Ukraine's Relations and Trade with Russia: A Game-Theoretical Illustration

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Author's contribution

The sole author designed, analysed, interpreted and prepared the manuscript.

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ABSTRACT

This paper briefly reviews Ukraine's industrialisation followed by a deindustrialisation in the post-USSR period. I construct an example called the 'Donbas game' to illustrate the use of game theory for analysing deteriorated relations between Ukraine and Russia. Intuitively, the game's best solution for Ukraine seems to accept separation by the rebellious republics, and for Russia to stop intervening in Ukraine's affairs. However, the only Nash-equilibrium solution is obtained when respective strategies are (*Regain territory, Keep intervening*). In a game-theoretical formulation of trade between Ukraine and Russia, the dominant strategies lead to a Nash-equilibrium solution (*Trade, Trade*). Yet the perceived optimal solution is obtained when both players are concerned with harming the opponent by minimising the latter's payoff rather than maximising their own.

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1. INTRODUCTION

The complexity of relations between Ukraine and Russia, in current conditions of open hostility and mutual accusations, attracts the attention of academics and political analysts. Many authors give their own assessment and prognoses of developments, optimistic or otherwise (see, for example, [1,2,3,4,5] and [6]). There were also attempts to estimate empirically the reasons for the secessionist movement and the war in Donbas [7]. My task is to provide a game-theoretical illustration of the developments related to the Ukraine-Russia conflict. In a nutshell, my view is that there are two conflicts intertwined there: external, between the two countries, and internal, between the parts of Ukraine with historically diverse cultural and religious traditions.

Research methodology in social sciences requires the formulation of certain hypotheses and involves quantitative and/or qualitative analysis of the subject matter. The multifaceted nature of my topic, involving economics and political science content, makes it difficult to design a one-for-all model. Thus, both qualitative and quantitative methodologies are appropriate. The qualitative approach implies subjectivity, especially in such politicised areas as Ukraine-Russia relations, and researchers often accept the prevailing official opinion. The description of relevant historic and current events in this paper is based on my own experience in planning and research, as well as available Ukrainian and Russian sources.

In the quantitative approach, I use game theory to model the relations and trade between the two countries. In the former case, I create an illustrating model called the 'Donbas game.' The obtained Nash equilibrium solution gives the best response for each player to the strategies of the rival that maximises economic welfare. However, as I show, the players do not follow these responses. Their 'optimal' solution is obtained when both players are concerned with harming the opponent by minimising the latter's payoff rather than maximising their own. In my game-theoretical model of trade, I use total trade as a proxy for the change in consumer welfare and demonstrate the computation of the payoffs. The data are obtained from Ukraine's and European Commission publications. Although the payoffs are maximised by mutual trade, the two countries choose instead to minimise trade because they are pursuing non-economic objectives.

In Section 2 following the Introduction, I indicate that Ukraine was one of the first regions in the Russian Empire to engage in industrial development in the 1870s. Most Ukraine's industrial enterprises were built in the Soviet period. An area where Ukraine had attained a leading position in the USSR was the military industrial complex. The demise of the USSR and the disappearance of technological links among industrial enterprises led to a gradual erosion of Ukraine's industrial potential and its deindustrialisation. The process accelerated with the escalation of hostility between Russia and Ukraine and a consequent decline in their mutual trade. Section 3 gives a basic game-theoretical interpretation of relations between Russia and Ukraine by concentrating on war in Donbas that began in 2014. I analyse the causes of the external conflict, between the two countries, and internal, between the territories of Ukraine with different economic, social and cultural traditions. Section 4 illustrates that politics plays a decisive role in Ukraine-Russia trade as well. The solution of the game-theoretical model reflects the fact that Ukraine's goal is to minimise trade with Russia in the hope to increase it with the EU, and Russia's is to use an import-substitution policy to replace rejected or lost supplies from Ukrainian industrial enterprises. Section 5 gives the conclusion.

2. UKRAINE'S INDUSTRIALISATION AND DEINDUSTRIALISATION

Ukraine was one of the first regions in the Russian Empire to begin industrial development in the 1870s, due to the discovery of coal in Donbas and iron ore in Kryvyi Rig. By 1900 Donbas became the coal and ferrous-metallurgical base of the Russian Empire. The development of heavy industry in Ukraine and the Ural Mountains in Russia was the prime objective of Empire's military strategy. The economy also benefited from expanded railroad construction that boosted exports of wheat through the Odesa port on the Black Sea.

Most of Ukraine's industrial enterprises were built in the Soviet period, starting with *Dniproges* (Dnipropetrovsk hydroelectric power station) with the help from US companies and engineers. *Dniproges* was followed by a group of metallurgical factories—*Azovstal'* in Zhdanov, *Zaporizhstal'*, Kryvyi Rig, Novomoskovsk tin, and Nykopil' pipe. Much attention was also paid to the construction of machine-building plants, with prominent locales of Novo-Kramatorsk and

Kharkiv, as well as transport and agricultural machinery in Odesa, Mykolaiv, Kherson, and Kirovograd. Dozens of chemical enterprises were constructed in all parts of the republic.

