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A Conjectured Cournot Duopoly Model for the EU–US Automobile Trade: A Game Theoretic Analysis of the TTIP's Most Traded Product

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Economic actors, in their interactions with each other, certainly make decisions which are able to improve their original situation. In the case of free trade agreements, tariffs have the effect to manipulate countries' trade and welfare. In this paper, we try to estimate the impacts of the Transatlantic Trade and Investment Partnership (TTIP) on the profit level of participating countries in the context of the Cournot duopoly model. More specifically, we elaborate the most traded product (MTP) and determine the profit levels in the equilibrium regarding two scenarios (pre and post situations of the TTIP). The findings suggest that the Cournot model seems suitable since it illustrates the possible options and provides a guideline for the decision-making process. Based on the model, it can be shown at which point the highest benefit can be achieved for the participating economies (EU, US) i.e. how long it is worth for the parties to apply additional automotive tariffs.
Keywords: game theory, duopoly model, trade policy, free trade agreements
JEL classification: C72, D43, F15

1. Introduction

Free trade agreements are treaties to reduce or eliminate tariff and non-tariff trade barriers between two or more partners. Since the 1950s, their numbers have grown exponentially as a result of globalization, and this trend is likely to continue in the coming decades. In parallel, their character has gradually changed. Today's world trade involves a number of rapidly integrating players who are forming even deeper, more profound collaborative relationships. The general trend is that modern agreements include the removal of services, standards, norms, and regulations.

Thus, exploring the relationship between trade agreements and their economic effects is an urgent issue.

The principal purpose of this paper is to illustrate the EU–US automotive trade and to analyse the impact of TTIP on the profit level of participants from a game theoretical perspective. The paper provides justification on whether the decision-making (autarky, or the conclusion of TTIP) brings a positive or negative end result to the participants. Understanding TTIP has been one of the most important foreign policy issues of the European Union and United States, but examining its effect on growth empirically with duopoly models is still an undiscovered area.

As a first step towards studying modern agreements and TTIP, the paper introduces the oligopolistic literature, and uses the Cournot duopoly model based on a non-repeated game and under perfect competition. It considers a simple setup with two trader economies. Cooperation between the parties during the game shall occur only because it is an individual interest of the players. Should the cooperation cease, such a decision would probably result in retaliation by the other party. In the game, we basically examine the competitive behaviour of individual parties, who, considering their circumstances (rules, possibilities), choose the best possible option available to them. (Markusen 2002, Kreps 2005, Kapás 2017)

The concept is rooted in interactions between economic actors. In their decisions, trading partners can form agreements, or maintain tariffs that divert profit to the internal market to the detriment of foreign trading partners. Strategies can only be maintained through repeated interactions, but strategy modification is allowed at any time. Application of customs is the outcome of a unilateral or multilateral decision, while cooperation is a multilateral choice. The goal of economic actors is to achieve welfare, so their decisions are made accordingly. Economic and/or geopolitical oriented choices are represented by reaction functions to identify equilibrium situations during the game, the optimal strategies of participants, and to determine potential gains and losses.

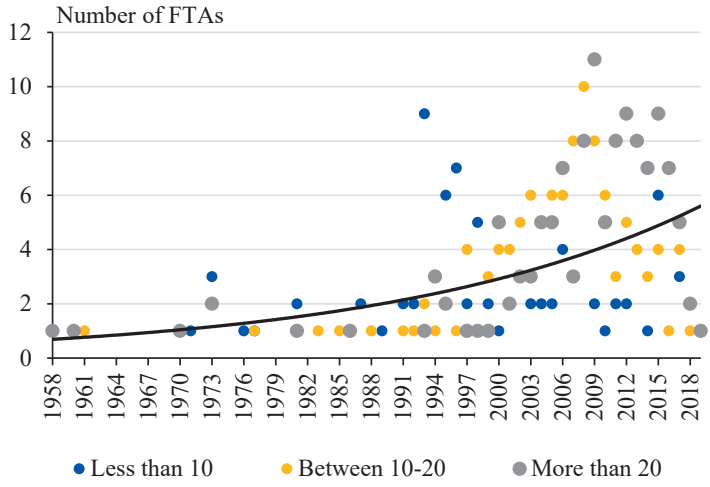
The remainder of this paper is classified as follows. Section 2 presents the evolution of modern free trade agreements (includes TTIP) and cooperation trends. Section 3 introduces stream literature of oligopolistic trade models. Section 4 sets up a conjectured Cournot model for examining the pre and post situations concerning the EU and the US. Section 5 provides the results under the two scenarios. Finally, Section 6 provides the conclusion.

