THE OPTIMAL FOREIGN TRADE POLICY FOR RUSSIAN CARS IN THE UKRAINIAN MARKET

by

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Abstract

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The thesis develops a new model of international oligopoly to fit the specifics of the Ukrainian automobile market. To provide the model with empirical content, the demand system for Ukrainian and Russian cars is estimated. On the basis of the theoretical model and the estimated demand system, the study provides a welfare assessment of the tariff in 2002 and recommends an optimal trade policy to be pursued in the automobile market.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

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Chapter 1

INTRODUCTION

Ukrainian automobile market has experienced a substantial revival following the resurge of economic growth in the country in 2001. However, by that time national automobile manufacturers were unable to cope with the increased demand, and the market was quickly filled with Russian cars that captured over a half of new vehicle sales in 2001.

Under circumstances, the lobby of Ukrainian automobile producers resulted in the initiation of a special investigation against the imports of Russian cars. This resulted in a temporary tariff being imposed on Russian car imports to stabilize market demand. The tariff has reached its objective, and the demand was shifted towards Ukrainian cars by the end of 2002.

At the same time, the prices for Russian cars have risen sharply, which could have caused a decline in domestic welfare. Besides, according to the survey conducted by IAG "Auto-Consulting", there was a substantial "postponed demand" for Russian cars caused by the tariff. Hence, a study is called for to analyze the welfare consequences of the tariff.

Recently a new wave of protectionist policy debate has emerged in the governmental circles. This has resulted in the announcement of Ukrainian Prime-Minister that a tariff of 28% will be imposed on the imports of all passenger cars. Therefore, another objective of the study is to provide an estimate for the optimal level of tariff protection for Ukraine.

In order to find the optimal level of tariff, one needs to set up a model of Ukrainian automobile market. Clearly, given the market structure presented in Chapter 2, competitive market models used in the context of international trade are not applicable for Ukraine. The models of international oligopolistic industries provided by the literature are also not adequate due to the presence of domestic importers who capture part of the surplus attributable to foreign cars. Hence, to estimate the optimal level of tariff protection an original model tailored to the specifics of Ukrainian automobile market should be developed.

The paper is structured as follows: first, brief background information about the structure of Ukrainian automobile market and the recent policy decisions around it will be presented in Chapter 2. Chapter 3 gives an outline of the related literature. The derivation of the theoretical model is presented in Chapter 4. Chapter 5 describes the data used in the empirical part of the paper and outlines their key features. Econometric estimation of the demand system used in the theoretical model is given in Chapter 6. The main results of the study are summarized in Chapter 7. Chapter 8 concludes.

Chapter 2

BACKGROUND INFORMATION

Sequence of Events

After the claims of Ukrainian car manufacturers that competition with Russian car makers is detrimental for the development of the automobile industry in Ukraine a special investigation was started on July 30, 2002 to determine whether the competition is indeed harmful for Ukraine. For the period of special investigation (from August 1, 2002 to December 8, 2002) a special tariff[1] of 31.8% was introduced for the import of Russian passenger cars with the engine volume from 1 to 1.5 liters. As a result of tariff imposition, the market share of Russian cars in the less expensive market segment dropped sharply from 56% to 36%. Following the termination of special investigation, import of Russian passenger cars was subjected to quota of 15777 cars per annum[2]. According to the conventional economic theory, the resulting decrease in the quantity of imported cars could have harmed not only Russian car manufacturers, but also Ukrainian consumers of the cars subjected to trade restriction. In fact, many of the would-be buyers of the Russian cars (mostly different makes of AutoVAZ cars) had to postpone their purchase till December 2002 when the tariff was cancelled. Therefore, the first objective of this study is to provide an assessment of the welfare loss brought about by the duty.

Furthermore, currently the association of Ukrainian car manufacturers insists on the imposition of a new permanent import tariff for Russian cars to protect

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[1] This term stems directly from Ukrainian legislation about foreign trade

[2] According to IAG "Auto-Consulting" (www.autoconsulting.com.ua)

domestic production. Therefore, it is of crucial importance to provide a sound theoretical and empirical justification for the claims of both parties and resolve the dispute on the basis of maximizing social welfare of Ukraine. In this light, the second objective of my thesis is to estimate an optimal level of tariff to be imposed on Russian cars.

In the following discussion I will consider only the market for low-price vehicles that is relevant for Ukrainian producers. Further I shall refer to this segment as the "Ukrainian market".

Structure of the Market

The majority of cars traded in the low-price segment of the Ukrainian automobile market is composed of Ukrainian vehicles (Tavria, Slavuta, Lanos, and Sens) and Russian ones (93-95% of which are the different models of AutoVAZ[3]). Hence, we may consider the influence of other producers as inconsequential. Therefore, the market represents an international oligopoly with differentiated products.

A distinct feature of the Ukrainian automobile market is that the Russian manufacturer, the AutoVAZ, does not have a significant dealer network (only about 5% of new AutoVAZ cars are sold through company dealerships, the remainder being either imported by independent dealers, or by private individuals). Therefore, for all practical purposes all dealers may be considered Ukrainian residents.

The Ukrainian market is relatively small in comparison with the production capacity of AutoVAZ (in 2002 372628 cars were manufactured, and only 26564 sold in Ukraine during January-July 2002, with a part of the market supplied by domestic assembly plants). Furthermore, an attempt of price discrimination of

[3] Ibid.

exported cars by AutoVAZ is likely to encounter a problem of arbitrage through re-export. Hence, it is unlikely that even a moderate change in Ukrainian demand alone will account for the change in car price. This implies that the cars will be supplied at a flat import price at Russian border.

The two groups of cars (Russian and Ukrainian) are relatively homogeneous within the groups, with the Russian AutoVAZ cars being more powerful and relatively more expensive than Ukrainian AutoZAZ ones. Therefore, to a rough approximation the market may be represented by two homogeneous groups of models that are imperfect substitutes to each other.

Chapter 3

LITERATURE REVIEW

While the existing body of theoretical literature is quite abundant, the empirical studies on the matter of evaluation of tariffs and quotas are relatively scarce. The reason for the scarcity is probably the lack of occasions for "natural experiments" which would allow an economist to accurately measure the impact of a particular policy instrument on the basis of empirical observation. Otherwise the question of tariff optimality remains a largely theoretical speculation. In what follows I review the existing theoretical and empirical evaluations of the trade policy under the conditions of international oligopoly prevalent in Ukrainian automobile market. The review of the relevant literature on the theoretical model and empirical estimation employed in the study will be presented in the corresponding chapters.

3.1 Theoretical Developments

The early work on the trade policy issues relied, primarily, on the assumption of perfect competition in the market of a domestic country. This assumption greatly simplified the calculations and derivation of policy recipes. An example of such early study is Wonnacott and Wonnacott (1981), where the authors question a policy prescription of (unilateral) uniform tariff reduction as opposed to forming a customs union. The conventional argument in favor of uniform tariff reduction was that with the tariffs reduced the domestic consumers would face lower prices for imported goods, and thereby domestic welfare would be improved. The authors argue that under most circumstances a customs union is welfare superior to a uniform tariff reduction, since the classical advice does not account for a better access to the markets of partner countries in customs union.

A later development in the area, Anderson (1997) studies the effect of elimination of trade distortions in a competitive economy. The crucial difference of the paper from a previous theoretical literature is that the author explicitly introduces government revenue from a tariff into the model. He argues that the reduction in tariff forces government to seek alternative sources of budgetary revenues through distortionary taxation, and, therefore, one should weigh the marginal benefits of funds raised through a tariff against marginal cost thereof. The conclusion from this theoretical model is that the quota liberalization is likely to enhance social welfare, while the aggregate efficiency of tariff liberalization is dubious.

The theoretical work in the markets under the conditions of imperfect competition *de facto* started only in the beginning of 1980s due to its complexity and the interdisciplinary character. Dixit (1984) provides a short summary of the literature existing at that time. He also gives examples of addressing various aspects of international oligopoly with a simple theoretical framework. The main conclusion of his paper is that the competitive policy recipes (almost universally accepted to be the best for the development of the domestic economy) may become harmful in the context of international oligopoly. Therefore, he warns from blind replication of domestic policy measures for international markets.

