The Impact of Trade Sanctions on the Supply and Demand of Sports, Recreational, and Cultural Services in Iran: A Recursive Dynamic Computable General Equilibrium Approach

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Abstract

Purpose: This study aimed to investigate the impact of Trade Sanctions (TS) on the supply and demand indicators of Sports, Recreational, and Cultural (SRC) services in Iran.

Methods: The research was applied in terms of objective and employed a descriptive-analytical approach. Data collection was carried out through documentary and library-based methods. We employed a standard recursive dynamic Computable General Equilibrium (CGE) model, based on the 2016 Social Accounting Matrix (SAM) from the Central Bank of Iran. To assess the impact of TS, we simulated two scenarios involving simultaneous increases in import prices and decreases in export prices. Subsequently, we calculated the changes in indices related to the supply and demand of SRC services. This study fills a critical gap in the literature by employing a recursive dynamic CGE model to assess the impact of TS on the SRC services subsector in Iran, a topic that has been largely overlooked in previous research.

Results: The results showed that TS disproportionately impacted SRC services across supply and demand dimensions. Supply-side vulnerability manifested through significant reductions in domestic production, domestic sales, exports, and imports, all substantially exceeding economy-wide averages, except exports. Demand-side impacts included pronounced household consumption declines alongside severe contractions in government consumption and intermediate demand.

Conclusion: The findings reveal the subsector's pronounced vulnerability to external shocks like TS, highlighting the need for policymakers to strengthen infrastructure and mitigate the adverse effects of sanctions and potential damage.

Keywords: Trade Sanctions, Recursive Dynamic Computable General Equilibrium, Sports, Recreational, Cultural.

Introduction

The aim of this study is to investigate the impact of Trade Sanctions (TS) on the supply and demand indicators of the Sports, Recreational, and Cultural (SRC) services in Iran. Economic Sanctions (ES) have been widely embraced by organizations and governments as an alternative to military confrontation to influence the behavior of target countries since World War II (Kazerooni et al., 2015). The theory of sanctions was first introduced by Galtung (1967) to express dissatisfaction and deter certain behaviors of target countries (Kazerooni et al., 2016). The parties involved in the sanction process can be classified into two main groups: the "sender" and the "target." In sanctions literature, the "sender" is the main country (or organization) starting the sanctions. Usually, one leading country enlists support from others through bilateral talks or international bodies like the United Nations (UN). Sometimes two countries or a country and an organization share leadership. The term “target” denotes the country that is the immediate object of the episode and subjected to these sanctions. On occasion, sanctions may be aimed at two or more countries—for example, the World War II sanctions directed against Germany and Japan (Hufbauer et al., 2007).

Eyler (2007) defines economic sanctions as discriminatory restrictions on trade or credit flows imposed by one country on another to change the target nation's policies. ES aim to weaken the target country's economy and its ability to meet citizens' basic needs. They do this by reducing production, devaluing currency, increasing unemployment, inflation, and budget deficits. This leads to public dissatisfaction and unrest (Nakhli et al., 2020). ES remain a ubiquitous foreign policy tool used by many countries to demand a change in the action of a target state. According to the sanctions literature, the cost of sanctions against a target country is supposed to result in maximum economic damage in order to coerce the target state to alter its policies in favor of the sender states (Afesorgbor & Mahadevan, 2016). ES involve targeted economic interventions using coercive diplomacy to achieve foreign policy goals (Zahrani, 2008). Most definitions of ES emphasize the creation of a mechanism to align the target country with the demands of the sanctioning countries. Some studies suggest that ES are imposed with political objectives, where sanctioning countries forgo certain economic and trade benefits to achieve foreign policy goals (Ezzati et al., 2020). Foreign policy goals encompass to changes the sender state explicitly or implicitly seeks in the target state’s political behavior (Hufbauer et al., 2007). These definitions converge on sanctions as coercive economic tools (Zahrani, 2008) but emphasize distinct aspects: Eyler (2007) focuses on discriminatory trade/credit restrictions, Afesorgbor and Mahadevan (2016) and Nakhli et al. (2020) stress the intent to inflict economic damage for policy change, Hufbauer et al. (2007) highlight explicit/implicit foreign policy goals, and Ezzati et al. (2020) underscore the political motivation behind forgoing economic benefits.

ES are generally categorized into two broad types based on their objectives: TS and Financial Sanctions (FS). TS are imposed on the export and import of specific goods of the target country, while FS focus more on the financial flows of the target country. Sanctions on banks or central banks are a type of FS. However, most sanctions are a combination of trade and FS (Toghyani & Derakhshan, 2015). TS themselves are classified into two categories: embargoes or export sanctions and boycotts or import sanctions (Caruso, 2005).

For over four decades, sanction designers in the United States (US) have targeted the Islamic Republic of Iran to influence its economic, political, and social dimensions (Eslami & Naghdi, 2016). The sanctions imposed on Iran can be divided into six main periods, each with

its own characteristics: 1) The hostage crisis period (1979-1981); 2) The Iran-Iraq war period (1981-1988); 3) The reconstruction period (1989-1992); 4) The Clinton administration period, dual containment (1993-2001); 5) Post-9/11 sanctions; 6) Post-UN Security Council resolutions sanctions (Toghyani & Derakhshan, 2015).

Recent sanctions against Iran aim to build global consensus and use international organizations to intensify sanctions, focusing on key sectors: banking networks (including the central bank), the oil sector/trade, and foreign direct investment (Nakhli et al., 2020). Each of these sanctions has various effects on the country and its citizens from different perspectives, affecting all aspects of society. For example, sanctions can lead to reduced economic growth, declining education levels, socio-economic problems, increased inflation, and economic instability (Goudarzi, 2017).

Overall, economists have concluded that ES can have significant, predictable, and often long-lasting effects on targets (Morgan et al., 2023). TS restrict exports and imports, pressuring the target country's entire production and consumption chain. This disruption aims to force the target to change policies, give up specific goals, or negotiate. In line with this, following the imposition of TS on Iran's economy in recent years, all main sectors (agriculture, industry, and services) and their subsectors have been grappling with these International Sanctions (IS). Among these subsectors is the SRC services as a subcategory of the services sector.

Cultural development underpins all development. Governments pursuing sustainable development must therefore view humans primarily as cultural beings (Salehnia et al., 2010). In today's world, the economic role and importance of cultural activities have made them one of the fundamental pillars of the economic system. The economy of culture studies the links between production, consumption, and the market for cultural goods. It analyzes the economic impact of cultural activities and identifies factors influencing supply and demand, rather than making normative judgments. This helps foster cultural prosperity (Ganji & Heydarian, 2014).

Sports are now widely used as a development tool across political, economic, social, and cultural areas. Identifying factors that boost sports growth is key to achieving national goals. Like other social fields, sports must continuously develop to stay relevant (Abedi et al., 2019). Modern sport is a powerful cultural commodity and the world's 11th largest industry. Its significant economic impacts – like job creation, higher productivity, reduced healthcare costs, improving health, increasing life expectancy, and reducing crime – lead governments to see sports spending as long-term investment, not cost. Therefore, the sports industry is not only a leading industry but also a factor influencing societal health (Ahmadi et al., 2012; Sarlab et al., 2020; Seyyed Ameri et al., 2009). The core phenomenon of the sports industry is physical activity and sports events, and in Iran, its most desirable outcomes are jobs and tourism. In developed nations, it drives economic growth. Thus, it can be a crucial pillar of economic development and social progress, significantly contributing to the national economy (Hajiheydari et al., 2020; Khosromanesh et al., 2019; Shariati et al., 2022).

Recent research on sanctions has advanced our understanding of their use, objectives, and effectiveness. According to Nakhli et al. (2020), studies conducted on the sanctions imposed on Iran can be classified into three categories: 1) Some of these studies present a theoretical explanation about the incentives, purposes, and fundamentals of the sanctions; 2) some of them emphasize the economic strategies for economic prosperity in the post-sanction period; 3) a considerable number of studies have focused on evaluating the

economic effects of sanctions and their effectiveness in reaching their goals using various quantitative methods.

