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Economic Sanction Games among the US, the EU and Russia: Payoffs and Potential Effects ①

Abstract

Economic sanction of the US and EU on Russia because of Ukraine crisis in 2014 lasts for a long time and is still a hot policy topic. This paper uses a 16-country or region numerical general equilibrium model with trade cost and exogenous trade imbalance to explore this three-country economic sanction game payoffs, and simulate the effects of sanctions on individual countries. Our analysis find that all sanction involved countries will be hurt, but comparatively Russia will be hurt more, and the US and EU will be hurt less. Sanction measures of EU have larger impacts to Russia than the US measures, and meanwhile Russian counter-sanction measures will generate larger impacts on the EU than on the US. From the economic perspective, the optimal choice for US and EU is to give up sanction measures to Russia, and retaliation is Russia's optimal choice when faced with sanction measures. Countries out of the sanction game will gain because of trade diversion effects.

Keywords: Economic Sanction; Game Solution; Numerical General Equilibrium; Economic Effects
JEL Classifications: F51; D58; D74

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1. Introduction

The Russian military intervention in Ukraine, which began in late February 2014, prompted a number of governments to apply sanctions against individuals, businesses and officials from Russia. These sanctions were mainly from the European Union (EU) and the United States (US). Russia has responded with counter sanctions against them, including a total ban on food imports from the EU, the US, Norway, Canada and Australia. The sanction and retaliation measures of the US and EU to Russia lasted for several years up to now. Recently on June 14 2017, the US Senate passed a bill imposing sanctions on Russia in response to Russia's involvement in presidential election. Meanwhile, the EU reiterated their stance on sanctions against Russia on this year's G7 summit in May 2017. Therefore the economic sanction among the US, EU and Russia is a hot topic in policy side. Based on these backgrounds, this paper focuses on how these different sanction measures influence involved countries and non-involved countries, and what are the payoffs to the sanction game.

Existing literatures on economic sanctions among US, EU and Russia are mainly analytical, few of them has ever used numerical methods to explore the sanction game payoffs and its influence to individual countries. Galbert (2015) assesses the outcome and future of Russia sanctions from a European perspective. Dreyer and Popescu (2014) analyzes the effects and possible impacts of sanctions against Russian. Oxenstierna and Olsson (2015) comprehensively studies the impacts and prospects of the economic sanctions against Russia with analytical methodology. ICC (2015) studies the potential impact of the EU sanctions against Russia on international arbitration administered by EU-based institutions. Nelson (2015) generally analyzes economic implications of the US sanctions on Russia. Some literatures analyze economic sanction from a theoretical perspective. Kaempfer and Lowenberg (1988) uses a public choice approach to study the theory of international economic sanction. This paper uses numerical general equilibrium modelling and simulation methodology to compute sanction game payoffs and then to explore the influences of economic sanctions. The methodology is new in sanction literatures and the results are important for policy.

The US and EU sanctions against Russia and Russia's counter sanctions are cycle, incremental, step-by step, and from soft sanctions to hard sanctions. From March 2014 to now, there are about three rounds of sanctions and counter sanctions among the US, the EU and Russia. The first round is the threat stage, the US and the EU use restrictive measures, mainly asset freezes and visa bans on selected individuals, to send a strong message to the Russian government that there are consequences for their actions that violate the sovereignty and territorial integrity of Ukraine is prepared to take additional steps to impose further political and economic costs. The second round is that the US and EU use concrete measures to increase Russia's political isolation as well as the economic costs to Russia, especially in areas of importance to Russia economy, the measures include import bans on Russia's energy and defense sectors, embargo on the import and export of arms, exports bans on certain energy-related equipment and technology to Russia and financial sanctions. The third round began from July 2014 to now. In response to the escalating War in Donbass, on 17 July 2014 the US extended its transactions ban to two major Russian energy firms and two banks. After that a series of EU countries take more tighten sanctions to Russia. Even though in June 2015 the G7 collectively extended sanctions already in place for an additional six months (Wikipedia, 2015). Russia's counter actions include travel bans, import ban on food from western countries, and import bans on used cars, clothes and consumer products in the first two stages. The economic sanction and counter sanction game among the US, the EU and Russia is in developing and will last a long time. So it is valuable to explore the impacts of this sanction game numerically.

We set up a three-round sequential game to analogue this sanction process and explore its possible influence. We compute payoffs for all game tree points, and explore the game equilibriums and simulate the sanction game impacts. We assume the three-round game are separately soft sanction round, hard sanction round and forbidden sanction round. Each round sanction has seven choice of game points. Sanction and counter-sanction measures include tariff, non-tariff, and capital flow control. In this paper, we construct a 16-country or region global general equilibrium model including fixed trade imbalance, controlled capital flow and trade cost. Controlled capital flow assumption can help to explore the capital control effects, and trade cost structure is helpful to explore the effects of tariff and non-tariff barriers. Some sanction measures are hard to modelling in the general equilibrium structure, so our analysis focus on trade sanction measures.

We use the numerical general equilibrium model calibration and simulation methodology to compute payoffs for game tree points, and then to explore the sanction game influences to individual countries. Our numerical model has 16 countries or regions or regions, which are the US, the EU, Russia, China, Japan, Korea, Canada, Mexico, India, AN (Australia and New Zealand), CP (Chile and Peru), BMSV (Brunei, Malaysia, Singapore, and Vietnam), CILMPT (Cambodia, Indonesia, Laos, Myanmar, Philippine, and Thailand), ODDC (other developed countries, including Switzerland, Norway, Israel, and Iceland), ODC (other developing countries, including Brazil, Egypt, Argentina, and South Africa), and ROW (the rest of the world). Each country produces two goods which are tradable manufacturing goods and non-tradable non-manufacturing goods with two factors (labor and capital).

Our numerical analysis find that sanction and counter-sanction measures among the US, the EU and Russia will definitely hurt all sanction involved countries, but benefit all non-involved countries. For the US and EU, their optimal choices from the economic perspective are giving up sanction measures. The optimal choice for Russia is retaliating when faced with sanction measures. The impacts of sanctions to different countries are different. Negative impacts to the US and EU are comparatively small compared with their economic scale, so they are not afraid of Russia's counter sanction threat. But negative impacts of sanction to Russia is large compared with her economic scale, which means that Russia will be heavily hurt by economic sanction from the US and EU. The EU sanction measures will generate more effects to Russia than the US measures, meanwhile Russia's counter sanction measures will hurt the EU more than the US. Additionally, soft sanctions have less influence than hard sanctions, and hard sanctions have less impact than forbidden sanctions. The negative influences to involved countries under optimal sanction are less than under arbitrary sanction.

2. A Game of Sequential Economic Sanction

We assume and build the sanction game according to the economic sanction facts among the US, the EU and Russia. In order to capture the full picture of the US and EU take sanction measures to Russia and Russia retaliate, and consider all possible policy choices by these three countries, we set up a three-round sanction-counter game, the sanctions are incrementally intensified. In this three-country economic sanction game, the senders are the US and EU, and the responder is Russia. The US and EU punish Russia, and Russia choose to retaliate.

The first round is the soft sanction game, the second round is the hard sanction game, and the third round is the forbidden sanction game. Each stage of the game is the same in theory, the difference is only in sanction degree/level (tariff level) and they are a sequential game. Each round of the games involves three players, the US, the EU and Russia. We assume that the US and EU are sanction initiation countries and they decide whether or not to take sanction measures to Russia, and Russia is the counter country and she decides whether or not to take counter retaliation measures. We also assume that Russia will take symmetric counter actions, which means Russia will retaliate the country who take sanction measures to her at the same sanction level but will not retaliate the countries without sanction measures to her. We further assume that this three-round sanction-counter game is a sequential game. Only at the situation that the US and EU take sanction measures simultaneously to Russia and meanwhile Russia retaliate, then the three players enter the second round sanction game, and the same assumption to the third round sanction game. In each round of the games, each player only has two action choices. For the US and EU, their two actions are Sanction (we denote it as S) and Non-Sanction (we denote it as NS). Russia's two action choices are Counter-Sanction (we denote it as CS) and Non-Counter-Sanction (we denote it as NCS).

