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The Loss of Crimea How Much Does Ukraine Lose, and How Much Does Russia Gain, a Computable General Equilibrium Model

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Abstract

The Crimean Penninsula has recently been transferred from Ukraine to the Russian Federation, and many signs point to more territories in Eastern Ukraine being similarly transferred to Russian control. Outide of the political ramifications of these events, what are the economic effects of such a transfer of resrources and productive capacity. In particular, Crimea and Eastern Ukraine are extremely rich in natural gas and oil reserves. How much does Ukraine lose and how much does Russia gain when control of these resources change? This paper attempts to address these and other issues through the use of a computable general equilibrium model (CGE). The model is a large, multi-regional, multi-sectoral, multi-factor system of simultaneous equations. The "shock" to the CGE model is the transfer of all endowment factors of production in the Crimea and the parts of Eastern Ukraine which might move into Russian hands. The model solves for a new equilibrium, and allows for analysis of effects. As expected. results suggest that Ukraine's economy suffers a major loss, and Russia experiences a major gain.

Keywords: Russia, Ukraine, energy economics, computable general equilibrium, CGE, development, Global Trade Analysis Project, GTAP.

JEL Classification Codes: H50, O10, C32

Executive Summary

The Crimean Penninsula has recently been transferred from Ukraine to the Russian Federation, and many signs point to more territories in Eastern Ukraine being similarly transferred to Russian control.

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Outide of the political ramifications of these events, what are the economic effects of such a transfer of resrources and productive capacity. In particular, Crimea and Eastern Ukraine are extremely rich in natural gas and oil reserves. How much does Ukraine lose and how much does Russia gain when control of these resources change? This paper attempts to address these and other issues through the use of a computable general equilibrium model (CGE). Selected results include:

- The loss of oil and gas reserves and the other factors of production would result in a major loss in GDP. According to simulation results, Ukrainian GDP would decrease by 14.74 percent. Meanwhile, Russia's GDP would increase by 1.42 percent.
- In Ukraine, sectoral output falls in every part of the economy. Ukrainian sectors hurt the most include the oil and gas sector (a decrease of 22.75 percent), light manufacturing (-17.39 percent), heavy manufacturing (-16.78 percent), extraction of minerals, forestry and fishing (-14.99 percent), services (-14.9 percent), agriculture (-14.77 percent), utilities and construction (-14.08 percent), and processed food (-12.92 percent).
- On a dollar basis, Ukrainian ouput losses by sector are even more striking. In total, Ukraine stands to lose more than $25.9 billion in annual output. Those Ukrainian sectors with the largest dollar decreases include the services sector ($7.58 billion decrease), heavy manufacturing (-$6.18 billion), utilities and construction (-$4.43 billion), light manufacturing (-$1.69 billion), and agriculture (-$1.47 billion).
- On a dollar basis, Russian sectors increase production by $19.3 billion, a gain which is less than the $24.9 billion loss of Ukraine. Russian sectors experiencing the greatest dollar gains include the sevice industry ($6.7 billion), heavy manufacturing ($4.7 billion), utility and construction ($2.0 billion), light manufacturing ($1.3 billion), and agriculture ($1.2 billion). Factors of production once used in Ukraine are put to use in the Russian economy, though Ukraine's loss is larger than Russia's gain.
- The change in output and and consumption directly effects market prices in all sectors. Overall, prices rise by 5.7 percent in Ukraine and fall by 0.6 percent in Russia.
- The Russian annexation of Ukrainian territory is a transfer of factors of production from Ukraine to Russia. The change in factor endowments has a direct impact on the prices of these factors in both countries. In Ukraine, factor prices increase for land (7.3 percent), capital (6.3 percent), skilled labor (6.2 percent), and unskilled labor (6.0 percent). In Russia, factor prices decrease for land (-3.1 percent), skilled labor (-1.0 percent), unskilled labor (-1.0 percent), and capital (-0.6 percent).
- Russia would experience a $699.2 million increase in its trade balance, while Ukraine's trade balance would decrease by $131.4 million.