When Soviet industrialisation gained steam in the 1930s, most of Ukraine's western territories were a part of Poland, until the signing of the 1939 Molotov-Ribbentrop pact which assigned vast provinces of Eastern Galicia, Volhynia, Podillia, and Northern Bukovyna to the USSR. At the end of WWII, thousands of Russian workers were mobilised for construction sites in Lviv and other west-Ukrainian cities. Living conditions were harsh, but eventually, after Stalin's death in 1953, the mobilisation was replaced by a more humane organised recruitment. One by one, newly built Lviv factories began making a variety of manufactured goods, and they were often equipped with up-to-date imported machinery whose technological standards exceeded those of many Soviet enterprises constructed earlier.

An area where Ukraine had attained a leading position in the USSR was its military industrial complex (MIC). The construction of MIC plants and research and development (R&D) facilities was expanding through all the metropolitan areas of Ukraine. In 1962 Ukraine's share in country's production constituted: 90% of diesel locomotives, 55% of iron ore, 53% of coal coke, 51% of cast iron, 41% of rolled sheets, 40% of steel, and 35% of electric power [8]. Although similar data for specific military goods are not available, it is generally thought that, overall, Ukraine inherited about a third of the total Soviet military production.

The deindustrialisation stage for Ukraine started with the demise of the USSR. To many Soviet engineers and technologists, the disappearance of mandatory technological links signaled the end of country's industrial potential. They understood that, because of poor competitiveness, options for heavy industry producers were limited to the domestic market.

Initially, for Ukraine such a market included Russian users. [1] When Ukraine signed an Association Agreement with the EU in 2014, it accepted the latter's technical standards and specifications. As a result, European goods need not undergo certification in Ukraine, a

convenience for EU exporters. But Ukraine is not always ready yet to adhere to European requirements for quality, including standards for materials, alloys, product finishing, dimensions, processing, multi-language specifications, and the like [10].

Yuzhmash, a Dnipropetrovsk production association, is a good example of what happened to formerly famous Ukrainian industrial giants. It was completely reshaped in 1951 in order to make intercontinental ballistic missiles (ICBM), spacecraft, satellites, rocket engines, wind turbines, and other sophisticated military and civilian machinery [11]. In the Soviet period, three quarters of spacecraft parts were coming to *Yuzhmash* from Russian enterprises. As joint production and quality control with Russia deteriorated, a carrier vehicle *Antarek* exploded during a launch of a space shuttle in 2014. According to official press releases, production came to a dramatic finale: Most of *Yuzhmash* shops were shut down, qualified workers laid off, and the work week was reduced to one day [12]. The situation is not much better at other enterprises, in particular, the Antonov Aviation and Technology Complex (which used to make the world largest cargo aircraft, An-124 *Ruslan* and An-225 *Mriya*), railroad cargo car plants (recently loaded at a 10% capacity), Kharkiv plant for electric heavy machinery (used to supply Russia with turbine generators, electric motors and mine-drilling equipment, until most orders were cancelled [13], and many other enterprises.

3. RELATIONS BETWEEN RUSSIA AND UKRAINE: A BASIC GAME-THEORETICAL INTERPRETATION

Most theories that explain how international relations form and evolve are variants of the two noteworthy cases, realism and liberalism [14]. According to realism, a state's primary interest is self-preservation, and it seeks power to protect itself. The ability to use power may affect the behavior of adversaries. A realistic approach to neighboring states helps select potential friends and rivals. Liberalism is a relatively recent phenomenon that rejects realism in politics as outdated. As a moral alternative to realism, liberalism considers reliance on military power divisive and dangerous. Instead, states' goal must be mutual prosperity and cooperation designed on the basis on supranational organisations (see [15] and [16]).

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[1] *As an empirical study of disaggregated data for Ukraine's industries from 1993 to 2000 demonstrates, employment growth occurred in Ukraine's manufacturing sectors that maintained strong trade ties with the FSU countries* [9].

Cooperation as viewed by realism is just one of the potential outcomes, conflict is a polar opposite, and there is a vast grey area in between. I find useful the following classification of international interactions: (a) defense alliances, (b) deterrence and arm races, (c) crises that may lead to war, (d) war and peace, and (e) battles in a war [17]. There is overlapping among the categories, and some are more specific than the others. A quite general Tolstoy war and peace category suits well to characterise the current state of Russian-Ukrainian relations.