Specifically, in the first round of the game, we assume a three-step action process. The first step is for the US to decide whether to sanction or not, the second step is for the EU to decide whether to sanction or not, the third stage is for Russia to decide whether to counter-sanction or not. Therefore, in each round of the game, there are 8 different decision choices (see Figure 1). We define them as follows:

The First Round Game: Soft Sanction

O11 = (US: S; EU: S; Russia: CS); O12 = (US: S; EU: S; Russia: NCS);
O13 = (US: S; EU: NS; Russia: CS); O14 = (US: S; EU: NS; Russia: NCS);
O15 = (US: NS; EU: S; Russia: CS); O16 = (US: NS; EU: S; Russia: NCS);
O17 = (US: NS; EU: NS; Russia: NCS);

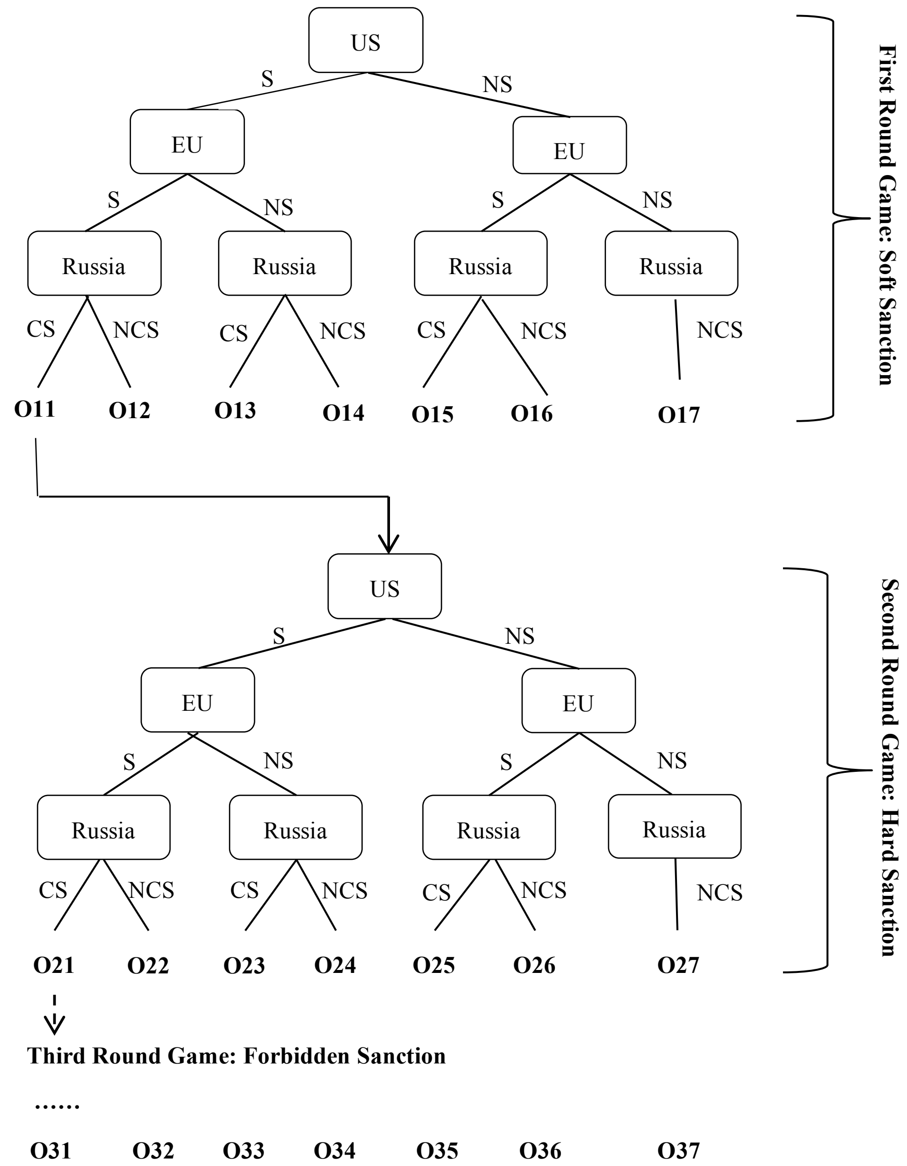
The Second Round Game: Hard Sanction

O21 = (US: S; EU: S; Russia: CS); O22 = (US: S; EU: S; Russia: NCS);
O23 = (US: S; EU: NS; Russia: CS); O24 = (US: S; EU: NS; Russia: NCS);
O25 = (US: NS; EU: S; Russia: CS); O26 = (US: NS; EU: S; Russia: NCS);
O27 = (US: NS; EU: NS; Russian: NCS);

The Third Round Game: Forbidden Sanction

O31 = (US: S; EU: S; Russia: CS); O32 = (US: S; EU: S; Russia: NCS);
O33 = (US: S; EU: NS; Russia: CS); O34 = (US: S; EU: NS; Russia: NCS);
O35 = (US: NS; EU: S; Russia: CS); O36 = (US: NS; EU: S; Russia: NCS);
O37 = (US: NS; EU: NS; Russia: NCS);

Figure 1: The US, the EU and Russia Sanction-Counter Game



Source: by authors.

3. A GE Model with Economic Sanction

3.1 Basic Set-up of the Model

We use a global general equilibrium model with an exogenous trade imbalance and trade barriers based on trade costs to compute game payoffs and effects of economic sanctions.

Let $N=\{1,2,\cdots n\}$ be the set of n countries $(n\geq 3)$, each of which is populated by identical consumers who consume a manufacturing goods and a non-manufacturing goods. We assume manufacturing goods is tradable and non-manufacturing goods is non-tradable. The two factors in each country are labor and capital, which are mobile between but immobile among countries.

Production

Output of each goods l produced by country i is given by

$$Q_i^l=\phi_i^l[\delta_i^l(L_i^l)^{\frac{\sigma_i^l-1}{\sigma_i^l}}+(1-\delta_i^l)(K_i^l)^{\frac{\sigma_i^l-1}{\sigma_i^l}}]^{\frac{\sigma_i^l}{\sigma_i^l-1}},\qquad i=country,l=goods \tag{1}$$

where L_i^l and K_i^l denote labor and capital respectively, used in the production of goods l. First order conditions imply the factor input demand equations.

Consumption

On the consumption side, we use the Armington assumption of product heterogeneity across countries, and use a nested CES utility function for each country

$$U_i(X_i^M,X_i^{NM})=[\alpha_{i1}^{\frac{1}{\sigma_i}}(X_i^M)^{\frac{\sigma_i-1}{\sigma_i}}+\alpha_{i2}^{\frac{1}{\sigma_i}}(X_i^{NM})^{\frac{\sigma_i-1}{\sigma_i}}]^{\frac{\sigma_i}{\sigma_i-1}},\quad i=country \tag{2}$$

where X_i^{NM} denotes the consumption of non-manufacturing goods in country i, X_i^M denotes the consumption of composite Armington manufacturing goods in country i. Additionally α_{i1} and α_{i2} are share parameters and σ_i is the top level elasticity of substitution in consumption.