2. The evolution of modern free trade agreements

The shift from traditional trade agreements to modern ones dates back to the 1990s. In the 2010s, however, trade negotiations reached another milestone. Forming of

deep and comprehensive trade agreements began (Figure 1), targeting not only trade and investment opportunities, but also global regulation. (Kutasi–Rezessy–Szijártó 2014) In addition to regional efforts, interregional concepts (TTIP, TPP) also appeared. The changing trade relations altered the nature of the conventions, leading to multi-sectoral liberalization and trade in goods. Investment Court System (ICS) or Investor State Dispute Settlement (ISDS), rule of origin (ROO), harmonization of law and standards, protection of intellectual property rights, competition law, or protection of state-owned firms are also part of modern free trade agreements. In some cases, the fight against corruption, environmental protection, or support for the SME sector also appears. Horn–Mavroidis–Sapir (2010) identify 52 such areas. (Appendix 1.) Of these, 18 key provisions contribute to market access and facilitate the operation of global value chains. (Baldwin 2006)

Figure 1. Changes in political areas covered by free trade agreements

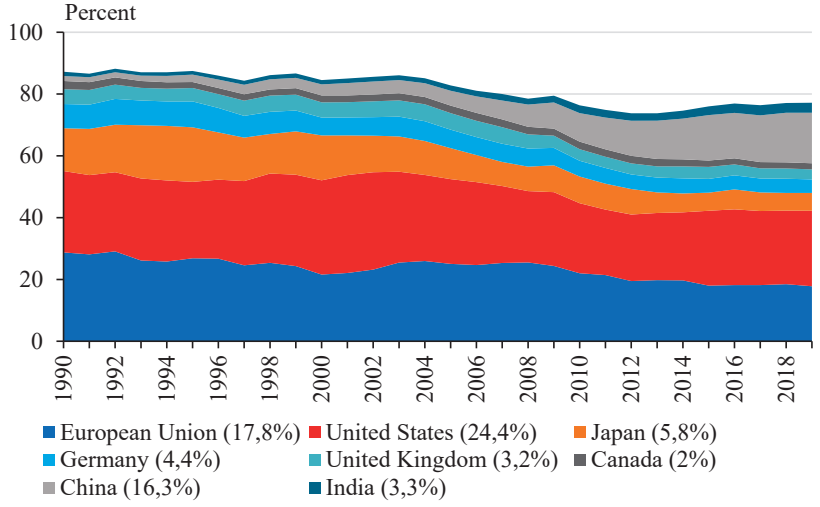


Note: free trade agreements in force.
Source: author's elaboration based on World Bank data (2021)

The most relevant trade agreements with a wide range of provisions have been negotiated over the last ten years. These include some agreements not yet signed (TTIP) or signed but not yet in force (RCEP, CETA). The existing agreements (JEFTA, CPTPP, USMCA) entered into force from 2018, which shows that they are still immature, and many policy areas need to be restructured and clarified. The world's largest free trade agreement, the Regional Comprehensive Economic Partnership (RCEP), was signed in 2020 by 15 countries in Asia and Oceania, covering 38 percent of the world's nominal GDP in 2019. Among signatories, China has the largest share, accounting for 16 percent of total production. The

United States–Mexico-Canada Agreement (USMCA), or NAFTA 2.0 was signed in 2018. The three member states have a 28 percent share of total output, of which the United States accounts for 24 percent. The most significant trade deal would have been the Transatlantic Trade and Investment Partnership (TTIP) negotiated between the United States and the European Union, but the US has withdrawn from the treaty. Their cooperation would have represented 42 percent of global production. In the Comprehensive and Progressive Agreement for Trans-Pacific Partnership (CPTPP), or TPP-11, among the seven participants, Japan accounts for six, Canada two, and Mexico 1 percent of global output. The significance of the Comprehensive Economic and Trade Agreement (CETA) between Canada and the European Union lies in the fact that trade volume between the two markets has increased by 9.1 percent since it entered into force, and it appears that the participating economies complement each other. Finally, the European Union-Japan Economic Partnership Agreement (EPA) accounts for nearly one-third of global production and sets out a number of policy areas to boost their trade. (Figure 2)

Figure 2. Distribution of large economies in world GDP



Note: based on nominal data, in parentheses the weight of countries in the world GDP in 2019
Source: author's elaboration based on World Bank data (2021)

2.1 Transatlantic Trande and Investment Partnership

TTTP would have been one of the largest bilateral free trade agreements, covering around 30 percent of world trade and 50 percent of global output, once fully rati-

fied by the two participants. President Trump expressed his willingness to reopen negotiations on the EU–US agreement in 2018, and the current Biden administration has not ruled it out, but so far no progress has been made on concluding the agreement. By bringing these economies together, the parties expect deeper cooperation and economic benefits. Once the negotiation process is completed and the agreement comes into force, it would strongly shape future global trends and foreign direct investments. The gains would come from lower commodity prices, greater product variety, technology transfer and higher productivity. (Felbermayr et al. 2013)

Regulatory changes may lead to additional tariffs levied on goods traded in some sectors (between 10 and 20 percent), compared to classical negotiations, where the average tariff level is only 4 percent. The additional growth effects would mean GDP growth of around 0.5 percent for the European Union's economy and 0.4 percent for the United States. This shows that the significance of TTIP relates more to the removal of non-tariff barriers (e.g., legislation, standards, licences) to economic benefits, and perhaps goes beyond these characteristics. This is now the biggest obstacle for activist groups and businesses who stand to lose in this process. (CEPR 2013)

The other impact is related to trade diversion, and this may be created by the European Union itself. Given the lack of internal trade barriers within the integration, significant intra-EU trade takes place within the region's borders. If the US removes tariff and non-tariff barriers, some EU trade would likely to be diverted to the US. The explanation would be as follows: Initially, EU countries trade with each other, but if a member state starts importing from the US, it reduces intra-EU trade, so trade creation becomes destructive for the EU. In addition, if the difference between the pre-and post-trade volumes is relatively large, the US will not be able to compensate the member states for the effects caused by trade diversion. (Felbermayr et al. 2013)