War in Donbas began in April 2014, after then Ukraine's acting president Turchynov issued a decree on the 'preservation of territorial unity of Ukraine' in response to signs of separatist movement and mass protests in the south-east of the country. The development followed a series of violent events that led to the ousting of president Yanukovych and the formation of an interim government. The chronology of events—the establishment of the separatist Donetsk and Luhansk People's Republics (LDNR), their fighting with Ukrainian regular army and voluntary battalions, signing of a Minsk and Minsk II Protocol ceasefire in 2014 and 2015, and about a dozen failed ceasefire attempts thereafter, numerous casualties on both sides, thousands of refugees and a humanitarian crisis in the war zone—are well known and publicised [18].

Critics of Ukraine's leadership blame an attempt at repealing the law on regional languages for triggering the conflict in 2014. Yet, in my view, there must be some more fundamental causes, with two conflicts intertwined there: external, between the two countries, and internal, between the territories of Ukraine with different economic, social and cultural traditions.

History tells us that the country is a blend of populations, divided and ruled by a variety of powers including Poland, Austria, Ottoman Empire, and Russian Empire. When Ukraine gained independence in 1991, the roots of division were not yet visible because, on the surface, everything was quiet in the Soviet period. The Central Committee of the Communist Party of Ukraine then recruited new cadre primarily from Kyiv, Dnipropetrovsk, Donetsk, and Kharkiv. Attitude toward Lviv was cautious for good reasons. The Soviet ideological machine and the KGB (Committee of State Security) were monitoring dissident activity there including, in particular, nationalism and 'religious

fundamentalism.' The center of the latter was Lviv, with most participants being Galicia-born students from Lviv University and Lviv Polytechnic Institute [19].

Western Ukraine was under intense surveillance also because of the underground activity of the outlawed Ukrainian Greek-Catholic Church (UGCC). It was founded by the Brest Sobor of 1596, which resulted in a schism between the mainstream Orthodoxy and a Uniate faction that recognised the power of the pope, accepted the basic tenets of the Catholic Church, but retained orthodox rituals and church language. Reestablished in the late-1980s, it is practiced by a small number of the population in Western Ukraine. But the main fight is going on among three Orthodox churches that anathematised one another: Ukrainian Orthodox Church-Moscow Patriarchate (UOC-MP), Ukrainian Orthodox Church-Kyiv Patriarchate (UOC-KP) and Ukrainian Autocephalous Orthodox Church (UAOC). The UOC-KP emerged in 1992 as a counterpart to UOC-MP. Of the three, the UOC-MP is the only church with an autonomous status, granted by the Moscow Patriarchate, but without full autocephaly. A 2016 poll (without Crimea and part of Donbas) shows that one third of believers in Ukraine belong to the UOC-KP, with most of others devoted to the UOC-MP. President Poroshenko has appealed to the Constantinople patriarch to grant an autocephalous status to the UOC-KP, in an attempt to make it a single legitimate religion entity in the country. In the meantime, the churches keep fighting for parishes and property [20].

Despite the prevailing western view blaming Russian intervention for the conflict in Ukraine, the chain of events gives each side plenty of evidence to blame the other one in the developments. In the case of Ukraine, the escalation of protests in Donbas into an armed conflict coincided with Petro Poroshenko's election as Ukraine's president. He promised to end the conflict in hours, while the army launched air strikes on separatists. At the time, one might expect Poroshenko's confidence was based on a plan to stop the bloodshed and to achieve a reasonable compromise by negotiations. Instead, to look 'weak' was the least of his intentions. The world powers, supporting Ukraine, were merely concerned with using the occasion to punish Russia for the annexation of the Crimea and its involvement in Donbas.

In the case of Russia, its government denies being a participant in the conflict, but it does not deny helping their 'Russian brothers' to withstand the offensive of the Ukrainian military. This help involved military intervention on the LDNR side whose scale is anyone's guess. What we know is that the combat was conducted by several types of fighters, the distinction among which was intentionally blurred (local militia, mercenaries who fought voluntarily or for pay, and units of the regular Russian army being on 'vacation.'). In any event, Russia is a participant in the conflict. Yet, while Ukrainians declare Russia a country-aggressor, the aggression is a bit peculiar: *De facto* diplomatic relations between the two countries are as normal as could be in spite of numerous back-and-forth accusations, thousands of Ukrainians cross the border to work in Russia, and mutual trade is still occurring.

In recent years hybrid war has become a frequent reference to a Russian meddling in Ukraine's affairs. As stated in [21], hybrid warfare covers some grey zone between war and peace, filled with disinformation, propaganda, instigation of civil disobedience, and the use of voluntary and paramilitary force. Conventional force may be mentioned as supplementary, but the main feature of hybrid warfare is that it remains below the threshold of the overt use of armed force. A major sticking point is whether any war, hybrid or other, can be waged without the use of conventional military capabilities (see, for example, [22]). If the answer is no, then the definition of hybrid war, which does not have a military conflict as a necessary condition, may simply be a figure of speech similar to, say, Cold War.