Numerous studies have examined the economic effects of sanctions, primarily focusing on macroeconomic indicators. Among the few studies conducted on various dimensions of sanctions, including those where the sports nature of sanctions is prominent, the following studies can be mentioned:

Alavi et al. (2021) used a qualitative method with a thematic analysis approach to identify the consequences of IS on the sports industry. The results of this study showed that the consequences of IS on the sports industry include six areas: economic, equipment and infrastructure, scientific-media, human and organizational resources, social, and international relations. Based on the results of the study by Afshari et al. (2020), using exploratory and confirmatory factor analysis, five important factors resulting from sports sanctions include monetary and financial problems, knowledge and technology, international interactions, marketing, and economic issues. Shariati Feizabadi (2020) using thematic analysis with two-rounds Delphi method, examined the impact of US sanctions on the sports of the Islamic Republic of Iran in 2018-2019 and concluded that the decrease in the imports of foreign products (4.01) was the most significant positive impact, the payment of salaries to foreign coaches and players (4.73) was the most significant direct negative impact, and hasty government decisions (4.84) were the most significant indirect negative impact of US political-economic sanctions on Iranian sports. Khodadadi et al. (2019) found weak sanctions (past & current) and strong sanctions (past) positively affected Iran's trade balance. Population, exchange rate, distance, and strong sanctions (current period) negatively affected Iran's trade share. Weak sanctions had a larger, asymmetric impact on sports goods trade fluctuations. Khodadadi et al. (2018) analyzed the effects of TS on Iran's bilateral trade with its major partners within the sports industry. Their findings indicated that both strong and weak sanctions, applied during pre- and post-sanctions periods, had differential effects (both positive and negative) on this trade. Additionally, the study projected an upward trend in Iran's sports industry trade with its partners during the post-sanctions era. Snyder and Byun (2018) analyzed US pressures in the context of the "Moon's Olympic diplomacy". In part of this study, while referring to US pressures on Samsung, the financial threats and tax deprivations of Americans for this company in the event of concluding a sports agreement with North Korea in the 2018 Winter Olympics were mentioned. Namazi et al. (2020) suggested improving domestic sports goods quality, fighting smuggling, and effective marketing could boost domestic production, neutralize sanctions' effects, and strengthen national solidarity. Eslami et al. (2016) considered IS as one of the obstacles to the entry of sports tourists into Iran. Also, Eydi and Yousefi (2016) considered sanctions as one of the weaknesses in hosting major sports events in Iran.

Studies examining sanctions' impacts on Iran's sports subsector reveal diverse methodological approaches and areas of focus. Alavi et al. (2021) and Afshari et al. (2020) both employed qualitative and factor analysis techniques, respectively, to identify multi-dimensional consequences (economic, infrastructural, social, international), though Alavi explored broader industry effects while Afshari pinpointed key resulting factors. Shariati Feizabadi (2020) utilized Delphi methods to quantify specific positive and negative impacts on Iranian sports operations. In contrast, Khodadadi et al. (2019, 2018) applied econometric trade analysis, differentiating between weak/strong sanctions and their asymmetric effects on Iran's sports goods trade balance and bilateral flows. Studies like Snyder and Byun (2018) highlight the diplomatic pressures and corporate risks

involved in international sports cooperation under sanctions. Namazi et al. (2020) shift focus towards domestic mitigation strategies. Finally, Eslami et al. (2016) and Eydi and Yousefi (2016) specifically link sanctions to challenges in sports tourism and event hosting.

The SRC subsector is highly sanctions-sensitive. It relies on international exchange, specialized equipment imports, discretionary funding, and collaboration. Sanctions cut access to imports, hinder travel for events, reduce leisure spending, and isolate practitioners. TS and their effects are highly significant for Iran's economy. The SRC subsector is also closely linked to the economy and politics and represents an important component of cultural identity, economic growth, and social development in any country. While the aforementioned studies provide valuable insights into specific dimensions or consequences of sanctions on sports (e.g., multidimensional impacts, trade effects, operational challenges, tourism barriers), no research has comprehensively modeled the impact of TS specifically on the supply and demand indicators of the SRC services subsector using a Computable General Equilibrium (CGE) framework. Therefore, in this study, we aim to fill this important gap in the existing literature by employing a recursive dynamic CGE model.

CGE models are numerical implementations of the theoretical general equilibrium. They consist of systems of simultaneous equations that describe economies as a whole and the interactions among their parts (households, firms, government, and the rest of the world), based on the principles of producer optimization, consumer optimization, and market clearance. They are widely used to analyze the impacts of deliberate economy-wide policy interventions and exogenous shocks (Burfisher, 2017). Previous studies on Iran's sanctions, which employed diverse approaches including CGE models, focused primarily on core sectors and macroeconomic indicators and overlooked subsectors such as SRC. Research on subsectors (e.g., sports) likewise lacked comprehensiveness, examining only specific dimensions. In this study, we specifically investigate how TS affect the supply and demand indicators of SRC services and provide insights for policymakers to mitigate these effects.

Materials and Methods

The present study employs a descriptive-analytical approach and is classified as an applied research based on its objective. Data and information have been gathered through documentary and library research methods.

Among the quantitative analytical methods, the CGE models stand out as a flexible approach applicable to a wide range of policy-related issues, offering a comprehensive framework for assessing the multidimensional impacts of shocks (Tayebi & Mesrinejad, 2006). The CGE model is defined as a macroeconomic general equilibrium framework that establishes interconnections among various income groups, demand patterns, balance of payments, and the multi-sectoral economic structure (Taheri et al., 2008). This model is a system of equations that describes an economy as a whole and the interactions among its parts. It is based on equations derived directly from economic theory. All of the equations in the model are solved simultaneously to find an economy-wide equilibrium in which, at some set of prices, the quantities of supply and demand are equal in every market (Burfisher, 2017).

After the presentation of the multi-sectoral growth model of Norway by Johansen (1960), which is considered the pioneer of general equilibrium models, and following the introduction of the calculation algorithm by Scarf and Hansen (1973) and the rapid advances in computer software, these models have been widely used as policy analysis models since the late 1970s (Hosoe et al., 2010;

Motavaseli & Fouladi, 2006).

CGE models are divided into two main types: static models and dynamic models.

Static CGE models simulate economic equilibrium at a single point in time, ignoring transitional dynamics. They compare pre-shock and post-shock equilibria (comparative statics) and assume instantaneous market clearance (Dixon & Rimmer, 2002; Hosoe et al., 2010).

Dynamic dimensions are incorporated into CGE model through two major approaches: the recursive dynamic model (i.e. the dynamic ordering of static equilibria) and the completely dynamic model. Recursive dynamic CGE model is employed for multi-period analyses. It obtains solutions for each one of many successive years and the equilibrium solution for year *t* obtained is used as baseline year for consecutive year *t+1* without any consideration for intertemporal aspects of decision making of the economic agents. Hence, the economic agents are implicitly faced with myopic or adaptive expectations. Forward-looking economic agents with perfect foresight can hardly be solved recursively but rather by complete dynamic CGE models. In this case, economic decisions in period *to* affect parameters in consecutive periods, which, however, rely on the expected values of these parameters. Therefore, a dynamic process is interrelated and the solution has to be sought and solved forward or addressed simultaneously. As a result, these type of CGE models become very complex and less consideration has been placed on its regional and sectoral details (Babatunde et al., 2017).

Model

We used the PEP-1-t model developed by Decaluwé et al. (2013). This model is a joint effort between International Food Policy Research Institute (IFPRI) and Partnership for Economic Policy (PEP) in the context of the African Growth and Development Policy (AGRODEP) modeling consortium project. The PEP-1-t model is a standard recursive dynamic CGE framework designed for single-country, multi-period analysis, adhering to standard theoretical assumptions. It distinguishes several categories of workers and of capital. Also, PEP-1-t is capable of taking into account a broad set of tax instruments, and it models all possible transfers between institutions (agents). Moreover, the aggregate output of each industry consists of several products, consistent with rectangular input-output tables. The country in question is a "small country" that receives world export and import prices at a fixed level. The information basis of this model is the Social Accounting Matrix (SAM), which is a coherent framework for the joint analysis of aspects related to production and monetary flows between institutions, which completely, flexibly, and separately shows all transactions of an economic-social system for a specific period of time.

The PEP-1-t model has a set of simultaneous equations, many of which are nonlinear. In general, these equations can be divided into nine blocks: 1) Production; 2) Income and savings; 3) Demand; 4) Producer supplies of products and international trade; 5) Prices; 6) Equilibrium; 7) Gross domestic product; 8) Real (volume) variables computed from price indices; 9) Dynamic equations (Decaluwé et al., 2013).

Figure 1 provides an overview of the main components of the PEP-1-t model. In this model, composite labor, composite capital, and intermediate inputs are used in the production process. At the top level of technology nest, a Leontief production function is considered, which combines intermediate inputs with value added based on fixed shares and without any substitution possibility to determine the output of each productive activity. At the second level, each activity's value added consists of composite labor and composite capital, following a Constant Elasticity of Substitution (CES) specification. At the bottom level on the

value added side, the various categories of labor are combined following a CES technology, which reflects the imperfect substitutability between different types of labor. Likewise, composite capital is a CES combination of the different categories of capital. As in the case of labor, it is assumed that different categories of capital are imperfect substitutes. Finally, returning to the second level, but on the intermediate consumption side, aggregate intermediate consumption is made up of various goods and services. Here it is assumed that intermediate inputs are perfectly complementary, and are combined following a Leontief production function and no substitutions are possible. At the next stage, it is assumed that, although an activity can reorganize its production to change the proportions of goods produced, the different products are not perfectly "transformable" into one another. This is represented by means of a Constant Elasticity of Transformation (CET) function that describes how easily the product-mix can be adjusted in response to price changes. Producers allocate output among products so as to maximize sales revenue, given product prices, subject to the CET function. Next, the output of each product of an activity is allocated between exports and domestic sales using a CET function. Consumers purchase composite commodities. These composite commodities are either imported or produced domestically. The combination of imports and domestic sales is determined by a CES function known as the Armington function. Composite commodities can be allocated to households' consumption, government consumption, investment, trade and transport margins and intermediate input demand. By establishing equilibrium in the system, including equilibrium in the markets (for factors and commodities) and macroeconomic constraints (e.g., balance for savings-investment), equilibrium in the entire system is established (Decaluwé et al., 2013).