Eaton and Grossman (1986) in their paper study the optimal trade policy under different assumptions about the nature of competition in international oligopoly. As one of their findings, the authors conclude that when domestic consumption exists the optimal trade policy may include a mix of import tariff/export subsidy and production tax/subsidy depending on the particular conditions of the market. Hence, there are no *a priori* reasons to suggest one or another trade policy regime as being optimal for all markets.

As a further theoretical development of the field, Cheng (1988) provides theoretical grounds for the protection of domestic industry under international oligopoly. His findings illustrate that the policy measures to be undertaken under different modes of competition vary significantly. For example, he argues that under Cournot competition the preferred policy would be a domestic production tax and a tariff, whereas under Bertrand competition production subsidy and free trade regime would be more desirable.

Parai (1999) gives a further extension of Cheng's model to the case of international duopoly with the instruments of domestic government being a tariff and a corporate profit tax. The author argues that in case when it is not feasible to raise the tariff, reduction in corporate profit tax can effectively shift net profits away from a foreign towards a domestic firm. Thereby government can accomplish a twofold objective: to increase corporate earnings at home and to boost domestic employment.

Corchón and González-Maestre (2001) evaluate the optimal magnitude of trade policy instruments under Cournot oligopoly in the product market. They argue that if the policy instrument is an import quota, the optimal trade regime is either free trade or autarky; while if the instrument is an import tariff, the welfare-optimal trade policy lies between the two extreme cases of autarky and free trade. Further, the authors claim that in the presence of fixed costs the welfare-enhancing role of a tariff may be not only in increasing domestic profits, but also in increasing domestic consumers' surplus.

Spencer and Jones (1991) provide a theoretical justification for the optimal trade policy under vertically integrated oligopolistic setup. They found that the optimal policy for exporting country might require either taxing of subsidizing exports of both a final product and an intermediary input. The basic theoretical development of vertical integration in the context of international trade dates back to Dixit and Grossman (1982). They also derive the optimal responses of the industry under free trade regime depending on the cost structure of the industry.

In their pioneering study of quota impact under international oligopoly subject to variable returns to scale Chao et al. (1990) showed that in the most circumstances the imposition of quota adversely affects the level of domestic welfare. However, they also argue that in case if the negative effect of quota is outweighed by the positive effect of increasing returns to scale the effect may actually become positive. This finding strongly contradicts the conventional textbook representation of quota as necessarily welfare-reducing and provides theoretical justification for imposition of import quotas.

Hwang and Mai (1991) recommend an optimal discriminatory tariff protection for a country supplied by an international duopoly as a welfare-enhancing policy. The basic conclusion is that the higher tariffs should be imposed for lower-cost producer. As a further development to discriminatory tariff branch of literature To (1999) introduces dynamics into a model by Hwang and Mai. The focus is on consumers' switching costs as proxied by firm's market share. The author argues that in the presence of significant switching costs the inability of domestic government to precommit the conclusion of a static model does not necessarily hold, since the discriminatory tariffs may induce the firms to charge higher prices, and thereby reduce welfare of consumers. Therefore, in the dynamic context the obedience to GATT MFN principle may be more desirable than activist trade policy. Although with a different theoretical setup, similar conclusion is shared by

Staiger and Tabellini (1987). In their framework, the source of time inconsistency stems from the costs of labor reallocation within the country.

A recent contribution to the field of policymaking under international oligopoly, Moraga-Gonzalez and Viaene (2002), studies the procompetitive trade policies. They compare in terms of welfare effects the trade regimes of free trade, Most Favored Nation (MFN) and nonuniform tariff. The key findings of the article state that the nonuniform trade policy is welfare superior to the MFN clause, which is, in turn, welfare superior to free trade policy. Another finding of the authors concerns the formation of regional trade agreements (RTAs). They claim that RTAs with low-quality producing country yield larger welfare gain than such agreements with high-quality producing country.

As can be seen, normative prescriptions regarding the optimal trade policy are abundant and vary substantially between different theoretical models. Therefore, it is a matter of an empirical study to resolve the dispute of theorists.

3.2 Empirical Studies

Goldberg (1995) provides a direct comparison of an import tariff and "voluntary export restraint" (VER) on Japanese cars in the case of American automobile market. The author relies on the demand estimated from microdata and the framework of oligopoly with differentiated products to derive her conclusions. The major conclusion of the paper is that the VER was binding during the most period under investigation. Its major incidence was found to be in protecting domestic producer, and it has probably hurt domestic consumers. Goldberg finds also that the VER (for the purposes of this study equivalent to quota) could be effectively replaced by a tariff of 55 to 64% to produce the same effect. Therefore, author argues that VER is welfare-inferior to tariff, and that a change of policy instrument from VER to import tariff would enhance welfare of the US.

Deardoff and Stern (1997) provide a detailed guide to study the impact of non-tariff measures of trade policy. The authors provide methodology for transforming non-tariff restrictions on import into an equivalent tariff measures. They use the described methods to investigate the equivalent levels of protection in a number of markets of selected OECD countries.

Harrison et al. (1997) pioneer the evaluation of trade policy for Chile. The authors find Chile's import tariff of 11% to be quite efficient, so that preferential reduction of its level potentially threatens to reduce welfare, while the (unilateral) uniform tariff cut to 6-8% will be beneficial for the country. This measure would also convert loss from participation in MERCOSUR into gain and would also increase gains from a potential agreement with NAFTA. As a later assessment of Chilean trade policy, Schiff (2002) studies the prospects of integration of Chile into a number of trade agreements. He finds that while the country will benefit from the FTA with the US, the benefits of participation in MERCOSUR and Andean Pact are more doubtful. Also, the author argues that the optimal trade policy should include the consolidation of all tariffs and reduction of GATT uniform MFN tariff to the level of 6% by the end of 2003.

Santos-Paulino (2001) investigates the impact of a reduction of import restrictions on the growth of imports in a selection of developing countries. The author finds that a reduction of import barriers increased the price and income elasticities of imports, and also increased the rates of import growth in the countries under investigation. This finding is broadly consistent with the import substitution trade policies employed prior to trade liberalization. However, the exact effect of the liberalization is depends on a region and a type of trade policy existing in a country.

An influential study that stands out from the body of theoretical literature on trade policy is a paper by Grossman and Helpman (1994). Their contribution is that they endogenize trade policy by making it a result of a political process. They argue that it is government who sets the policy, and its preferences may include other constituents aside from the welfare of the nation. In their model the government maximizes utility that comprises social welfare and "political support", i.e. the contributions to the electoral campaign. As a direct empirical development of the topic, Goldberg and Maggi (1999) test the predictions of Grossman and Helpman model. They find that the empirical results are roughly consistent with the theory in its most parsimonious form, and extended specifications do not contribute much to enhance the explanatory power of the model. On the basis of US data Goldberg and Maggi find that the weight assigned by government to the social welfare is grossly larger than the one assigned to political support. Eicher and Osang (2002) test the model further, and find that the "protection is indeed for sale", and that not only the existence of the lobbies matter in the setting of protection level, but also the relative size of pro and anti protection contributions. The results of the authors also suggest that "influence driven" Grossman-Helpman model fares much better against empirical evidence that the alternative model of "tariff function" by Findlay and Wellisz (1982).

To summarize, the literature on the subject of trade policy under international oligopoly remains a relatively new and rapidly developing area of economic research. The consensus on the matter of approach to the subject has not yet been formed. At the same time, the conclusions and policy recipes of the different authors critically depend on the assumptions about the market that they adopt. Therefore, any further study in the area should carefully state and justify the premises on which the research is based.

Chapter 4

THEORETICAL MODEL OF THE MARKET

The Ukrainian automobile market represents an international oligopoly. The theoretical framework for national oligopolistic setting is well developed in the literature. However, similar models for the international setting are not as common and diverse. The emphasis of this chapter will be on the use of theoretical models and the evidence from empirical studies of the automobile market.

4.1 Previous Studies

A theoretical explanation of an empirical fact that international trade can occur even between the identical countries was done by Markusen (1981) and generalized by Cordella (1998). The conclusion stands valid, though, only under imperfect competition in the product market. Cordella also shows that the exact pattern of international trade in an imperfectly competitive industry cannot be derived either from pre-trade prices, or from comparative advantage principle.