To illustrate the outlined relations between Ukraine and Russia, I use the basic game theory which is a formalised study of decisions made by two or more players; the latter can be individuals, companies, groups, or states. The players are assumed to attempt to optimise their payoff, i.e., the gain or loss from the game. A strategy is a set of moves for the player in each position in the game. A strictly dominant strategy results in the best payoff given the strategies of other players. A strictly dominated strategy is inferior compared to all other strategies. The elimination of strictly dominated strategies is often the shortest way to find a solution. Needless to say, there is subjectivity in players' perception of their best interests, payoffs, means at their disposal, assessment of rival's intentions, and the like. The set of strategies for all players is called a strategy

profile. The latter is a Nash equilibrium when no player can improve his/her payoff by changing the strategies.

To illustrate the current stalemate in Donbas, I use a simple version of the prisoner's dilemma model. Table 1 depicts a static position in what I call the 'Donbas game', with strategies for Ukraine and Russia. Ukraine's options are given by the two rows: *Accept separation* on the part of LDNR and *Regain territory* by diplomatic or military means. Since Ukraine would not agree to accept the separation, its strictly dominant strategy is given by the second row, *Regain territory*. Russian strategies are given by the two columns, *Keep intervening*, the action their leadership denies, and *Stop intervening*, which they will not do until the situation is resolved to their satisfaction. Thus, the Russian strictly dominant strategy is *Keep intervening*. Four outcomes in the table are (*A, K*), (*A, S*), (*R, K*), and (*R, S*), respectively.

An easy approach to determine the Nash equilibrium solution in this game is to delete the dominated strategies from the matrix. Since *Regain territory* is a strictly dominant strategy for Ukraine, the other one, *Accept separation*, as a strictly dominated strategy could be eliminated. Thus, only the second row remains. By symmetry, the *Stop intervening* column, as a strictly dominated strategy for Russia, is eliminated, too, leaving the first column in the table. The only remailing solution (*R, K*), is a Nash equilibrium, and it provides the best response for both players to the strategies of the rival.

A more complete illustration of this game is given in Table 2, with payoffs assigned.[2] Of the four outcomes for Ukraine, the best is (*R, S*) and the worst (*A, K*). Taking also into account that outcome (*R, K*) is preferable to (*A, S*) (the former is a part of the dominant strategy), the full ranking of the outcomes for Ukraine is (*R, S*) >(*R, K*) >(*A, S*) >(*A, K*). Given that *Keep intervening* is dominant strategy for Russia, the best outcome for it is (*A, K*) and the worst (*R, S*). Since (*R, K*) is a part of the dominant strategy, it is preferable to (*A, S*) for Russia whose full ranking of strategies is (*A, K*) >(*R, K*) >(*A, S*) >(*R, S*). Let us assign payoffs, say, from 0 to a maximum of 4. If one of the players achieves his/her goal and the rival fails, then the optimal

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[2] *The situation is in part similar to the one used by Guner* [23].

payoffs are: (4, 0) for Ukraine in outcome (*R, S*) and, symmetrically, (0, 4) for Russia in outcome (*A, K*). If both players fail to achieve their goals, the payoffs (0, 0) are obvious in outcome (*A, S*). Finally, assume both players achieve their goal but must compromise on the rival's side. Such a combination is given by an outcome (*R, K*), and the maximum payoff is split equally (2, 2). Even though the last outcome provides a compromised solution, it is a Nash equilibrium because it provided the maximum payoff to both players. Indeed, if Russia pursues the *Keep intervening* strategy, Ukraine will respond by the *Regain territory* strategy, and *vice versa*.

Since it is well known that Ukraine's strategy in Donbas is to 'regain' territory from its own population and Russia's strategy is to intervene in Ukraine's affairs, one may ask what kind of eye opening we gain from a game-theoretical formulation except for some new terminology. There are several responses to this challenge. Firstly, by imposing economic and personnel sanctions against Russia, US and EU push for a (*R, S*) solution. For Russia the (4, 0) is a lose-lose position. Ukraine is a formal winner in that case, but it will regain the territory from its rebellious population only after it regains their minds. Thus, a game-theoretical approach provides a bold illustration that Ukraine is encouraged by its international supporters to pursue an unrealistic goal.

