Macroeconomic Impacts of Export Barriers in a Dynamic CGE Model

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Abstract

A large economic literature discusses the implications of export sanctions for a variety of states around the world. This paper investigates the macro-level consequences of imposing oil export barriers on an oil exporting country. We employ a large real financial computable general equilibrium for Iran. The model is calibrated based on 1999 Social Accounting Matrix for Iranian economy including 112 commodities and 47 activities. We find that the impact of a 50% negative shock in oil export would amount to a 4.6% reduction in GDP, a 6.8% fall in private consumption, a 20.2% cut in government spending, a 20.4% decrease in import, a 9.9% contraction in capital formation, and a +29.2% increase in non-oil export. We also find that there is a conflict between government benefits and national benefit. Our sensitivity analysis proves the robustness of the results.

Keywords: export barriers, government spending, capital formation, Computable General Equilibrium, Social Accounting Matrix

JEL No.: F51, F47, C68, E16

1 Introduction

The lower export levels expected by economic sanctions portend a cutback in macroeconomic variables such as GDP, capital formation, government spending, and private consumption. Since policy makers' concern is the shock's incidence and impacts, the questions may arise that how much will an economy suffer from a discriminatory export cut? What are the impacts of a trade sanction on limited number of goods? What would happen in the economy with lower export of one commodity?

The macroeconomic impacts of discriminatory export barriers are still not well understood, despite the contributions of many fine scholars. To measure the detailed impacts and to answer the above arisen questions, it is required to make a general equilibrium analysis of the shock. To this end, policymakers need numerical information on incidence and impacts of the shock. They concern mainly about GDP and other macro-level variables which is well addressed in this study.

Theoretically, there are at least two opposite scale effects due to one commodity export restriction. From one hand, cut in one commodity exports may reduce the national income and decreases aggregate demand and production. On the other hand, it makes the domestic currency cheaper. Therefore, it stimulates the exports of other commodities and motivates production. Depending on the size of these opposite effects in each sector, production may rise or fall (We will discuss the transmission channels in section 3).

However, a multi sector comprehensive framework is required to provide a complete analysis of the shock. To measure the macro-level consequences of one commodity export shock, this paper performs a general equilibrium analysis. General Equilibrium structure provides an appropriate framework to consider most of the direct and indirect effects of the shock (Shoven and Whalley, 1992). To consider sectoral reallocation, we will make the simulation by specific modeling of capital-labor substitution, imperfect mobility of factors across sectors, sector specific capital, imperfect substitution of import and domestic products, and imperfect transformation of export and domestic supply.

This paper investigates the impacts of imposing oil export barriers on Iran as an oil exporting economy. Iran has experienced numerous export sanctions. As Iranian government highly relies on oil revenue, it is presumed that the 2012 sanctions on Iran will reduce public spending. Furthermore, it may increase the costs of imported commodities and the foreign exchange rate. This study seeks to numerically measure the macro-level impacts of counterfactual scenarios of a fall in oil export and a rise in exchange rate.

We calibrate our multi-sector general equilibrium model based on 1999 Social Accounting Matrix for Iranian economy including 112 commodities and 47 activities. This rich database enables us to consider most of the inter-sectoral linkages and reallocations in the economy.

The structure of the paper is as follows. The next section briefly describes the literature. Then the theoretical backgrounds of the model and the CGE framework are introduced in section 3. Section 4 introduces the database. Section five then provide empirical results. Finally, discussion and conclusions are provided in section six.

2 Economic Literature

2.1 Sanction and Export Barriers

There is a large qualitative literature on the impacts of economic sanctions on the target states. Sanctions can negatively affect the access to food, clean water, medicine and health-care services (Cortright and Lopez, 2000; Weiss et al., 1997; Garfield, 2002; Gibbons and Garfield, 1999). They may also have a negative impact on life expectancy and infant mortality (Ali Mohamed and Shah, 2000; Daponte and Garfield, 2000). Economic sanctions may worsen the targeted government's respect for human rights (Peksen, 2009) and the level of democracy (Peksen and Drury, 2010).

However, research on the macroeconomic consequences of economic sanctions is scarce. In a recent study, Neuenkirch & Neumeier (2014), find that the imposition of UN sanctions decreases the target state's real per capita GDP growth rate by 2.3%–3.5%. While, comprehensive UN economic sanctions, embargoes affecting nearly all economic activity, trigger a reduction in GDP growth by more than 5%. Few empirical researches exist on the impact of oil export sanction or other types of export barriers. In most recent study, Yahia and Saleh (2008) have examined the link between oil prices, economic sanctions and employment in Libyan economy. In other studies, Jafarey and Lahiri (2002) have examined the interaction between credit markets, trade sanctions, and the incidence of child labor. Tarr (1989) developed a general equilibrium model to analyze the welfare and employment effects of US quotas in textiles and steel. Black and Cooper (1987) have illustrated how economic sanctions affect level and distribution of welfare and employment in South Africa. Feenstra (1984) have studied employment and welfare effects of voluntary export restraint on U.S. autos as a form of trade barriers.

There are also some general equilibrium modeling efforts to analyze the effects of NTBs. Fugazza and Maura (2008) present previous general equilibrium applications of the effects of NTBs. According to this survey, the most comprehensive study made so far of the impact of NTBs in a CGE model is Andriamanajara et al. (2004). Other important works are Gasiorek, Smith and Venables (1992) and Harrison, Tarr and Rutherford (1994) and Chemingui and Dessus (2007).

2.2 History of financial CGE modeling

The financial computable general equilibrium (FCGE) modeling started two decades ago. In first versions of Robinson model, one static model was repeated at several periods and growth of stock variables has been defined in every period. They usually were repeated in 5-10 periods (Robinson, 1991). More complicated models have been employed rational expectation models in which households maximize their utility during the given period (Devarjan and Go, 1998). In the recent years financial CGE models has received increasing attention from researchers. Xiao and Wittwer (2009) use a dynamic CGE model of China with a financial module and sectoral detail to examine the real and nominal impacts of a nominal exchange rate appreciation alone, fiscal policy alone and a combined fiscal and monetary package to redress China's external imbalance. Li and Yang (2012) use a financial CGE model to analyze real and financial sectors interaction in China's economy. They have considered the wage rigidity as a failure of the labor market. The results show that wage rigidity has meaningful effects on the results of their study. In another study, Lemelin, et al. (2013) have presented an applied computable general equilibrium world model with financial assets and endogenous current account, and capital and financial account balances. In their simulations, the interaction of portfolio choices with trade supply and demand behavior leads to endogenous sign reversals in some current account balances, and it results in a different allocation of investment among regions.