 On a sector basis, Ukraine's trade balance in oil and gas improves by $1.7 billion while its trade balance in heavy manufacturing decreases by $1.4 billion. Russia's balances are reversed—its trade balance in oil and gas falls by $1.0 billion while its balance in heavy manufacturing increases by $1.2 billion (Table 11). These shifts reflect a large decrease in both Ukrainian imports and exports of oil and gas (-13.7 percent and -27.4 percent, respectively) due to decreased production in heavy manufacturing, decreased personal consumption, and the shift in factor endowments.
 According the CGE model results, Ukraine suffers a -$7.0 billion annual decine in welfare, while Russia sees a $7.1 billion increase.

1. Introduction

How much does Ukraine lose, and how much does Russia win?

A computable general equilibrium (CGE) model is employed to look at this question. The model is a large, multi-regional, multi-sectoral, multi-factor system of simultaneous equations. The "shock" to the CGE model is the transfer of all endowment factors of production in the Crimea and the parts of Eastern Ukraine which might move into Russian hands. The model solves for a new equilibrium, and allows for analysis of effects. As expected, results suggest that Ukraine's economy suffers a major loss, and Russia experiences a major gain.

2.1. Background of Crimea Crisis

In early 2014, Crimea became the focus of the worst East-West crisis since the Cold War, after Ukraine's pro-Moscow president Viktor Yanukovych was driven from power by violent protests in Kiev. Kremlin-backed forces seized control of the Crimean peninsula, and the territory, which has a Russian-speaking majority, voted to join Russia in a referendum that Ukraine and the West deem illegal.

A few months earlier, protests gathered on Kiev's Maidan square, where hundreds of thousands of Ukrainians expressed anger after Yanukovych postponed the signing of a Ukraine–European Union Association Agreement. It appeared than the Ukrainian government was under severe economic pressure from Russia, even though previously Yanukovych had considered this agreement one of his key policy objectives.

Instead, Yanukovych struck a deal with the Russian Federation and President Vladimir Putin. This alternative agreement meant, among other things, that Russia would buy $15 billion in Ukrainian bonds, and discount gas prices to Ukraine by one-third.

The protests grew, and eventually led to deaths of both protesters and police. In battles between protestors and police between February 18 and February 20, a reported 103 people were killed and 1419 injured. Yanukovych fled the country and new interim government formed in preparations for new elections scheduled for May 25, 2014.

Citing opression of the Russian majority living in Crimea, the Russian government eventually called for a referendum vote among Crimeans for annexation of the pennninsula by Russia. The referendum was called illegal by the West, but was notheless held, and passed. The Russian Duma quickly voted to annex Crimea, and the territory is now under Russian military control and territorial jurisdiction. It has become a part of Russia.

In recent months, the tension has spread to Easter Ukraine, where Russian-speaking populations are not in the majority, but nonetheless have significant numbers. These Russian supporters have themselves opened their own protest movements, and have forcefully occupied government buildings, even declaring independence from Ukraine.

Again, the Russian government cites what it sees as Ukrainian oppression of Russian-speaking populations, now in Eastern Ukraine. Russia threatens military support for the pro-Russian supporters, and a standoff has ensued. Many in the West fear a repeat of the Crimean annexation, whereby Russia will move into Eastern Ukraine in sipport of the pro-Russian demonstrators, and soon declare parts of the Ukrainian east to be Russian territory.

The question for this paper is the loss in Crimea of land, capital, labor, and natural resources to Russia. What does this annexation of productive capacity do to the two countries' economies and those of their trade and investment partners in Europe, Asia, the United States, and around the world?

2. CGE Model for a Transfer of Crimea and Sections of Eastern Ukraine

What does this tranfer of territories do to regional economies? This section will develop a computable general equilibrium model to quantify the macroeconomic effects of a two-way trade embargo between Russia and the United States. The section is broken into several parts, including, (a) a background of CGE models; (b) the Global Trade Analysis Project (GTAP); (c) the structure of this paper's model, (d) model results; (e) model limitations and future research.

2.1. Background of General Equilibrium Models

General equilibrium, a concept which dates back to Leon Walras (1834-1910), is a pillar of modern economic thought. General equilibrium recognizes that there are many markets in an economy, and that these markets all interact in complex ways with each other. In rough terms, everything depends on everything else. Demand for any one good depends on the prices of all other goods and on income. Income, in turn, depends on wages, profits, and rents, which depend on technology, factor supplies and production, the last of which, in its turn, depends on sales (i.e., demand). Prices depend on wages and profits and vice versa (Hertel, et al., 2007).