Secondly, one can see that the best solution for achieving peace in Donbas is (*A, S*), but it is unattainable: Payoffs of (0, 0) reflect the perceptions on both sides that under the circumstances they have nothing to gain from compromising. In other words, a reasonable intuitive solution is not corroborated in a formalised position. Thirdly, although the only sustainable equilibrium solution (*R, K*) and the related dominant strategies are all bad, one of the players will need to blink first before both players overcome the temptation to seek the solution on their terms. This probably cannot happen without a big push from the outside. The last suggestion from this game-theoretical analysis is that a comforting principle 'bad guy-good guy,' which the US and EU use for taking sides in this and other international conflicts, is naïve.[3]

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[3] *American experience is instructive because, after an enthusiastic support of a yet another uprising in the suffering world, the US often appears to be on the wrong side in the conflict. An example is given in a June 3, 2016 BBC report on the US abandoning the 'bad' shah of Iran in 1979 and*

It also pays to mention an additional methodological issue. The solution obtained in this game is static. Dynamic processes are modeled with the use of repeated games, where the outcome depends on how long the game is played. Suppose the considered 'Donbas game' is played repeatedly, but in the finite number of periods *N* and the outcome (*R, K*) in Table 2 pertains to the last period. By using backward induction, we move to period *N-1* knowing that, no matter what happens, the equilibrium solution in period *N* is (*R, K*). By the same reasoning, the game at *N-1* also has the dominant strategy (*R, K*), and so on for each period. Thus, the play does not differ from a one-shot game. If taken at face value, this exercise leaves little hope that Ukraine and Russia will move toward some form of cooperation in the near future.

The diversion to cooperation might happen, at least theoretically, in the case of infinitely repeated games. A so-called folk theorem states that in this case a Nash equilibrium may occur even when the players cooperate, provided they are sufficiently patient and rational. The difference with the finitely-repeated games is that now, in the absence of the final period, the players realise they will always face yet another period and there may be benefits from a cooperating strategy. Enforceability of such strategies as well as a design of appropriate punishments for violators (e.g., sanctions) are essential for players to consider cooperation in earnest. Most likely, the absence of a constraint on the last period makes the difference because history teaches that sooner or later former enemies become peaceful neighbors, often difficult though.

4. UKRAINE'S TRADE WITH RUSSIA

When it comes to international trade, non-economic factors, including politics, significantly affect trade policy and can even play a decisive role [25]. With the demise of the USSR, mutual trade between Ukraine and Russia initially went uninterrupted because of a high degree of integration among Soviet republics' economies. But soon elites in Ukraine initiated the disentangling the economic knit that tied together the two countries. The motivation in this case is similar to the phenomenon of the so-called economic nationalism. The latter emerged as a

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embracing ayatollah Khomeini who as a 'good guy' promised to the Carter administration that America's interests and citizens in Iran would be protected [24].

protectionist policy aimed to regain the autonomy of individual states, insulate their national interests, eliminate outsourcing of production and jobs, and isolate national markets from increasingly globalised world economies [26].

At the same time, the rise in nationalist tendencies manifested in an antagonistic turn in Ukraine-Russia trade is at odds with an overall positive impact of the disappearance of the Soviet-type economic model which used to isolate the socialist regimes from the hostile capitalist environment. The removal of this ideological obstacle was expected to promote freer international trade with lower economic and non-economic barriers in all parts of the world. To an extent, new stratifications did lead to changing preferences among political leaders and societal groups, democratisation, and rising pressure from the international organisations to liberalise trade as a financing condition for developing countries [27].

In 2016 Ukraine exported to Russia 3.5 billion USD worth of merchandise and imported 5.1 billion USD, with the trade deficit of 1.6 billion USD. Table A1 in the Appendix provides major export and import commodities, in million USD. All data in Table 1 and other tables in the Appendix refer to 2013-2016. So far Russia as a country remains Ukraine's biggest investor, with 1.7 billion USD in 2015. Ukraine's machinery and heavy equipment formerly comprised the bulk of Ukraine's exports to Russia; however, in 2015 the number fell by 80% compared to 2012 [28].

In 2014 Ukraine *de jure* banned any ongoing cooperation with the Russian military industrial complex (MIC) even though the Ukrainian producers could cover only 40% of demand of the country's military force. A complete abandonment of Russian armaments is simply not viable as it would require a long time and billions in investment to develop generic prototypes [29]. Moreover, because of a lack of spare parts, it is impossible for Ukraine to repair arms damaged in combat operations. Since buying from Russia is the only option, military producers knowingly break the law whereas the authorities embody a proverbial principle of not seeing, hearing, or speaking. The situation is similar in the nuclear energy sector where nine out of 15 Ukraine's nuclear power stations can only operate on Russian-made fuel elements [29]. Another, even more controversial example is Donbas anthracite coal, a fuel for thermoelectric plants. Ukraine started buying it

elsewhere, most recently from the US which happens to be more expensive than buying coal from Donbas. In numerous tit-for-tat steps, both Ukrainian and Russian governments set mutual embargoes on many essential goods, in particular meat, fish, poultry, and dairy products.

Table A2 gives recent data on Ukraine's trade with the EU, aggregated according to the UN Standard International Trade Classification. The comparison of data in Tables A1 and A2 is complicated because of dissimilar principles of combining items in groups, international in Table A2 and Ukraine' own in Table A1 (the latter is close to the one applied in Soviet economic planning). However, the totals are not affected by the methods of aggregation.