The two parties waged a tariff war during the period 2017-2019. Under the Trump administration, the US began to impose protective tariffs on steel and aluminum export products from the EU in 2017. As a result, the EU announced the intention to impose countervailing tariffs to the full list of US products submitted to the WTO to recover the amount lost. From 2019, the US (due to prohibited subsidies) has applied additional tariffs, among other actions, to aircraft parts and automotive products, and has amended its list of targeted products several times since then. In 2020, the EU levied digital taxes on a number of large US technology firms. In response, the US envisaged raising car import tariffs. The most favoured nation (MFN) principle has already been applied to a number of product groups, but the parties are currently imposing high tariffs on each other on those goods and services with the highest revenues. (European Parliament 2015)

2.2 EU–US automobile trade

From 2010 to 2020, export-import trends have not changed for the European Union and the United States. The most exported EU manufactured goods to the US were machinery and transport equipment (37 percent of total exports) and EU imports of machinery and vehicles from the US also have the highest share of total manufactured imports (38 percent of total imports), followed by chemicals and related products in 2020. Export and import ratios for the US are almost the same as for the EU. (Figure 3) The EU has a trade surplus with the US in the most traded product.

Regarding vehicle exports, the European Union accounts for around 12.5 percent of all vehicle imports from the United States, and around 18 percent of all exported cars to the US arrive from the EU. This is one of the rationales for launching the TTIP negotiations between the parties. At the same time, controversial issues have disappeared. These are connected to technical standards (gas emission, safety) and regulation harmonization (including greenhouse effect, fuel efficiency). (Canis–Lattanzio 2014)

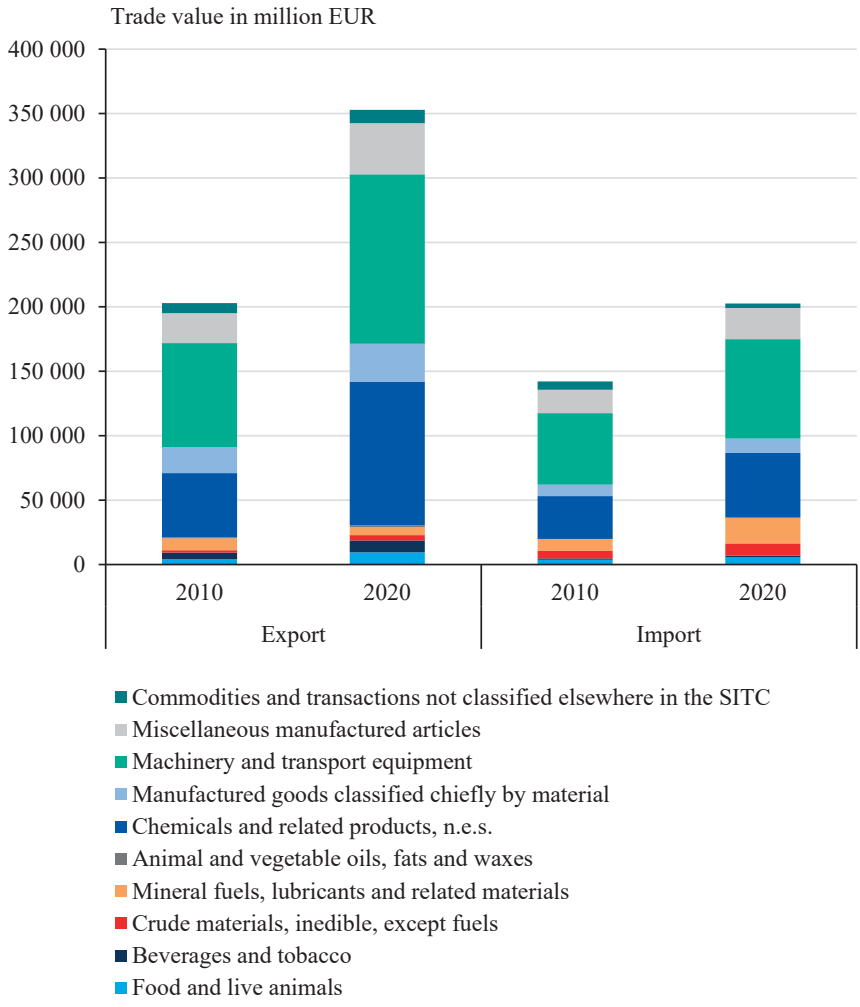
Auto-related trade (motor cars and other motor vehicles principally designed for the transport of persons, including station wagons and race cars) accounts for around 7.2 percent of total trade in goods between the European Union and the United States. Concerning the annual automobile trade, 1 170 579 cars (worth about 32 990 million EUR) were exported from the EU to the US, while 297 541 cars (worth about 8 603 million EUR) were exported from the US to the EU in the average of 2018-2020. (Table 1)

Table 1. EU–US annual automobile trade in the average of 2018-2020

Economy	*Descriptions*	*Passenger car export*
EU to US	Total value (million EUR)	32 990
	Quantity (units)	1 170 579
	Average tariff level (percent)	10
US to EU	Total value (million EUR)	8 603
	Quantity (units)	297 541
	Average tariff level (percent)	2.5