The composite manufacturing goods is defined as another reflecting the country from which goods come. We assume this level 2 composite consumption is also of CES form and represented as

$$X_i^M=[\sum_j\beta_{ij}^{\frac{1}{\sigma_i'}}x_{ij}^{M\,\frac{\sigma_i'-1}{\sigma_i'}}]^{\frac{\sigma_i'}{\sigma_i'-1}},\quad j=country \tag{3}$$

where x_{ij}^M is the consumption of manufacturing goods from country j in country i. If $i=j$ this implies that this country consumes its domestically produced tradable goods. β_{ij} is the share parameter for country $j's$ manufacturing goods consumed in country i. $\sigma_i^{'}$ is the elasticity of substitution in level 2 preferences in country i.

The utility optimization problem above yields

$$X_i^M = \frac{\alpha_{i1} E_i}{(P_i^M)^{\sigma} [\alpha_{i1} (P_i^M)^{1-\sigma} + \alpha_{i2} (pc_i^{NM})^{1-\sigma}]} \tag{4}$$

$$X_i^{NM} = \frac{\alpha_{i2} E_i}{(pc_i^{NM})^{\sigma} [\alpha_{i1} (P_i^M)^{1-\sigma} + \alpha_{i2} (pc_i^{NM})^{1-\sigma}]} \tag{5}$$

where P_i^M and pc_i^{NM} are the separate consumption prices of composite manufacturing goods and non-manufacturing goods in country i. E_i is the total consumption expenditure of country i. For the composite manufacturing goods which enter the second level preferences and come from different countries, the country specific demands are

$$x_{ij}^M = \frac{\beta_{ij} (X_i^M P_i^M)}{(pc_{ij}^M)^{\sigma_i^{'}} [\sum_j \beta_{ij} (pc_{ij}^M)^{(1-\sigma_i^{'})}]} \tag{6}$$

where pc_{ij}^M is the consumption price in country i of manufacturing goods produced in country j, $X_i^M P_i^M$ is the total expenditure on manufacturing goods in country i. Consumption price of the composite manufacturing goods is

$$P_i^M = [\sum_{j=1}^{N} \beta_{ij} (pc_{ij}^M)^{(1-\sigma_i^{'})}]^{\frac{1}{1-\sigma_i^{'}}} \tag{7}$$

and the total consumption expenditure of country i is

$$E_i = P_i^M X_i^N + pc_i^{NM} X_i^{NM} \tag{8}$$

<u>Trade Cost</u>

We add trade cost into our model, which can be divided into import tariff and non-tariff barrier. We denote the import tariff in country i as t_i, and non-tariff trade barrier as N_{ij} (ad volume tariff-equivalent non-tariff barrier for country i imported from country j). This yields the following relationship between consumption price and production price in country i for country $j's$ export,

$$pc_{ij}^{M} = (1 + t_i + N_{ij}) p_j^M \quad (9)$$

Where p_j^M is the production price of manufacturing goods in country j. We assume trade costs are covered by importing country. Import tariffs generate revenue R_i, which are given by

$$R_i = \sum_{j, i \neq j} p_j^M x_{ij}^M t_i \quad (10)$$

Non-tariff barriers generate no revenue, and importers need to use real resources to cover the costs involved. In the model, we assume that these resource costs are denominated in terms of domestic non-manufacturing goods. We incorporate this resource using feature through use of non-manufacturing goods equal in value terms to the cost of barriers. We assume reduced non-tariff barrier (including transportation cost) will thus occur under trade liberalization as an increase in non-manufacturing goods consumption NR_i by the representative consumer in importing countries, where

$$NR_i = \sum_{j, i \neq j} p_j^M x_{ij}^M N_{ij} \quad (11)$$

Market Clearing Conditions

Equilibrium in the model characterized by market clearing prices for goods and factors in each country such that

$$Q_i^M = \sum_j x_{ji}^M \quad (12)$$

$$Q_i^{NM} = \frac{NR_i}{p_i^{NM}} + X_i^{NM} \quad (13)$$

$$\sum_l K_i^l = \overline{K_i} \;, \quad \sum_l L_i^l = \overline{L_i} \quad (14)$$

For the trade clearance, we assume an exogenously determined fixed trade imbalance, denoted as S_i, which will be positive when in trade surplus and negative when in trade deficit. Trade equilibrium will influence individual country's budget constraint. In the equilibrium, we have

$$I_i = E_i + S_i \qquad (15)$$

which means that one country's total income equals its total consumption expenditure plus its surplus (trade imbalance), if one country has trade surplus then its income will more than consumption expenditure, but if one country has trade deficit then its income will be less than consumption expenditure.

In the equilibrium, the representative consumer's income in country i is given by

$$w_i^K \overline{K_i} + w_i^L \overline{L_i} + R_i = I_i \qquad (16)$$

A zero profit condition must also be satisfied in each industry in each country, such that

$$p_i^l Q_i^l = w_i^K K_i^l + w_i^L L_i^l \qquad l = M, NM \qquad (17)$$

3.2 Economic Sanctions

According to the real economic sanctions among the US, the EU and Russia, two main kinds of measures are taken by these three countries. One is the tariff and non-tariff barrier sanction, and the other is financial sanctions like controlling capital flow.

In order to capture the effects of both trade barrier sanction and financial sanction, our multi-country global general equilibrium model has included relevant structure to explore the both sanction measures. Firstly, we have included trade cost structure into the model which can be divided into tariff and non-tariff barrier, and so that can explore the tariff and non-tariff barrier sanction effects. Secondly, we have included a fixed trade imbalance assumption in the model, and the model does not permit freely capital flow so as to explore the financial sanction. Under this assumption, capital flow is forbidden in the model which fit for the capital flow control sanction between the US, the EU and Russia.

In our multi-country global general equilibrium model, the assumption of capital control have been included. So we focus on the trade related economic sanctions including both tariff and non-tariff. In our model, they are separately t_i and N_{ij}.

In the equilibrium, the total utility of representative consumer in country i equals to

$$U_i = I_i \times [\alpha_{i1}(P_i^M)^{1-\sigma_i} + \alpha_{i2}(pc_i^{NM})^{1-\sigma_i}]^{\frac{1}{\sigma_i - 1}} \tag{18}$$

We take the equation of I_i and P_i^M into the utility equation and get

$$U_i = \{w_i^K \overline{K_i} + w_i^L \overline{L_i} + [\sum_{j,i \neq j}^{N} p_j^M \frac{\beta_{ij}(\sum_j \beta_{ij}^{\frac{1}{\sigma_i'}} x_{ij}^{M\,\frac{\sigma_i'-1}{\sigma_i'}})^{\frac{\sigma_i'}{\sigma_i'-1}}}{(pc_{ij}^M p_j^M)^{\sigma_i'}} \times [\sum_{j=1}^{N} \beta_{ij}(pc_{ij}^M)^{(1-\sigma_i')}]^{\frac{\sigma_i'}{1-\sigma_i'}} t_i\} \times$$
$$[\alpha_{i1}([\sum_{j=1}^{N} \beta_{ij}(pc_{ij}^M)^{(1-\sigma_i')}]^{\frac{1}{1-\sigma_i'}})^{1-\sigma_i} + \alpha_{i2}(pc_i^{NM})^{1-\sigma_i}]^{\frac{1}{\sigma_i - 1}} \tag{19}$$

As $pc_{ij}^M = (1 + t_i + N_{ij})p_j^M$, so tariff and non-tariff barrier will undoubtedly influence the welfare of country i. This means that one country can use tariff and non-tariff barrier as economic sanction weapons to force other countries to concede in negotiation.

