.4})^{2.5}$$

$$Y_{services} = 0.96 \cdot (0.29 \cdot E_{services}^{-0.29} + 0.71 \cdot D_{services}^{-0.29})^{-0.71}$$

Here, the total output of sectors is denoted by **Y**, exports by **E**, and the volume of domestic production sold in the local market is denoted by **D**.

The results of estimating the elasticities for CES, CET, and Armington functions for all three sectors are summarized in Table 5.

Table 5. The results of the estimation of elasticities for oil, non-oil and services sectors

Sectors	CES elasticity	Armington elasticity	CET elasticity
Oil sector	0.16	0.99	1.17
Non-oil sector	0.31	3.3	1.67
Services	0.3	0.99	0.41

Source: author's calculations

The fact that the CES elasticity is less than 1 for all three sectors further proves that expressing the dependence of the production volume on the main production factors in the country's economy using the Cobb-Douglas function would not be appropriate. This is because in the Cobb-Douglas function, elasticity is typically assumed to be equal to one. The elasticity being less than one indicates an imbalance between the labor and capital markets in the country, which shows that, given the rapid influx of capital into the country due to oil revenues, the local workforce's skill level is insufficient to mobilize this capital effectively[7].

[7] *Hasanli Y.H., Sadik-Zada E.R., Ismayilova S., Rahimli G.F., Ismayilova F., Could the Lacking Absorption Capacity of the Inflowing Capital Be the Real Cause of the Resource Curse? — A Case Study of Transition Economies // Sustainability -2023, 15, 10837.*

The fact that the Armington elasticity is close to one for the oil and services sectors indicates that import and domestic products in these sectors can substitute for each other. In contrast, a higher elasticity was observed in the non-oil sector, suggesting a greater degree of substitution between imports and domestic products in this sector.

The CET elasticity shows that producers in the oil and non-oil sectors have elastic choices between local and foreign markets, whereas in the services sector, this choice is inelastic.

After estimating the parameters of the model, the multiplicative effects of a 1% increase in the price of goods and services in the oil sector were evaluated for the country.

Overall, the constructed model allows for the evaluation of the effects of any changes in exogenous variables or model parameters on the country. It also enables the evaluation of decisions made by various government bodies or planned scenarios by making appropriate changes in the model's equation system and database.

The main conclusions and proposals of the dissertation work

The main results of the research are as follows:

The dissertation presents the construction of a 59-dimensional Social Accounting Matrix (SAM) for the Azerbaijani economy, based on the most recent input-output tables and national account data, covering 25 production sectors and 25 commodity and service groups. Using this matrix, the SAM-based multiplier model and price equilibrium model were implemented in Excel, and the CGE model was realized in the GAMS software package.

The constructed SAM multiplier model allows for the evaluation of the additional demand generated in the products of 25 commodity and service groups due to changes in exogenous demand. It also assesses the share of this demand that is covered by domestic production, as well as the changes in factor incomes and household and enterprise incomes. Additionally, a 25-sector input-output model was developed, and the results of both models were compared.

As a result of evaluating the multiplicative effects of investments in “Education”, it was found that the SAM effect is approximately twice as high as the production effect. The largest difference occurred in sectors where household income expenditures are the dominant factor, including "Trade; repair of transport means", "Agriculture, forestry and fishing", "Production of non-metallic products and base metals", "Transportation and storage" and "Production of food, drinks and tobacco". Additionally, it was revealed that while most sectors cover a significant portion of the additional demand arising from investments in education through domestic production, this figure is considerably lower in sectors with high import dependence, such as "Production of machinery, equipment and furniture", "Research and development" and "Production of non-metallic products and base metals".

The results of evaluating investments allocated for construction in the liberated territories through the input-output model show that, due to production linkages, there was an approximately twofold increase in total demand. However, the SAM effect was not as high, which can be explained by the use of imported products to satisfy the demand. Taking this issue into account can help increase the domestic effects of future investments allocated for this sector.

The multiplicative effects of an equal increase in exogenous demand for all sectors were evaluated through the input-output and SAM multiplier models, identifying the most effective investment expenditure directions, as well as the existing issues in the sectors:

- According to the results of the input-output model, the sectors that generate the highest multiplicative effects through production linkages are "Production of food, drinks and tobacco", "Production of machinery, equipment and furniture" and "Construction".
- In the SAM-based multiplier model, where income flows are also taken into account, it was observed that an increase in exogenous demand leads to higher demand across the country compared to the input-output model in most sectors. The largest differences were observed in the sectors of "Education", "Library, archive, museum, and other cultural services" and "Waste treatment and disposal". In contrast, the difference was negative in the "Production of non-

metallic products and base metals", "Production of machinery, equipment and furniture" and "Research and development" sectors, which can be explained by the high share of imports in intermediate products of these sectors.

- According to the results of SAM based multiplier model, the largest increase in demand across various commodities and services was observed in the sectors of "Waste treatment and disposal", "Social services", "Water supply" and "Arts, entertainment and rest".
- The largest increase in enterprise revenues was observed in the sectors of "Mining", "Real estate services" and "Financial and insurance activities", while the largest increase in household revenues occurred in the sectors of "Education", "Waste treatment and disposal", "Library, archive, museum, and other cultural services" and "Other services". The sectors with the smallest increase in household and enterprise revenues were "Production of machinery, equipment and furniture" and "Research and development". As mentioned earlier, this can be explained by the high share of imports in these sectors, leading to the "leakage" of the multiplicative effects to foreign markets.

A comparative analysis of multipliers across sectors was conducted based on the 2016 and 2021 Input-Output Tables and SAM. The results of the analysis indicate that the increase in multipliers in most service sectors can be attributed to the rise in unit costs of expenditures. In contrast, the decline in multipliers across most production sectors is primarily explained by advancements in technology and the optimization of production processes, which have led to a reduction in unit production costs. Furthermore, changes in multipliers may also reflect ongoing long-term structural transformations, as well as the economic impacts and price fluctuations that occurred in the post-pandemic period.

The dissertation also includes the construction of a CGE model for the oil, non-oil, and service sectors. And elasticities of substitution between the capital and labor, as well as between imports and local products, and between exports and local market sales for these three sectors were estimated.

Using a computable general equilibrium (CGE) model in GAMS, the impact of changes in oil prices on various volume and price indicators in the oil, non-oil, and service sectors was assessed under two scenarios: with and without transfers from the State Oil Fund. The results of both simulations were compared. The comparison revealed that, under conditions of rising global oil prices, transfers from the State Oil Fund mitigate the negative impact on the indicators of the non-oil and service sectors.

Overall, the constructed model allows for the evaluation of the impacts of any changes in exogenous variables or model parameters on the economy. It also enables the assessment of decisions or planned scenarios by different institutions through modifications in the model's equation system and database.

The Main Content of the Dissertation is Reflected in the Following Published Works:

1. Həsənli Y.H., Rəhimli G.F., Azərbaycan iqtisadiyyatının 2021-ci ilə aid Sosial Hesablar matrisinin tərtibi // Statistika xəbərləri: elmi praktiki jurnal - 2024, 4-cü buraxılış, -s.4-13
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