Two applied studies have been conducted in Iran using financial computable general equilibrium model. In the first study, Haqiqi (2011) has developed Shahmoradi et al (2010). He described how to model the financial variables in computable general equilibrium models with different approaches. In his study various approaches of modeling a financial CGE has been introduced. Then, based on three different approaches, three financial models have been compared. Overall, comparing the results of different scenarios suggest that static financial CGE and stock adjustment models give more realistic results than flow equilibrium models. The other study was carried out by Salami and Javanbakht, (2011); they have presented a real-financial CGE model for the economy of Iran and used it to examine the effects of reducing interest rate of credits on investment and growth. Their results showed that following a reduction in interest rate of credits, the prices of commodities and services declined which resulted in reduction of inflation rate by 0.53%. In addition, households' income and savings increased by 0.54 and 7.83%, respectively.

To our knowledge, our paper is the first study in Iran in which a large dynamic Financial CGE model with multi-assets and various financial markets is employed. Although Haqiqi (2011) develops some dynamic models, the models are too aggregated and include only two or three production sectors. CGE model in Salami and Javanbakht (2011) is a static model without any financial market. Although a considerable body of research has done in Iran employing CGE models, a small number of studies tests the sensitivity of their results. In this research we conduct a sensitivity analysis to prove the robustness of our findings. Furthermore, the present paper provides important insights in regard to the effects of oil export on non-oil export and other macroeconomic variables.

3 Theory and the Model

Reduction in oil exports has two opposite “scale effects” in the economy. One effect tends to reduce the production and employment level while the other tends to motivate export, production, and employment. The country may also face a “substitution effect”, “reallocation effect”, and a change in production mix. We describe these effects on the following paragraphs.

The first impact of a fall in oil exports is “shrinking effect” or “negative scale effect”. A fall in the oil exports would lead to a substantial demand deficit. It is plausible that the government expenditure decrease. According to macroeconomic theory, decline in public expenditure brings a fall in aggregate demand in the country, which may shrink economic activity and employment in short run (Mankiw, 2012). The effect will be intensified when the cost of imported input rises and activity levels fall.

The second impact is an “expansion effect” or “positive scale effect”, and happens due to increase in foreign exchange rate and import substitution. Since, fall in oil exports would diminish supply of export dollars (or any other foreign currency) a shortage in foreign currency would increase the foreign exchange rate. According to economics theory, the rise in the foreign exchange rate would foster non-oil export expansion. The more the change in export of a commodity is, the more the change in activity level and employment will be expected in that sector. On the other hand, the rise in import prices would increase the demand for domestically produced goods and services. Hence, it would have a positive impact on the activity and employment levels, too (James, Marsh, Sarno, 2012).

There would be also a third “reallocation effect” or a substitution towards tradable sectors, especially those sectors with more exports share. When this occurs, the changes in exchange rate will motivate more non-oil exports by bringing more profit than before. Therefore, the production resources re-allocate towards more non-oil export. Therefore, labor and capital would move to tradable sectors and to more exporting sectors.

We also expect a “substitution effect” due to import price increase. It occurs when exchange rate increases and the imported commodities seem to be more expensive. Hence, people prefer to buy domestic goods instead of foreign goods (Hertel, 1998), which may encourage domestic production and employment.

The economy also might face changes in the labor market. According to neoclassical theory of labor supply, the choice between consumption and leisure depends on wages and prices (Cahuc and Zylberberg, 2004). Hence, the supply of skilled labor would change due to change in the price of consumption goods after the shock in import prices.

On the other hand, changes in wages and prices would influence the production technology. Depending on the changes in relative prices for each sector, it would adjust toward more labor-intensive or more capital-intensive technology.

However, the overall effect of oil export barriers on macroeconomic variables is unknown and requires numerical calculations.

3.1 Optimizations in a Typical CGE Model

We consider an economy comprising multiple activities indexed by $s \in S \equiv \{1,...,47\}$, multiple commodities indexed by $g \in G \equiv \{1,...,112\}$, and multiple institutions indexed by $h \in H \equiv \{con, gov, cor, fco, oil\}$. Each activity employs two factors of production, labor and capital, which can be used to produce different commodities. Factors are heterogeneous and imperfectly mobile across sectors. $N_{f,h}$ denotes the total endowment of each factor f owned by institution h. The model has a nested structure in which there is an optimization behavior in each nest.

Inter-temporal preferences. In this model, we have assumed that agent's action is based on inter-temporal optimization behavior. There is a representative household whose objective is to find his lifetime optimal consumption path. This agent derives utility from consuming "composite commodity" at each period of time, C_t. (Note that the combination of this composite commodity is determined through another optimization in "expenditures".) The lifetime maximization problem to determine composite consumption in each period is known as Ramsey problem:

$$\max U_h = \left(\sum \alpha_{h,t}^{\theta} C_{h,t}^{1-\theta} \right)^{\frac{1}{1-\theta}} \tag{1}$$

$s.t.$

$$Y_h = \sum_t \left(\frac{PL_t L_{h,t} + PK_t K_{h,t} + TR_{h,t}}{(1+\rho)^t} \right) \tag{2}$$

where t is time periods, U_h is utility function of households, $C_{h,t}$ denotes household composite consumption in period t, α shows the CES parameter, θ shows relative risk aversion parameter, Y is the lifelong income, PL is wage of labor, PK displays capital return, TR stands for transfer payments, and ρ displays discount factor. Note that θ is the inverse of intertemporal elasticity of substitution. In other words, we assume a substitution between today consumption and future consumption.