4. Numerical Model Data and Parameters Calibration

We build a 16-coountry or region numerical general equilibrium model using above model structure. These sixteen countries are the US, the EU, Russia, China, Japan, Korea, Canada, Mexico, India, AN (Australia and New Zealand), CP (Chile and Peru), BMSV (Brunei, Malaysia, Singapore, and Vietnam), CILMPT (Cambodia, Indonesia, Laos, Myanmar, Philippine, and Thailand), ODDC (other developed countries, including Switzerland, Norway, Israel, and Iceland), ODC (other developing countries, including Brazil, Egypt, Argentina, and South Africa), and ROW (the rest of the world). These 16 countries or regions include most economically large individual countries and some geographically nearby country groups, we have also considered the need for future research to choose this 16-country or region structure.

4.1 Data and Calibration

We use 2011 as our base year in building a benchmark general equilibrium dataset for use in calibration and simulation following the methods set out in Shoven and Whalley (1992). We use world values minus all individual countries to generate ROW values. For the two goods, we assume secondary industry (manufacturing) reflects manufacturing goods, and primary and tertiary industries (agriculture, extractive industries, and services) yield non-manufacturing goods. For the two factor inputs, capital and labor, we use total labor income (wage) to denote labor values for inputs by sectors. All data are in billion US dollars. We adjust some of the data values for mutual consistency for calibration purposes.

EU data is from EU statistics, and the currency unit is Euro, we use annual average exchange rate to change them into US dollar; Other countries' data are all calculated from WDI of World Bank database. We use agriculture and service share of GDP data and GDP data to yield production data of manufacturing goods and non-manufacturing goods, and use capital/GDP ratio to yield capital and labor input in production. Trade data between each pair of countries are from the UN Comtrade database. We use individual country total export and import values to indirectly yield exports to and imports from the ROW. Using production and trade data, we can then calculate each country's consumption values.

We divide trade costs into two parts, import tariffs and non-tariff barriers. We obtain each country's import tariff data from WTO Statistics Database. For ROW, we use EU's tariff rate to denote these values. We calculate non-tariff barriers by using trade costs minus import tariffs.

There are no available estimates of elasticities for individual countries on the demand and production sides of the model. We set all these elasticities in our model to 2 following Whalley and Wang (2010). We change these elasticities later in sensitivity analysis to check their influence on simulation results.

With these data, we calibrate the model parameters. When used in model solution these will regenerate the benchmark data as an equilibrium for the model. Then, using these parameters we can simulate the game equilibrium and explore effects of sanction games among the US, the EU and Russia.

4.2 Trade Cost Calculation

We report our calculations of trade cost in this part which provides trade cost estimates for use in our general equilibrium model. The methodology we use is from Novy (2013) and Wong (2012). We calculate and report ad valorem tariff-equivalent trade costs between countries.

The measure of trade barriers used here is based on the gravity equation derived from Chaney's (2008) model of heterogeneous firms with bilateral fixed costs of exporting. Trade barriers can take two forms in the model, a variable trade barrier τ_{ir} and a fixed cost of exporting F_{ir}. The variable trade barrier τ_{ir} is an iceberg cost. In order to deliver one unit of good to i from r, $\tau_{ir} > 1$ unit of good has to be delivered. The gravity equation supported by this model is:

$$X_{ir} = \frac{Y_i \times Y_r}{Y} \left(\frac{w_r \tau_{ir}}{\theta_i}\right)^{-\gamma} F_{ir}^{-\left(\frac{\gamma}{\sigma-1}-1\right)} \tag{20}$$

Where X_{ir} is import of country i from country r. Y_i, Y_r and Y are the economic sizes of both countries and the total world, w_r is labor costs, τ_{ir} is variable trade costs and F_{ir} is the fixed cost of exporting. The

Pareto parameter γ governs the distribution of firm productivities. σ is the elasticity of substitution in preferences. θ_i is a remoteness measure for the importing country which captures trade diversion effects. The mechanism is that the further away i is from the rest of the world, the more likely that r could export more to i due to less competition from third party countries in the importer country. This has a similar interpretation to the multilateral resistance term in Anderson and Wincoop (2003).

We can relate data on trade flows to unobservable trade barriers by taking ratios of bilateral trade flows of two regions over local purchases of each of two countries:

$$\frac{X_{ir}X_{ri}}{X_{ii}X_{rr}} = \left(\frac{\tau_{ri}\tau_{ir}}{\tau_{ii}\tau_{rr}}\right)^{-\gamma}\left(\frac{F_{ri}F_{ir}}{F_{ii}F_{rr}}\right)^{-\left(\frac{\gamma}{\sigma-1}-1\right)} \quad (21)$$

This equation reveals the relationship between observable trade data and unobservable trade barriers and eliminates the need to worry about the omission of unspecified or unobserved trade barriers. If the fixed costs of exporting are not bilaterally differentiated ($F_{ri} = F_r$) or is they are constant across locations ($F_{ri} = F$), the fixed costs drop out of this measure and the measured trade costs would simply be interpreted as variable trade costs, as in models without fixed export costs such as Eaton and Kortum (2002) and Anderson and Wincoop (2003).

For simplicity of exposition, we normalize domestic trade costs to 1, i.e. $\tau_{ii} = 1$ and $F_{ii} = 1$. Defining the geometric average of trade costs between the country pair i and r as

$$t_{ir} = \left(\frac{X_{ii}X_{rr}}{X_{ir}X_{ri}}\right)^{\frac{1}{2\gamma}} = (\tau_{ir}\tau_{ri})^{\frac{1}{2}}(F_{ri}F_{ir})^{\frac{1}{2}\left(\frac{1}{\sigma-1}-\frac{1}{\gamma}\right)} \quad (22)$$

Data for this equation is relatively easy to obtain, and so we have a comprehensive measure of trade barriers, and the ad valorem tariff-equivalent bilateral average trade cost between country i and r can be written as

$$\bar{t}_{ir} = t_{ir} - 1 = \left(\frac{X_{ii}X_{rr}}{X_{ir}X_{ri}}\right)^{\frac{1}{2\gamma}} - 1 \quad (23)$$

Using the trade costs equation above, we can calculate actual trade costs between countries in our general equilibrium model, which are needed in building a benchmark data set for use in calibration and simulation. We need to calculate trade costs between each country pair for China.

For trade costs, in equation (23), X_{ir} and X_{ri} are separately exports and imports between countries i and r. This trade data is from the UN Comtrade database, and total world trade data is from WTO International

Trade Statistics. Due to market clearing, intranational trade X_{ii} or X_{rr} can be rewritten as total income minus total exports

$$X_{ii} = y_i - X_i \tag{24}$$

where X_i is the total exports, defined as the sum of all exports from country i, which is

$$X_i \equiv \sum_{r, i \neq r} X_{ir} \tag{25}$$

This data is from the UN Comtrade database. For y_i, GDP data are not suitable because they are based on value added, whereas the trade data are reported as gross shipments. In addition, GDP data include services that are not covered by the trade data (Novy, 2013). It is hard to get this income data according to such a definition, so here we use GDP data minus total service value added. We get GDP data from World Bank database, and the service share of GDP data from World Development Indicators (WDI) of World Bank database, we then calculate results for GDP minus services. We take the value of γ to be 8.3 as in Eaton and Kortum (2002).

5. Numerical Analysis of Sanction Game Payoffs and Effects

We solve the three-stage sanction game among the US, the EU and Russia numerically in this part. We focus our analysis on two aspects. One is game payoffs, we compute payoff matrix for each game tree point. The other is the effects of the three-stage economic sanctions.