Computable General Equilibrium (CGE) modeling specifies all economic relationships in mathematical terms and puts them together in a form that allows the model to predict the change in variables such as prices, output and economic welfare resulting from a change in economic policies. To do this, the model requires information about technology (the inputs required to produce a unit of output), policies and consumer preferences. The key of the model is "market clearing," the condition that says supply should equal demand in every market. The solution, or "equilibrium," is that set of prices where supply equals demand in every market—goods, factors, foreign exchange, and everything else (Hertel, et al., 2007).

A CGE model is a closed system. This means that no production or financial flow escapes the system and none are created outside of the system. In basic closure terms, we assume output will equal income. Households, businesses, the government, and the financial sector, and the foreign sector are all connected by real flows and financial flows. Intuitively, the idea of a "general" equilibrium is captured; any given market is connected to all of the other markets for the system.

Over the last 25 years, CGE models have become an important tool for analyzing economic issues, including trade policy, taxation policy, technological growth, energy policy, environmental issues, and even warfare. This development is explained by the ability of CGE models to provide an elaborate and realistic representation of the economy including the linkages between all agents, sectors and other economies. While this complete coverage permits a unique insight into the effects of changes in the economic environment throughout the whole economy, single country, and especially global CGE models very often include an enormous number of variables, parameters and equations (Brockmier, 2001).

CGE modeling is a very powerful tool, allowing economists to explore numerically a huge range of issues on which econometric estimation would be impossible; in particular to forecast the effects of future policy changes. The models have their limitations, however. First, CGE simulations are not unconditional predictions but rather 'thought experiments' about what the world would be like if the policy change had been operative in the assumed circumstances and year. The real world will doubtless have changed by the time we get there. Second, while CGE models are quantitative, they are not empirical in the sense of econometric modeling: they are basically theoretical, with limited possibilities for rigorous testing against experience. Third, conclusions about trade and other policies are very sensitive to data assumption. One can readily do sensitivity analysis on the parameter values assumed for economic behavior, although less so on the data, because altering one element of the base data requires compensating changes elsewhere in order to keep the national accounts and social accounting matrix in balance. Of course, many of these criticisms apply to other types of economic modeling, and therefore, while imperfect, CGE models remain the preferred tool for analysis of many global issues.

2.2. The Global Trade Analysis Project

One of the most widely-used CGE models is the GTAP Model. The Global Trade Analysis Project (GTAP), with headquarters at Purdue University, has organized a consortium of national and international agencies which provide guidance and base-level support for the Project (GTAP, 2008).

GTAP is a multi-regional CGE model which captures world economic activity in 57 different industries of 66 regions. The underlying equation system of GTAP includes two different kinds of equations.

One part covers the accounting relationships which ensure that receipts and expenditures of every agent in the economy are balanced. The other part of the equation system consists of behavioral equations which based upon microeconomic theory. These equations specify the behavior of optimizing agents in the economy, such as demand functions (Brockmier, 2001). Input-out tables summarize the linkages between all industries and agents.

The mathematical relationships assumed in the GTAP model are simplified, though they adhere to the principle of "many markets." The simplification is that thousands of markets are "aggregated" into groups. For example, 'transport and communications services' appear as a single industry. In principle all the relationships in a model could be estimated from detailed data on the economy over many years. In practice, however, their number and parameterization generally outweigh the data available. In the GTAP model, only the most important relationships have been econometrically estimated. These include the international trade elasticities and the agricultural factor supply and demand elasticities. The remaining economic relationships are based on literature reviews.

2.3. Structure of this Paper's Model

The model employed in this paper is that of the GTAP project. While the core database has 57 sectors and 66 regions, we have aggregated the matrices to simplify the world into just nine sectors (plus capital investment goods), nine regions, and five factors of production. This aggregation is described in Table 1.

The data is first, "calibrated," meaning the model is solved for its original equilibrium prices and volumes in all markets.

This baseline is meant to represent the economy as is, before any shock takes place. Thousands of equations are created, each representing supply and demand conditions in markets inside each region, including markets for goods, services, factors of production, savings, government expenditure, and more. Equations are also generated for trade of all goods between each of the regions, separately created for each industry. The calibrated result is a large set of simultaneous equations, of which the solution matches the existing prices and quantity levels of the economy.