Expenditure: Aggregate consumption, $C_{h,t}$, depends on the consumption of each commodity, $QC_{g,h,t}$. Representative agent minimizes the cost of consumption bundle in each period. Household's consumption is a CES aggregator of different goods and services. This agent minimizes the cost of preparing the aggregate bundle at each period of time:

$$\min \sum_g PC_{g,t} . QC_{g,h,t}$$

$$s.t. \; C_{h,t} = \left(\sum_g \varphi_{g,h}^{\frac{1}{\sigma_h}} QC_{g,h,t}^{\frac{\sigma_h - 1}{\sigma_h}} \right)^{\frac{\sigma_h}{\sigma_h - 1}} \tag{3}$$

where $PC_{g,t}$ denotes price index of each commodity at each period, C is aggregate consumption, QC is consumption demand for each good or service, φ is share parameter, σ is the elasticity of substitution, g refers to goods and services, and h refers to households. Cost minimization by households at each period of time requires that:

$$QC_{g,h,t} = \varphi_{g,h} C_{h,t} \left(\frac{CPI_{h,t}}{PC_{g,t}} \right)^{\sigma_h}$$

$$CPI_{h,t} = \left(\sum_g \varphi_{g,h} PC_{g,h,t}^{1-\sigma_h} \right)^{\frac{1}{1-\sigma_h}} \quad \textbf{(4)}$$

Where $CPI_{h,t}$ denotes CES consumer price index associated with composite consumption of agent *h* in time *t*.

Technology and cost. Producers' behavior is modeled through Nested Constant Elasticity of Substitution (NCES) functions. Producers combine labor and capital with other intermediate inputs in order to produce products. Output of each sector is produced using capital (K), labor (L) and intermediate goods (M). Producers minimize the cost of production according to production technology:

$$\min \; PKL_{s,t}.QKL_{s,t} + PINT_{s,t}.QINT_{s,t}$$

$$s.t. \; Q_{s,t} = \left(\varphi_{KL,s}^{\frac{1}{\gamma_s}} QKL_{s,t}^{\frac{\gamma_s - 1}{\gamma_s}} + \varphi_{INT,s}^{\frac{1}{\gamma_s}} QINT_{s,t}^{\frac{\gamma_s - 1}{\gamma_s}} \right)^{\frac{\gamma_s}{\gamma_s - 1}} \quad \textbf{(5)}$$

Where *QKL* is value added composite, *QINT* is intermediate input composite, Q_s shows total product, *PKL* is price of composite value added, and *PINT* is price index for composite intermediate. Furthermore, *KL* denotes the value added nest, *INT* shows the intermediate nest, γ is the elasticity of substitution, and φ is the share parameter.

Producers optimize the cost of all sub-nests. In other words, producers minimize the cost of composition of that nest. For example, the cost of value added composite should be minimized. Assuming a constant elasticity of substitution between labor and capital, the optimization problem is:

$$\min \; PL_{s,t}.QL_{s,t} + PK_{s,t}.QK_{s,t}$$

$$s.t. \; QKL_{s,t} = \left(\varphi_{L,s}^{\frac{1}{\mu_s}} QL_{s,t}^{\frac{\mu_s - 1}{\mu_s}} + \varphi_{K,s}^{\frac{1}{\mu_s}} QK_{s,t}^{\frac{\mu_s - 1}{\mu_s}} \right)^{\frac{\mu_s}{\mu_s - 1}} \quad \textbf{(6)}$$

where, *QK* is capital, *QL* is labor, μ is the elasticity of substitution between labor and capital, and φ is the share parameter in this nest. Similarly, optimization problem to find optimal technology in the intermediate input nest is:

$$\min \; \sum_g PI_{g,t}.QC_{g,s,t}$$

$$s.t. \; QINT_{s,t} = \left(\sum_g \varphi_{g,s}^{\frac{1}{\alpha_s}} QC_{g,s,t}^{\frac{\alpha_s - 1}{\alpha_s}} \right)^{\frac{\alpha_s}{\alpha_s - 1}} \quad \textbf{(7)}$$

Where *PI* is price index, *QINT* is intermediate composite, $QC_{g,s}$ is the commodity *g* purchased by firms, φ is share parameter; and α is elasticity of substitution.

Given previous equation, cost minimization behavior requires that:

$$QC_{g,s,t} = \varphi_{g,s}\varphi_{int,s}Q_{s,t}\left(\frac{PKLM_{s,t}}{PINT_{s,t}}\right)^{\lambda_s}\left(\frac{PINT_{s,t}}{PI_{g,s,t}}\right)^{\alpha_s} \quad \textbf{(8)}$$

$$QK_{s,t} = \varphi_{k,s}\varphi_{kl,s}Q_{s,t}\left(\frac{PKLM_{s,t}}{PKL_{s,t}}\right)^{\lambda_s}\left(\frac{PKL_{s,t}}{PK_{s,t}}\right)^{\mu_s} \quad \textbf{(9)}$$

$$QL_{s,t} = \varphi_{k,s}\varphi_{kl,s}Q_{s,t}\left(\frac{PKLM_{s,t}}{PKL_{s,t}}\right)^{\lambda_s}\left(\frac{PKL_{s,t}}{PL_{s,t}}\right)^{\mu_s} \quad \textbf{(10)}$$

$$PKLM_{s,t} = \left(\varphi_{KL,s}PKL_{s,t}^{1-\gamma_s} + \varphi_{INT,s}PINT_{s,t}^{1-\gamma_s}\right)^{\frac{1}{1-\gamma_s}} \quad \textbf{(11)}$$

It shows that the demand for an input g depends on activity level, relative prices, share parameters, and elasticity of substitution.