For the game payoffs, we simulate payoff matrixes for all game points. We use both equivalent variation (EV) and compensation variation (CV) to denote payoffs of sanctions. Equivalent variation refers to the amount of additional money an agent would need to reach its initial utility after a change in prices, or a change in product quality, or the introduction of new products. Compensation variation can be used to find the effect of a price change on an agent's net welfare. CV reflects new prices and the old utility level. EV is a closely related measure that uses old prices and the new utility level. It measures the amount of money a consumer would pay to avoid a price change, before it happens. They have the following equations

$$\begin{cases} EV = e(p^0, v(p^1, m^1)) - e(p^0, v(p^0, m^0)) = e(p^0, v(p^1, m^1)) - m^0 \\ CV = e(p^1, v(p^1, m^1)) - e(p^1, v(p^0, m^0)) = m^1 - e(p^1, v(p^0, m^0)) \end{cases} \tag{26}$$

where 0 denotes former situation, 1 denotes the situation after change. We use the benchmark scenario as former situation and sanction scenario as the situation after change. Then EV and CV can show the welfare changes affected by economic sanctions. For the effects of economic sanctions, we pay attention to the influence on utility, export and import. We separately explore the effects of soft sanction, hard sanction and forbidden sanction to main countries.

As to the sequential three stage sanctions. We define soft sanction as a 20% trade barrier raise and controlled capital flow, hard sanction as a 50% trade barrier raise and controlled capital flow, and forbidden sanction as a 900% trade barrier increase and controlled capital flow. The forbidden sanction is assumed to be no trade, we use a very high trade barrier of 900% to denote this situation for simplicity. These soft, hard and forbidden sanction tariff levels are mostly assumptions according to true sanction measures, not accurate sanction tariffs with calculation.

5.1 Three-Stage Game Payoffs with EV and CV

We have assumed a three-stage sequential game among the US, the EU and Russia. For each stage game, there are seven game tree points which we have already denoted them in the previous part. We simulate and compute payoffs for each point in the game tree. EV is used to be the main indicator of payoffs, and we use CV to compare the results for robustness.

Payoff matrix for all game points are listed in Table 1. We find that mutual economic sanctions will hurt all involved countries, comparatively the negative impacts of forbidden sanctions are larger than hard sanctions, and the negative effects of hard sanctions are larger than soft sanctions. These loss by trade sanctions are caused by decreased trade among sanction and retaliation countries. On the country side, if the US and EU both take sanction measures to Russia, and Russia retaliate to both the US and EU, all three involved countries will hurt. Specifically, Russia will be hurt the most, then will be the EU, and the US will receive the least impact. The reason for these results is that Russia's trade relied more on the US and EU. Meanwhile, the effects of the EU's sanction measures to Russia is significant and severe, comparatively the negative impacts of the US sanction to Russia is weak, which are also caused by mutual trade relations and economic scale of these countries. The effects of Russia's retaliation to the EU are much more significant than to the US.

Therefore, economic sanction and retaliation measures will hurt all involved countries. The optimal game tree point for the US is that the EU take sanction measures to Russia and Russia retaliate to the EU but the US does not take sanction measures, then the US can gain from mutual sanctions between the EU and Russia. The optimal game tree point for the EU is that the US take sanction measures and Russia retaliate to the US but the EU does not take sanction measures. The optimal game tree point for Russia is that all three country groups take free trade, but if the US or EU or both took sanction measures, Russia's optimal choice is retaliation. From the sanction game payoffs, it is not wise for the US and EU to take sanction measures to Russia; although they can hurt Russia more, but these sanction and retaliation measures also will hurt the US and EU. Therefore, the purpose of sanction measures is to force Russia to make concessions in political field. Faced with sanction measures, the Russia's best choice is retaliation, so the Russia has been forced to passively choose revenge. For the equilibrium of the game, if we do not think of political purpose, the equilibrium should be this three countries do not take any sanction or retaliation measures; but after introduced the political purpose, the equilibrium will be the US and EU take sanction measures to Russia and Russia retaliate.

Table 1: Game Payoffs with EV (Unit: Billion US$)

Country	O11	O12	O13	O14	O15	O16	O17
US	-2.335	-1.562	-2.600	-1.617	0.355	0.255	0
EU	-13.717	-3.647	0.276	0.478	-13.98	-4.108	0
Russian	-25.316	-23.035	-2.756	-1.855	-22.587	-21.147	0
Country	**O21**	**O22**	**O23**	**O24**	**O25**	**O26**	**O27**
US	-6.191	-5.176	-6.438	-4.716	-1.637	-1.828	-2.335
EU	-41.660	-22.479	-13.181	-12.856	-42.108	-23.200	-13.717
Russian	-76.185	-75.76	-29.686	-28.71	-71.924	-72.179	-25.316
Country	**O31**	**O32**	**O33**	**O34**	**O35**	**O36**	**O37**
US	-5.909	-6.079	-4.728	-1.488	-1.135	0.201	-6.191
EU	-46.401	-24.841	-28.289	-28.002	-45.83	-22.692	-41.66
Russian	-161.537	-221.723	-56.917	-61.286	-158.689	-212.199	-76.185

Source: compiled by authors.

We use CV to recalculate payoffs for the game and to check the robustness of game payoffs with EV. All results are reported in Table 2. We find that all results are close to the results of EV. So above results are reliable.

Table 2: Game Payoffs with CV (Unit: Billion US$)

Country	O11	O12	O13	O14	O15	O16	O17
US	-2.707	-1.813	-3.132	-2.128	0.339	0.198	0
EU	-15.25	-4.303	0.276	0.473	-15.576	-4.89	0
Russian	-27.995	-23.277	-3.215	-1.856	-24.719	-21.356	0
Country	**O21**	**O22**	**O23**	**O24**	**O25**	**O26**	**O27**
US	-10.423	-8.519	-11.949	-10.113	-1.73	-1.873	-2.707
EU	-61.607	-34.992	-14.592	-14.072	-62.624	-36.838	-15.25
Russian	-108.435	-83.253	-37.232	-31.609	-98.839	-79.293	-27.995
Country	**O31**	**O32**	**O33**	**O34**	**O35**	**O36**	**O37**
US	-162.46	-144.326	-209.946	-205.315	-1.384	-1.387	-10.423
EU	-1258.479	-1066.428	-36.045	-34.953	-1285.441	-1101.065	-61.607
Russian	-1373.883	-275.705	-251.324	-76.718	-1186.001	-263.942	-108.435

Source: compiled by authors.

In general, economic sanctions among the US, the EU and Russia will hurt all involved countries. The US's sanction threats to Russia are weaker than the EU's, and the Russia's retaliation to the EU has much larger negative influence than the retaliation to the US. When Russia receives economic sanction measures, her optimal choice is retaliation.

5.2 Sensitivity Analysis to Elasticities for Game Payoffs

We perform sensitivity analysis for game payoffs to elasticities in this part. In our main numerical simulation model, we choose elasticities to equal 2. Here we assume elasticities to separately equal 1.5 and 2.5 to compare game solution results. For simplicity, we just perform sensitivity analysis to the second round game (hard sanction). Results are shown in Table 3.

Sensitivity analysis results reveal that as the elasticities of substitution increase, negative effects of economic sanction and retaliation will decrease for the US and Russia, and will increase for the EU. The influence direction of the impacts are the same.