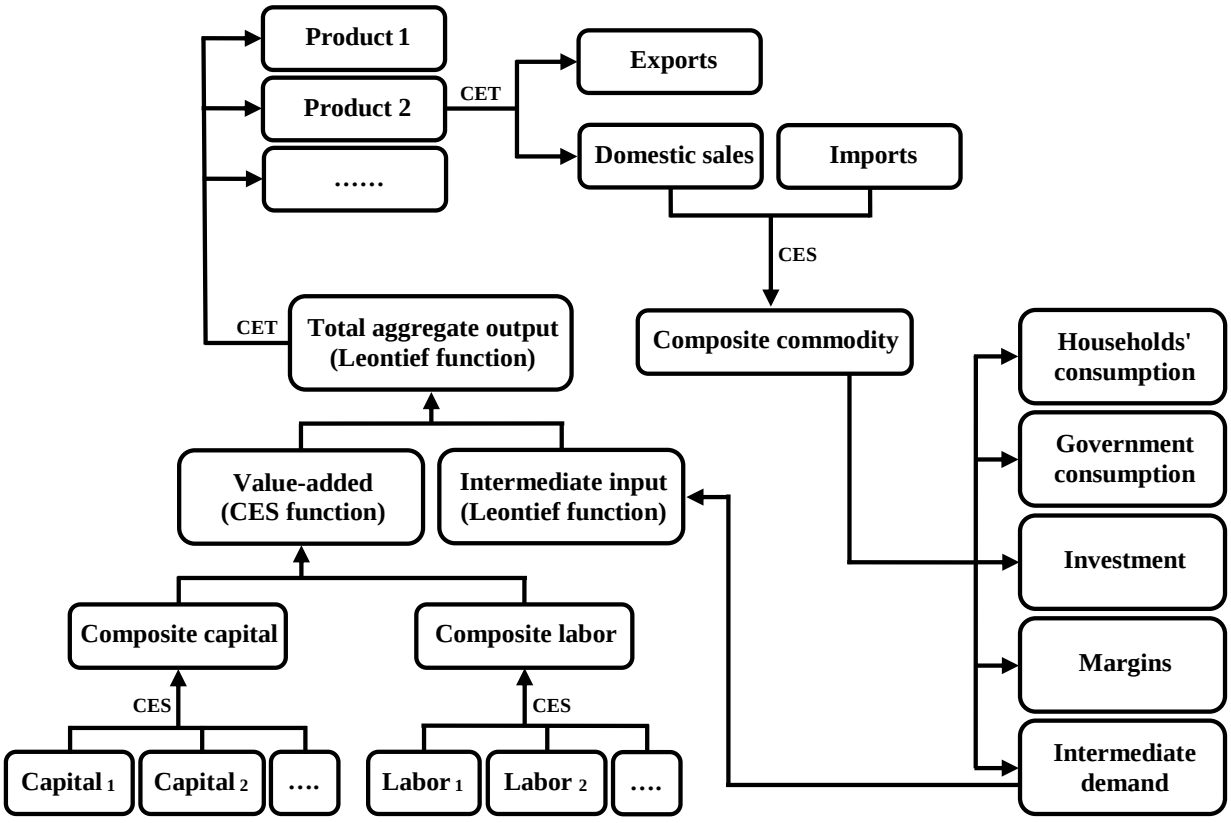

Figure 1. Components of the PEP-1-t model

Data, calibration and model closure

A SAM is a comprehensive and economy-wide database recording data about all transactions between economic agents in a specific economy for a specific period of time. A SAM extends the classical input-output framework, including the complete circular flow of income in the economy. SAMs provide databases for simple linear (multiplier) models and sophisticated CGE models, which can be used for the analyses of environment, employment, taxation, productivity, trade, poverty and inequality, development, technological change, etc., issues. SAMs are also useful for the comparison, over time or space, of socio-economic systems (Mainar Causap et al., 2018). A SAM is a snapshot of an economy, for a given year. It must be square because each account appears both as a row and as a column of the table: the account's income is registered in the corresponding row, and its expenditures in the corresponding column. The value in every cell of the matrix, therefore, is an expenditure for the corresponding column-account, and an income for the corresponding row-account. The SAM to be used as the basis of a CGE model must be balanced, meaning that, for each account, the sum of income from all sources must be exactly equal to the sum of expenditures (Decaluwé et al., 2013).

In this study, we employed the 2016 SAM provided by the Central Bank of the Islamic Republic of Iran, which was adjusted to align with the requirements of the applied model. Table 1 presents Iran's aggregated macro SAM for the year 2016. The SAM utilized in this study, following aggregation, comprises five activity sectors, five commodity groups, three production factors, and nine institutional accounts (including eight domestic institutions and the rest of the world). It also includes accounts for trade and transport margins, taxes, and savings-investment. Table 2 provides detailed information on the aggregated SAM structure employed in the study.

Table 1. Iran's macro SAM for the year 2016 (Billion Rials)

	Activities	Commodities	Margins	Factors	Institutions	Taxes	Investment	Total
Activities	0	23262122.76	0	0	0	0	0	23262122.76
Commodities	9076700.56	0	2883429.83	0	12376567.20	0	4931472.32	29268169.91
Margins	0	2883429.83	0	0	0	0	0	2883429.83
Factors	13983421.29	0	0	0	85561.12	0	0	14068982.41
Institutions	0	2662555.70	0	14068982.41	8020367.46	1155916.12	0	25907821.70
Taxes	202000.91	460061.62	0	0	493853.60	0	0	1155916.12
Savings	0	0	0	0	4931472.32	0	0	4931472.32
Total	23262122.76	29268169.91	2883429.83	14068982.41	25907821.70	1155916.12	4931472.32	0

Table 2. Details of the aggregated SAM used

Set	**Sub-set**		
Activities	Agriculture, Mining, Industry, SRC Services, Other Services		
Commodities	Agriculture, Mining, Industry, SRC Services, Other Services		
Margins	Domestic Trade and Transport Margins, Export Trade and Transport Margins		
Factors of Production	Skilled Labor, Unskilled Labor, Capital		
Institutions	Households	Urban Households	The Bottom Three Deciles
			The Middle Four Deciles
			The Top Three Deciles
		Rural Households	The Bottom Three Deciles
			The Middle Four Deciles
			The Top Three Deciles
	Other Institutions	Firms, Government, Rest of the World	
Taxes	Direct Taxes, Net Taxes on Products (Except Import Tax), Import Tax, Net Other Taxes on Production		
Savings-Investment	Institutions' Savings, Investment plus Inventory Changes		

To implement a CGE model, values must be assigned to its parameters and exogenous variables. This process comprises two aspects: calibration of the parameters that can be determined from the information contained in the underlying SAM, and assignment of values to the so-called "free" parameters that remain. CGE models are, as their name indicates, models of economy-wide supply-and-demand equilibria regulated by the price system. In order for economic agents to be responsive to price changes, at least some of the functional forms which represent their behavior in CGE models have to be more flexible than simple fixed-proportions Leontief functions. However, more flexible functional forms have more parameters. Consequently, the information contained in the SAM is not sufficient to uniquely determine the values of all parameters (Decaluwé et al., 2013). Pyatt (1988) suggests that many of the weakness of CGE models appear at the point where the SAM data need to be complemented with additional data outside of the SAM framework, e.g. with regard to estimation of parameters (elasticities) of some of the functions and the choice of closure rules, because it is separate from the SAM but it can significantly influence the modelling results.

The parameters (elasticities) that cannot be calibrated (that is, determined from the SAM) are called "free", and they must be assigned values by other methods. These include ad hoc econometric estimation, or, more frequently, a search of the empirical literature to find plausible values for the free parameters (Decaluwé et al., 2013).

Calibration is a procedure that calculates quantities and normalized prices, and the shift and share parameters used in the production and utility functions in the CGE model so that the solution to model equations replicates the initial equilibrium as reported in the base data. The inputs to the calibration process are the SAM, the model's behavioral equations, and the elasticity parameters (Burfisher, 2017). In this study, we employ Iran's 2016 SAM as the core dataset for the model, supplemented by a set of elasticities estimated from prior literature. Table 3 summarizes these elasticity parameters and their respective sources.