Table 1: Aggregation used in the Model

Regions	Sectors	Factors
Russia	Oil and Natural Gas	Land
Ukraine	Agriculture	Unskilled Labor
Eastern Europe	Extraction	Skilled Labor
Western Europe	Light Manufacturing	Capital
Other Former Soviet Union	Heavy Manufacturing	Natural Resources
Middle East	Utilities and Construction	
Africa	Services	
United States	Capital Goods	
Rest of World		

Source: Generated by Author

A "shock" is then introduced to system. Mathematically, a "shock" is the alteration of a single parameter or variable in the giant system. That change acts like a stone thrown in a pond, with waves created throughout every one of the thousands of equations in the system. The model is re-solved with the one autonomous change, and the effects on the system are then measured.

The "shock" in this model is the tansfer of factor endowments from Ukraine to Russia. This includes the transfer of land, natural resource endowments like the oil and gas reserves and otehrs, skilled labor, unskilled labor, and capital. As an economic experiment, the model tests a 15 percent loss in these endowments from Ukraine, and the corresponding gain to Russia. (on a percentage basis, the gain is lower, because Russia is a larger country, but the model computes the absolute dollar magnitude of endowment transfer). Possible economic effects will be seen in GDP, prices, employment, consumption, imports, exports, and overall economic welfare.

The role of a CGE model is to trace and quantify the direction and magnitude of these changes. Scarce inputs are used to produce a different combination of outputs, and the economy consumes a different mix of goods.1

3. Model Results

A computable general equilibrium model can generate an enormous array of matrix results. In this model, results are grouped into the following sections: 1) output, income, and consumption; 2) market prices; 3) factor markets; 4) international trade; and 5) overall welfare effects.

3.1 Output, Income, and Consumption

The loss of oil and gas reserves and the other factors of production connected to Crimea and Eastern Ukraine would result in a major loss in GDP. According to simulation results, Ukrainian GDP would decrease by 14.74 percent. Meanwhile, Russia's GDP would increase by 1.42 percent. Note Russia has a much larger economy than Ukraine on

which the percentage changes are based. As will be later assessed, the GDP change reflects changes in input quantities, changes in production efficiencies and resource allocation, changes to relative prices and demand conditions, and changes to savings and the stock of capital goods and production capaicity. Changes to real GDP are reflected in Table 2.

Table 2: Real GDP

qgdp	Percent change
Russia	1.41
Ukraine	-14.74
EastEurope	0.01
WestEurope	0
FSU	-0.04
MiddleEast	0
Africa	0
US	0
RestofWorld	0

Source: Generated by author

Different sectors of the economy are affected in different ways. In Ukraine, sectoral output falls in every part of the economy. Ukrainian sectors hurt the most include the oil and gas sector (a decrease of 22.75 percent), light manufacturing (-17.39 percent), heavy manufacturing (-16.78 percent), extraction of minerals, forestry and fishing (-14.99 percent), services (-14.9 percent), agriculture (-14.77 percent), utilities and construction (-14.08 percent), and processed food (-12.92 percent). All other Ukrainian industries experience a similar blow to output. Output changes by percent are shown in Table 3.

On a dollar basis, Ukrainian ouput losses by sector are even more striking. In total, Ukraine stands to lose more than $25.9 billion in annual output. Those Ukrainian sectors with the largest dollar decreases include the services sector ($7.58 billion decrease), heavy manufacturing (-$6.18 billion), utilities and construction (-$4.43 billion), light manufacturing (-$1.69 billion), and agriculture (-$1.47 billion). In additon, the $1.33 annual decrease in capital good production implies lower investment in productive capacity and thus slowe long-term growth prospects for Ukraine. Output changes expressed in absolute dollars are shown in Table 4.

In contrast, the Russian Federation experiences a boon to output in all sectors. Those Russian sectors with the largest output gains include light manufacturing (2.47 percent increase), heavy manufacturing (2.36 percent), agriculture (1.93 percent), processed food (1.88 percent), and utilities and construction (1.51 percent). The Russian oil and gas industry experiences a 0.82 percent increase, a measure applied to an extremely large base in Russia. (Table 3).