Foreign trade. Purchased commodity is either imported or domestically produced. The whole economy minimizes the cost of purchasing a commodity. Assuming imperfect substitution between domestic commodity and imports (Armington, 1969), the optimization is:

$$\min PD_{i,t}.QD_{i,t} + PM_{i,t}.QM_{i,t}$$

$$QTD_{i,t} = \left(\varphi_{d,i}^{1/\beta_i}QD_{i,t}^{\frac{\beta_i-1}{\beta_i}} + \varphi_{m,i}^{1/\beta_i}QM_{i,t}^{\frac{\beta_i-1}{\beta_i}}\right)^{\frac{\beta_i}{\beta_i-1}} \quad \textbf{(12)}$$

Where *PD* is price index for domestic commodity, *PM* is import price index, *QTD* shows the Armington aggregator (total demand for commodity i), φ is share parameter, and β is Armington elasticity of substitution. Given this assumption, optimization requires that:

$$QM_{i,t} = \varphi_{m,i}QTD_{i,t}\left(\frac{\left(\varphi_{d,i}PD_{i,t}^{1-\beta_i} + \varphi_{m,i}PM_{i,t}^{1-\beta_i}\right)^{\frac{1}{1-\beta_i}}}{PM_{i,t}}\right)^{\beta_i} \quad \textbf{(13)}$$

$$PM_{i,t} = PFX_t.PMF_{i,t}$$

where PFX is the index of foreign exchange rate and PMF is the foreign price of imported commodity. According to this equation, the demand for importing commodity i depends on total domestic demand, relative price of imported commodity, Armington elasticity, and share of import in total supply of commodity i. Similarly, the demand for domestically produced commodity is:

$$QD_{i,t} = \varphi_{m,i} QTD_{i,t} \left(\frac{\left(\varphi_{d,i} PD_{i,t}^{\ 1-\beta_i} + \varphi_{m,i} PM_{i,t}^{\ 1-\beta_i} \right)^{\frac{1}{1-\beta_i}}}{PD_{i,t}} \right)^{\beta_i} \quad \textbf{(14)}$$

Likewise, domestic demand for domestically produced good depends on total domestic demand, relative price of domestic products to imports, Armington elasticity, and share of import in total supply of commodity i. Armington aggregator determines the weighted price of domestically purchased commodity. The price index possesses a CES form as follows:

$$P_{g,t} = \left(\varphi_{d,g} PD_{d,t}^{\ 1-\beta_g} + \varphi_{m,g} PM_{m,t}^{\ 1-\beta_g} \right)^{\frac{1}{1-\beta_g}} \quad \textbf{(15)}$$

Domestically produced commodities are either exported to other countries or supplied domestically. Producers choose to supply overseas or at home according to the possibility of transformation and relative prices. Assuming a Constant Elasticity of Transformation (CET) function for each commodity:

$$\max PD_{i,t} .QD_{i,t} + PX_{i,t} .QX_{i,t}$$

$$QTO_{i,t} = \left(\theta_{d,i}^{1/\lambda_i} QD_{i,t}^{\frac{\lambda_i - 1}{\lambda_i}} + \theta_{x,i}^{1/\lambda_i} QX_{i,t}^{\frac{\lambda_i - 1}{\lambda_i}} \right)^{\frac{\lambda_i}{\lambda_i - 1}} \quad \textbf{(16)}$$

where *PD*, *QD*, *PX*, and *QX* denote domestic supply price index, quantity of domestic supply, export price index, and quantity of export, respectively. *QTO* shows the total output, θ is share parameter, and λ<0 is the elasticity of transformation. Let *PXF* denotes the foreign price index of exported commodity. Solving this optimization problem, we obtain the following expression for supply of a commodity to foreign countries:

$$QX_{i,t} = \theta_{x,i} QTO_{i,t} \left(\frac{\left(\theta_{x,i} PX_{i,t}^{1-\lambda_i} + \theta_{d,i} PD_{i,t}^{1-\lambda_i} \right)^{\frac{1}{1-\lambda_i}}}{PX_{i,t}} \right)^{\lambda_i} \quad \textbf{(17)}$$

$$PX_{i,t} = PFX_t .PXF_{i,t}$$

Given our assumption about export, the optimization behavior yields the supply of commodity i to domestic market:

$$QD_{i,t} = \theta_{d,i} QTO_{i,t} \left(\frac{\left(\theta_{x,i} PX_{i,t}^{1-\lambda_i} + \theta_{d,i} PD_{i,t}^{1-\lambda_i} \right)^{\frac{1}{1-\lambda_i}}}{PD_{i,t}} \right)^{\lambda_i} \quad \textbf{(18)}$$

Note that λ measures the extent of technical possibility of transforming export to domestic supply. Given our assumptions about trade and technology, the nested form of production sector is shown in Figure 1.

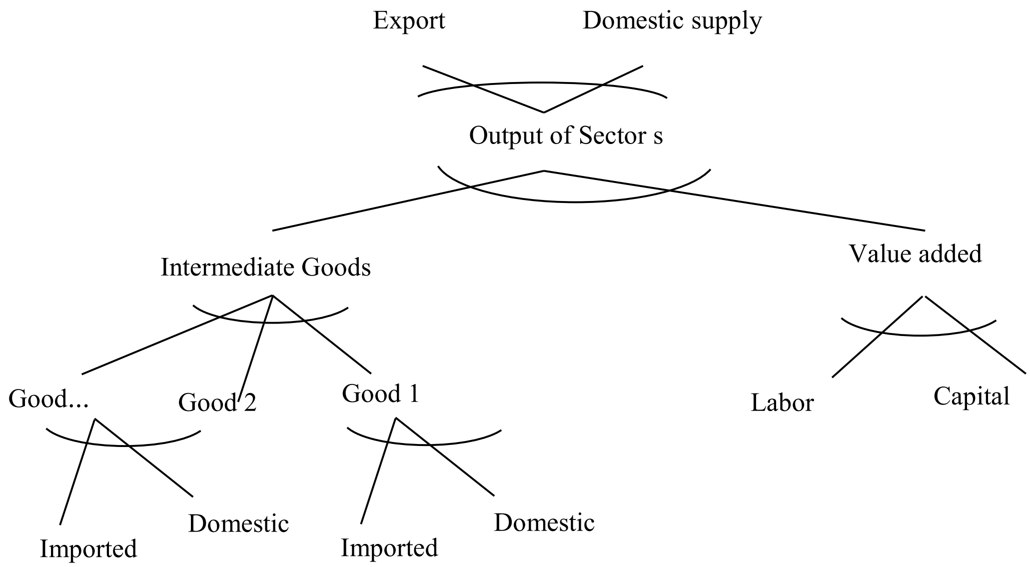

Figure 1: Production structure in the model

Factor mobility. Factors are neither perfectly mobile nor specific at each sector. We assume that factors of production are not homogenous. In other words, it is not easy to move freely across sectors. A CET type function is able to demonstrate imperfect factor mobility. Let $\tau<0$ denotes the ease of movement across sectors. A factor owner choose to supply factor f to sector s ($QF_{f,s}$) according to factor endowment level (QN), sectoral factor wages (PF), and the possibility of move across sectors. Given these assumption, the optimization behavior is:

$$\max \sum_s PF_{f,s,t} QF_{f,s,t}$$

$$\sum_h QN_{f,h,t} = \left(\sum_{s=1}^{47} \xi_{f,s}^{1/\tau_f} QF_{f,s,t}^{\frac{\tau_f - 1}{\tau_f}} \right)^{\frac{\tau_f}{\tau_f - 1}} \tag{19}$$