Table 3. Elasticity values used for the PEP-1-t model

Elasticity		Value					Source
CES - value added		1.50					(Decaluwé et al., 2013)
CET - total output (to products)		0.90					(Punt, 2013)
CET - exports and domestic sales		1.20					(Fahimifard, 2023)
CES - imports and domestic sales		1.45					(Bajzik et al., 2020)
Price elasticity of export demand		1.20					(Prati et al., 2011)
Frisch parameter	Urban Households	-2.91					(Hassanzadeh et al., 2013)
	Rural Households	-3.66					
		Agriculture	Mining	Industry	SRC Services	Other Services	
Income elasticity of consumption	Urban Households	0.98	0.45	0.67	1.10	1.10	(Khiabani, 2008)
	Rural Households	0.97	0.97	0.61	1	1	

A CGE model describes only relative prices. To express all prices in relative terms, the modeler chooses one price variable in the CGE model to remain fixed at its initial level. This price serves as the model's numeraire, a benchmark of value against which the changes in all other prices can be measured. Any price in the CGE model can be chosen as the numeraire. This

choice of numeraire has no impact on real, or quantity, variables that result from an experiment (Burfisher, 2017). In line with the nature and objectives of our research, we employed the exchange rate as the numeraire in the model.

Modelers decide which variables are exogenous and which are endogenous. These decisions are called model closure (Burfisher, 2017). To derive mutually consistent equilibrium solutions, constraints and closure conditions must be imposed on the model's structural equations and relationships. The choice of model closure determines both the adjustment mechanisms and the equilibrium attainment processes (Shahraki et al., 2010). The default PEP-1-t model closure defines the exchange rate as the numeraire, with government expenditures and the current account balance fixed in each period. Capital stock in each period is exogenous insofar as it is the result of the capital accumulation rule. Some variables are generally considered to be exogenous, and they are routinely fixed in each period. They are: minimum consumption, labor supply, the volume of inventory changes, and world prices of imports and exports. Among the variables that are fixed exogenously, those that are not prices are assumed to grow from period to period at the same rate as population. Such is the case of government expenditures, and the current account balance, as well as minimum consumption, labor supply and the volume of inventory changes. In addition, the intercepts of household savings and income tax functions are also increased in the same proportion (Decaluwé et al., 2013).

To solve the PEP-1-t model, we applied the general algebraic modeling system (GAMS) software.

The simulations and scenarios

From the perspective of the sender country, import sanctions effectively reduce the exports of the target country, while export sanctions diminish the imports of the target country. In the case of import sanctions—which decrease the target country's exports—producers in the target country are confronted with reduced prices and lower quantities of goods. Conversely, under export sanctions—which restrict the target country's imports—consumers in the target country face higher prices and reduced availability of goods (Golliard, 2013).

Figure 2 illustrates the simulation of TS shock transmission within the CGE modeling framework employed in this research.

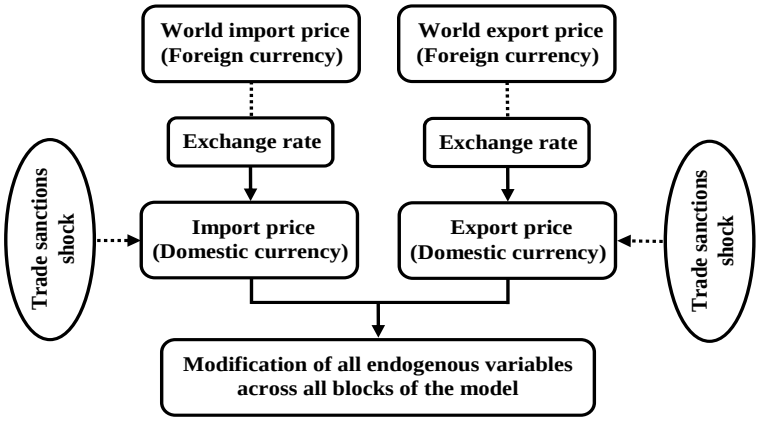

Figure 2. Simulation of TS shock transmission

In the PEP-1-t model framework, the exchange rate and world export/import prices are exogenous and fixed. Therefore, to simulate the effects of TS, the shock must be applied to export and import prices denominated in domestic currency. Following the adjustment of export and import prices (in domestic currency) due to the imposed shock, other relative prices

and all endogenous variables across the model's equation blocks will adjust accordingly. By comparing the values of the target variables before and after the shock, we can quantify the magnitude of its impact.

This study adapts the modeling framework of Mohammadi Khabbazan et al. (2015) — originally designed to analyze oil sanctions in Iran—to simulate the impact of TS. Since export and import prices (in domestic currency) are endogenous variables, we introduced a parameter termed "*sanction*" into the export price equation (Equation 1) and the import price equation (Equation 5). According to Equation 1, incorporating this parameter increases the FOB price of exports ($PE_{i,t}^{FOB}$) while simultaneously reducing the net price received for exports ($PE_{i,t}$)—a result evident when Equation 1 is reformulated in terms of $PE_{i,t}$. Equations 2 and 3 demonstrate that the "*sanction*" parameter's application and the ensuing changes in $PE_{i,t}$ and $PE_{i,t}^{FOB}$ equally reduce both the supply and demand of export commodities. Equation 4, which represents the equilibrium of export supply and demand, confirms this outcome.

$$PE_{i,t}^{FOB} = \left(PE_{i,t} + \sum_{ij} PC_{ij,t} tmrg_{ij,i}^{X}\right)\left(1 + ttix_{i,t} + \boldsymbol{sanction}\right) \quad Eq.1$$

Where:

$PE_{i,t}$: Price received for exported commodity *i* (excluding export taxes)

$PE_{i,t}^{FOB}$: FOB price of exported commodity *i* (in domestic currency)

$ttix_{i,t}$: Export tax rate on exported commodity *i*

$PC_{ij,t}$: Purchaser price of composite commodity *i* (including all taxes and margins)

$tmrg_{ij,i}^{X}$: Rate of margin *ij* applied to export *i*

$$EX_{j,i,t} = \left(\frac{1-\beta_{j,i}^{X}}{\beta_{j,i}^{X}}\frac{PE_{i,t}}{PL_{i,t}}\right)^{\sigma_{j,i}^{X}} DS_{j,i,t} \quad Eq.2$$

$$EXD_{i,t} = EXD_i^0 pop_t \left(\frac{e_t PWX_{i,t}}{PE_{i,t}^{FOB}}\right)^{\sigma_i^{XD}} \quad Eq.3$$

$$\sum EX_{j,i,t} = EXD_{i,t} \quad Eq.4$$

Where:

$EX_{j,i,t}$: Quantity of commodity *i* exported by activity *j*

$\beta_{j,i}^{X}$: Share parameter (CET – exports and domestic sales)

$PL_{i,t}$: Price of local commodity *i* (excluding all taxes on products)

$\sigma_{j,i}^{X}$: Elasticity of transformation (CET – exports and local sales)

$DS_{j,i,t}$: Supply of commodity *i* by activity j to the domestic market

$EXD_{i,t}$: Quantity of commodity *i* exported

EXD_i^0 : Quantity of commodity *i* exported (Base)

pop_t : Population index

e_t : Exchange rate; price of foreign currency in terms of domestic currency

$PWX_{i,t}$: World price of exported commodity *i* (expressed in foreign currency)

σ_i^{XD} : Price-elasticity of the world demand for exports of commodity *i*

Similarly, adding the "*sanction*" parameter to the import price equation (Equation 5) raises the price of imported commodities. As per Equation 6, this price increase leads to a decline in import volume.

$$PM_{i,t} = \left(1 + ttic_{i,t}\right)\left(\left(1 + ttim_{i,t} + \boldsymbol{sanction}\right)e_t PWM_{i,t} + \sum_{ij} PC_{ij,t} tmrg_{ij,i}\right) \quad Eq.5$$

Where:

$PM_{i,t}$: Price of imported commodity *i* (including all taxes and margins)

$ttic_{i,t}$: Tax rate on commodity *i*

$ttim_{i,t}$: Rate of taxes and duties on imports of commodity *i*

$PWM_{i,t}$: World price of imported commodity *i* (expressed in foreign currency)

$tmrg_{ij,i}$: Rate of margin *ij* applied to commodity *i*

$$IM_{i,t} = \left(\frac{\beta_i^M}{1-\beta_i^M}\frac{PD_{i,t}}{PM_{i,t}}\right)^{\sigma_i^M} DD_{i,t} \qquad Eq.6$$

Where:

$IM_{i,t}$: Quantity of commodity *i* imported

β_i^M : Share parameter (CES – composite commodity)

$PD_{i,t}$: Price of local commodity *i* sold on the domestic market (including all taxes and margins)

σ_i^M : Elasticity of substitution (CES – composite commodity)

$DD_{i,t}$: Domestic demand for commodity *i* produced locally

To simulate the impact of TS, we tested various values for the "*sanction*" parameter and ultimately defined two scenarios:

1) Scenario 1: A "*sanction*" parameter value of 0.2.
2) Scenario 2: A "*sanction*" parameter value of 0.4.