The EU uses quotas in its trade with associated countries. A quota specifies a certain quantity of merchandise imported to the EU with no or low import tariff, primarily for agricultural goods and raw materials. The EU-Ukraine association agreement gives 36 product groups subject to tariff rate quotas on the EU side and three on Ukraine's side [30]. EU quotas cover: meat, milk and dairy, eggs, honey; plant products including grains, mushrooms, garlic; processed foods and other products including sugar, juices, corn, processed tomatoes, cigarettes, and ethanol. According to Ukraine's Ministry of Economic Development and Trade, in June 2017 the country exhausted its annual tariff quotas for exports to the EU for honey, corn, sugar, barley grains, wheat, processed tomatoes, grapes, and apple juices. Partially utilised were quotas for malt, barley, butter, poultry, milk, eggs [31]. Recently the European parliament raised quotas for Ukraine's corn, barley, outs, and honey, that is, allowed higher imports of these goods. At the same time, a request by Ukrainian exporters for greater quotas for wheat, tomatoes, and urea was denied.[4]

To quantify the features of Ukraine's trade policy in a game-theoretical formulation, one should recall that the payoff to each nation is the change in its consumer welfare. I use total trade in goods

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[4] *Recent data for the first two 2018 months show some impressive results in Ukraine's agricultural and raw material trade with the EU (exports/imports, million USD): grain 992/62.4; vegetable oil and butter 701/38.1; wood and wood products 227/42,7; ferrous metals 1,710/184. There were some deficit manufacturing items: pharmaceuticals 25/292; fertilizers 17.7/212; transport 86.6/594; boilers and reactors 257/886; machinery and equipment 732/1,594 [32].*

as a proxy for the change in welfare. Ukraine has gradually decreased the level of exports to and imports from Russia and hopes to compensate the loss by increasing the respective shares from the EU countries. Russia is also involved in what it declares 'mirror sanctions,' and it is engaged in costly and time-consuming import substitution. Because of the large size of its aggregate economy, the EU is the most indifferent between the status quo and the loss of welfare from the trade war, although this is not the case for the individual member states. The Ukraine's economy, as the smallest of all three players, is the most vulnerable.

In Table 3 I specify the strategies and the payoffs in the Ukraine-Russia trade game. Payoffs consist of Ukraine's and Russia's annual trade with each other and the EU in billion USD. In trade literature the rise in consumer welfare is often identified with exports promotion [33]. The latter is an important function of trade policy, as selling in foreign markets increases job availability and income. However, since consumers also benefit from goods availability, quality and variety, they also value imports.[5] For this reason, I consider the total trade in goods as a barometer of consumer welfare, rather than exports only. This way I make total trade of any two trade partners a mirror image of each other because what one exports, another imports, and *vice versa*. This guarantees symmetry in the formulation of payoffs.

Both Ukraine and Russia have two strategies in Table 3, *Trade* and *Boycott trade*. In cell (*Trade*, *Trade*) I take into account that the closest to uninterrupted trade between Ukraine and Russia, 37.9 billion USD, happened in 2013 (Table A1). This numeral is therefore taken as the maximum potential trade for the whole period of interest. The trade between Ukraine and Russia is also affected by the countries' trade with the EU. For Ukraine, a major factor is the EU annual quotas and individual countries' demand. As to Russia, in March 2014 the EU imposed the first travel ban and asset freezes for individuals involved in actions against Ukraine's sovereignty [34]. Additional sanctions were set in July 2014 and reinforced in September 2014. In March 2015 the duration of the sanctions was extended.

To reflect the impact of sanctions, I add the 2016 EU trade data from Tables A2 and A3 that reflect all changes in EU's trade with Ukraine and Russia, to the maximum levels of trade for Ukraine and Russia, i.e., 37.9 billion USD. As a result, the respective payoffs for the outcome (*T*, *T*) in Table 3 are: Ukraine's payoff = 37.9 + 32.7 = 70.6; Russia's payoff = 37.9 + 211.6 = 249.5.

Outcome (*T*, *B*): The partial boycott of trade on the Russian side occurred when it imposed economic sanctions against Ukraine in the summer of 2015. I thus take the 2015 trade between the two countries from Table A1, 12.3 billion USD, as the minimum amount. To switch to the payoffs, one just needs to add the same trade values with the EU as in cell (*T*, *T*). Hence, the payoffs in cell (*T*, *B*) in Table 3 are: Ukraine's payoff = 12.3 + 32.7 = 45.0; Russia's payoff = 12.3 + 211.6 = 223.9.

Outcome (*B*, *T*): The partial boycott of trade with Russia on Ukraine's side led to an 8.7 billion USD in 2016 as shown in Table A1. Using the same levels of trade with the EU as in the two previous outcomes, the payoffs in cell (*B*, *T*) in Table 3 are: Ukraine's payoff = 8.7 + 32.7 = 41.4; Russia's payoff = 8.7 + 211.6 = 220.3.