Table 3: Sensitivity Analysis of Hard Sanction Game Payoffs to Elasticities (Unit: % Change)

Countries	O21	O22	O23	O24	O25	O26	O27	O21	O22	O23	O24	O25	O26	O27
				EV, E=1.5							CV, E=1.5			
US	-7.39	-6.049	-7.735	-5.718	-2.147	-2.329	-2.85	-10.651	-8.44	-12.162	-10.01	-2.209	-2.386	-3.134
EU	-41.303	-17.093	-12.846	-12.243	-41.848	-18.235	-13.393	-55.799	-24.74	-13.888	-13.094	-56.801	-26.836	-14.533
Russian	-84.564	-86.503	-31.897	-30.941	-79.476	-82.112	-26.753	-111.25	-92.269	-38.209	-33.423	-101.72	-87.655	-29.038
				EV, E=2.0							CV, E=2.0			
US	-6.191	-5.176	-6.438	-4.716	-1.637	-1.828	-2.335	-10.423	-8.519	-11.949	-10.113	-1.73	-1.873	-2.707
EU	-41.66	-22.479	-13.181	-12.856	-42.108	-23.2	-13.717	-61.607	-34.992	-14.592	-14.072	-62.624	-36.838	-15.25
Russian	-76.185	-75.76	-29.686	-28.71	-71.924	-72.179	-25.316	-108.44	-83.253	-37.232	-31.609	-98.839	-79.293	-27.995
				EV, E=2.5							CV, E=2.5			
US	-5.152	-4.349	-5.302	-3.781	-1.267	-1.458	-1.921	-10.229	-8.526	-11.74	-10.119	-1.395	-1.505	-2.377
EU	-40.14	-23.98	-13.041	-12.846	-40.491	-24.441	-13.539	-65.09	-41.015	-14.802	-14.407	-66.092	-42.728	-15.44
Russian	-70.204	-69.568	-28.195	-27.425	-66.657	-66.469	-24.511	-107.42	-78.421	-36.842	-30.736	-97.788	-74.845	-27.584

Source: Compiled by authors.

5.3 Three-Stage Game Payoffs with EV and CV as a Share of GDP

EV and CV show an absolute value change of welfare but cannot reveal the comparative burden of the welfare change. We use EV and CV as a share of GDP to show the comparative influences of sanction games to involved countries. These indicators can reveal whether the influence is huge to the country or not. We set EV as a share of GDP to indicate our main results, and use CV as a share of GDP as a robustness check indicator.

Table 4 reports payoffs for game payoffs. We find that impacts to both the US and EU are small compared with their economic scale, especially for the influence to the US. The reason is that their trade scale with Russia is small. This result can explain why the US and EU are not afraid of retaliations and negative impacts. But the influences to Russia are significantly large and will hurt Russia heavily.

Table 4: Game Payoffs with EV as a Share of GDP (Unit: %)

Country	**O11**	**O12**	**O13**	**O14**	**O15**	**O16**	**O17**
US	-0.016	-0.011	-0.018	-0.011	0.002	0.002	0
EU	-0.083	-0.022	0.002	0.003	-0.084	-0.025	0
Russian	-1.45	-1.313	-0.158	-0.106	-1.294	-1.206	0
Country	**O21**	**O22**	**O23**	**O24**	**O25**	**O26**	**O27**
US	-0.043	-0.036	-0.045	-0.033	-0.011	-0.013	-0.016
EU	-0.251	-0.136	-0.079	-0.077	-0.254	-0.14	-0.083
Russian	-4.351	-4.288	-1.700	-1.643	-4.11	-4.089	-1.45
Country	**O31**	**O32**	**O33**	**O34**	**O35**	**O36**	**O37**
US	-0.041	-0.043	-0.033	-0.01	-0.008	0.001	-0.043
EU	-0.279	-0.15	-0.17	-0.169	-0.276	-0.137	-0.251
Russian	-8.863	-12.173	-3.242	-3.5	-8.744	-11.674	-4.351

Source: compiled by authors.

The influences of forbidden sanctions are larger than hard sanctions, and the impacts of hard sanctions are larger than soft sanctions, these results are obvious. For individual countries, the optimal choice for both the US and EU are free trade and have no sanction measures to Russia, the optimal choice for Russia is retaliation when the US and EU take sanction measures.

Table 5: Game Payoffs with CV as a Share of GDP (Unit: %)

Country	**O11**	**O12**	**O13**	**O14**	**O15**	**O16**	**O17**
US	-0.019	-0.013	-0.022	-0.015	0.002	0.001	0
EU	-0.092	-0.026	0.002	0.003	-0.094	-0.029	0
Russian	-1.604	-1.327	-0.184	-0.106	-1.416	-1.218	0
Country	**O21**	**O22**	**O23**	**O24**	**O25**	**O26**	**O27**
US	-0.073	-0.06	-0.084	-0.071	-0.012	-0.013	-0.019

EU	-0.371	-0.211	-0.088	-0.085	-0.377	-0.222	-0.092
Russian	-6.193	-4.712	-2.132	-1.809	-5.648	-4.492	-1.604
Country	**O31**	**O32**	**O33**	**O34**	**O35**	**O36**	**O37**
US	-1.14	-1.013	-1.473	-1.44	-0.01	-0.01	-0.073
EU	-7.571	-6.426	-0.217	-0.211	-7.733	-6.634	-0.371
Russian	-75.379	-15.137	-14.314	-4.382	-65.347	-14.521	-6.193

Source: compiled by authors.

We use CV as a share of GDP to check the robustness of our results (see Table 5). We find results are close. Negative impacts of sanction and retaliation to the US and EU are comparatively weak, but are strong to Russia.

In general, the economic sanction losses of the US and EU are small compared with their big economic scale, but the loss of Russia are large compared with her own economic scale. Therefore, the economic sanction and retaliation will hurt Russia much more than the US and EU. But faced with sanction, the optimal choice for Russia is retaliation.

5.4 Effects of Soft Sanctions among US, EU and Russia

We explore the impacts of economic sanctions and retaliations among the US, the EU and Russia from this part, and we analyze three different stages of sanctions (soft sanction, hard sanction, and forbidden sanction) one by one. Three aspects of influences are chosen which are utility, export and import. We explore the influences on both sanction involved countries and some other large countries. This part explores the effects of soft sanctions.

Table 6 reports the simulation results. We find that all three sanction involved countries hurt, but almost all other countries gain from the sanction and retaliation measures which may be caused by trade diversion effect. For the sanction involved countries, Russia will be hurt the most. The impacts to the US and EU are small and comparatively the EU will be hurt more than the US, the reason may be that the EU export more to Russia than the US. For other main countries out of the sanction game, most of them will gain. On the utility side, China and Korea will comparatively gain more than other countries. On the export and import side, China, Canada and Mexico can gain comparatively more than other countries, which are caused by economic scale and trade relations.

Table 6: Effects of Soft Sanctions to Major Countries (Unit: % change)

Countries	**O11**	**O12**	**O13**	**O14**	**O15**	**O16**	**O17**
			<u>**Utility**</u>				
US	-0.016	-0.011	-0.018	-0.012	0.002	0.001	0
EU	-0.080	-0.022	0.002	0.003	-0.082	-0.025	0
Russian	-1.541	-1.354	-0.172	-0.107	-1.368	-1.241	0
China	0.012	0.017	0.0008	0.002	0.011	0.015	0
Japan	0.005	0.006	0.0004	0.0007	0.004	0.006	0
Korea	0.022	0.029	0.002	0.002	0.02	0.026	0
Canada	0.003	0.003	0.002	0.003	0.001	-0.0006	0

Mexico	0.007	0.012	0.003	0.007	0.004	0.005	0
India	0.007	0.008	0.0003	0.0005	0.006	0.007	0
			Export				
US	-0.123	0.002	-0.145	-0.037	0.021	0.041	0
EU	-1.098	-0.611	0.003	-0.008	-1.1	-0.602	0
Russian	-4.987	-3.486	-0.439	-0.284	-4.546	-3.196	0
China	0.015	0.018	0.001	0.002	0.014	0.016	0
Japan	0.001	-0.005	0.0009	0.002	0.0004	-0.007	0
Korea	-0.008	-0.025	0.0003	-0.001	-0.008	-0.024	0
Canada	0.022	0.064	0.008	0.033	0.012	0.03	0
Mexico	0.027	0.08	0.009	0.039	0.016	0.04	0
India	0.014	0.03	-0.0008	-0.002	0.015	0.032	0
			Import				
US	-0.082	0.001	-0.097	-0.025	0.014	0.027	0
EU	-0.907	-0.505	0.003	-0.007	-0.91	-0.498	0
Russian	-7.961	-5.565	-0.701	-0.454	-7.257	-5.102	0
China	0.017	0.019	0.001	0.002	0.015	0.017	0
Japan	0.001	-0.005	0.0009	0.002	0.0004	-0.007	0
Korea	-0.009	-0.027	0.0003	-0.001	-0.009	-0.025	0
Canada	0.022	0.064	0.008	0.033	0.012	0.03	0
Mexico	0.027	0.08	0.009	0.039	0.016	0.04	0
India	0.009	0.019	-0.0005	-0.001	0.01	0.021	0

Source: compiled by authors.