Solving this problem, we obtain the optimum supply of each factor to each sector as

$$QF_{f,s,t} = \xi_{f,s} \left(\sum_h QN_{h,f,t} \right) \left(\frac{PN_{f,t}}{PF_{f,s,t}} \right)^{\tau_f}$$

$$PN_{f,t} = \left(\sum_{s=1}^{47} \xi_{f,s} PF_{f,s,t}^{1-\tau_f} \right)^{\frac{1}{1-\tau_f}} \tag{20}$$

where PN is the CET weighted average of factor wages across sectors.

Saving and investment. The saving behavior of agents depends on consumption at each time period. Agents are maximizing their consumption and equating the marginal benefit of consumption today with that of consumption in the future. Thus, the saving at each time period is determined by:

$$S_{h,t} = Y_{h,t} - C_{h,t}$$

where S shows the amount of saving and Y denotes the total income of agent h at each time t.

At each period of time, agents may also borrow funds from financial markets. These funds plus savings are used either to make physical capital formation which is called investment or to purchase domestic and foreign financial assets (supply of loanable funds). This condition requires that:

$$I_{h,t} + VTA_{h,t} + VNCO_{h,t} = S_{h,t} + VBOR_{h,t}$$

where VTA is the total value of domestic financial portfolio, VNCO demonstrates the total value of foreign financial portfolio (net capital outflow), and VBOR is total amount of borrowing. These are explained in following paragraphs.

Financial portfolio. We consider a financial market comprising multiple assets indexed by “a” (deposit, loan, bond, equity, etc.). Each agent seeks to maximize the return to financial portfolio and decides how to supply loanable funds. We assume imperfect substitution between financial assets as in reality they are not similar in risk and return[1]. It allows to consider how purchasing of different assets may change due to change in relative return of assets. The optimization behavior in financial portfolio is:

$$\max \sum_a r_{a,t} VFA_{a,h,t}$$

$$VTA_{h,t} = \left(\sum_a \theta_{a,h}^{1/\sigma_{a,h}} VFA_{a,h,t}^{\frac{\sigma_{a,h}-1}{\sigma_{a,h}}} \right)^{\frac{\sigma_{a,h}}{\sigma_{a,h}-1}}$$

where VTA is the total value of financial portfolio, VFA denotes the value of purchasing each asset, r shows the assets’ return, σ<0 is substitution elasticity among assets, and θ is share parameter. Solving this problem, we obtain optimum value of each asset in the portfolio (supply of loanable funds) as

$$VFA_{a,h,t} = \theta_{a,h} VTA_{h,t} \left(\left(\sum_{a=1}^{7} \theta_{a,h} r_{a,t}^{1-\sigma_{a,h}} \right)^{\frac{1}{1-\sigma_{a,h}}} \Big/ r_{a,t} \right)^{\sigma_{a,h}}$$

Borrowing channels. Agents can borrow through various assets (demand of loanable funds). We assume that borrowers are minimizing their cost of finance. Given this assumption, the optimization problem is:

[1]Tobin, James (1969) “A General Equilibrium Approach to Monetary Theory.” Journal of Money, Credit, and Banking, 1:1, 15—29.

$$\min \sum_{a} rr_{a,h.t} VBA_{a,h.t}$$

$$VBOR_{i.t} = \left(\sum_{a} \beta_{a,h}^{1/\gamma_{a,h}} VBA_{a,h.t}^{\frac{\gamma_{a,h}-1}{\gamma_{a,h}}} \right)^{\frac{\gamma_{a,h}}{\gamma_{a,h}-1}}$$

in which, rr is the interest rate of each asset (channel of borrowing), VB shows the amount of borrowing through each asset, VBOR demonstrates total borrowing, β is share parameter, γ denotes elasticity of substitution among channels of finance. This optimization leads to optimum borrowing for agent h as:

$$VB_{a,h.t} = \beta_{a,h} VBOR_{i.t} \left(\left(\sum \beta_{a,h} rr_{a,h.t}^{1-\gamma_{a,h}} \right)^{\frac{1}{1-\gamma_{a,h}}} \Big/ rr_{a,h.t} \right)^{\gamma_{a,h}}$$

Sectoral investment decision. Physical capital formation is made in different sectors. Agents minimize the cost of purchasing capital composite commodity in production sectors. Therefore, the optimization behavior is:

$$\min \sum_{k} PK_{k,t} QK_{k,h,t}$$

$$I_{h,t} = \left(\sum_{i} \theta_{k,h}^{1/\sigma_{k,h}} QK_{k,h,t}^{\frac{\sigma_{k,h}-1}{\sigma_{k,h}}} \right)^{\frac{\sigma_{k,h}}{\sigma_{k,h}-1}}$$

where I is the total amount of capital formation by each agent h, PK is the cost of capital composite commodity in sector k, QK amount of capital formation by each agent h at each sector k, θ shows share parameter, and σ is the substitution possibility. Solving this problem, we obtain the optimum investment by each agent at each sector:

$$QK_{k,h} = \theta_{k,h} VTK_{h} \left(\left(\sum \theta_{k,h} PK_{k}^{1-\sigma_{k,h}} \right)^{\frac{1}{1-\sigma_{k,h}}} \Big/ PK_{k} \right)^{\sigma_{k,h}}$$