These modifications to export and import prices propagate throughout the economic system via adjustments across all relevant blocks, thereby enabling the simulation of the quantitative effects of TS.

Results

In this section, we analyze the impact of TS on the supply and demand indicators of SRC services under two designed scenarios. To this end, consistent with the block structure of the PEP-1-t model equations and as depicted in Figure 1, we first examine changes in the supply-side variables, followed by changes in the demand-side variables. The supply-side variables include: domestic production of commodity, domestic sales, exports, imports, and the composite commodity. The demand-side variables comprise: households' consumption, government consumption, intermediate demand, investment, and trade and transport margins. To enable more granular analysis, changes in SRC service variables are compared with economy-wide average changes.

Impact of TS on the supply of SRC services

As illustrated in Figure 1, a Leontief production function is assumed at the top level of technology nest, combining value-added and intermediate inputs with fixed shares to determine the total output of each activity. At the secondary level, value-added for each activity is generated from primary factors (labor and capital) via a CES function. At the next stage, producers allocate output among products (domestic production of commodities) so as to maximize sales revenue, given product prices, subject to the CET function.

Table 4 indicates changes in the demand for primary factors (labor and capital) and intermediate inputs by economic activities resulting from TS. These alterations stemmed from shifts in the relative prices of intermediate inputs and primary factors. The most pronounced adverse impact across both scenarios occurred in labor demand within the SRC services activity. The reduction in SRC labor demand substantially exceeded the economy-wide average. Similarly, contractions in intermediate input and capital demand for SRC services significantly outpaced the

economy-wide average.

Table 4. Impact of TS on activity demand for intermediate input, labor and capital (percentage)

		Activity	Period									
			1	2	3	4	5	6	7	8	9	10
Scenario 1	Intermediate input	SRC services	-4.76	-5.66	-6.25	-6.67	-6.97	-7.21	-7.40	-7.55	-7.67	-7.78
		Total activities	-1.27	-0.80	-0.55	-0.40	-0.29	-0.22	-0.17	-0.13	-0.11	-0.09
	Labor	SRC services	-7.57	-8.11	-8.39	-8.53	-8.59	-8.59	-8.56	-8.51	-8.45	-8.39
		Total activities	-0.15	-0.08	-0.05	-0.03	-0.02	-0.02	-0.02	-0.01	-0.01	-0.01
	Capital	SRC services	0	-1.52	-2.64	-3.53	-4.27	-4.90	-5.45	-5.94	-6.37	-6.77
		Total activities	0	-0.13	-0.21	-0.28	-0.35	-0.43	-0.50	-0.58	-0.66	-0.75
Scenario 2	Intermediate input	SRC services	-8.52	-9.89	-10.78	-11.40	-11.85	-12.20	-12.47	-12.69	-12.87	-13.02
		Total activities	-2.19	-1.14	-0.61	-0.29	-0.07	0.09	0.22	0.31	0.39	0.45
	Labor	SRC services	-13.44	-14.20	-14.59	-14.76	-14.81	-14.78	-14.70	-14.60	-14.48	-14.36
		Total activities	-0.46	-0.23	-0.14	-0.09	-0.07	-0.06	-0.05	-0.04	-0.04	-0.03
	Capital	SRC services	0	-2.46	-4.24	-5.65	-6.82	-7.82	-8.69	-9.46	-10.15	-10.77
		Total activities	0	-0.15	-0.21	-0.26	-0.31	-0.37	-0.44	-0.52	-0.61	-0.70

Table 5 outlines the share of the SRC services in various commodity supply-related quantities, including domestic production of commodity, domestic sales, exports, imports, and composite commodity. As illustrated, SRC services account for a negligible proportion of these items, with its largest shares being 0.28% of total exports and 0.22% of total imports.

Table 5. The share of the SRC services subsector and other commodities in total commodity supply quantity

Commodity		Domestic production of commodity	Domestic sales	Exports	Imports	Composite commodity
SRC services	Base (Billion Rials)	37720.50	29927.38	7793.12	5962.61	35889.99
	Share (Percentage)	0.16	0.15	0.28	0.22	0.15
Other commodities	Base (Billion Rials)	23224402.26	20476454.67	2747947.60	2656593.09	23133047.76
	Share (Percentage)	99.84	99.85	99.72	99.78	99.85

Based on the results in Table 6 and considering Table 5, although SRC services constitute a negligible share of the supply-side variables quantities, they exhibit significantly higher vulnerability compared to the economy-wide average in both scenarios. Following the imposition of TS, the domestic production of SRC services declined in both scenarios, with the reduction intensifying over time. In Scenario 1, domestic production of SRC

services decreased by 4.29% in the first period and reached 7.22% by the tenth period. In Scenario 2, this reduction was 7.69% initially and rose to 12.05% by the tenth period. In contrast, the decline in domestic production for total commodities was marginal in both scenarios. Furthermore, vulnerability for this index followed a downward trend until period 7 (Scenario 1) and period 9 (Scenario 2). Thus, from the perspective of domestic production, the SRC services subsector is substantially more susceptible to TS than the economy-wide. A crucial point to note is that the aggregate total output of activities is transformed into domestic production of commodities via a CET function. Table 4 demonstrated the adverse impact of TS on the demand for both primary factors (labor and capital) and intermediate inputs. This reduction in demand for primary factors and intermediate inputs constitutes the primary driver behind the decline in aggregate total output. Consequently, the decrease in domestic production of commodities observed both in the SRC services subsector and the economy-wide level can be attributed to this reduction in aggregate total output.

As illustrated earlier (Figure 1), domestic production is allocated to domestic sales and exports. Table 6 indicates that reduced domestic production of SRC services led to declines in both domestic sales and exports under both scenarios, with a consistent upward trend in reduction rates. In Scenario 1, domestic sales decreased from 1.71% to 4.53% between periods 1-10, while in Scenario 2, the decline ranged from 3.34% to 7.46%. Notably, export reductions consistently exceeded domestic sales reductions across all periods. Under Scenario 1, exports decreased from 14.78% to 18.18% between periods 1-10. Under Scenario 2, exports decreased from 26.13% to 30.87% over the same interval. For total commodities, despite marginal declines in domestic production, relative price shifts increased domestic sales while decreasing exports—with both trends intensifying over time. Crucially, TS primarily affected total commodities through exports contraction. Notably, export reduction rates were nearly identical between SRC services and total commodities across all periods and scenarios.

Alongside domestic production, domestic sales, and exports, imports constitute a critical component of the supply block variables in the model structure. The composite commodity for each commodity comprises domestic sales and imports. Table 6 indicates that SRC services imports decreased under TS in both scenarios, following a downward trend: from 16.48% to 14.17% (Scenario 1) and from 27.91% to 23.73% (Scenario 2). Conversely, imports reduction rates for total commodities displayed an upward trend in both scenarios. Crucially, the imports reduction rates for SRC services substantially exceeded the economy-wide average across all periods. Considering changes in domestic sales and imports, the composite commodity quantity of SRC services declined steadily in both scenarios between periods 1-10: from 4.34% to 6.18% (Scenario 1) and 7.77% to 10.46% (Scenario 2). The combined effect of reduced imports and domestic sales resulted in a steeper decline in the composite commodity quantity compared to domestic sales alone. Since total commodities imports declined in both scenarios throughout the period, this partially offsets the impact of rising domestic sales on the composite commodity. Thus, the net effect of domestic sales and imports leads to positive growth in the composite commodity in both scenarios across all periods—although at a rate lower than the growth in domestic sales.

As anticipated, Table 6 confirms that TS under both scenarios severely impacted Iran's international trade. These effects were more pronounced for SRC services relative to the economy-wide average. Beyond international trade sector, the adverse repercussions of TS on domestic trade and production in SRC services

also substantially exceeded the economy-wide average. This disproportionate vulnerability underscores the critical need for targeted policy interventions to enhance the resilience of the SRC services sector.