Source: author's elaboration based on Eurostat data (2021)

Figure 3. EU–US trade by product group



Note: based on nominal data
Source: author's elaboration based on Eurostat data (2021)

3. Literature review

The following section addresses key literature that deals with the impact assessment of international trade agreements. Cost-benefit theories have appeared several times in relation to states. Integration theories draw attention to trade creation and trade diversion. (Palánkai 2011) In the economics of international

organizations, states can establish collaborations as profit-maximizing individuals. (Blahó 2004) Fratianni–Pattison (1982) and the functional approaches underline the marginal benefits and marginal costs of these agreements. The market theory analyses cartels and identifies their welfare-increasing, welfare-reducing effects at a national economic level. The realist school sees countries as individual competitors, which is a microeconomic approach, as states seek to maximize welfare in the international system.

3.1 The impact assessment of free trade agreements

Since the 1970s–80s, a comprehensive integration process has taken place in the world economy, encompassing micro- and macro-processes. In other words, the corporate, national, regional and global integration processes in the international trading system happen in parallel, and are intertwined. (Blahó 2004)

The literature generally distinguishes the regional economic integration levels according to the typology by Balassa (1961). In the case of a free trade area, tariffs and quotas within the zone are abolished, but customs duties and quotas are applied to outsiders. (EFTA, AFTA, NAFTA) The customs union does not apply customs duties and quotas within the zone, but defines a common external customs duty and foreign trade policy vis-à-vis outsiders. (EU–Turkey Customs Union) The common market liberalizes not only goods and services in the customs union, but also the flow of capital and labour. (MERCOSUR) In addition to the abolition of customs barriers, the single market includes the removal of non-tariff barriers. (EC) (Palánkai 2011) The economic and monetary union also accomplishes the unification and coordination of economic and monetary policies. (EMU)[1] Political union means raising power and legislation to a supranational level where a "supranational authority" can make decisions.

With the appreciation of regional economic integrations, there has been an increasing emphasis on assessing the benefits and costs they bring. Customs union theories are the first to analyse the links between free trade and the international division of labour. Within this framework, Viner (1950) considers trade creation to be a positive effect of the customs union, and even trade diversion to be a negative outcome of the customs union. Meade (1955) already highlights the impacts of production and consumption. As a result of cheaper imports, savings became higher, which increases consumption. He calls such an increase in imports trade expansion, and a change in the opposite direction trade contraction. The transportation costs of trade are identified by Samuelson (1952) in the iceberg trade

[1] Economic Union is characterized by a certain level of harmonization with regard to economic policies (current EU), while in a Monetary Union, members adopt a common currency, as well as harmonize economic policies (EA).

cost metaphor, meaning that some of the profits 'melt' as the geographical distance increases.

Mainly two methodological approaches are used to illustrate the economic impacts of a trade negotiation: the computable general equilibrium (CGE) model and the structural gravity (SG) model. These models are regarded as basic instruments to calculate overall trade policy effects. The CGE model is based on the multi-sector model of general macroeconomics: household sector, government sector, and corporate sector. An explanation of the CGE model can be found in the following studies: Zalai (1998), Berden et al. (2009), Francois et al. (2013). These models use an elasticity-based estimation. For trade forecasts, price elasticity, trade elasticity, long-distance transport cost elasticity and tariff cost elasticity are usually calculated. In the model described by Arkolakis et al. (2012), a formula (consists of import share and trade elasticity) estimates the impact of trade growth on macroeconomic income. The structural gravity model application is based on a one-sector model. (Felbermayr et al. 2013) It can be used to estimate the cost burden of a given type of regulation for trade. The gravity model assumes that the economic size of the partner Player is decisive in trade.

In case of TTIP, CGE- and SG-based models are used to estimate the effects of the agreement. The most cited CEPR study by Francois et al. (2013) is based on a multi-sector and multi-regional CGE model. The CEPII study published by Fontagné et al. (2013) uses the CGE model called MIRAGE, also using the GTAP database. The Bertelsmann study by Felbermayr et al. (2013) explains that non-tariff barriers can be further broken down into those related to trade policy, other policies or natural constraints. The model based on one-sector SG model. The CESifo study by Aichele et al. (2014) uses a multi-sector, input-output gravity model. These studies find that GDP for both regions is expected to increase at around 0.0-1.82 percent. The Felbermayr study was considered excessive by the European Commission, which means the potential growth surplus remained essentially unchanged (0.0-0.5 percent).

3.2 Game theory and oligopoly models

Strategic options for trade policies have been explored in a game theory approach[2] by several authors who have regarded international markets as oligopolistic. The first trade wars analysis using a game theoretical model was introduced by Johnson (1953). Brander and Spencer (1984) dealt with domestic and foreign oligop-

[2] The basics of game theory and models can be found, among others the studies of Neumann –Morgenstein (1944), Olson (1965), Hardin (1968), Szép–Forgó (1974), Harsányi–Selten (1988), Ostrom (1990), Myerson (1997), Dixit (1984), Mészáros (2003), Simonovits (2007), Owen (2013), Molnár–Szidarovszki (2010).

oly competition and showed that through state subsidies, firms can make higher profits. Additionally, dynamic oligopoly commercial games have been researched by Dixit (1984), Eaton–Grossmann (1986), Helpman–Krugman (1989), Krugman–Obstfeld (1994), and Collie (1991).