The literature has developed two approaches to the modeling of an oligopolistic setting. The first one is based on a discrete game-theoretic framework and is mostly used to explain discrete type of decisions, like entry or exit, accommodation or entry prevention. The second one roots in a continuous strategy game-theoretic framework, and is mostly used to model "continuous" decisions, like price of a good or quantity supplied to the market.

The first approach may be represented by the Dixit (1982), who studies entry in the oligopolistic setup with commitments and reputation in place; and Dixit and

Kyle (1985), who model the strategic interaction of the two governments each of which hosts an international duopolist. A substantial drawback of this approach is that due to the discrete nature of the game it cannot be effectively solved without prior information about payoff functions, and this feature renders discrete models a purely theoretical exercise, with little or no ability to generate policy implications.

The second approach is much more appealing for the analysis of oligopolistic behavior, since it enables one to study the implications of the change in model parameters directly and predict the magnitude and the direction of the system's response. One of the earlier works in the area of oligopoly analysis using continuous framework is Dixit (1979). The author applies now conventional Cournot oligopoly setup to investigate the entry, entry accommodation and entry deterrence decisions within duopoly.

The theoretical modeling of international oligopoly using the continuous game-theoretic framework dates back to the work of Dixit (1984). The model he uses relies on Cournot concept of equilibrium. Although simple, this framework enables one to determine the major differences between the case of perfect competition and oligopoly for trade policy. A more general study of Eaton and Grossman (1986) continues the development aimed at a rigorous modeling of international oligopoly under different assumptions about the nature of competition. The emphasis of the paper is on the case where there is no domestic consumption of the goods produced by oligopoly. However, the authors also provide some tools for modeling the international oligopoly with domestic consumption present. Cheng (1988) further develops the approach pioneered by Eaton and Grossman, and in particular elaborates the case of domestic consumption of a good produced by international oligopoly.

The automobile market is usually modeled as a Bertrand type oligopoly, for example by Goldberg (1995), Goldberg and Verboven (1999). The studies use a multiproduct oligopoly setting to derive Nash equilibrium conditions for the firms in the industry facing the previously estimated demand. The main assumption underlying Bertrand model is that the firms compete via setting the prices for their products. As Goldberg and Verboven (1999) note, "The assumption of price setting is common, and consistent with industry wisdom." However, it is also true that Bertrand model is only plausible in the majority of cases, but not all of them. Supporting this claim, Kirman and Schueller (1990) argue that in the presence of significant import tariffs or strong consumer preferences towards the national automobile brands a more appropriate model of the market is Stackelberg leadership. The authors use this model to explain price discrimination in European automobile market. Brander and Zhang (1990) in an empirical study of an airline industry suggest that Bertrand competition model, and especially its predictions of aggressive pricing are not supported by the data, whereas the Cournot model is much more consistent with the data.

With respect to the choice of theoretical setup it is instructive to look at Feenstra and Levinsohn (1995). They estimate markups and market conduct of multiproduct oligopolies under the various assumptions about the nature of competition in the market. Aside from the standard cases of oligopoly, the authors create a theoretical framework for the mixed Nash equilibrium for international oligopoly where different players are subject to different import restrictions. The findings of the authors indicate that the empirical results of the model crucially depend upon the assumptions made about the competitive environment of the market, since the estimated markups differ by 300 percent and more under different assumptions. Therefore, it is necessary to provide either empirical, or common sense justification for the choice of the nature of competition prior to the construction of a theoretical model.

4.2 Model of Ukrainian Market

Based on the market description given in Chapter 2, it is clear that no standard model exactly fits the specifics of Ukrainian automobile market. Therefore, a special theoretical model must be developed to adequately reflect the actual situation in Ukraine.

Broadly speaking, the model is structured as presented on Figure 1. The foreign firm sells cars to a small number of domestic importers ($I_1 \ldots I_n$), who in turn sell them to the dealers. The domestic firm sells the cars directly to the dealers. All dealers are small enough to be unable exercise any strategic behavior in this setup. Hence, for the purpose of modeling, the fact of their existence may be ignored.

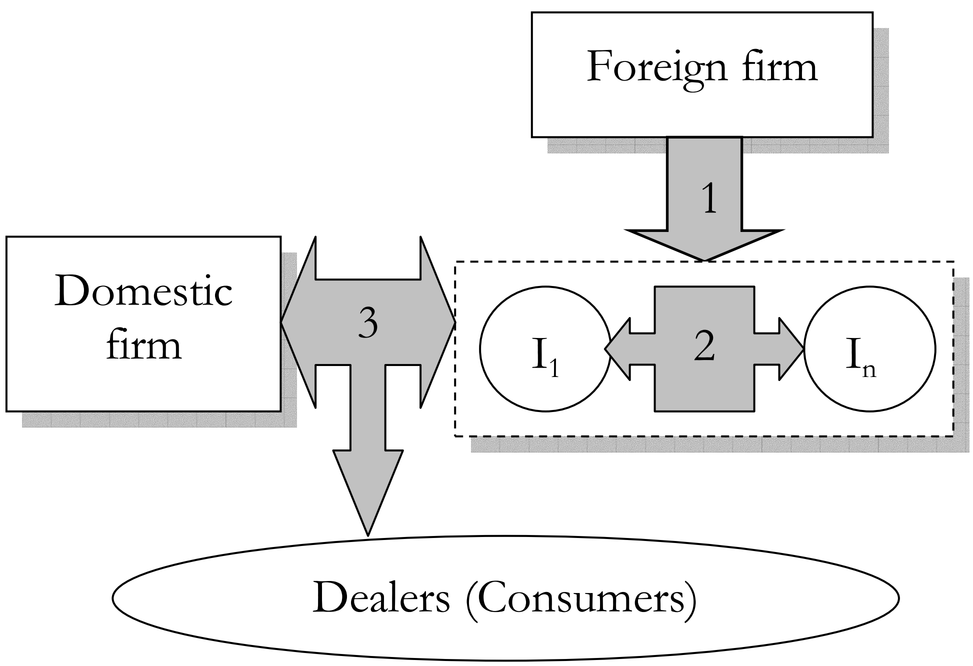

Figure 1. Structure of the Model.

The major focus in the model lies in the three interactions labeled in the Figure 1. Interaction 1 arises between the foreign firm and domestic importers when the car is imported to Ukraine. Interaction 2 occurs between the importers in the foreign car segment of the market. And, finally, interaction 3 takes place between the domestic firm and the importers when the car is sold.

As far as the interaction 2 is concerned, arguably the most appropriate structure for it would be Cournot quantity rivalry. The rationale behind this assertion is that by importing cars importers in fact commit to the quantity they will sell in the market. Hence, Cournot model seems to be most reasonable here.

It is more difficult to impose certain structure on the other two interactions, though. For interaction 1 we could imagine the situation when the actions of importers could not change the price commitment of the foreign firm, or, on the opposite extreme, the foreign firm could exercise absolute monopoly power in that interaction. In the third interaction the most frequently used model in the case of an import tariff would be Stackelberg leadership (Kirman and Schueller, 1990). Hence, further I will examine the combinations of the options listed.

Formally, the discussion above translates into a set of assumptions. In what follows I will take them up in turn and examine how the change in the assumptions about the behavior of market actors will alter the predictions of the model. Then, having examined the model of the market, I will introduce government as a strategic player into the model and let it choose its policy variable, the level of the tariff t.

Assumptions:

A1. There are two segments of the market, the one for domestic (Ukrainian) cars, with Q_D units sold at price P_D, and the one for foreign (Russian) cars, with Q_F units sold at price P_F.

A2. The domestic cars segment is supplied by a single Ukrainian firm with a constant marginal cost of production MC_D.

A3. The foreign cars segment is supplied by n identical firms (importers), who each import q_F units of cars from a foreign country at a constant transfer price and face an *ad valorem* import tariff t. The transfer price is synonymous with the baseline marginal cost of the importers, MC_F.

A3a. The foreign cars segment is supplied by n identical firms (importers), who each import q_F units of cars from a foreign country at a price MC_F set by the foreign monopoly and face an *ad valorem* import tariff t.

A4. The group of domestic cars is homogeneous and the group of foreign cars is homogeneous, but the groups are imperfect substitutes to each other.

A5. The rivalry between the two market segments is assumed to be Stackelberg quantity leadership of the domestic firm (because both domestic and foreign car suppliers commit to quantities of cars supplied to the market when making their production/purchase decisions and because the domestic firm has a first mover advantage).