On a dollar basis, Russian sectors increase production by $19.3 billion, a gain which is less than the $24.9 billion loss of Ukraine. Russian sectors experiencing the greatest dollar gains include the sevice industry ($6.7 billion), heavy manufacturing ($4.7 billion), utility and construction ($2.0 billion), light manufacturing ($1.3 billion), and agriculture ($1.2 billion). Factors of production once used in Ukraine are put to use in the Russian economy, though Ukraine's loss is larger than Russia's gain.

As shown in Table 5, the change in output directly affects consumers. Ukrainian consumers experience a 12.5 percent decrease in personal consumption expenditures, while Russian consumers experience a 1.3 percent increase in consumption.

Table 3: Change in Output (percent change)

	Russia	Ukraine	EastEurope	WestEurope	FSU	MiddleEast	Africa	US	RestofWorld
Oil_Gas	0.82	-22.75	-0.17	-0.07	-0.21	-0.03	-0.04	-0.05	-0.04
Agriculture	1.93	-14.77	0.02	0.01	-0.03	0.04	0.01	0	0
Extraction	1.13	-14.99	0.11	0.02	0.24	0.03	0	0.01	0.01
ProcFood	1.88	-12.92	0.01	0.01	0.11	0.01	0	0	0
LightMnfc	2.47	-17.39	-0.03	0	0.06	0.04	0.01	0	0
HeavyMnfc	2.36	-16.78	0.01	0	0.27	0.14	0.07	0	0
Util_Cons	1.51	-14.08	-0.01	0.01	0	-0.01	-0.01	0	0.01
Services	1.68	-14.9	0	0	-0.03	0	0	0	0
CGDS	1.22	-9.9	-0.06	0.01	-0.01	-0.02	-0.03	0.01	0.01

Source: Generated by author

Table 4: Change in Output (millions of dollars)

	Russia	Ukraine	EastEurope	WestEurope	FSU	MiddleEast	Africa	US	RestofWorld
Oil_Gas	1,041.6	-661.8	-7.9	-77.0	-77.4	-89.3	-44.9	-94.5	-133.4
Agriculture	1,220.3	-1,469.9	28.4	55.8	-12.1	30.2	12.5	5.4	29.1
Extraction	261.9	-564.3	33.1	21.3	21.1	3.0	1.8	6.0	26.6
ProcFood	652.4	-1,003.1	16.8	65.8	23.3	4.3	2.6	-0.2	1.6
LightMnfc	1,339.5	-1,691.9	-83.2	-113.8	16.8	34.0	19.4	24.5	-84.8
HeavyMnfc	4,682.0	-6,188.9	28.1	113.5	133.9	286.4	142.6	4.0	205.0
Util_Cons	2,041.5	-4,434.8	-11.5	103.1	0.6	-8.3	-14.8	81.0	141.0
Services	6,716.8	-7,586.6	-7.6	-69.0	-42.3	-20.7	-7.3	0.0	-58.0
CGDS	1,299.6	-1,331.9	-124.5	270.5	-5.6	-38.5	-42.5	101.5	259.0

Source: Generated by author

Table 5: Private Consumption

ypev	Percent change
Russia	1.28
Ukraine	-12.46
EastEurope	-0.02
WestEurope	0
FSU	-0.1
MiddleEast	-0.03
Africa	-0.02
US	0
RestofWorld	0

Source: Generated by author

3.2 Market Prices

The change in output and and consumption directly effects market prices in all sectors. Overall, prices rise by 5.7 percent in Ukraine and fall by 0.6 percent in Russia. (Table 6).

By sector, the largest price increases in Ukraine include those for sevices (5.0 percent increase), agriculture (4.5 percent), extraction industries (4.3 percent), utilities and construction (4.3 percent), and processed food (3.7 percent).

Russian market prices fall in all sectors, including those for agriculture (-1.1 percent), services (-0.7 percent), processed food (0.6 percent), light manufacturing (0.5 percent), and heavy manufacturing (0.4 percent). Market prices by sector are presented in Table 7, while import prices are shown in Table 8.