We take the game point of both the US and EU take sanction measures and Russia retaliate as an example to specifically compare different effects. On the utility side, the US will lose -0.016%, the EU will lose -0.08%, the Russia will lose -1.541%; it is obvious that the US and the EU lose less and nearly can be neglected, but the negative impacts to Russia is significant. China will gain 0.012%, Japan will gain 0.005%, Korea will gain 0.022%, Canada will gain 0.003%, Mexico will gain 0.007%, and India will gain 0.007%.

5.5 Effects of Hard Sanctions among US, EU and Russia

We then explore the effects of hard sanctions. Table 7 reports all results. It is obvious that hard sanction measures will hurt involved countries more than soft sanction measures, and will benefit non-involved countries more than soft sanction measures. Impacts on individual countries of hard sanctions are the same as the influences of soft sanctions.

All sanction involved countries will be hurt, comparatively Russia will receive heavier impacts than both the US and EU, and the EU will receive more influence to the US. The economic sanction among the US, the EU and Russia will heavily hurt Russia but just slightly hurt the US and EU. All non-involved countries can gain from this sanction game. China and Japan can gain more on utility. Mexico, Canada and China can gain more on both export and import. These general results are the same as soft sanctions, but effects are much larger than the previous one.

We take the export impacts under the situation of US and EU both take sanction measures and Russia retaliate as an example to specifically compare the influence. The exports of sanction involved countries of the US, the EU and Russia are separately -0.317%, -3.435% and -15.642%. China's export increases 0.054%, Japan's export increases 0.005%, Korea's export decreases -0.031%, Canada's export increases about 0.081%, Mexico's export increases 0.101% and India's export increases 0.051%. These specific results are valuable for policy consideration.

Table 7: Effects of Hard Sanctions to Major Countries (Unit: % change)

Countries	O11	O12	O13	O14	O15	O16	O17
				Utility			
US	-0.051	-0.042	-0.056	-0.044	-0.011	-0.012	-0.016
EU	-0.282	-0.157	-0.077	-0.075	-0.286	-0.164	-0.080
Russian	-5.252	-4.715	-1.908	-1.747	-4.88	-4.483	-1.541
China	0.044	0.058	0.014	0.016	0.041	0.053	0.012
Japan	0.018	0.022	0.006	0.006	0.016	0.020	0.005
Korea	0.079	0.102	0.026	0.027	0.075	0.094	0.022
Canada	0.011	0.01	0.008	0.010	0.006	0.003	0.003
Mexico	0.023	0.035	0.013	0.020	0.016	0.020	0.007
India	0.023	0.027	0.007	0.008	0.022	0.026	0.007
				Export			
US	-0.317	-0.086	-0.384	-0.190	-0.064	-0.015	-0.123
EU	-3.435	-2.435	-1.091	-1.110	-3.439	-2.420	-1.098
Russian	-15.642	-12.629	-5.784	-5.508	-14.837	-12.084	-4.987
China	0.054	0.064	0.018	0.019	0.051	0.058	0.015
Japan	0.005	-0.008	0.004	0.005	0.002	-0.012	0.001
Korea	-0.031	-0.067	-0.008	-0.011	-0.031	-0.064	-0.008
Canada	0.081	0.167	0.039	0.084	0.058	0.099	0.022
Mexico	0.101	0.209	0.047	0.102	0.074	0.129	0.027
India	0.051	0.085	0.013	0.011	0.053	0.089	0.014
				Import			
US	-0.211	-0.057	-0.256	-0.126	-0.043	-0.010	-0.082
EU	-2.839	-2.013	-0.902	-0.918	-2.843	-2.000	-0.907
Russian	-24.97	-20.16	-9.232	-8.793	-23.684	-19.289	-7.961
China	0.059	0.07	0.020	0.021	0.056	0.064	0.017
Japan	0.005	-0.007	0.004	0.005	0.002	-0.011	0.001
Korea	-0.033	-0.071	-0.008	-0.012	-0.033	-0.068	-0.009
Canada	0.081	0.167	0.039	0.084	0.058	0.099	0.022
Mexico	0.100	0.209	0.046	0.101	0.074	0.128	0.027

India	0.034	0.056	0.008	0.007	0.035	0.058	0.009

Source: compiled by authors.

5.6 Effects of Forbidden Sanctions among US, EU and Russia

Forbidden sanction is the heaviest sanction and retaliation. Table 8 reports simulation results. The effects of forbidden sanctions are much stronger than hard sanctions. All involved countries lose and all non-involved countries gain. Russia will be hurt heavily, the US and EU are hurt slightly. All non-involved sanction countries will gain, and comparatively China and Korean will gain more than other countries on utility; Mexico, Canada and China can gain more than other countries on both export and import.

We take the utility effects under mutual sanction and retaliation situation as an example to compare impacts on different countries. Effects on the US, the EU and Russia are separately -0.178%, -1.569% and -19.815%. Influences on China, Japan and Korea are separately 0.217%, 0.089% and 0.404%. Impacts on Canada, Mexico and India are separately 0.040%, 0.102% and 0.108%.

Table 8: Effects of Forbidden Sanctions to Major Countries (Unit: % change)

Countries	O11	O12	O13	O14	O15	O16	O17
			Utility				
US	-0.178	-0.174	-0.181	-0.16	-0.008	-0.004	-0.051
EU	-1.569	-1.36	-0.178	-0.174	-1.579	-1.369	-0.282
Russian	-19.815	-15.852	-4.779	-3.983	-18.597	-15.072	-5.252
China	0.217	0.296	0.035	0.037	0.201	0.271	0.044
Japan	0.089	0.121	0.015	0.015	0.081	0.109	0.018
Korea	0.404	0.557	0.064	0.065	0.374	0.509	0.079
Canada	0.040	0.042	0.021	0.025	0.021	0.017	0.011
Mexico	0.102	0.134	0.034	0.049	0.07	0.086	0.023
India	0.108	0.138	0.018	0.018	0.102	0.129	0.023
			Export				
US	-0.325	0.071	-0.733	-0.356	0.075	0.224	-0.317
EU	-8.772	-6.798	-2.394	-2.43	-8.789	-6.739	-3.435
Russian	-41.277	-35.241	-12.471	-12.014	-39.735	-33.988	-15.642
China	0.266	0.35	0.045	0.046	0.246	0.318	0.054
Japan	0.034	0.033	0.01	0.011	0.022	0.014	0.005
Korea	-0.132	-0.202	-0.018	-0.026	-0.13	-0.199	-0.031
Canada	0.370	0.563	0.102	0.191	0.254	0.369	0.081
Mexico	0.466	0.712	0.12	0.23	0.331	0.482	0.101
India	0.22	0.301	0.029	0.027	0.225	0.313	0.051
			Import				
US	-0.216	0.047	-0.488	-0.237	0.05	0.150	-0.211
EU	-7.251	-5.620	-1.979	-2.009	-7.265	-5.571	-2.839
Russian	-65.891	-56.255	-19.908	-19.178	-63.429	-54.256	-24.97

China	0.290	0.380	0.049	0.051	0.268	0.346	0.059
Japan	0.033	0.032	0.01	0.011	0.021	0.013	0.005
Korea	-0.140	-0.214	-0.019	-0.027	-0.137	-0.210	-0.033
Canada	0.370	0.563	0.102	0.191	0.254	0.369	0.081
Mexico	0.464	0.710	0.120	0.229	0.330	0.480	0.100
India	0.145	0.198	0.019	0.018	0.148	0.205	0.034

Source: compiled by authors.