A6. The rivalry between the suppliers of foreign cars is assumed to be Cournot[4] (because by importing a certain number of cars the importer essentially pre-commits to a certain quantity thereof).

A7. The demand system is characterized by the following system of equations[5]:

$$\begin{pmatrix} Q_D \\ Q_F \end{pmatrix} = \begin{pmatrix} a_D \\ a_F \end{pmatrix} + \begin{pmatrix} -b_D & c_D \\ c_F & -b_F \end{pmatrix} \begin{pmatrix} P_D \\ P_F \end{pmatrix} \tag{1}$$

I further assume that $b_i > c_i$, $a_i>0$, $b_i>0$, $c_i>0$, $i=D,F$.

A8. The taxation system of the economy is characterized by the marginal cost of public funds equal to (η-1), that is, a marginal hryvna of tax revenue collected would result in an excess burden of (η-1) hryvna.

A9. The production function of the foreign car manufacturer is (dually) characterized by constant marginal cost MC_R.

For further manipulation with the demand system it is convenient to state and prove the following lemma:

Lemma 1. For the (direct) demand system given by A7 there is a unique inverse demand system given by (2):

$$\begin{pmatrix} P_D \\ P_F \end{pmatrix} = \begin{pmatrix} \alpha_D \\ \alpha_F \end{pmatrix} + \begin{pmatrix} -\beta_D & -\gamma_D \\ -\gamma_F & -\beta_F \end{pmatrix} \begin{pmatrix} Q_D \\ Q_F \end{pmatrix}, \tag{2}$$

where $a_i>0$, $\beta_i>0$, $\gamma_i>0$, $i=D,F$

[4] As has been noted in Chapter 2, there are only three official importers of AutoVAZ cars in Ukraine. Hence, one would not expect to have a severe competition between them. Therefore, I use Cournot model as an appropriate description of the market conduct.

[5] This demand system might come form the maximization of quasilinear preferences in the case when $c_F=c_D$. Here due to the empirical difference of the two cross-effects I will let them be different.

□ Let us first rewrite (1) as follows:

$$\begin{pmatrix} Q_D - a_D \\ Q_F - a_F \end{pmatrix} = \begin{pmatrix} -b_D & c_D \\ c_F & -b_F \end{pmatrix} \begin{pmatrix} P_D \\ P_F \end{pmatrix}$$

Clearly, this is a system of two linear equations in two unknowns, P_D and P_F. Hence, it may be further re-written as:

$$B = \begin{pmatrix} Q_D - a_D \\ Q_F - a_F \end{pmatrix} = \begin{pmatrix} -b_D & c_D \\ c_F & -b_F \end{pmatrix} \begin{pmatrix} P_D \\ P_F \end{pmatrix} = A \begin{pmatrix} P_D \\ P_F \end{pmatrix};$$

$$A^{-1}B = A^{-1}A \begin{pmatrix} P_D \\ P_F \end{pmatrix} = \begin{pmatrix} P_D \\ P_F \end{pmatrix}; \tag{L1.1}$$

$$A^{-1} = \begin{pmatrix} -b_D & c_D \\ c_F & -b_F \end{pmatrix}^{-1} = \frac{1}{\det A} \begin{pmatrix} -b_F & -c_D \\ -c_F & -b_D \end{pmatrix} = \frac{1}{(b_D b_F - c_D c_F)} \begin{pmatrix} -b_F & -c_D \\ -c_F & -b_D \end{pmatrix} \tag{L1.2}$$

Matrix A will always be invertible, since, given the magnitude of the parameters in A7, det A is strictly positive. From here also stems the uniqueness of solution (i.e. of the inverse demand system). Substituting (L1.1) into (L1.2), we get:

$$\frac{1}{(b_D b_F - c_D c_F)} \begin{pmatrix} -b_F & -c_D \\ -c_F & -b_D \end{pmatrix} \begin{pmatrix} Q_D - a_D \\ Q_F - a_F \end{pmatrix} = \begin{pmatrix} P_D \\ P_F \end{pmatrix};$$

$$\frac{1}{(b_D b_F - c_D c_F)} \begin{pmatrix} b_F & c_D \\ c_F & b_D \end{pmatrix} \begin{pmatrix} a_D - Q_D \\ a_F - Q_F \end{pmatrix} = \begin{pmatrix} P_D \\ P_F \end{pmatrix};$$

$$\frac{1}{(b_D b_F - c_D c_F)} \begin{pmatrix} b_F & c_D \\ c_F & b_D \end{pmatrix} \left[\begin{pmatrix} a_D \\ a_F \end{pmatrix} - \begin{pmatrix} Q_D \\ Q_F \end{pmatrix} \right] = \begin{pmatrix} P_D \\ P_F \end{pmatrix}.$$

Denoting $D = \det A = (b_D b_F - c_D c_F) > 0$ (as follows from A7), we get:

$$\frac{1}{D} \left[\begin{pmatrix} a_D b_F + a_F c_D \\ a_D c_F + a_F b_D \end{pmatrix} - \begin{pmatrix} b_F & c_D \\ c_F & b_D \end{pmatrix} \begin{pmatrix} Q_D \\ Q_F \end{pmatrix} \right] = \begin{pmatrix} \alpha_D \\ \alpha_F \end{pmatrix} + \begin{pmatrix} -\beta_D & -\gamma_D \\ -\gamma_F & -\beta_F \end{pmatrix} \begin{pmatrix} Q_D \\ Q_F \end{pmatrix} = \begin{pmatrix} P_D \\ P_F \end{pmatrix}$$

Here $\alpha_i = \dfrac{a_i b_j + a_j c_i}{D} > 0$, $\beta_i = \dfrac{b_j}{D} > 0$ and $\gamma_i = \dfrac{c_i}{D} > 0$ for all $i, j = D, F$ and $i \neq j$ (given that A7 holds). ■

Model 1. Stackelberg Leadership with a Fixed Transfer Price.

Let us first consider the model characterized by assumptions A1-A3, A4, A5, A6-A8. Then, the interaction between market actors has two stages:

- Stage 1. Domestic firm chooses its level of production to maximize its profit.
- Stage 2. Importers choose the amount they are willing to supply to the market on the basis of the domestic firm's quantity to maximize individual profits.

Now, as it is conventionally done, let us solve the game backwards, i.e. from the second stage to the first.

Stage 2. Each importer maximizes its profit observing the quantity supplied to the market by the domestic firm Q_D and tariff t set by the government by choosing individual quantity supplied to the market q_F such that

$$q_{F_i}^* = \arg\max_{q_{F_i}} \pi_F = \arg\max_{q_{F_i}} \left\{ q_{F_i} P_F(Q_F, Q_D) - q_{F_i} MC_F (1+t) \right\} \tag{3}$$

Proposition 1. Given assumptions A1-A7, the Cournot-Nash equilibrium for problem (3) is:

$$q_{F_i}^* = q_F^* = \frac{\alpha_F - \gamma_F Q_D - MC_F(1+t)}{\beta_F(n+1)}, \tag{4}$$

where the parameters of the inverse demand system a_F, β_F and γ_F are equal to those found in Lemma 1.