Outcome (*B, B*): It is the ultimate stage in the game when both players attempt to accomplish the full boycott of their trade with the opponent, by minimisation of the sum of exports and imports. Considering that within a three-year period, from 2013 to 2016, trade between the two countries fell by a whopping 77% and assuming that the trade war between the two countries continue beyond 2016, a further decline by a similar proportion will bring the trade volume to a virtual nil.[6] This leaves in the respective cell of Table 3 for both countries the amount of their trade with the EU: Ukraine's payoff = 32.7; Russia's payoff =211.6.

If the formulated problem is considered from a conventional game-theoretical perspective, the objective of both players must be to maximise their payoffs. Then the dominant strategy for Ukraine should be *Trade* and dominated strategy *Boycott trade* (because payoffs in the first row are greater than the respective payoffs in the

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[5] *The behavior of Soviet consumers illustrates the role of imports in their lives. They did not care about operations of governmental exporting organizations. Yet the same consumers hastily formed long lines as soon as the stores began selling, for example, women's shoes from Italy or oranges from Morocco.*

[6] *This is the lowest level of payoff because, even technically, they cannot become negative. Indeed, by design of my payoffs, if, for example, Ukraine's export to Russia is a and its import from Russia is -b, then for Russia the respective values are b and -a. Hence, the two payoffs form an identity* $a + \left|-b\right| \equiv b + \left|-a\right|$, *i.e., both are non-negative.*

Table 1. Strategies for the 'Donbas Game'

Players	Strategies	Russia	
		Keep intervening	**Stop intervening**
Ukraine	Accept separation	A, K	A, S
	Regain territory	R, K	R, S

Table 2. Strategies for the 'Donbas Game' with Payoff assignment

Players	Strategies	Russia	
		Keep intervening	**Stop intervening**
Ukraine	Accept separation	(0, 4)	(0, 0)
	Regain territory	(2, 2)	(4, 0)

Table 3. Strategies and Payoffs in Ukraine-Russia trade game

Strategies		Russia	
		Trade	**Boycott trade**
Ukraine	Trade	(70.6, 249.5)	(45.0, 223.9)
	Boycott trade	(41.4, 220.3)	**(32.7, 211.6)**

Source: Calculations from data in tables A1-A5.

second row). Symmetrically, *Trade* is a dominant strategy for Russia. After eliminating the dominated strategies, the (*T*, *T*) outcome emerges a Nash equilibrium.

However, the game theory ends at this point. The real game is shaped not by Nash equilibrium, but political and emotional considerations. Namely, an 'optimal' solution for Ukraine's elite is to completely eliminate trade with Russia, and *Boycott trade* achieves this goal. Let us recall that outcome (*B*, *B*) in Table 3 is designed so that it gives the values of trade of Ukraine and Russia only with the EU. In the two outcomes, (*T*, *B*) and (*B*, *T*), minimisation goes on the one side only, which sets the trade value at some sufficiently low level. The response of the other side is to sell at this level because by definition of the payoff that player cannot exceed or reduce it. In the ultimate outcome (*B, B*) minimisation goes on until both players hit the value of zero. In reality, of course, this does not happen right away. In such a reformulated game, the dominant and dominated strategies reverse their positions in Table 3, and, regardless of cost, the players are concerned with minimisation of the opponent's payoff rather than maximising their own. As usual, a Nash equilibrium solution is given in bold in Table 3.

5. CONCLUSION

Ukraine, one of the most industrialised republics of the former USSR, entered the process of deindustrialisation with a gradual disappearance of technological links among former Soviet industrial enterprises since 1992. This was a shock to Ukraine's population that enthusiastically supported the declaration of independence, believing that their standards of living could only rise. Industrial decline accelerated with the escalation of hostility between Russia and Ukraine. Some accusations on the Ukrainian side include Russification, Soviet regime as a *de facto* occupation, mass starvation (*golodomor*) of 1932-33 directed at Ukrainians, imperial attitudes of the Russians, president Putin's authoritarianism, and the like.

I use the game theory to model the relations between Ukraine and Russia. In what I call the 'Donbas game,' the best solution for achieving peace on Ukraine's side is *Accept separation* by the rebellious republics, and on Russia's side *Stop intervening* in Ukraine's affairs. However, the only sustainable Nash equilibrium solution is obtained when Ukraine continues its attempts to regain territory and Russia keeps meddling in Ukraine's affairs. Although the solution is bad from the perspective of suffering population and international peace, it indicates that so far both sides believe have nothing to gain from a compromise.