Table 6: Aggregate Price Index

pgdp	Percent change
Russia	-0.59
Ukraine	5.70
EastEurope	-0.02
WestEurope	0.00
FSU	-0.08
MiddleEast	-0.03
Africa	-0.02
US	0.00
RestofWorld	0.00

Source: Generated by author

Table 7: Market Price of Output (percent change)

pm	Russia	Ukraine	EastEurope	WestEurope	FSU	MiddleEast	Africa	US	RestofWorld
Oil_Gas	-0.12	2.22	-0.08	-0.07	-0.25	-0.05	-0.06	-0.03	-0.04
Agriculture	-1.07	4.47	0	0	-0.04	0.01	0	0	0
Extraction	0.01	4.31	0.09	0.01	0.15	0.01	-0.01	0.01	0.01
ProcFood	-0.64	3.67	-0.01	0	-0.02	0	0	0	0
LightMnfc	-0.51	2.82	-0.01	0	-0.02	-0.01	0	0	0
HeavyMnfc	-0.42	2.56	-0.01	0	-0.06	-0.03	-0.01	0	0
Util_Cons	-0.51	4.25	-0.01	0	-0.05	-0.02	-0.01	0	0
Services	-0.68	4.99	-0.02	0	-0.04	-0.02	-0.01	0	0
CGDS	-0.37	2.19	0	0	-0.03	0	0	0	0

Source: Generated by author

Table 8: Market Price of Aggregate Imports (percent change)

pim	Russia	Ukraine	EastEurope	WestEurope	FSU	MiddleEast	Africa	US	RestofWorld
Oil_Gas	-0.23	-0.15	-0.11	-0.08	-0.12	-0.1	-0.05	-0.05	-0.05
Agriculture	0.12	-0.03	0.08	0.01	-0.01	0.08	0.03	0.01	0.01
Extraction	0.26	0.03	0.57	0.03	0.16	0.03	0.05	0.02	0.02
ProcFood	0.31	-0.12	0.04	0.01	0.16	0.03	0.02	0	0
LightMnfc	0.1	-0.08	0.01	0	-0.01	0	0	0.01	0
HeavyMnfc	0.13	-0.09	0.03	0	0	0.02	0.02	0	0
Util_Cons	0.01	-0.02	0.24	0	-0.03	0	0	0.01	0
Services	0.01	0	0.01	0.01	0.01	0.01	0.01	0.01	0.01

Source: Generated by author

3.3 Factor Markets

The Russian annexation of Ukrainian territory is a transfer of factors of production from Ukraine to Russia. The change in factor endowments has a direct impact on the prices of these factors in both countries. In Ukraine, factor prices increase for land (7.3 percent), capital (6.3 percent), skilled labor (6.2 percent), and unskilled labor (6.0 percent). In Russia, factor prices decrease for land (-3.1 percent), skilled labor (-1.0 percent), unskilled labor (-1.0 percent), and capital (-0.6 percent).

Interestingly, model results show the prices for natural resources would increase by 2.0 percent in Russia, and decrease by 4.1 percent in Ukraine. Factor price changes are presented in Table 9.

Table 9: Market Price of Factors of Production (percent change)

pm	Russia	Ukraine	EastEurope	WestEurope	FSU	MiddleEast	Africa	US	RestofWorld
Land	-3.12	7.28	0.07	0.04	-0.15	0.14	0.02	0.01	0.01
UnSkLab	-1.03	6.05	-0.03	0	-0.02	0	-0.01	0.01	0
SkLab	-1.05	6.18	-0.03	0	-0.04	-0.02	-0.01	0.01	0
Capital	-0.63	6.29	-0.03	0	-0.05	-0.02	-0.01	0	0
NatRes	2.01	-4.19	0.56	-0.15	-0.7	-0.15	-0.16	-0.12	-0.08

Source: Generated by author

3.4 International Trade

Trade balances are significantly affected for several regions. As shown in Table 10, Russia would experience a $699.2 million increase in its trade balance, while Ukraine's trade balance would decrease by $131.4 million. Other regions would also see lower trade balances, including Western Europe (-$250.4 million), the United States (-$193.9 million), and the rest of the world (-$238.6 million). Eastern Europe and Africa would see improved trade balances ($112.3 million and $24.8 million, respectively).