From the above analysis in this part, we find that all sanction involved countries will lose and all non-involved countries will gain. For three involved countries, Russia will be hurt heavily, but the US and EU will be hurt just slightly. The EU's sanction threat to Russia are much stronger than the US's, and Russia's retaliation measures will hurt the EU more than the US. Optimal game choice for the US and EU is to avoid sanction measures, and the optimal choice for Russia is to choose retaliation measures.

6. Optimal Sanctions for US, EU and Russia

We have explored the payoffs of trade sanction and retaliation measures with randomly selected tariffs. In this part, we calculate the optimal sanction and retaliation tariffs for three countries, which is called the optimal sanction level for the US, EU and Russia. We also simulate the effects of this optimal tariff sanctions and retaliations.

We firstly explore the optimal sanction tariffs for the US, the EU and Russia and then study the potential effects of the optimal sanction tariffs. In our numerical multi-country general equilibrium model, economic sanctions include both tariff and non-tariff barriers. We assume that the sanction measures are mainly tariff, therefore the optimal sanctions will be the optimal tariff. Here, the optimal tariff is not a whole optimal tariff that targeted to all countries in our numerical model, but it is a partial optimal tariff that targeted to economic sanction related countries of the US, the EU and Russia, which means that the US and the EU choose the optimal tariffs to levy on Russia, and the Russian choose the optimal sanction tariffs to levy on both the US and the EU.

There are two kinds of optimal sanction tariffs. One is optimal sanction tariff without retaliation, which means all three sanction countries choose their own optimal sanction tariffs at the same time. The other one is optimal sanction tariff with retaliation, which means that all three sanction countries firstly choose their own optimal tariff but then three sanction countries change their optimal sanction tariff according to their partner's choice and iterate until all three countries will not change and convergence to an equilibrium. The optimal sanction tariff with retaliation is actually a non-cooperate Nash equilibria.

We firstly calculate the optimal tariffs without retaliation. In the computation, we maximize one country's utility subject to the global general equilibrium and assume all other countries do not change their tariff and non-tariff barriers, and then we get the optimal sanction tariff without retaliation for this country. This process can be described as

$$MaxU_i(t_i) \quad s.t.\ GE \qquad i = country \tag{27}$$

Then we calculate the optimal tariff with retaliation, which are non-cooperative Nash equilibria. In order to compute non-cooperative Nash equilibria, we iterate over calculations of optimal tariff policy responses by individual region to tariff settings of other regions; subject to the constraint of full general equilibrium within the period. We then iterate across country tariffs and then countries until convergence to a non-cooperative Nash equilibrium is achieved. In computing non-cooperative equilibria, we adopt Nash's (1951) non-cooperative solution concept. We use (27) to obtain convergence to a Nash equilibrium. Optimal sanction tariffs are reported in Table 9.

Table 9: Optimal Sanction Tariffs for the US, the EU and Russia (Unit: %)

Countries	Without Retaliation	With Retaliation
US	27.4	28.3
EU	65.7	71.3
Russian	64.9	68.2

Source: Calculated and compiled by authors.

Table 10: Effects of Optimal Sanction among the US, the EU and Russia (Unit: % Change)

Countries	US	EU	Russian	China	Japan	Korea	Canada	Mexico	India
				Optimal Tariff Without Retaliation					
Welfare	0.009	-0.022	-5.837	0.453	0.040	0.161	-0.013	-0.063	0.126
Export	-1.124	-5.29	-21.497	0.770	-0.96	-0.915	-1.182	-1.242	-1.266
Import	-0.749	-4.373	-34.316	0.838	-0.925	-0.968	-1.181	-1.238	-0.831
Trade	-0.899	-4.788	-26.434	0.802	-0.942	-0.941	-1.182	-1.240	-1.003
				Optimal Tariff With Retaliation					
Welfare	0.010	-0.030	-6.201	0.459	0.042	0.171	-0.013	-0.061	0.129
Export	-1.124	-5.477	-22.403	0.777	-0.961	-0.92	-1.176	-1.235	-1.260
Import	-0.749	-4.527	-35.761	0.845	-0.925	-0.973	-1.176	-1.231	-0.827
Trade	-0.899	-4.957	-27.548	0.809	-0.943	-0.946	-1.176	-1.233	-0.998

Source: Calculated and compiled by authors.

Using the optimal sanction tariffs, we can explore the impacts of optimal sanctions to some major countries. Table 10 reports these results. Under the optimal sanction equilibrium, all three sanction involved countries will hurt but the negative effects are much less than arbitrary sanctions, the reason is that they are all optimal tariff sanction and retaliation measures. Comparatively, Russia hurts the most, then goes the EU, and the US lose the least. Most of non-involved countries in the economic sanction will gain except Canada and Mexico, which means that not all non-involved sanction game countries gain under optimal sanction scenario. Influence results under optimal tariff without retaliation and optimal tariff with retaliation are close.

The influence direction of optimal sanction are the same as arbitrary soft, hard and forbidden sanctions. The difference is that the negative effects on all involved countries are much smaller than arbitrary sanction measures. Optimal sanction is the equilibrium in which no countries want to move.

7. Conclusions

The economic sanction and counter-sanction game among the US, the EU and Russia has attracted extensive attention in the world. This paper uses a numerical general equilibrium model to explore the sanction game payoffs and to simulate the effects of sanctions. We set up a three-stage sanction game including soft sanction, hard sanction and forbidden sanction. Each stage game has seven game tree points and we compute payoffs for each point.

Our general equilibrium model has 16 countries or regions who produce 2 goods (manufacturing goods and non-manufacturing goods) with 2 factors (capital and labor). We include trade cost structure into the model which can be divided into tariff and non-tariff barrier, to explore the trade sanction policy effects. We also use a fixed trade imbalance assumption in the model to form an endogenously determined trade imbalance structure. We use both EV and CV to denote payoffs for individual countries.

The three-stage game solution analysis find that stricter sanction measures have stronger effects to all involved countries. All three countries of the US, the EU and Russia will be hurt by sanction and counter-sanction measures. Comparatively Russia will be heavily hurt, and both the US and EU will receive small loss. The EU sanction measure will generate stronger negative impact to Russia than the US measures, and Russia counter-sanction measure will has more impact to the EU than to the US. The optimal choice for the US and EU is to avoid taking sanction measures, and the optimal choice for Russia when faced with sanction measures is retaliation. The sanction effects analysis show that all sanction and counter-sanction involved countries will lose but all non-involved countries will gain.

Our empirical analysis prove that the US and EU may continue to use sanction measures to give pressure to Russia for the comparative impacts to them are small compared with their economic scale. Faced with sanction measures, Russia has no better choice than retaliation, but the ultimate results is Russia be hurt heavily.

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