3.2 Equilibrium Conditions in a Typical CGE Model

In equilibrium, all consumers maximize their utility; all firms minimize their costs, and all markets clear. Market clearing for each factor *f* requires that total supply of that factor by households equals total demand of that factor by firms:

$$\sum_{h} QN_{f,h,t} = \sum_{s} QF_{f,s,t} \qquad \textbf{(21)}$$

Similarly, Market clearance for each commodity requires that total supply equals total demand. Given the structure of our model, total supply is determined by import and domestic production (other models may have inventory reduction). Total demand is determined by firms' purchases, institutions' purchases, and export (capital formation and increase in inventory is done by institutions). Therefore market clearing condition for commodity *g* requires that:

$$QM_{g,t} + \sum_s QO_{g,s,t} = \sum_s QC_{g,s,t} + \sum_h QC_{g,h,t} + QX_{g,t} \quad \textbf{(22)}$$

Finally, for each asset a and in each period of time t, the equilibrium condition requires that:

$$\sum_h VBA_{a,h,t} = \sum_h VFA_{a,h,t}$$

3.3 Model Dynamics and Calibration

In the CGE literature the calibration of the single-period equilibrium is straightforward. But, calibration procedure of dynamic models needs more attention. Calibration in a dynamic context is generally means the model is parameterized in such a way that the balanced growth path is simulated when the base policy is maintained (Pereira and Shoven 1988). For specifying CGE models all the markets are assumed to be in equilibrium. Then, the parameters of the model are chosen through a calibration procedure. Calibration of the model involves specifying values for certain parameters based on outside estimates, and deriving the remaining ones from the restrictions posed by the equilibrium conditions. Thus, it is assumed that the benchmark data base reflect period equilibrium. The calibrated parameter values can then be used to solve the model for alternative equilibrium associated with exogenous changes in policy variables. The so-called "counterfactual" scenarios are imposed on the model to explore and evaluate the impacts of different policy measures and shocks by comparing the results of the benchmark equilibrium with the counterfactual (Springer, 1999).

Our dynamic CGE model can also be interpreted as a sequence of counterfactuals to the base year run by altering the factor endowments holding everything else constant. The first step in calibration of the dynamic model is the same as in the static case. After having calibrated the benchmark period of the model, the dynamics come in by updating the factor endowments after every time step. We assume a constant growth rate for labor endowment. In other words, labor supply evolves exogenously over time. The labor endowment in first period is given by L_0. Let n denotes the labor growth rate. Therefore labor supply at each period will be:

$$L_{h,t} = L_{h,t-1}\left(1+n\right) \quad \textbf{(23)}$$

Current period's investment augments the capital stock in the next period. Capital stock in each time period is updated by an accumulation function equating the next period capital stock to the sum of depreciated capital stock of the current period and the current period real investment.

$$K_{h,t+1} = K_{h,t}(1-\delta) + I_{h,t} \quad \textbf{(24)}$$

where δ denotes the rate of capital depreciation; K is capital stock and I shows the investment.

The equilibrium in any sequence is connected to each other through capital accumulation and labor growth. Each single period equilibrium calculation begins with an initial labor and capital services endowment resulting from the end of the period t-1. A new equilibrium of supply, demand and relative prices is calculated for the next time period t based on the exogenous and endogenous changes in endowments. Savings of the current period *t* will augment the capital-services endowment at the end of period *t* available in the next period *t*+1. Finally, lifetime decision comes in. Households choose the consumption level at each period according to inter-temporal relative prices and lifetime income. Our model is programmed in the GAMS (Generalized Algebraic Modeling System) / MPSGE (Mathematical Programming System for General Equilibrium analysis) language (Rutherford, 1999).

Starting from the initial steady state, we shock the economy through a parametric decline of oil export. We observe that all endogenous variables converge to their steady state level in the period immediately following the shock.

1. Data

CGE models generally use two kinds of data as their database: the first are share and sectoral interactions parameters and the second are exogenous parameters such as elasticity of substitution. Share parameters are calibrated based on 1999 Iranian Social Accounting Matrix (SAM), while other parameters are obtained using other sources rather than SAMs. Table 1 shows the amount of exogenous parameters and the sources which we have used to obtain these parameters.

Table 1: Exogenous parameters in the model

Parameter	level	Source
Population growth rate	1.29%	Statistical Center of Iran, 2011
Relative risk aversion parameter	1.5	Tavakolian, 2012
Time preference rate	0.96	Tavakolian, 2012
Depreciation rate	4.2%	Amini and Haji Mohammad, 2005

In addition to exogenous parameters, we need additional data describing both interaction between economics sectors and agents, and interaction between real and financial sectors. Since 1999 SAM for Iran has all this features, we use this database in our model calibration.

A Social Accounting Matrix is a descriptive tool which represents details of the economy according to System of National Accounts. The SAM is a square matrix which contains all the interactions and monetary flows between economic agents and sectors. Table 2 shows the aggregated form of 1999 SAM for Iran. In this matrix, each cell shows the payment from the account of its column to the account of its row. Therefore, the incomes of an account appear along its row; and its expenditures appear along its column (Pyatt, 1999).

Table 2: The 1999 Social Accounting Matrix for Iran

	Goods and services	Firms	Factors	Institutions	Households	Saving	Capital formation	Finical account	Rest of the world	Sum
Goods and services		241572			309080	6357	128289		93116	778414
Firms	698039									698039

Factors		456467							1051	457519
Institutions	14068		456447	93491					317	564323
Households				470003	49866					519869
Saving					160876	20313		194929	1769	377888
Capital formation						128289				128289
Finical account						222928			8786	231714
Rest of the world	66307		1072	829	47			36785	-27999	77040
Sum	778414	698039	457519	564323	519869	377888	128289	231714	77040	

Source: CBI (2004)

This SAM is appropriate for dynamic modeling as it involves detailed information about saving, capital, and financial accounts. This matrix includes the interaction between saving, capital formation, and net capital flow. The intersection of the saving account and capital formation account shows how each economic agent holds new investment. Generally, portfolio of each agent includes fixed capital formation and financial assets. As Table 3 indicates, the value of households' investment is 4599 billion Rls (domestic currency) in agricultural sector, while it is 205066 billion Rls in construction sector; likewise, households investment is 22744 billion Rls in the form of cash and deposits and is 3310 billion Rls in the form of securities such as bonds.