Table 10: Change in Trade Balance

DTBAL	Millions of dollars
Russia	699.2
Ukraine	-131.4
EastEurope	112.3
WestEurope	-250.4
FSU	-4.8
MiddleEast	-17.2
Africa	24.8
US	-193.9
RestofWorld	-238.6

Source: Generated by author

Table 11: Change in Trade balance by Sector (millions of dollars)

DTBALi	Russia	Ukraine	EastEurope	WestEurope	FSU	MiddleEast	Africa	US	RestofWorld
Oil_Gas	-1,023.7	1,727.1	17.9	2.1	-163.8	-303.3	-121.3	-29.0	-70.3
Agriculture	182.5	-238.1	11.9	24.1	-5.2	13.5	11.0	3.6	10.4
Extraction	-86.5	72.9	5.1	6.4	13.8	0.4	-1.9	3.3	5.2
ProcFood	77.6	-155.7	16.9	34.6	18.6	4.5	8.3	-3.1	0.4
LightMnfc	102.3	196.3	-37.9	-168.5	16.6	33.0	22.6	-44.3	-100.8
HeavyMnfc	1,246.6	-1,448.8	17.5	-4.8	89.8	191.2	85.0	-57.9	-14.8
Util_Cons	25.3	-65.7	28.3	-0.7	7.3	1.1	1.2	0.3	3.0
Services	175.0	-219.4	52.7	-143.5	18.2	42.3	20.0	-66.8	-71.7

Source: Generated by author

On a sector basis, Ukraine's trade balance in oil and gas improves by $1.7 billion while its trade balance in heavy manufacturing decreases by $1.4 billion. Russia's balances are reversed—its trade balance in oil and gas falls by $1.0 billion while its balance in heavy manufacturing increases by $1.2 billion (Table 11). These shifts reflect a large decrease in both Ukrainian imports and exports of oil and gas (-13.7 percent and -27.4 percent, respectively) due to decreased production in heavy manufacturing, decreased personal consumption, and the shift in factor endowments (Crimea has a large endowment of oil and gas reserves).

Decreased economic activity in Ukraine results in a decline in both imports and exports in every single Ukrainian sectors. Sectors with the largest percent export declines in Ukraine include oil and gas (-27.4 percent), agriculture (-20.6 percent), ultilities and construction (-16.9 percent), heavy manufacturing (-15.7 percent), ligjht manufacturing (-15.9 percent), and processed food (-13.0 percent). (Table 12). Likewise, Ukrainian imports decline in all sectors, including oil and gas (-13.7 percent), extraction (-11.8 percent), light manufacturing (-11.0 percent), heavy manufacturing (-10.0 percent), and processed food (-5.1 percent). (Table 13.)

Table 12: Exports by Sector (percent change)

qxw	Russia	Ukraine	EastEurope	WestEurope	FSU	MiddleEast	Africa	US	RestofWorld
Oil_Gas	-1.02	-27.41	-0.01	-0.09	-0.8	-0.09	-0.07	-0.36	-0.08
Agriculture	5.83	-20.57	0.01	0.02	-0.19	0.06	0.04	0	0
Extraction	-0.59	-9.55	-0.09	0.04	0.5	0.03	0	0.03	0.01
ProcFood	2.4	-12.99	0.08	0.02	0.46	0.04	0.03	0	0
LightMnfc	2.2	-15.96	-0.07	-0.02	0.11	0.06	0.03	-0.02	-0.01
HeavyMnfc	2.54	-15.68	-0.05	0	0.36	0.19	0.1	0	0
Util_Cons	2.32	-16.01	0.19	0.01	0.24	0.08	0.03	0.01	0.02
Services	2.1	-11.74	0.05	-0.02	0.08	0.04	0.03	-0.03	-0.02

Source: Generated by author

Table 13: Imports by Sector (percent change)

qim	Russia	Ukraine	EastEurope	WestEurope	FSU	MiddleEast	Africa	US	RestofWorld
Oil_Gas	2.74	-13.74	0.04	0.02	-0.3	0.35	0.04	0.06	0.02
Agriculture	-1.53	-2.98	-0.2	-0.02	-0.1	-0.15	-0.08	-0.01	-0.02
Extraction	1.58	-11.83	-0.66	-0.01	0.08	-0.01	-0.05	-0.01	-0.01
ProcFood	-0.21	-5.09	-0.11	-0.01	-0.32	-0.05	-0.04	0	0
LightMnfc	0.41	-11.01	-0.05	0	-0.02	-0.03	-0.02	0	0
HeavyMnfc	0.36	-10.03	-0.08	0	-0.05	-0.05	-0.06	0.01	0
Util_Cons	0.25	-2.92	-0.53	0.02	-0.04	-0.05	-0.02	0	0.01
Services	0.35	-7.49	-0.06	0	-0.13	-0.05	-0.03	-0.02	-0.01

Source: Generated by author

4.4. Welfare Decomposition

Table 14 presents the overall welfare decomposition from the CGE simulation. The welfare decomposition is essentially a consumer surplus concept, broken down by gains or losses to consumers from efficiency gains, factor endowments, technological improvements, terms of trade effects, and the savings-investment mechanism. According the CGE model results, Ukraine suffers a -$7.0 billion annual decine in welfare, while Russia sees a $7.1 billion increase.