In another formulation of a game-theoretical model, that reflects trade between Ukraine and Russia, I use the total amount of trade as a proxy for the change in consumer welfare. The

conventional Nash equilibrium solution is obtained when out of two strategies for each player, *Trade* and *Boycott trade,* the former maximises their payoffs. However, this is not a perceived optimal solution for both players, where hardliners' objective is to terminate any trade with a not-so-long ago 'brotherly republic.' Consistent with the objective, the players choose the strategy that harms the opponent by minimising the latter's payoff rather than maximising their own.

The international organisations impose a requirement that Ukraine fight corruption, an obstacle on its way to economic prosperity. Ukrainian economist Korablin [35] stresses that the initiative by itself will not pull Ukraine out of economic depression. A responsible government would concentrate its effort on the economy and poverty of the working and non-working population, as is crucial for Ukraine: The 2017 average wage in dollar terms is estimated at 250-280 USD per month there. This is a third of what it used to be in 2013 [36]. Depopulation is another problem about which the government is silent and intentionally postpones an overdue census: According to Ukrstat, in 1993 Ukraine had 52.2 million people; the World Health Organization forecasts the country population in 2030 at 30 million [37]. People are forced to leave in large numbers simply because there are no jobs. The main sources of hard currency are foreign borrowing, remittances from labour migrants, and agricultural exports.

The last comment is on the idea of federalism versus unitarism. Twenty-eight countries, home to 40% of the world population, are federations [38]. Federalism may take a variety of forms. While it is often practiced for governing large countries, it is also used to accommodate regionalised differences as, for example, in Belgium. Even without sufficient expertise, one may conclude from my analysis that Ukraine lacks the necessary conditions to be a strict unitary state, in particular, common historical experience, economic development, culture, and religion. Thus, a debate in the academic community on some alternative form of governing might be productive. Ukrainian public does not raise the issue because that would be considered as unpatriotic. As to the world powers, they demonstrate an ostrich syndrome by ignoring an obvious regional dissonance in Ukraine.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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APPENDIX

Table A1. Ukraine Trade with Russia in 2016, Major Commodities, Million USD

Merchandise	Ukraine exports
Ferrous metals and metal goods	893
Nuclear reactors and boilers	643
Inorganic chemical products	505
Paper and cardboard	230
Electric machinery	174
Plastics and polymers	158
Railway locomotives	112
Salt, sulphur, soil, and stones	92
Ceramics	52
Ores, stags, and cinder	44
Total	**3500**
Merchandise	**Ukraine imports**
Fossil fuel, oil, and petroleum products	1900
Nuclear reactors and boilers	585
Fertilizers	552
Ferrous metals and metal goods	327
Plastics and polymers	237
Paper and cardboard	144
Inorganic chemical products	131
Electric machinery	129
Rubber	121
Vehicles	113
Total	**5100**

Sources: Kyiv Post, 24 March 2017 and Ukrstat 2017.

Table A2. Ukraine Trade with the EU in 2016, Major Commodities, Million USD

Merchandise	Ukraine exports	Ukraine imports
Food and live animals	2598	1174
Beverages and tobacco	19.92	257.8
Crude materials, inedible, except fuels	2489	520.1
Mineral fuels, lubricants and related materials	602	1140
Animal and vegetable oils, fats and waxes	1194	40.94
Chemicals and related products	438.2	3817
Manufactured goods classified by materials	4019	2713
Machinery and transport equipment	1753	6637
Miscellaneous manufactured articles	879.7	1692
Commodities and transactions not classified	32.09	162.7
Other	459.2	104
Total	**14487**	**18260**

Source: European Commission, Directorate-General for Trade, 03-05-2017.

Table A3. Ukraine-Russia Trade in Goods, Million USD

	Exports	%	Imports	%	Total	%	% 16/13
2013	14787	-	23098	-	37885	-	
2014	9798	-33.7	12700	-45.0	22498	-40.6	
2015	4828	-50.7	7493	-41.0	12321	-45.2	
2016	3593	-25.6	5149	-31.3	8742	-29.0	-76.9

Sources: Ukrstat 2017.

Table A4. Ukraine-EU Trade in Goods, Million USD

	Exports	%	Imports	%	Total	%	% 16/13
2013	18442	-	31750	-	50192	-	
2014	18251	-1.0	22578	-28.9	40829	-18.7	
2015	14241	-21.9	15579	-31.0	29820	-27.0	
2016	14487	1.7	18260	17.2	32747	9.8	-34.8%

Source: European Commission, Directorate-General for Trade, 03-05-2017.

Table A5. Total Ukraine Trade in Goods with Russia and EU, Million USD

	Total Russia	Total EU	Russia+EU	%	% 16/13
2013	37885	50192	88077	-	-
2014	22498	40829	63327	-28.1	-
2015	12321	29820	42141	-33.5	-
2016	8742	32747	41489	-1.5	-52.9

Sources: European Commission, Directorate-General for Trade, 03-05-2017.

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