The commonly used models that quantify trade agreements can be divided into two groups. Microeconomic models illustrate pre-and post-negotiation situations with micro-level profit analyses. These oligopoly models mostly generate the profit function with linear cost and revenue functions and then show the equilibrium output levels (reaction functions) with the first-order condition of optimization. Such analyses are addressed, for example, in the study of Bagwell–Staiger (2009), Zizzimos (2011), or Soegaard (2013), who use extended versions of the models of Brander–Spencer (1984), and Yi (1996). However, Jinji–Mizoguchi (2015) have already examined the effect of rules of origin and technology spill-over in their oligopolistic approach. They used a three-Player model to demonstrate the optimal choice of rules of origin when one party is required to import FDI at the time of concluding a trade agreement. Bond and Park (2002) note that in an infinitely repeated game, asymmetries between the economies make more difficult the conclusion of a trade negotiation, thus suggest a number of solutions containing the use of transfers between the players. Yu-Ter et al. (2004) investigate the policy and welfare effects of forming an economic region. Mrázová (2011) analyses the profit-shifting externality under oligopoly. Ossa (2015) considers the firm-delocation externality under monopolistic competition. Collie (2020) analyses the outcome of a trade war between two countries in a Cournot model and in a Bertrand model with differentiated products. The author highlights that, when the two countries are similar, both of them will be worse off in a trade war compared to when there is free trade, but the Player with the uncompetitive firm may win the trade war, if the asymmetries are large enough.

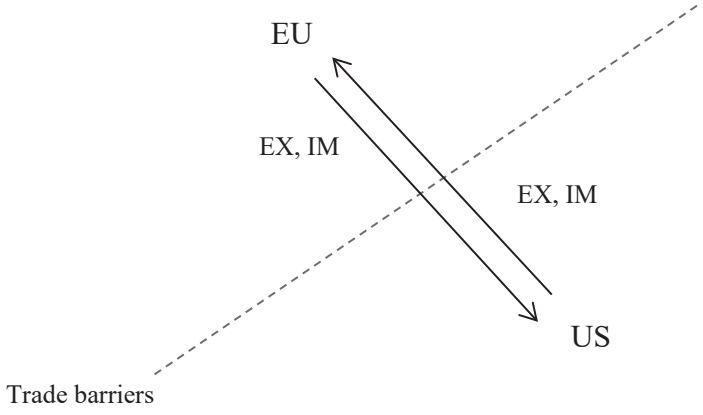
At the same time, while these oligopoly models investigate the trade relations mainly from a theoretical perspective, some of them describe empirical facts. Hollis (2003) explores the relationship between concentration, output and trade theory and finds that the higher the domestic concentration in an industry is compared to international concentration, the lower the domestic share of global GDP is and the smaller net exports are. Baggs and Brander (2006) developed a segmented market Cournot model to describe the trade liberalization effects on heterogenous firms in the case of the Canada–US Free Trade Agreement and found that Canadian (domestic) tariff reductions resulted in declining profits, while falling American (foreign) tariffs are associated with increasing profits.

4. The model

In this section, we apply a discrete 2-player Cournot duopoly game model, and compare the two scenarios, one for the pre-free trade agreement case and the other for the post-free trade agreement case. There are two economies (EU, US), who export passenger cars to each other. In the pre-agreement stage, they impose tariffs on the imported products, but after the free trade agreement, these regulations are eliminated. (Figure 4)

In this game, a perfect information game model can be captured, where players trade and compete with each other in a Cournot–Nash fashion. We assume that the EU and US determine the output level simutaneously for a year. Next, no new entrants are noticed. Third, we assume that the variables used are the export number of passenger cars in the average of 2017-2020 with the average price per unit for the same time period. The export revenue functions show the relationship between the export number of passenger cars and the average price, while export cost functions are derived from the import number of passenger cars and tariff expenses. Finally, the players have an idea of the outcome of the game and are usually able to judge what the favorable strategy for them is, within a certain margin of error.

Figure 4. Two-player trade relations



Source: author's elaboration

To set a game, we need to determine the players, strategies, and payoffs. In our case, we define the players as the European Union and the United States, with two situations and payoffs. (Table 2)

We assume that each player is a strategically rational individual in the game in which each decides its own quantity of goods intended for trade ($\Re^+ \cup \{0\}$) simultaneously. According to Neumann–Morgenstein (1944), rational behavior must possess four properties.

Completeness: either M is preferred, L is preferred, or the individual is indifferent. L $\prec$ M, M $\prec$ L, L ~ M.

Transitivity: assumes that preferences are consistent across any three options. If L $\prec$ M and M $\prec$ N, then L $\prec$ N, and similarly for ~.

Continuity: if L $\preceq$ M $\preceq$ N, then there exists a probability p $\in$ [0,1], such that pL + (1 – p) N ~ M.

Independence: if L $\preceq$ M, then for any N and p $\in$ [0,1], pL + (1 – p) N $\preceq$ pM + (1 – p) N.