□ The first-order conditions for problem (3) are given by:

$$\frac{\partial \pi_{F_i}}{\partial q_{F_i}} = P_F(Q_F, Q_D) + q_{F_i}^* \frac{\partial P_F}{\partial Q_F} \frac{\partial Q_F}{\partial q_{F_i}} - MC_F(1+t) \overset{set}{=} 0;$$

$$\frac{\partial \pi_{F_i}}{\partial q_{F_i}} = \alpha_F - \beta_F (q_{F_i}^* + \sum_{j \neq i} q_{F_j}^*) - \gamma_F Q_D + q_{F_i}^* (-\beta_F)(1) - MC_F (1+t) \overset{set}{=} 0;$$

$$\frac{\partial \pi_{F_i}}{\partial q_{F_i}} = \alpha_F - \beta_F (2q_{F_i}^* + \sum_{j \neq i} q_{F_j}^*) - \gamma_F Q_D - MC_F (1+t) \overset{set}{=} 0 \qquad \text{(P1.1)}$$

Since all importers are assumed (assumption A3) to be identical, $q_{F_i}^* = q_F^*, \forall i = 1,...,n$. Then, (P1.1) simplifies to:

$$\frac{\partial \pi_{F_i}}{\partial q_{F_i}} = \alpha_F - \beta_F q_F^* (n+1) - \gamma_F Q_D - MC_F (1+t) \overset{set}{=} 0 \qquad \text{(P1.2)}$$

Solving (P1.2) for q_F^* results in

$$q_F^* = \frac{\alpha_F - \gamma_F Q_D - MC_F (1+t)}{\beta_F (n+1)}.$$

Second-order condition is also satisfied here: $\frac{\partial^2 \pi_{F_i}}{\partial q_{F_i}^2} = -\beta_F (n+1) < 0$

Since at $q_{F_i} = q_F^*$ all firms' reaction functions intersect, it is a Cournot-Nash equilibrium for this game. ■

Since there are n identical importers, the total quantity of foreign cars supplied to the market is $Q_F^* = Q_F^*(Q_D) = \sum_{i=1}^{n} q_{F_i}^* = nq_F^* = n\frac{\alpha_F - \gamma_F Q_D - MC_F (1+t)}{\beta_F (n+1)}$. (5)

Stage 1. At this stage the domestic firm sets its quantity supplied to the market Q_D observing the tariff set by the government t. The quantity supplied is chosen to maximize profits:

$$Q_D^* = \arg\max_{Q_D} \pi_D = \arg\max_{Q_D} \{Q_D P_D (Q_F^*(Q_D), Q_D) - Q_D MC_D\} \qquad (6)$$

Proposition 2. Given assumptions A1-A7, the equilibrium quantity of domestic cars supplied to the market is:

$$Q_D^* = \frac{(\alpha_D - MC_D)\beta_F - \gamma_D \frac{n}{n+1}(\alpha_F - MC_F(1+t))}{2(\beta_D\beta_F - \gamma_D\gamma_F \frac{n}{n+1})} \quad (7)$$

□ The first-order condition for problem (6) is given by:

$$\frac{\partial \pi_D}{\partial Q_D} = P_D(Q_F^*(Q_D^*), Q_D^*) + Q_D^*\left[\frac{\partial P_D}{\partial Q_D} + \frac{\partial P_D}{\partial Q_F^*}\frac{\partial Q_F^*}{\partial Q_D}\right] - MC_D \overset{set}{=} 0;$$

$$\frac{\partial \pi_D}{\partial Q_D} = \alpha_D - \beta_D Q_D^* - \gamma_D Q_F^*(Q_D^*) + Q_D^*\left[(-\beta_D) + (-\gamma_D)(-\frac{n\gamma_F}{\beta_F(n+1)})\right] - MC_D \overset{set}{=} 0;$$

$$\frac{\partial \pi_D}{\partial Q_D} = \alpha_D - 2\beta_D Q_D^* - \gamma_D n\frac{\alpha_F - \gamma_F Q_D^* - MC_F(1+t)}{\beta_F(n+1)} +$$

$$+ Q_D^*\left[(-\gamma_D)(-\frac{n\gamma_F}{\beta_F(n+1)})\right] - MC_D \overset{set}{=} 0;$$

$$\frac{\partial \pi_D}{\partial Q_D} = \alpha_D - 2\beta_D Q_D^* - \gamma_D n\frac{\alpha_F - 2\gamma_F Q_D^* - MC_F(1+t)}{\beta_F(n+1)} - MC_D \overset{set}{=} 0;$$

$$\frac{\partial \pi_D}{\partial Q_D} = \alpha_D - MC_D - \gamma_D n\frac{\alpha_F - MC_F(1+t)}{\beta_F(n+1)} + \gamma_D n\frac{2\gamma_F Q_D^*}{\beta_F(n+1)} - 2\beta_D Q_D^* \overset{set}{=} 0;$$

$$(\alpha_D - MC_D)\beta_F - \gamma_D \frac{n}{n+1}(\alpha_F - MC_F(1+t)) = 2Q_D^*(\beta_D\beta_F - \gamma_D\gamma_F \frac{n}{n+1});$$

$$Q_D^* = \frac{(\alpha_D - MC_D)\beta_F - \gamma_D \frac{n}{n+1}(\alpha_F - MC_F(1+t))}{2(\beta_D\beta_F - \gamma_D\gamma_F \frac{n}{n+1})}, \text{ or}$$

$$Q_D^* = \frac{(\alpha_D - MC_D)\beta_F - \gamma_D \frac{n}{n+1}(\alpha_F - MC_F(1+t))}{2D'},$$

where $D' \equiv (\beta_D\beta_F - \gamma_D\gamma_F \frac{n}{n+1})$.

The second-order conditions are also satisfied for this problem:

$\frac{\partial^2 \pi_D}{\partial Q_D^2} = \frac{2\gamma_F \gamma_D n}{\beta_F (n+1)} - 2\beta_D = -\frac{2D'}{\beta_F} < 0$ according to the parameter specification given in assumption A7. ■

Substituting (7) into (5), we obtain equilibrium, the total quantity supplied to the market by the importers:

$$Q_F^* = \frac{n}{\beta_F (n+1)} \left[\alpha_F - MC_F (1+t) - \gamma_F Q_D^* \right];$$

$$Q_F^* = \frac{n\left[2D'(\alpha_F - MC_F (1+t))\right]}{2D'\beta_F (n+1)} +$$

$$+ \frac{n\left[\gamma_D \gamma_F \frac{n}{n+1} (\alpha_F - MC_F (1+t)) - (\alpha_D - MC_D)\beta_F \gamma_F \right]}{2D'\beta_F (n+1)},$$

$$Q_F^* = n \frac{\left[(D' + \beta_D \beta_F)(\alpha_F - MC_F (1+t)) - (\alpha_D - MC_D)\beta_F \gamma_F \right]}{2\beta_F D'(n+1)} \tag{8}$$

Also, substituting (7) and (8) into (2) we obtain equilibrium prices in the market:

$$P_D^* = \alpha_D - \beta_D Q_D^* - \gamma_D Q_F^* = \alpha_D - \beta_D \frac{(\alpha_D - MC_D)\beta_F - \gamma_D \frac{n}{n+1}(\alpha_F - MC_F (1+t))}{2D'}$$

$$- \gamma_D n \frac{\left[(D' + \beta_D \beta_F)(\alpha_F - MC_F (1+t)) - (\alpha_D - MC_D)\beta_F \gamma_F \right]}{2\beta_F D'(n+1)};$$

Simplifying this expression, we come to the following result:

$$P_D^* = \frac{(\alpha_D + MC_D)}{2} - \frac{\gamma_D n(\alpha_F - MC_F (1+t))}{2\beta_F (n+1)} \tag{9}$$

Similarly, for P_F^*:

$$P_F^* = \alpha_F - \beta_F Q_F^* - \gamma_F Q_D^* = \alpha_F - \beta_F n \frac{\left[(D' + \beta_D \beta_F)(\alpha_F - MC_F (1+t)) - (\alpha_D - MC_D)\beta_F \gamma_F \right]}{2\beta_F D'(n+1)}$$

$$-\gamma_F \frac{(\alpha_D - MC_D)\beta_F - \gamma_D \dfrac{n}{n+1}(\alpha_F - MC_F(1+t))}{2D'},$$

or, after simplification,

$$P_F^* = \alpha_F - \frac{\alpha_F - MC_F(1+t)}{2D'} \frac{n}{n+1}\left(2D' - \frac{\gamma_F \gamma_D}{n+1}\right) - \frac{(\alpha_D - MC_D)\beta_F \gamma_F}{2D'(n+1)} \qquad (10)$$

Inspection of equations (7) – (10) reveals the following relationships between the domestic tariff (policy instrument) and market equilibrium prices and quantities:

A. $\frac{\partial Q_D^*}{\partial t} = \frac{\gamma_D MC_F}{2D'} \frac{n}{n+1} > 0$, the quantity of domestic cars that the domestic firm is willing to supply to the market increases when the tariff increases. The magnitude of this effect crucially depends on the substitutability of the two types of cars. Notice that when there is a complete differentiation of the brands (γ_D=0), there is no effect on the domestic supply at all.

B. $\frac{\partial Q_F^*}{\partial t} = -\frac{n(D' + \beta_F \beta_D)MC_F}{2(n+1)\beta_F D'} < 0$, the quantity of foreign cars that the importers are willing to supply to the market declines. Intuitively, tariff increases the baseline marginal costs of the importers and makes them less competitive.