Table 3: The portfolio formation matrix

		Household	Government	Oil and gas	Non-financial firms	Financial firms
Fixed capital formation	Agriculture	4599			1596	
	Oil and gas			10533		
	Other mining	31			658	
	Industry	6841			15228	
	Electricity, water and gas	194			7376	
	Construction	86			344	
	Transportation	9745			10367	
	Communications				3623	
	Estates	20506			2879	
	Other services	11541	6360		13878	1903
Financial assets'	Monetary gold and SDR					1192
	Cash and deposits	22744	3970	2312	20731	7381
	Securities except for shares	3310				-464
	Facilities and loans		8448		1007	54100
	Shares and similar assets	2035	5682	1603	7276	538
	Other receivable/payable accounts	-389	1036	16415	53336	10544

Source: CBI (2004)

4 Results

Assume a 50% permanent reduction in oil export of Iran. We simulate the new steady state equilibrium variables. Then we calculate the change in macro-level variables compared to baseline scenario. Our simulation is repeated with different scenarios of export-domestic CET parameter. These scenarios help us to understand the sensitivity of results to parameter choices. Table 4 depicts the results.

Table 4: The impacts of 50% cut in oil exports on macro-level variables, in different CET elasticity

	Export-domestic CET parameter		
	0.5	1.0*	1.5
Gross Domestic Products	-4.74	-4.61	-4.51
Private consumption	-6.47	-6.83	-7.06
Government expenditure	-19.5	-20.17	-20.83
Non-oil exports	+21.59	+29.20	+34.54
Imports	-23.62	-20.44	-18.24
Fixed capital formation	-10.19	-9.63	-9.26

Note: * denotes Main scenario. The results are calculated using Dynamic Financial CGE model for Iran.

As expected, oil export cut reveals a negative and significant influence on GDP. The adverse effect is -4.61% when the elasticity of transformation between export and domestic supply is 1. The impact is slightly higher when the CET parameter presents lower possibility of export-domestic transformation. The simulations depicts that when CET parameter is 1.5, the GDP reduction is 4.51%. Therefore, we can affirm the conclusion that with higher possibility of export-domestic transformation, the harmful effect on GDP is a bit lower.

Government expenditure is highly affected by decline in the oil export revenue. In main scenario, reduction in public spending is 20.17%. The higher export-domestic CET parameter, the fall in government expenditure is higher. Given the fact that exchange rate is higher when the CET parameter is low (due to more foreign exchange supply from more non-oil export), our results show a very important finding. Although Iranian government is highly dependent on oil export revenue, the government can avoid the revenue loss if the exchange rate is higher. That means the government may seek to keep the foreign exchange rate high.

In contrast, we find that non-oil export increases due to 50% fall in oil export. In main scenario, the positive jump in non-oil export is equal to 29.20%. Furthermore, when the export-domestic CET parameter is higher, the rise in non-oil export is also higher. When the CET parameter is 1.5, the rise in non-oil export is 34.54%. In short, fall in oil export will increase the foreign exchange rate and motivates non-oil exports.

To test the sensitivity of our results to other parameters, we repeat the simulation with different levels of various parameters. The analysis proves the robustness of the results. The only exception is Armington elasticity. The results are a bit sensitive to Armington parameter (substitution elasticity between import and domestic products). Table 5 shows the simulation results with different Armington parameter.

Table 5: The impacts of 50% cut in oil exports on macro-level variables, in different Armington elasticity

	Import-domestic Armington parameter		
	0.5	1.0*	1.5
Gross Domestic Products	-4.73	-4.61	-4.52

Private consumption	-6.67	-6.83	-6.95
Government expenditure	-19.60	-20.17	-20.58
Non-oil exports	+33.52	+29.20	+26.14
Imports	-16.37	-20.44	-23.38
Fixed capital formation	-9.94	-9.63	-9.42

Note: * denotes Main scenario. The results are calculated using Dynamic Financial CGE model for Iran.

We find that reductions in GDP, consumption, public spending, and capital formation are not much affected by Armington elasticity. However, when the possibility of import-domestic substitution is low, GDP loss is higher. When Armington elasticity is low, the export jump is also higher. There is a good explanation for our results. As import is the demand side in foreign exchange market, lower Armington parameter leads to higher foreign exchange rate. That is, because the possibility of import adjustment (foreign exchange reduction) is lower.

Table 6: The impacts of different scenarios of reduction in oil exports on macro-level variables

	10%	25%	50%	75%	90%
Gross Domestic Products	-1.1	-2.7	-4.61	-5.6	-6.0
Private consumption	-1.3	-3.4	-6.83	-9.6	-11.2
Government expenditure	-3.8	-9.9	-20.17	-28.4	-31.1
Non-oil exports	+6.8	+16.2	+29.20	+35.7	+33.9
Imports	-5.2	-12.0	-20.44	-25.8	-28.5
Fixed capital formation	-2.3	-5.4	-9.63	-12.8	-14.5

Note: The results are calculated using Dynamic Financial CGE model for Iran.

We also simulate other scenarios of permanent oil export cut (10%, 25%, 75%, and 90%). As shown in Table 6, we find that a 10% permanent reduction in oil export leads to 1.1% steady state GDP loss. While GDP loss is 2.7% in 25% oil export fall, it is calculated 6.0% in 90% oil export reduction. With a 90% reduction in oil export, the reduction in private consumption is 11.2%; the fall in government expenditure is 31.1%; imports decreases by 28.5%; and capital formation reduces by 14.5%. In this scenario, the increase in non-oil export is 33.9%.

5 Conclusion

In order to gain a complete understanding of impacts of reduction in oil exports, it is useful to conduct a Computable General Equilibrium framework that examines all aspects of the shock including direct and indirect effects. Theoretically, export barriers would have two opposite effects: "Shrinking Effect" due to fall in oil export and rise in import costs, and "Expansionary Effect" due to increase in the foreign exchange rate and export growth.

The current CGE analysis demonstrates that a 50% decline in oil export would amount to a 4.6% reduction in GDP, a 6.8% fall in private consumption, a 20.2% cut in government spending, a 20.4% decrease in import, a 9.9% contraction in capital formation, and a 29.2% increase in non-oil export. Our results are robust to modification of exogenous parameters and possibility of substitution and transformation in different markets.