Table 2. A game model's elements

Players	i (1=EU, 2=US)
Strategies	FTA formation or participants maintain status quo position, these are the only two options for the participants.
Payoffs	Profit and welfare of players from trade

Source: author's elaboration

The cooperation between the European Union and the United States can be seen as a discrete, perfect information (relating automotive trade, the draft agreement contains all necessary details) Cournot duopoly trade game model, which is an extended framework for determining the economic effects of TTIP. The actors eliminate tariff rates between them, which has an influence on their profit levels. Due to the nature of the agreement, appearance of new entrants is not typical, so this is ignored in the model. The actors export passenger cars to each other, within the automotive industry. Further similar other market structures, they seek to minimize cost and maximize profit.

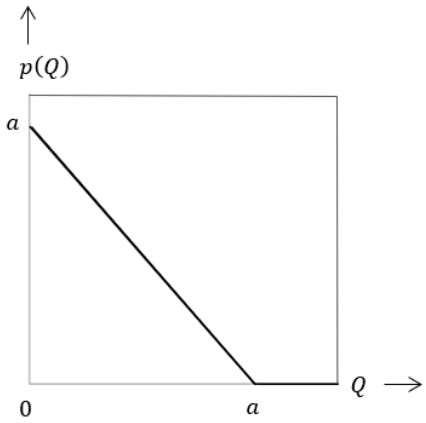
Regarding the structure of the model, the Cournot–Nash equilibrium situation can be created as follows:

The linear inverse export revenue function for the passenger cars in Player i:

$$ex\ p_i(R) = a_i - b_i Q, Q = q_1 + q_2 \quad (1)$$

where p_i is the average car price, and q_i is the export passenger car quantity, $a_i, b_i > 0$ and $c_i \geq 0$ are constants, and $q_1;\ q_2$ can be different, or equal. Finally, $t_1 = c_2$ and $t_2 = c_1$.

Figure 5. The export revenue function in the duopoly model



Source: author's elaboration

Player 's profit function can be derived from the total export revenue function (Figure 5) minus the total export cost function, which is given by:

$$ex\ R_1^t = p_1 q_1{}^3 \tag{2}$$

$$ex\ C_1^t = c_1 q_1, \tag{3}$$

where a_1 notes a coefficient of q_1 variable, while $t = PRE, POST$ illustrates the situation before and after the conclusion of the free trade agreement. The total cost to Player 1 of exporting q_1 units is $c_1 q_1$ (imposed tariff by Player 2 for q_1). Tariff levels are eliminated in the examined post free trade agreement period.

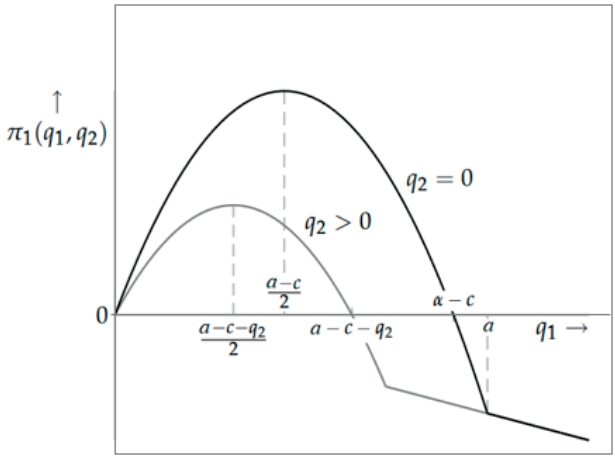
The payoff of each economic actor is determined by its own strategy and that of the other participants, so the payoff function of Player can be matched by its export profit function:

$$ex\ \pi_1^t = R_1^t - C_1^t \tag{4}$$

For determining the Player 1's best response function, we regard to q_2 as a given export quantity of Player 2. If $q_2 = 0$, then $ex\ \pi_1^t = (a - c_1 - q_1)q_1$ and maximum profit of Player 1 is $q_1 = (a - c)/2$. As export output of Player 2 increases, the Player 1's profit decreases, because more output results in a lower market price.

[3] b coefficient is included in q_1 and q_2 quantities.

Figure 6. Player 1's profit function, given Player 2's export output



Source: author's elaboration

The profit functions of Player 1 and Player 2 are based on the first-order condition of optimization:

$$\frac{\partial\, ex\, \pi_1^t}{\partial q_1} = (q_1 - a - q_2 - c_1)q_1 = 0 \tag{5}$$

$$\frac{\partial\, ex\, \pi_2^t}{\partial q_2} = (q_2 - a - q_1 - c_2)q_2 = 0 \tag{6}$$

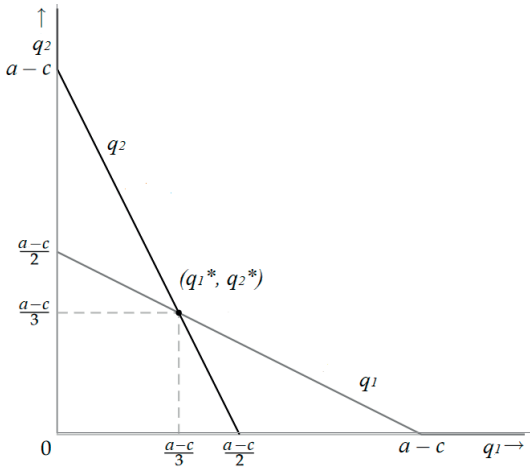
The reaction functions of Player 1 and Player 2 are thus:

$$r_1(q_2) = \frac{a - q_2 - c_1}{2} \tag{7}$$

$$r_2(q_1) = \frac{a - q_1 - c_2}{2} \tag{8}$$

The intersection of countries' reaction functions determines the Cournot-Nash equilibrium situation, which illustrates the quantities where the greatest profit can be achieved (q_1^* is the best reaction to q_2^*, and q_2^* is the best response to q_1^*). (Figure 7).