Table 6. Impact of TS on the quantity of commodity supply

	Period	Percentage changes									
		Domestic production of commodity		Domestic sales		Exports		Imports		Composite commodity	
		SRC services	Total commodities	SRC services	Total commodities	SRC services	Total commodities	SRC services	Total commodities	SRC services	Total commodities
Scenario 1	1	-4.29	-0.84	-1.71	0.75	-14.78	-13.42	-16.84	-2.60	-4.34	0.27
	2	-5.23	-0.56	-2.59	1.18	-15.91	-14.31	-15.85	-2.77	-4.89	0.68
	3	-5.82	-0.43	-3.17	1.41	-16.60	-14.96	-15.29	-2.90	-5.26	0.88
	4	-6.23	-0.36	-3.56	1.55	-17.06	-15.47	-14.93	-3.01	-5.52	1.00
	5	-6.52	-0.33	-3.84	1.64	-17.39	-15.90	-14.68	-3.10	-5.71	1.07
	6	-6.74	-0.33	-4.05	1.70	-17.63	-16.28	-14.51	-3.17	-5.85	1.11
	7	-6.90	-0.33	-4.21	1.74	-17.82	-16.60	-14.39	-3.24	-5.96	1.14
	8	-7.03	-0.34	-4.34	1.76	-17.96	-16.90	-14.29	-3.30	-6.05	1.15
	9	-7.13	-0.37	-4.44	1.77	-18.08	-17.16	-14.22	-3.36	-6.12	1.15
	10	-7.22	-0.39	-4.53	1.77	-18.18	-17.41	-14.17	-3.41	-6.18	1.15
Scenario 2	1	-7.69	-1.68	-3.34	0.98	-26.13	-23.67	-27.91	-4.82	-7.77	0.08
	2	-9.12	-0.96	-4.73	1.96	-27.78	-24.98	-26.27	-5.10	-8.58	1.02
	3	-10.03	-0.62	-5.63	2.45	-28.76	-25.91	-25.39	-5.30	-9.14	1.47
	4	-10.64	-0.44	-6.24	2.75	-29.39	-26.63	-24.86	-5.47	-9.53	1.72
	5	-11.07	-0.33	-6.66	2.95	-29.84	-27.23	-24.50	-5.60	-9.81	1.89
	6	-11.38	-0.26	-6.97	3.09	-30.17	-27.74	-24.24	-5.72	-10.01	2.00
	7	-11.62	-0.22	-7.20	3.19	-30.41	-28.20	-24.06	-5.82	-10.17	2.08
	8	-11.80	-0.20	-7.38	3.26	-30.60	-28.61	-23.92	-5.92	-10.29	2.13
	9	-11.94	-0.20	-7.52	3.31	-30.75	-28.98	-23.81	-6.00	-10.38	2.16
	10	-12.05	-0.21	-7.64	3.34	-30.87	-29.32	-23.73	-6.08	-10.46	2.18

Impact of TS on the demand of SRC services

Figure 1 illustrates the allocation of composite commodities to households' consumption, government consumption, intermediate demand, investment, and trade and transport margins. These components collectively determine the demand quantity for each composite commodity. In Table 7, we presented the share of SRC services in total commodities across various demand categories based on baseline values. The highest demand share for SRC services (0.54%) pertains to government consumption. The share of SRC services demand for intermediate demand is 0.2%. Regarding household consumption of SRC services, the wealthiest three deciles of urban and rural households hold the highest shares (0.17% and 0.2%, respectively). No investment demand for SRC services has materialized, nor are trade and transport margins associated with this commodity group. Critically, the demand share for SRC services across all demand categories remains extremely low and negligible. An analogous pattern is observed for SRC services supply across its various forms in Table 5.

Table 7. Share of the SRC services subsector and other commodities in total commodity demand quantity

Description		Base (Billion Rials)		Share in commodity demand (Percentage)	
		SRC services	Other commodities	SRC services	Other commodities
Urban households consumption	The bottom three deciles	473.45	737541.78	0.06	99.94
	The middle four deciles	1731.39	1723210.23	0.10	99.90
	The top three deciles	5439.13	3176069.76	0.17	99.83
Rural households consumption	The bottom three deciles	50.98	98693.26	0.05	99.95
	The middle four deciles	223.45	235202.00	0.09	99.91
	The top three deciles	737.27	360564.80	0.20	99.80
Government consumption		12114.44	2249229.49	0.54	99.46
Intermediate demand		15119.88	7697160.34	0.20	99.80
Investment and inventory change		0	3987585.74	0	100
Commodities as a trade or transport margin*		0	2867790.35	0	100

* These commodities belong to the services sector of the economy and include wholesale and retail trade, and transportation services.

Table 8 presents the impact of TS on household consumption. Key findings are summarized as follows:

1) TS reduced consumption for all urban/rural household groups under both scenarios.
2) Reductions in SRC services consumption for all household groups exhibited an upward trend in both scenarios.
3) Reductions in total commodities consumption across household groups followed non-uniform patterns.
4) Under Scenario 1 (from Period 3) and Scenario 2 (from Period 2 or 3), reductions in SRC services consumption exceeded the average reduction in total goods consumption.
5) Rural households experienced marginally greater impacts from TS than urban households under both scenarios.
6) The middle four rural deciles showed relatively lower vulnerability to TS among rural groups.
7) The wealthiest three urban deciles exhibited relatively lower vulnerability until Period 6 in both scenarios.

Critically, over time and alongside intensifying sanctions, SRC services consumption declined more than the average consumption of total commodities.

Table 8. Impact of TS on the households' consumption

	Period	Percentage changes											
		Urban households' consumption						Rural households' consumption					
		The bottom three deciles		The middle four deciles		The top three deciles		The bottom three deciles		The middle four deciles		The top three deciles	
		SRC services	Total commodities	SRC services	Total commodities	SRC services	Total commodities	SRC services	Total commodities	SRC services	Total commodities	SRC services	Total commodities
Scenario 1	1	-3.79	-4.41	-3.79	-4.26	-2.47	-2.72	-4.33	-4.76	-3.70	-4.27	-4.02	-4.46
	2	-3.67	-3.98	-3.71	-3.91	-2.87	-2.89	-4.19	-4.32	-3.77	-3.98	-4.04	-4.15

	3	-3.69	-3.75	-3.77	-3.74	-3.20	-3.04	-4.19	-4.09	-3.90	-3.85	-4.16	-4.02
	4	-3.74	-3.62	-3.85	-3.65	-3.47	-3.15	-4.24	-3.96	-4.03	-3.78	-4.30	-3.96
	5	-3.81	-3.53	-3.94	-3.60	-3.68	-3.25	-4.30	-3.88	-4.15	-3.75	-4.43	-3.94
	6	-3.87	-3.48	-4.02	-3.57	-3.85	-3.32	-4.36	-3.84	-4.26	-3.74	-4.54	-3.94
	7	-3.94	-3.44	-4.10	-3.56	-3.99	-3.39	-4.43	-3.81	-4.35	-3.74	-4.65	-3.95
	8	-4.00	-3.43	-4.17	-3.55	-4.11	-3.44	-4.49	-3.80	-4.44	-3.75	-4.75	-3.97
	9	-4.05	-3.42	-4.24	-3.56	-4.22	-3.49	-4.55	-3.81	-4.52	-3.77	-4.83	-4.00
	10	-4.11	-3.42	-4.31	-3.57	-4.31	-3.53	-4.61	-3.82	-4.60	-3.79	-4.92	-4.02
Scenario 2	1	-5.70	-6.20	-5.92	-6.20	-3.97	-3.99	-6.59	-6.86	-5.60	-6.11	-6.42	-6.65
	2	-5.55	-5.69	-5.74	-5.73	-4.56	-4.31	-6.42	-6.33	-5.76	-5.82	-6.36	-6.21
	3	-5.65	-5.49	-5.87	-5.58	-5.10	-4.63	-6.51	-6.12	-6.05	-5.75	-6.58	-6.11
	4	-5.81	-5.40	-6.05	-5.54	-5.54	-4.88	-6.65	-6.03	-6.32	-5.75	-6.83	-6.11
	5	-5.96	-5.36	-6.22	-5.53	-5.88	-5.07	-6.79	-5.99	-6.56	-5.78	-7.06	-6.14
	6	-6.10	-5.33	-6.38	-5.53	-6.16	-5.22	-6.93	-5.98	-6.76	-5.82	-7.26	-6.18
	7	-6.22	-5.32	-6.52	-5.54	-6.39	-5.33	-7.05	-5.98	-6.93	-5.86	-7.44	-6.23
	8	-6.33	-5.32	-6.65	-5.56	-6.58	-5.43	-7.17	-5.99	-7.09	-5.90	-7.60	-6.28
	9	-6.44	-5.33	-6.76	-5.58	-6.75	-5.51	-7.27	-6.01	-7.22	-5.94	-7.75	-6.33
	10	-6.53	-5.34	-6.87	-5.61	-6.89	-5.58	-7.37	-6.04	-7.34	-5.99	-7.88	-6.39

Figure 3 depicts changes in average nominal households' income and the consumer price index (CPI). The aforementioned indices in both scenarios recorded positive but decelerating growth with a mild downward trend. Average nominal income growth declined from 10.1% to 8.8% (Scenario 1) and from 20% to 18% (Scenario 2) between Periods 1–10. CPI growth decreased from 14.8% to 12.8% (Scenario 1) and from 28% to 25% (Scenario 2) over the same interval. As CPI growth consistently exceeded nominal income growth, real households' income declines throughout both scenarios. Given that households' consumption is a function of real income, this reduction thereby suppresses consumption levels. Figure 3 corroborates the results in Table 8.