For Ukraine, the sources of the welfare decline are varied. The largest source is the loss of factor endowment (-$6.0 billion), reflecting the loss of land, workers, capital, and resources to Russia. But further, Ukraine sees a -$2.3 billion efficiency loss as industries struggle to adjust to the new relative prices and supplies of inputs for production. The reverse is true for Russia, which sees a $5.8 billion increase in welfare due to factor endowment gains and a $1.8 billion gain from efficiency gains.

Terms of trade between nations is sigificantly altered. Ukraine actually sees a $1.2 billion gain in welfare due to an improvement in its terms of trade. Conversely, a deterioration in Russia's terms of trade results in a welfare loss measuring $0.8 billion. Terms of trade is a measure of trade competitiveness. While production costs and domestic inflation rise in Ukraine, the volume of trade falls, most especially in heavy manufacturing. This volume change results in a sift in relative prices and the Ukrainian terms of trade gains.

Table 14: Welfare Decomposition by Region (millions of dollars)

WELFARE	Allocative Efficiency	Factor Endowment	Technological Change	Terms of Trade	Savings and Investment	Total
1 Russia	1,830.1	5,832.4	0.0	-806.9	271.0	7,126.6
2 Ukraine	-2,275.2	-5,955.8	0.0	1,209.2	68.3	-6,953.3
3 EastEurope	-49.2	0.0	0.0	-116.7	-2.4	-168.4
4 WestEurope	21.8	0.0	0.0	20.7	-90.2	-47.6
5 FSU	-64.2	0.0	0.0	-54.0	-5.2	-133.3
6 MiddleEast	-6.0	0.0	0.0	-193.3	-11.0	-210.3
7 Africa	-27.4	0.0	0.0	-103.5	-6.0	-136.9
8 US	2.8	0.0	0.0	58.2	-43.9	17.1
9 RestofWorld	-18.7	0.0	0.0	-26.5	-181.2	-226.4
Total	-586.0	-123.4	0.0	-22.6	-0.5	-732.5

Source: Generated by author

5. Model Limitations and Future Research

This experiment raises several methodological questions. The first is the nature of the Russian anneation of Ukrainian resoures and the status of Eastern Ukraine. This model assumes Russia does annex some resources in Eastern Ukraine. If this does ot occur, and the transfer of resources is limited to just those of Crime, the results would be smaller.

In addition, this type of model is a static model. This means that it does not fully capture the changes over time which such events have on investment decisions and capital accumulation. If these sifts are permanent, investors will have altered incentives as to which parts of the economy are the best for investment and which are least advantageous. Such changes in capital accumulation change productive capacity, GDP growth, and long term results. In particular, the energy reserves of Ukraine, the transit role of Ukraine in Russian energy exports to Europe, and changes to Ukraine's level of energy efficiency seem to be important, but will not be fully captured in this model.

These and other questions are relevant for further research. Results from a CGE similation are useful, but are not interpreted as forecasts, per se. There are many other influences on the economy, and are not introduced into this model. And while the exact magnitude of results should not be taken as solid forecasts, the direction of results are probably the most telling. In this experienment, the results are pretty clear – Ukraine loses and Russia gains from the transfer of Crimea.

Other References

Global Trade Analysis Project (GTAP) (2008), Department of Agricultural Economics, Purdue University, Website: https://www.gtap.agecon.purdue.edu/about/consortium.asp.

Brockmier, Martina (2001). "A Graphical Exposition of the GTAP Model," GTAP Technical Paper No. 8, October 1996, Minor Edits, January 2000, Revised, March 2001.

Hertel, T., Keeney, R., Ivanic M. and Alan Winters, L (2007). Distributional effects of WTO agricultural reforms in rich and poor countries. Economic Policy (April): 289-337.