C. $\frac{\partial P_D^*}{\partial t} = \frac{\gamma_D MC_F}{2\beta_F} \frac{n}{n+1} > 0$, as a response to the tariff the domestic firm is willing to increase its price (observing the price increase of the rival products). Again, as it was the case with the quantity, the magnitude of the increase in price depends on the degree of differentiation of the two car types.

D. $\frac{\partial P_F^*}{\partial t} = \frac{MC_F}{2D'} \frac{n}{n+1}\left(2D' - \frac{\gamma_F \gamma_D}{n+1}\right) > 0$, the price of the foreign cars rises as a result of a tariff. This is quite intuitive and expected. However, there is something more to be said about the price that the importers charge. $\frac{\partial P_F^*}{\partial[(1+t)MC_F]} = \frac{1}{2D'} \frac{n}{n+1}\left(2D' - \frac{\gamma_F \gamma_D}{n+1}\right) < 1$, which means that the importers do not pass on the tariff to consumers completely. And the degree of pass-through depends on the competitiveness between the importers, i.e. their number. Clearly, a monopolist would be able to absorb more burden of the tariff than a firm in a very competitive environment.

This completes the assessment of the Nash equilibrium for Model 1, where the foreign firm's transfer price is fixed and the domestic firm is a Stackelberg leader with respect to the importers.

Model 2. Stackelberg Leadership with a Monopoly Transfer Price

Now, let us bring the foreign firm into play and allow it have monopoly power over the price of cars supplied to importers. In terms of the overall model, this amounts to changing assumptions to A1-A2, A3a, A4, A5, A6-A9. Now the strategic interaction between the actors is done as follows:

- Stage 1. Foreign monopoly chooses its price to maximize profit.
- Stage 2. Domestic firm chooses its level of production to maximize profit.
- Stage 3. Importers choose the amount they are willing to supply to the market on the basis of the domestic firm's quantity to maximize individual profits.

Clearly, stage 3 and stage 2 have already been solved previously. Now what left is to solve stage 1 and provide the solution for the entire model.

Stage 1. Recall that the price that the foreign monopolist charges importers (plus a tariff) becomes the marginal cost for the importers. At this stage foreign firm chooses price of its cars MC_F such that:

$$MC_F^* = \arg\max_{MC_F}\left(Q_F^*(MC_F)(MC_F - MC_R)\right) \tag{11}$$

Proposition 3. Given assumptions A1-A2, A3a, A4, A5, A6-A9, the optimal price for a foreign monopoly to charge is

$$MC_F^* = \frac{\alpha_F + MC_R(1+t)}{2(1+t)} - \frac{(\alpha_D - MC_D)\beta_F\gamma_F}{2(D' + \beta_F\beta_D)(1+t)} \tag{12}$$

□ The first-order condition for problem (11) is:

$$\frac{\partial \pi_R}{\partial MC_F} = \frac{\partial Q_F^*}{\partial MC_F}(MC_F^* - MC_R) + Q_F \overset{set}{=} 0$$

$$\frac{\partial \pi_R}{\partial MC_F} = -\frac{n(D' + \beta_F\beta_D)(1+t)}{2\beta_F D'(n+1)}(MC_F^* - MC_R) + n\frac{\left[(D' + \beta_D\beta_F)(\alpha_F - MC_F^*(1+t)) - (\alpha_D - MC_D)\beta_F\gamma_F\right]}{2\beta_F D'(n+1)} \overset{set}{=} 0$$

Solving this equation for MC_F yields:

$$MC_F^* = \frac{\alpha_F + MC_R(1+t)}{2(1+t)} - \frac{(\alpha_D - MC_D)\beta_F\gamma_F}{2(D' + \beta_F\beta_D)(1+t)}$$

Clearly, the second-order conditions are satisfied as well:

$$\frac{\partial^2 \pi_R}{\partial MC_F^2} = -\frac{n(D' + \beta_F\beta_D)(1+t)}{\beta_F D'(n+1)} < 0$$

according to the restrictions on the model parameters imposed in assumption A7 and provided that t>-1. ■

Substituting the expression for optimal foreign firm's price into the equilibrium price and quantity expressions in the domestic market yields:

$$Q_D^* = \frac{(\alpha_D - MC_D)\beta_F - \gamma_D \frac{n}{n+1}\alpha_F}{2D'} + \frac{(1+t)\gamma_D n}{2D'(n+1)}\left[\frac{\alpha_F + MC_R(1+t)}{2(1+t)} - \frac{(\alpha_D - MC_D)\beta_F\gamma_F}{2(D'+\beta_F\beta_D)(1+t)}\right]$$

$$Q_D^* = \frac{\beta_F(\alpha_D - MC_D)(3D' + \beta_F\beta_D)}{4D'(D'+\beta_F\beta_D)} - \frac{n\gamma_D}{4D'(n+1)}(\alpha_F - MC_R(1+t)) \qquad (13)$$

$$Q_F^* = n\frac{\left[\alpha_F(D'+\beta_D\beta_F) - (\alpha_D - MC_D)\beta_F\gamma_F\right]}{2\beta_F D'(n+1)}$$

$$- \frac{n(D'+\beta_D\beta_F)(1+t)}{2(n+1)\beta_F D'}\left[\frac{\alpha_F + MC_R(1+t)}{2(1+t)} - \frac{(\alpha_D - MC_D)\beta_F\gamma_F}{2(D'+\beta_F\beta_D)(1+t)}\right]$$

$$Q_F^* = n\frac{\left[(\alpha_F - MC_R(1+t))(D'+\beta_D\beta_F) - (\alpha_D - MC_D)\beta_F\gamma_F\right]}{4\beta_F D'(n+1)} \qquad (14)$$

$$P_D^* = \frac{(\alpha_D + MC_D)}{2} - \frac{\alpha_F\gamma_D n}{2\beta_F(n+1)} + \frac{\gamma_D n(1+t)}{2\beta_F(n+1)}\left[\frac{\alpha_F + MC_R(1+t)}{2(1+t)} - \frac{(\alpha_D - MC_D)\beta_F\gamma_F}{2(D'+\beta_F\beta_D)(1+t)}\right]$$

$$P_D^* = MC_D + \frac{(\alpha_D - MC_D)(D'+\beta_F\beta_D)}{4(D'+\beta_F\beta_D)} - \frac{\gamma_D n}{(n+1)}\frac{(\alpha_F - MC_R(1+t))}{4\beta_F} \qquad (15)$$

$$P_F^* = \alpha_F - \frac{\alpha_F}{2D'}\frac{n}{n+1}\left(2D' - \frac{\gamma_F\gamma_D}{n+1}\right) - \frac{(\alpha_D - MC_D)\beta_F\gamma_F}{2D'(n+1)}$$

$$+ \frac{(1+t)}{2D'}\frac{n}{n+1}\left(2D' - \frac{\gamma_F\gamma_D}{n+1}\right)\left[\frac{\alpha_F + MC_R(1+t)}{2(1+t)} - \frac{(\alpha_D - MC_D)\beta_F\gamma_F}{2(D'+\beta_F\beta_D)(1+t)}\right]$$

$$P_F^* = \frac{1}{2}\left(1 + \frac{D' + \beta_F \beta_D}{2D'(n+1)}\right)\left[\alpha_F - \frac{(\alpha_D - MC_D)\gamma_F \beta_F}{D' + \beta_F \beta_D}\right] + \frac{nMC_R(1+t)}{4D'(n+1)}\left(2D' - \frac{\gamma_F \gamma_D}{n+1}\right) \quad (16)$$

Inspection of equations (12) – (16) reveals the following relationships between the domestic tariff (policy instrument) and market equilibrium prices and quantities:

A. $\frac{\partial Q_D^*}{\partial t} = \frac{\gamma_D MC_R}{4D'} \frac{n}{n+1} > 0$, the quantity of domestic cars that the domestic firm is willing to supply to the market increases when the tariff increases. Once again, the magnitude of this effect crucially depends on the substitutability of the two types of cars. Notice that when there is a complete differentiation of the brands (γ_D=0), there is no effect on the domestic supply at all. Also observe that the impact on the domestic quantity is smaller in this model than in the Model 1 (as long as $2MF_F < MC_R$).