Figure 7. The best response functions for Player 1 and Player 2



Source: author's elaboration

5. Results

In this section, the paper presents the empirical results of EU-US most traded product for two scenarios under the linear Cournot trade model. The Cournot model was chosen for this situation, as its assumptions fit well the automobile situation of the EU-US. Specifications of the Cournot model are the simultaneous decision-making process and perfect information. In our trade game, the players seek to maximize their profit levels. Two scenarios have been examined to choose the best strategy for each economy. At the same time, these results are compared to the original profit solution.

Transatlantic bilateral trade determines European and American trade relations. The elimination of barriers will lead to an increase in EU-US trade and the competitiveness of these economies' firms.

Game theory has been widely applied to illustrate the decision-making process among participants, in which one players' decision influence the others' decision. Considering the strategic move of players, a decision tree can depict the possible options and the best payoff.

The revenues and costs are obtained for each economy in the two different periods *(PRE, POST)*. After the cooperation, we calculated zero tariff levels. Applying the Cournot model, we determine the export revenue and cost functions. (Figure 7)

Table 3. Pre and post FTA revenue and cost functions for passenger cars under original solution and the Cournot model

		Original solution	Cournot model
EU	*PRE*	$ex\ R_1^{PRE} = 0{,}0281826q_1$	$ex\ R_1^{PRE} = -0{,}00000004815q_2^2 + 0{,}0845479q_2 - 0{,}00000004815q_1q_2$
		$ex\ C_1^{PRE} = 0{,}0007046q_1$	$ex\ C_1^{PRE} = 0{,}0007046q_1$
	POST	$ex\ R_1^{POST} = 0{,}0281826q_1$	$ex\ R_1^{PRE} = -0{,}00000004815q_2^2 + 0{,}0930027q_2 - 0{,}00000004815q_1q_2$
		$ex\ C_1^{POST} = 0q_1$	$ex\ C_1^{POST} = 0q_1$
US	*PRE*	$ex\ R_2^{PRE} = 0{,}0289137q_1$	$ex\ R_2^{PRE} = -0{,}00000019435_2^2 + 0{,}0867410q_2 - 0{,}00000019435q_1q_2$
		$ex\ C_2^{PRE} = 0{,}0028914q_1$	$ex\ C_2^{PRE} = 0{,}0028914q_1$
	POST	$ex\ R_2^{POST} = 0{,}0289137q_1$	$ex\ R_2^{PRE} = -0{,}00000019435q_2^2 + 0{,}0954151q_2 - 0{,}00000019435q_1q_2$
		$ex\ C_2^{POST} = 0q_2$	$ex\ C_2^{POST} = 0q_2$

Source: author's elaboration

The best response functions (BRFs) are paired according to scenarios and derived from the equations of Table 3. The analysis uses a simultaneous equations method for solving the BRFs. (Table 4)

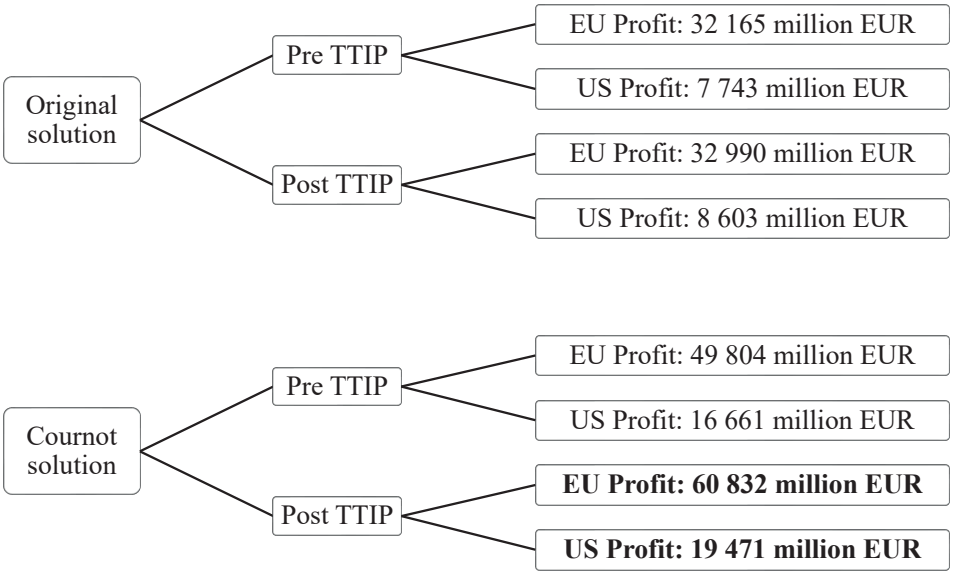
Table 4. Pre and post FTAs best response functions for the passenger cars

EU	Pre FTA	$r_1{}^{PRE}(q_2) = \frac{0{,}0845479 - 0{,}0007046}{0{,}00000009630} - 0{,}5q_2$
	Post FTA	$r_1{}^{POST}(q_2) = \frac{0{,}0930027}{0{,}00000009630} - 0{,}5q_2$
US	Pre FTA	$r_2{}^{PRE}(q_1) = \frac{0{,}0867410 - 0{,}0028914}{0{,}00000038870} - 0{,}5q_1$
	Post FTA	$r_2{}^{POST}(q_1) = \frac{0{,}0954151}{0{,}00000038870} - 0{,}5q_1$

Source: author's elaboration

Finally, the quanties from the best resonse functions are used to obtain the optimal profits. Similar steps have been applied to solve each profit function. The outcome of the estimations can be seen in Table 5.