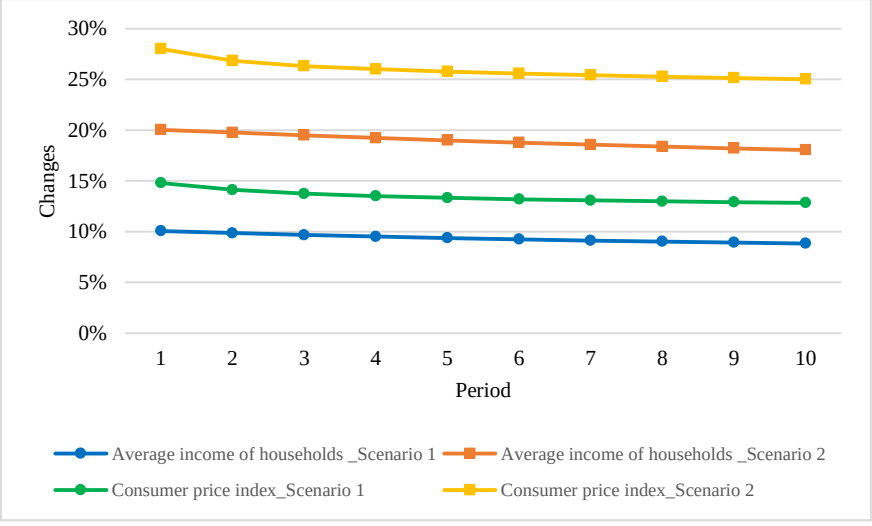

Figure 3. Impact of TS on the average households' income and consumer price index

Table 9 demonstrates the effects of TS on government consumption and intermediate demand. Government consumption of SRC services declined with an upward trend under both scenarios, exceeding the reduction in total commodities consumption. Decreases ranged from 8.22% to 11.39% (Scenario 1) and from 15.35% to 20.21% (Scenario 2) between Periods 1–10. According to the Iran's SAM for the year 2016, government consumption

demand is only from services. Also, based on the CGE model utilized, the main component of government consumption demand is the services provided by the government labor force.

Figure 4 shows that TS simultaneously increased government income and the public expenditure price index (PEPI). Government income growth declined gradually while PEPI growth rose steadily. In the PEP-1-t model closure, government expenditure is fixed and exogenous. Thus, PEPI—not government income—determines changes in government consumption. As PEPI increased under both scenarios, government consumption decreased correspondingly.

Regarding intermediate inputs demand, Table 9 indicates that TS reduced demand for SRC services as intermediate inputs with an upward trend in both scenarios. Declines ranged from 2.02% to 3.04% (Scenario 1) and from 3.45% to 4.65% (Scenario 2) between Periods 1–10. Conversely, demand for total intermediate inputs followed a downward trend: Scenario 1 showed marginal reduction, while Scenario 2 exhibited negative growth until Period 5 and slight positive growth thereafter. The change in the economy-wide average demand for commodities used as intermediate inputs may be considered a factor contributing to reduced domestic production.

Overall, as concluded from Table 9, demand for SRC services—both as government consumption and intermediate demand—has suffered greater harm from TS in both scenarios, exceeding the economy-wide average.

Table 9. Impact of TS on the government consumption and intermediate demand (percentage)

		Commodity	Period									
			1	2	3	4	5	6	7	8	9	10
Scenario 1	Government consumption	SRC services	-8.22	-9.32	-9.98	-10.41	-10.71	-10.93	-11.09	-11.22	-11.31	-11.39
		Total commodities	-5.28	-7.09	-8.11	-8.73	-9.13	-9.38	-9.54	-9.64	-9.71	-9.74
	Intermediate demand	SRC services	-2.02	-2.30	-2.51	-2.67	-2.78	-2.86	-2.92	-2.97	-3.01	-3.04
		Total commodities	-1.27	-0.80	-0.55	-0.40	-0.29	-0.22	-0.17	-0.13	-0.11	-0.09
Scenario 2	Government consumption	SRC services	-15.35	-17.15	-18.17	-18.82	-19.25	-19.57	-19.80	-19.97	-20.11	-20.21
		Total commodities	-10.46	-13.51	-15.15	-16.11	-16.70	-17.06	-17.29	-17.42	-17.50	-17.53
	Intermediate demand	SRC services	-3.45	-3.73	-4.01	-4.23	-4.37	-4.47	-4.54	-4.59	-4.62	-4.65
		Total commodities	-2.19	-1.14	-0.61	-0.29	-0.07	0.09	0.22	0.31	0.39	0.45

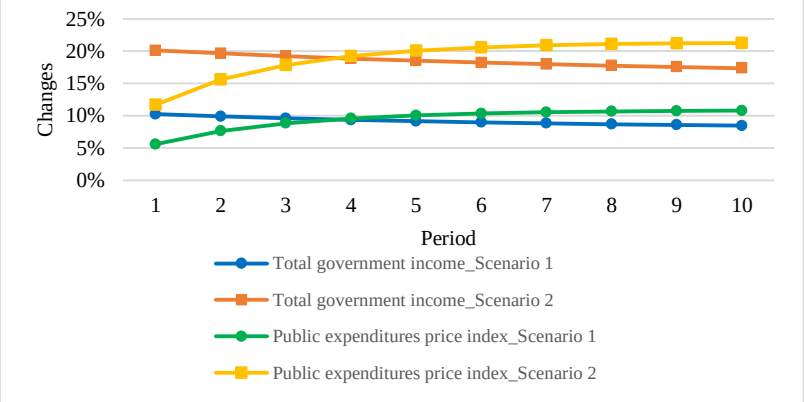

Figure 4. Impact of TS on the government income and public expenditure price index

Discussion

In recent years, the imposition of TS on Iran has significantly impacted various sectors of its economy, including agriculture, industry, and services. The SRC services subsector, as a component of the services sector, has not been immune to these external shocks. Given the importance of SRC services for national identity, economic growth, and social development, this study assessed the impact of TS on supply and demand in this subsector in Iran.

One commonly used method for quantitatively assessing the effects of external shocks and policy interventions is the CGE model, which has been extensively utilized since the late 1970s. CGE models are divided into two main types: static models and dynamic models. Static and dynamic CGE models differ significantly in their treatment of time and their ability to capture dynamic economic effects. Static CGE models analyze the economy at a single point in time, focusing on comparative analysis of the effects of policy changes. Dynamic CGE models, on the other hand, incorporate time as a dimension, allowing for the analysis of economic changes and growth over multiple periods. The reason for employing a dynamic CGE model is due to fact that a dynamic CGE model is capable of capturing the growth effects of policy reforms. The inability of the static CGE model to account for growth effects make them inadequate for long-run analysis of the economic policies or external shocks. They exclude accumulation effects and do not allow the study of transition path of an economy where short-run policy impacts are likely to be different from those of the long-run. To overcome this limitation, a recursive dynamic CGE model is usually used. This kind of dynamics will not be the result of inter-temporal optimization by economic agents. Instead, these agents have myopic behavior. It is a series of static CGE models that are linked between periods by updating procedures for exogenous and endogenous variables.

Given that TS are dynamic in nature, the core methodology of this study relied on the standard recursive dynamic CGE model (PEP-1-t), developed by Decaluwé et al. (2013) for single-country, multi-period analysis. A balanced 2016 SAM from Iran's Central Bank, aggregated to 5 activities, 5 commodities, 3 factors, and 9 institutions, served as the core database. Non-SAM parameters (elasticities) were sourced from prior literature (Table 3). The exchange rate was the model's numeraire. Model closure fixed government expenditures, current account balance, labor supply, inventory changes, and world prices. Given the model's exogenous and fixed exchange rate and world prices, the shock was applied to export and import prices denominated in domestic currency to simulate TS. Following Mohammadi Khabbazan et al. (2015), a "*sanction*" parameter was introduced into the export and import price equations. After testing multiple values, two scenarios were defined: Scenario 1 ("*sanction*" parameter = 0.2) and Scenario 2 ("*sanction*" parameter = 0.4). The adjusted export and import prices propagated endogenously through all equation blocks of the model, enabling the quantification of TS effects by comparing pre-shock and post-shock equilibria. The PEP-1-t model was solved using the GAMS software.

Our analysis demonstrated that TS disproportionately impact both supply and demand indicators of SRC services in Iran compared to the economy-wide average, despite SRC services constituting a negligible share of total commodity supply (e.g., ≤0.28% of exports, ≤0.22% of imports) and demand (e.g., ≤0.54% of government consumption, ≤0.2% of intermediate demand).