B. $\frac{\partial Q_F^*}{\partial t} = -\frac{n(D' + \beta_F \beta_D)MC_R}{4(n+1)\beta_F D'} < 0$, the quantity of foreign cars that the importers are willing to supply to the market declines. Intuitively, tariff increases the baseline marginal costs of the importers and makes them less competitive. Also notice that the effect is smaller that in the Model 1, as the foreign firm will absorb part of the tariff incidence.

C. $\frac{\partial P_D^*}{\partial t} = \frac{\gamma_D MC_R}{4\beta_F} \frac{n}{n+1} > 0$, as a response to the tariff domestic firm is willing to increase its price (observing the price increase of the rival products). Again, as was the case with the quantity, the magnitude of the increase in price depends on the degree of differentiation between the two car types.

D. $\frac{\partial P_F^*}{\partial t} = \frac{MC_R}{4D'}\frac{n}{n+1}\left(2D' - \frac{\gamma_F \gamma_D}{n+1}\right) > 0$, the price of the foreign cars rises as a result of a tariff. This is quite intuitive and expected.

E. $\frac{\partial MC_F^*}{\partial t} = -\frac{\alpha_F (D' + \beta_F \beta_D) + (\alpha_D - MC_D)\beta_F \gamma_F}{2(D' + \beta_F \beta_D)(1+t)^2} < 0$, the foreign firm lowers its transfer price for domestic firms as the tariff increases. This is consistent with terms of trade argument in favor of imposing import tariffs.

The Government

Now it is time to add government as a strategic actor into the model. Its instrument will be an *ad valorem* tax *t*. Formally, this adds another stage, stage 0, to the previously discussed games.

Stage 0. At this stage government sets a tariff level *t* to maximize social welfare of the nation as measured by the sums of consumer and producer surplus in the market for domestic cars and in the market for foreign cars, and adjusted tariff revenue. The adjustment of tariff revenue must take into account the fact that with the revenue from the tariff government could reduce some other taxes, and thereby decrease the excess burden caused by other them. The measure of the excess burden is usually taken to be the marginal cost of public funds. It measures the excess burden associated with collecting another hryvna of tax revenue.

Diagrammatically, the surplus to be maximized is presented in Figure 2. More formally, the change in consumer surplus for the case of two markets is defined in Auerbach (1999) to be:

$$\Delta CS = -\int_{P_0^D}^{P_1^D} x^D(P^D, P_0^F)\,dP^D - \int_{P_0^F}^{P_1^F} x^F(P_1^D, P^F)\,dP^F \quad (17)$$

Clearly, total consumer surplus can be calculated as a change in price from $\hat{P}$, the price at which demand equals zero, or from infinity (if demand curve asymptotically approaches the axis) to current price P. For further computations I assume that the equilibrium is reached at the prices P_D and P_F, and quantities Q_D and Q_F in domestic and foreign market segments, respectively.

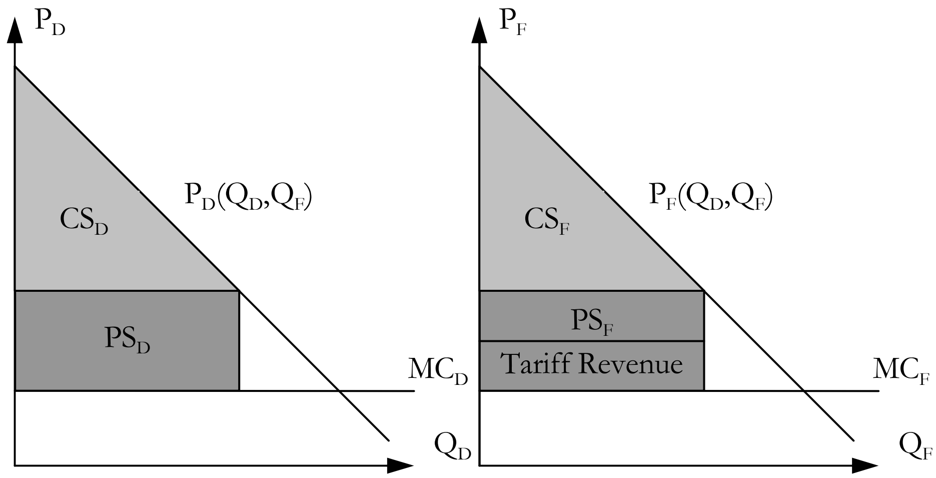

Figure 2. Total Surplus Graph

For a linear demand system given by assumption A7, there obviously are prices at which the demand is zero. Therefore, it is necessary to compute these prices for both domestic and foreign market segments. Provided that in terms of the notation above 1=domestic and 2=foreign, $\hat{P}_D$ solves Q_D=0 at the current price P_F:

$$Q_D = a_D - b_D \hat{P}_D + c_D P_F = 0 \Rightarrow \hat{P}_D = \frac{a_D + c_D P_F}{b_D} \qquad (18)$$

By the similar line of argument, $\hat{P}_F$ solves Q_F=0 at the price $\hat{P}_D$:

$$Q_F = a_F - b_F \hat{P}_F + c_F \hat{P}_D = 0 \Rightarrow \hat{P}_F = \frac{a_D c_F + a_F b_D + c_F c_D P_F}{b_F b_D}$$

or, putting it in more convenient terms (see Lemma 1),

$$\hat{P}_F = \frac{\alpha_F D + c_F c_D P_F}{b_F b_D} \tag{19}$$

In case of the linear demand system the integrals are especially easy to take, and the consumer surplus in market segment *i* is given by:

$$CS_i = \frac{Q_i}{2}(\hat{P}_i - P_i) \tag{20}$$

The producer surplus in market segment i and the tariff revenue in the foreign market segment are defined as:

$$PS_i = (P_i - MC_i)Q_i\,, \tag{21}$$

where MC_i=MC_D for domestic market and MC_i=$MC_F(1+t)$ for the foreign market.

$$TR_F = tMC_F Q_F\,. \tag{22}$$

The government solves:

$$t^* = \underset{t}{\arg\max}\{TS_F + TS_D\} = \underset{t}{\arg\max}\{CS_F + PS_F + \eta TR + CS_D + TS_D\} \tag{23}$$

The term η appears in the equation due to the fact that by collecting tariff revenue government can reduce the burden of some other taxes in the economy, and therefore the value of the tariff revenue in terms of welfare is greater than the amount of money collected in the form of the tariff. For the interpretation of this coefficient see assumption A8.

In terms of the parameters of the model this may be recast as:

$$t^* = \underset{t}{\arg\max}\left\{\frac{Q_D^*(t)}{2}\left(\frac{a_D + c_D P_F^*(t)}{b_D} - P_D^*(t)\right) + (P_F^*(t) - MC_F^*(t)(1+t))Q_F^*(t)\right.$$
$$\left. + (P_D^*(t) - MC_D)Q_D^*(t) + \eta tMC_F^*(t)Q_F^*(t) + \frac{Q_F^*(t)}{2}\left(\frac{\alpha_F D + c_F c_D P_F^*(t)}{b_F b_D} - P_F^*(t)\right)\right\}$$

Simplifying this expression yields:

$$t^* = \arg\max_t \left\{ (P_D^*(t) - MC_D) Q_D^*(t) + \frac{\left(Q_D^*(t)\right)^2}{2b_D} - (1 + t - \eta t) MC_F^*(t) Q_F^*(t) \right.$$

$$\left. + \frac{Q_F^*(t)\alpha_F D}{2b_F b_D} + \frac{Q_F^*(t) P_F^*(t)(c_F c_D + b_F b_D)}{2b_F b_D} \right\} \quad (24)$$

Given assumptions of the model, the welfare-maximizing level of tariff must satisfy first-order condition for problem (24), namely:

$$\frac{\partial SW}{\partial t} = \frac{Q_D^*}{2b_D}\frac{\partial Q_D^*}{\partial t} + Q_D^* \frac{\partial P_D^*}{\partial t} + (P_D^* - MC_D)\frac{\partial Q_D^*}{\partial t} + \frac{\alpha_F D}{2b_F b_D}\frac{\partial Q_F^*(t)}{\partial t} + MC_F^* Q_F^*(\eta - 1)$$

$$+ \frac{(c_F c_D + b_F b_D)}{2b_F b_D}\left(Q_F^* \frac{\partial P_F^*}{\partial t} + P_F^* \frac{\partial Q_F^*}{\partial t} \right) - \left(\frac{\partial Q_F^*}{\partial t} MC_F^* + \frac{\partial MC_F^*}{\partial t} Q_F^* \right)(1 + t - \eta t) \quad (25)$$

Now, for each of the four models described above I will present the first-order condition for optimal tariff.