This study find that lower possibility of substitution between domestic and imported commodities, would lead to slightly higher GDP loss but definitely higher non-oil exports. We find that exchange rate is significantly important in this analysis. As import of goods and services would form the demand side in foreign exchange market, lower Armington parameter would lead to lower possibility of adjustment and import reduction. Therefore, higher foreign exchange rate is expected.

Our results suggest that when transformation elasticity between export and domestic supply is low, GDP loss is higher and Jump in non-oil export is lower. It seems that this happens due to a lower expansionary effect. In other words, the expansionary effect depends on the possibility of transformation between export and domestic supply.

We find that there is a conflict between government benefits and national benefits. Although higher possibility of substitution would reduce the GDP loss, the government loss would be less in lower CET and Armington elasticity. This may prevent the government to motivate export or import substitution. An interesting finding is that government may prefer to keep the foreign exchange rate higher to compensate their lost revenue.

A useful extension of this work would be to discover the sectoral consequences of export sanctions. Another interesting research is the influence of export reduction on poverty and income distribution. The impact of sanctions on labor market and migration is another subject of interest.

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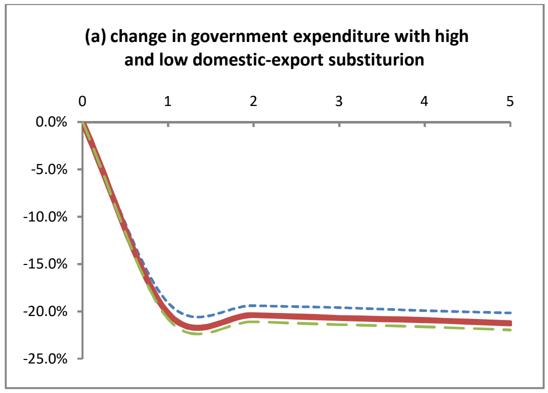
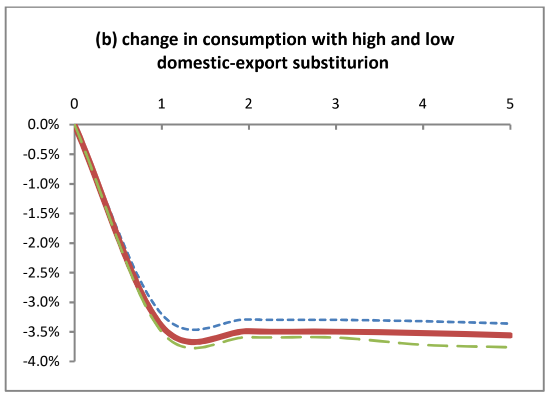
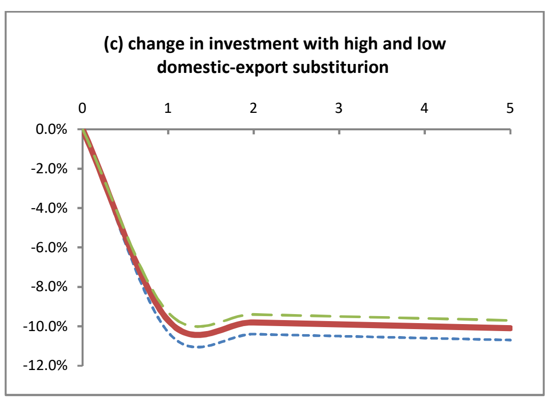
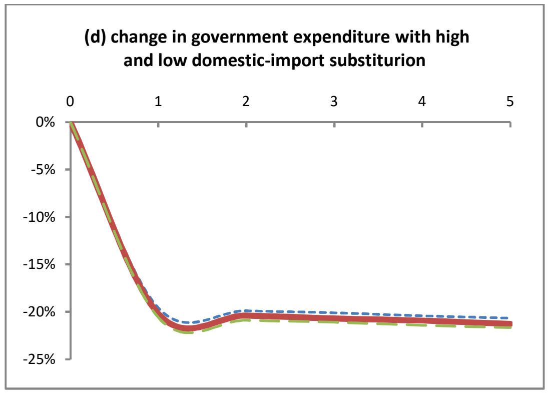
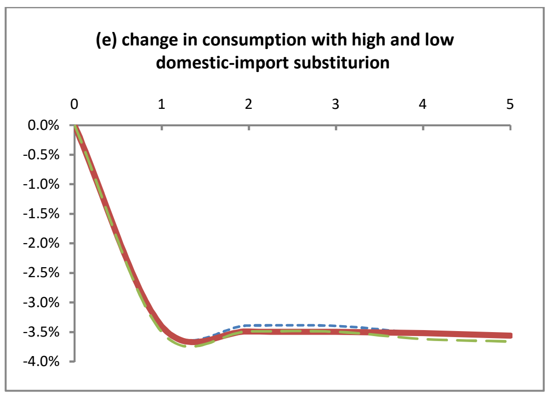
Appendix: Figures of macroeconomic changes after oil export shocks

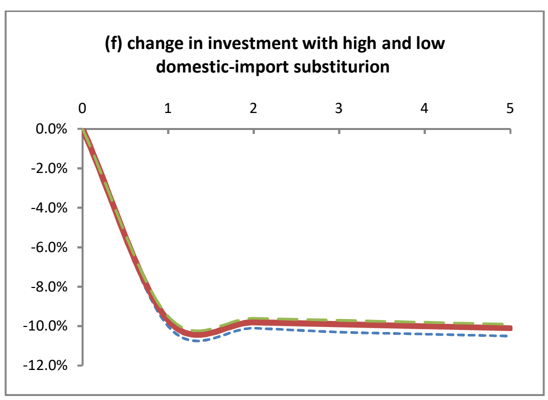







(d) change in government expenditure with high and low domestic-import substiturion
0
1
2
3
4
5
0%
-5%
-10%
-15%
-20%
-25%


(e) change in consumption with high and low domestic-import substiturion
0
1
2
3
4
5
0.0%
-0.5%
-1.0%
-1.5%
-2.0%
-2.5%
-3.0%
-3.5%
-4.0%


(f) change in investment with high and low domestic-import substiturion
0
1
2
3
4
5
0.0%
-2.0%
-4.0%
-6.0%
-8.0%
-10.0%
-12.0%