The imposition of TS resulted in significant changes in the demand for primary factors (labor and capital) and intermediate inputs within SRC services activity. The most pronounced adverse impact observed in both

scenarios was the reduction in labor demand within the SRC services activity, which substantially exceeded the economy-wide average decline. Similarly, contractions in intermediate input demand and capital demand for SRC services significantly outpaced their respective economy-wide average reductions. TS induced significant declines in SRC services domestic production, intensifying over time (Scenario 1: -4.29% to -7.22%; Scenario 2: -7.69% to -12.05%), far exceeding marginal reductions in total commodities. This production decline drove reductions in domestic sales (Scenario 1: -1.71% to -4.53%; Scenario 2: -3.34% to -7.46%) and exports (Scenario 1: -14.78% to -18.18%; Scenario 2: -26.13% to -30.87%). Notably, export reductions consistently surpassed domestic sales reductions and aligned closely with economy-wide export contraction rates. Imports of SRC services also decreased substantially (Scenario 1: -16.48% to -14.17%; Scenario 2: -27.91% to -23.73%), exceeding the upward-trending import reductions observed for total commodities. Consequently, the composite commodity quantity for SRC services declined steadily (Scenario 1: -4.34% to -6.18%; Scenario 2: -7.77% to -10.46%), reflecting steeper declines than domestic sales alone.

Household consumption of SRC services decreased across all urban/rural groups, with reductions intensifying over time and eventually exceeding average total commodities consumption reductions (from Period 3 in Scenario 1; Period 2 or 3 in Scenario 2). Rural households experienced marginally greater impacts than urban households. Government consumption of SRC services declined sharply (Scenario 1: -8.22% to -11.39%; Scenario 2: -15.35% to -20.21%), exceeding reductions in total commodities consumption, driven by rising public expenditure price index (PEPI) against fixed government budgets. Intermediate demand of SRC services also decreased (Scenario 1: -2.02% to -3.04%; Scenario 2: -3.45% to -4.65%), contrasting with mixed trends for total intermediate inputs. Critically, TS adversely affected all SRC services demand components (households' consumption, government consumption, intermediate demand) more severely than the economy-wide average.

Our analysis provided robust evidence of the significant economic impact of TS on Iran's SRC services subsector. Furthermore**,** the results underscore that SRC services exhibit heightened sensitivity to TS across both supply and demand dimensions relative to economy-wide average, highlighting the sector’s acute vulnerability. This disproportionate impact necessitates targeted policy interventions to bolster sector resilience.

Our findings demonstrate the direct effects of TS on both supply-side and demand-side variables through a recursive dynamic CGE model focusing on SRC services. These findings align with the theoretical expectations outlined in the ES literature. Although the present study furnishes no evidence regarding the indirect effects of sanctions, the implications of these findings remain pronounced. They underscore the necessity for future research to investigate not only the direct repercussions of sanctions but also their secondary and indirect impacts on non-traditional subsectors, such as SRC services. Evaluating indirect effects requires considering various factors and using different methods, including econometric models, qualitative analysis, and expert consultations.

Recent literature on ES has made notable strides in analyzing their macroeconomic effects. However, this study's results underscore the necessity of examining overlooked subsectors. Regarding sanctions' impact on the sports subsector, no comparable studies were identified, complicating comparative analysis. Notwithstanding this limitation, certain findings—particularly the

minimal economic contribution of Iran's SRC services subsector—align with studies by Kalashi et al. (2016) and Rostamzadeh and Yadegar (2024). Kalashi et al. (2016) demonstrated that the share of sports expenditures (by both government and households) in the gross domestic product (GDP) is considerably low. They proposed that the possible reasons for this outcome at the government level include the high proportion of public spending allocated to sectors such as industry and mining, agriculture, and transportation. At the household level, contributing factors encompass the high share of housing and food expenses in household budgets, low average annual household income relative to expenditures, elevated inflation rates, and limited public participation in sporting activities. Rostamzadeh and Yadegar (2024) employed an input-output table alongside centrality metrics to examine the position of the sports industry within Iran's economy. Their findings revealed that the sports industry's betweenness centrality rank was 1 and its in-closeness rank was 2. However, regarding other centrality measures, it occupies the lowest ranks. Consequently, the role of the sports industry in Iran's economy is negligible, attributable to low societal participation in sports and the industry's small economic scale. This contrasts sharply with developed nations, where the sports industry contributes substantially to the economy. Our findings underscored the adverse effects of sanctions on Iran's economy, specifically focusing on SRC services. These results converged with studies by Shariati Feizabadi (2020), Eslami et al. (2016), and Eydi and Yousefi (2016), which similarly examined the negative consequences of sanctions on Iran's sports subsector, albeit from different perspectives. Concerning the adverse effects of sanctions, our findings also show partial alignment with Khodadadi et al. (2018, 2019), who investigated the impact of trade sanctions on Iran's sports industry bilateral trade with major partners. Their research demonstrated that both strong and weak sanctions, imposed across different periods, have had differential impacts—both positive and negative—on Iran's bilateral trade with these partners. Furthermore, our findings demonstrated the detrimental impact of TS on the overall economy. Similar results were obtained in numerous empirical studies examining the effects of sanctions on macroeconomic variables in various contexts [e.g., (Ebrahimi & Noori, 2022; Eisazadeh et al., 2022; Farzanegan et al., 2016; Gharibnavaz & Waschik, 2018; Haqiqi & Bahador, 2015; Haqiqi & Bahalou Horeh, 2013; Havasbeigi et al., 2021; Kazerooni et al., 2016; Kazerooni et al., 2015; Keshavarz Haddad et al., 2020; Mohammadi Khabbazan et al., 2015; Moradi et al., 2023; Motaghi et al., 2023; Nakhli et al., 2020; Sadigh Mohammadi et al., 2023; Shirazi et al., 2016; Tofigh & Matin, 2017)].

Conclusion

This study provides valuable insights into the economic repercussions of TS on Iran's SRC services subsector, an area that has received limited attention in the existing literature. The findings demonstrate that even small subsectors, such as SRC services which are integral to cultural identity, national development, and economic diversification, are highly susceptible to the adverse effects of sanctions. Previous studies employing CGE models have provided valuable insights into the extent and mechanisms through which sanctions impact Iran's economy. Nevertheless, these studies have primarily focused on major economic sectors, evaluating changes in macroeconomic indicators, while overlooking subsectors such as SRC services. Furthermore, in studies utilizing methodologies like econometric modeling to examine the effects of sanctions on specific subsectors like the sports industry, only a particular dimension has been analyzed, failing to present a comprehensive perspective of these impacts. Consequently, our study by employing a recursive dynamic CGE

model addresses a significant gap within the existing literature.

Our analysis indicates that TS impose disproportionate adverse effects on Iran's SRC services subsector compared to the economy-wide average. Sanctions significantly reduce labor demand in SRC services, exceeding economy-wide declines. Capital and intermediate input demand for SRC services also contract more severely than the economy-wide average. Domestic production of SRC services declines substantially over time, driving reductions in domestic sales and exports. Imports of SRC services decrease markedly, further reducing composite commodity availability. Household consumption of SRC services falls across all income groups, with rural households experiencing marginally greater losses. Government consumption and intermediate demand of SRC services decline more sharply than total commodities, reflecting heightened sectoral vulnerability. Despite SRC services constituting a negligible share of Iran's economy, the subsector exhibited more and more severe vulnerability to TS across all supply and demand indicators relative to economy-wide averages. This highlights the need for policymakers to consider the broader implications of sanctions on non-traditional subsectors such as the SRC services subsector. The suppression of these subsectors not only impedes economic growth but may also contribute to social dissatisfaction, particularly among youth and those dependent on such subsectors for employment and social engagement.

We propose several policy recommendations to mitigate the negative impacts of sanctions on the SRC services subsector:

1) ***Sector-Specific Resilience Programs:*** Establish targeted support mechanisms (e.g., incentives, subsidies, tax relief) for SRC services to mitigate production declines and labor demand reductions.
2) ***Trade Diversification for Critical Inputs:*** Secure alternative import channels for essential SRC-related goods and technologies through regional partnerships to offset import shortages.
3) ***Household Welfare Protection:*** Implement subsidies or vouchers for low-income (especially rural) households to maintain access to SRC services amid consumption declines.
4) ***Public Sector Budget Adjustment:*** Index government expenditures for SRC services to inflation to counteract real budget erosion and stabilize public consumption.
5) ***Industrial Linkage Strengthening:*** Foster domestic supply chains for intermediate inputs used in SRC services to reduce import dependency.

Below, we provide recommendations for future research that could enrich the subject's literature:

1) ***Regional Comparative Studies:*** Compare SRC services' resilience in Iran with other sanctioned economies to identify transferable adaptation strategies.
2) ***Dynamic Expectation Structures:*** Explore forward-looking (non-myopic) agent behavior in CGE models to better capture intertemporal decision-making under prolonged sanctions.
3) ***Multi-Country CGE Models:*** Extend analysis to regional/global contexts to assess cross-border spillovers of sanctions on SRC services.
4) ***Indirect Impact Analysis:*** Examine spillover effects of SRC services' decline on linked sectors (e.g., tourism, education) using mixed methods (econometric models, qualitative analysis).

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Conflict of Interest

No conflicts of interest are declared by the authors.

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