Table 5. Payoffs of the optimal profit for EU and US under the original solution and the Cournot solution



Source: author's elaboration

The values show that TTIP results in a higher benefit for all the players compared to the preexisting situation, both under the original situation and the Cournot solution. Total profit of the two economies accounts for 66 465 million EUR before the TTIP, while this value rises to 80 304 million EUR after the agreement in the Cournot solution.

The European Comission's impact assessment report noted the economic potential in EU–US auto-related trade in the case of the elimination of tariff and non-tariff barriers. The study calls attention to the ambitious outcome, the estimated increase in automotive trade would more than a third of the total estimated increase with TTIP. (European Parliament 2015)

Our results are in line with the EC's calculation, but to gain a better insight, future research should consider other factors, such as NTBs on trade patterns.

6. Conclusion

The resurgence of modern free trade agreements since the 2010s has led to many studies regarding their impacts. This paper used the Cournot model to analyse the economic impacts of TTIP on the European Union and profit for the United States.

In contrast to previous studies, it was shown that the model can determine the effects on a macroeconomic level when different quantities and prices are used. The Cournot duopoly game model presents a simultaneous decision-making process under perfect information. We first determined all the two participants' profit functions, then the best response functions. Table 5. illustrates the options for all the payoffs. Using the Cournot–Nash equilibrium, the optimal profit level in the case of two scenarios was determined. From these scenarios, it is possible to select the best strategy for each Player and for both of them combined.

We assumed that the cooperation among the economies happens within new entrants to the agreement.

Our results are as follows: (1) post-FTAs situations show constant export output in the model; (2) the tariff elimination () in Player 2 will raise the Player 1's profit level from its pre-FTAs level (the positive profitability are true also in case of Player 2); (3) trade liberalization will improve the profit level of both economies if within the regions will higher profit from export output compared tariff income. In sum, a trade agreement could be a win-win situation, if the best strategy is chosen and applied by the participants. We highlight that these results may not be directly generalizable, if one or more circumstances change.

To the best of our knowledge, research that applies the Cournot model to determine the profit level of players has not yet been undertaken in this form. However, game theory has been widely applied for examining the strategic decisions of players in certain situations, where each individual's decision will affect themselves and another. The Cournot model was chosen and we find that its model assumptions (with changes in some cases) fit well with the example of free trade agreements since it analyses duopolistic market structures. In this model, the two players compete in terms of quality.

We can observe that impact assessments of modern trade agreements generally report low welfare-enhancing effects. This confirms the fact that a free trade agreement is very complex, mixing not just economic, but geopolitical targets. That is why it is impossible to capture all features in our model. However, we still hope that our aspect has shed some light on countries' behaviour in a free trade agreement.

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Appendix

Appendix 1. Categorization of WTO+ and WTO-X provisions

WTO+	WTO-X	
· Tariffs Industrial goods	· Anti-corruption	· Financial assistance
· Tariffs agricultural goods	· Competition policy	· Health
· Customs administration	· Environmental laws	· Human Rights
· Export taxes	· IPR	· Illegal immigration
· SPS measures	· Investment measures	· Illicit drugs
· State trading enterprises	· Labour market regulation	· Industrial cooperation
· TBT measures	· Movement of capital	· Information society
· Countervailing measures	· Consumer protection	· Mining
· Anti-dumping	· Data protection	· Money laundering
· State aid	· Agriculture	· Nuclear safety
· Public procurement	· Approximation of legislation	· Political dialogue
· TRIMS measures	· Audiovisual	· Public administration
· GATS	· Civil protection	· Regional cooperation
· TRIPS	· Innovation policies	· Research and technology
	· Cultural cooperation	· SMEs
	· Economic policy dialogue	· Social Matters
	· Education and training	· Statistics
	· Energy	· Taxation
		· Terrorism
		· Visa and asylum

Source: author's elaboration based on Hofmann–Osnago-Ruta (2017)

Appendix 2. List of mathematical symbols and notations

i	EU and US respectively with the index $i = 1, 2$
t	Periods representing pre and post FTAs
p_i^t	Product's unit price in Player i
c_i^t	Tariff unit cost of Player i
q_i^t	Player i's total automotive export output in terms of s
Q_i^t	Total automotive export quantity for the two countries in terms of s
a_i^t, b_i^t	Coefficient of a variable in the revenue function for Player i
r_i^t	Reaction function of Player i for period t
π_i^t	Automotive export profit function of period t for Player i
R_i^t	Countries total automotive export revenue function of period t for Player i
C_i^t	Countries total automotive export cost function of period t for Player i

Source: author's elaboration

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