Constant Transfer Price

In this case the derivatives of the model parameters with respect to *t* are:

$$\frac{\partial Q_D^*}{\partial t} = \frac{\gamma_D MC_F}{2D'}\frac{n}{n+1} > 0$$

$$\frac{\partial Q_F^*}{\partial t} = -\frac{n(D' + \beta_F \beta_D) MC_F}{2(n+1)\beta_F D'} < 0$$

$$\frac{\partial P_D^*}{\partial t} = \frac{\gamma_D MC_F}{2\beta_F}\frac{n}{n+1} > 0$$

$$\frac{\partial P_F^*}{\partial t} = \frac{MC_F}{2D'}\frac{n}{n+1}\left(2D' - \frac{\gamma_F \gamma_D}{n+1} \right) > 0$$

Substituting the derivatives into the formula for first-order condition for optimal tariff yields:

$$\frac{\partial SW}{\partial t} = \frac{n}{2(n+1)}\frac{\gamma_D MC_F}{\beta_F D'}\left(\frac{1}{2DD'} + 1 \right) Q_D^* + (P_D^* - MC_D)\frac{n}{2(n+1)}\frac{\gamma_D MC_F}{D'}$$

$$+Q_F^*\left[MC_F(\eta-1)+\frac{c_Fc_D+b_Fb_D}{2b_Fb_D}\frac{n}{(n+1)}\frac{MC_F}{2D'D}(D'D+1)\right]$$

$$-\frac{n(D'+\beta_F\beta_D)MC_F}{2(n+1)\beta_F D'}\left[\frac{\alpha_F D}{2b_Fb_D}+P_F^*\frac{c_Fc_D+b_Fb_D}{2b_Fb_D}-MC_F(1+t-\eta t)\right]\overset{set}{=}0 \quad (26)$$

Further substitution does not provide any insight into a problem, but the notation becomes very obscure. Therefore, I will not provide further manipulations here, especially considering the fact that the first-order condition just found will be subjected to numerical optimization routine.

Monopoly Transfer Price

Again, find the derivatives first:

$$\frac{\partial Q_D^*}{\partial t}=\frac{\gamma_D MC_R}{4D'}\frac{n}{n+1}>0$$

$$\frac{\partial Q_F^*}{\partial t}=-\frac{n(D'+\beta_F\beta_D)MC_R}{4(n+1)\beta_F D'}<0$$

$$\frac{\partial P_D^*}{\partial t}=\frac{\gamma_D MC_R}{4\beta_F}\frac{n}{n+1}>0$$

$$\frac{\partial P_F^*}{\partial t}=\frac{MC_R}{4D'}\frac{n}{n+1}\left(2D'-\frac{\gamma_F\gamma_D}{n+1}\right)>0$$

$$\frac{\partial MC_F^*}{\partial t}=-\frac{\alpha_F(D'+\beta_F\beta_D)+(\alpha_D-MC_D)\beta_F\gamma_F}{2(D'+\beta_F\beta_D)(1+t)^2}<0$$

As we can see from the last formula, foreign monopolist would react to an increase in tariff by lowering its price. Substituting the derivatives into the formula for first-order condition for optimal tariff yields:

$$\frac{\partial SW}{\partial t}=Q_D^*\frac{n\gamma_D MC_R(2DD'+1)}{8(n+1)\beta_F DD'}+(P_D^*-MC_D)\frac{n\gamma_D MC_R}{4D'(n+1)}+Q_F^*\left[MC_F(\eta-1)\right.$$

$$+\frac{c_F c_D + b_F b_D}{2b_F b_D}\frac{MC_R}{4D'D}\frac{n(D'D+1)}{(n+1)} + \frac{\alpha_F(D'+\beta_F\beta_D)+(\alpha_D - MC_D)\beta_F\gamma_F}{2(D'+\beta_F\beta_D)(1+t)^2}(1+t-\eta t)\Bigg]$$

$$-\frac{n(D'+\beta_F\beta_D)MC_R}{4(n+1)\beta_F D'}\left[\frac{\alpha_F D}{2b_F b_D} + \frac{c_F c_D + b_F b_D}{2b_F b_D}P_F^* - MC_F^*(1+t-\eta t)\right]$$

$$+\frac{\alpha_F(D'+\beta_F\beta_D)+(\alpha_D - MC_D)\beta_F\gamma_F}{2(D'+\beta_F\beta_D)(1+t)^2}Q_F^*(1+t-\eta t)\overset{set}{=}0 \qquad (27)$$

This first-order condition results in a cubic equation with respect to t^*, and the number of roots will depend on the parameters of the model. Hence, the optimal tariff will again be found numerically.

To summarize, the theoretical model developed seems to adequately reflect the key features of the oligopolistic market in the international context, namely the strategic interactions between the market actors and their responses to a tariff as a policy instrument. Now, armed with the theoretical model, I may proceed to estimation of the key ingredient of the model, the demand equations. Then, the predictions of the models will be faced with the real world data to assess their empirical validity.

Chapter 5

DATA DESCRIPTION

The data series employed for the empirical part of the study and sources thereof are presented in Table 1.

Table 1. Data Description

Variable	Source
Quarterly data on sales of cars by region for 2001	Auto-Consulting
Quarterly data on prices of cars by region for 2001	Automobile magazines and price lists
Average wage rate by region, 2001 and 2003	Derzhkomstat yearbook "Ukraine 2001", web site of Derzhkomstat
Population by region	Derzhkomstat yearbook "Ukraine 2001", web site of Derzhkomstat

Summary statistics for the data are presented in Table 2. It is interesting to note that the variability of the prices and quantities across the regions and within a year may be very high. At the same time, prices seem to be relatively less volatile than quantities. For many car models there are some zero observations in the data set. This suggests a significant heterogeneity of demand across regions and/or over time.

An interesting feature of the data that sales have been steadily increasing over the entire sample period for almost all car models (see Figure 3). This suggests that in econometric estimation the heterogeneity in demand over time should be accounted for. Figure 3 shows another feature of the data, the heterogeneity across car models. This observation will also be taken into account when building the econometric model.

Table 2. Summary Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
p1	104	21898.51	715.1972	17885	24035
q1	104	48.36538	38.76192	5	163
p2	104	19702.5	1732.634	15060	26777
q2	104	11.58654	13.21195	0	80
p3	104	19860.42	1794.553	15735	24656
q3	104	43.31731	35.65919	4	183
p4	104	20925.47	1253.244	17083	24984
q4	104	43.91346	33.50065	3	173
p5	104	24913.94	1137.267	19920	31428
q5	104	42.46154	37.53055	3	179
p6	104	28051.85	1025.801	22254	29733
q6	104	62.77885	57.62264	3	302
p7	104	30855.73	2465.821	23419	39450
q7	104	65.07692	76.01465	3	328
p8	104	31976.85	2658.359	24726	41422
q8	104	23.95192	30.67569	0	143
p9	104	36842.1	2618.905	28323	45713
q9	104	6.461538	11.86078	0	76
p10	104	36203.64	2235.694	29671	44052
q10	104	13.28846	19.28311	0	101
p11	104	29856.66	2526.296	23377	39102
q11	104	20.72115	20.99258	2	161
p12	104	12513.79	724.5821	9169	13486
q12	104	38.32692	45.17462	1	260
p13	104	14438.55	657.954	12260	15490
q13	104	19.14423	25.62175	0	135
p14	104	32411.17	2040.955	27847	36983
q14	104	20.375	29.29733	0	153
wage01	27	282.7778	76.9537	190	549
pop00	27	1816.167	947.3639	388.6	4873
pop01	27	1802.696	942.1028	379.7	4872.3

As can be seen from Figure 4, prices did not experience any significant fluctuations in 2001. There is no trend in prices like there was in sales of cars. Figure 4 also illustrates the claim that Russian (the first eleven) and Ukrainian (the last three) car models belong to the low-end segment of the automobile market, and that they are quite close substitute for each other (at least in terms of price).

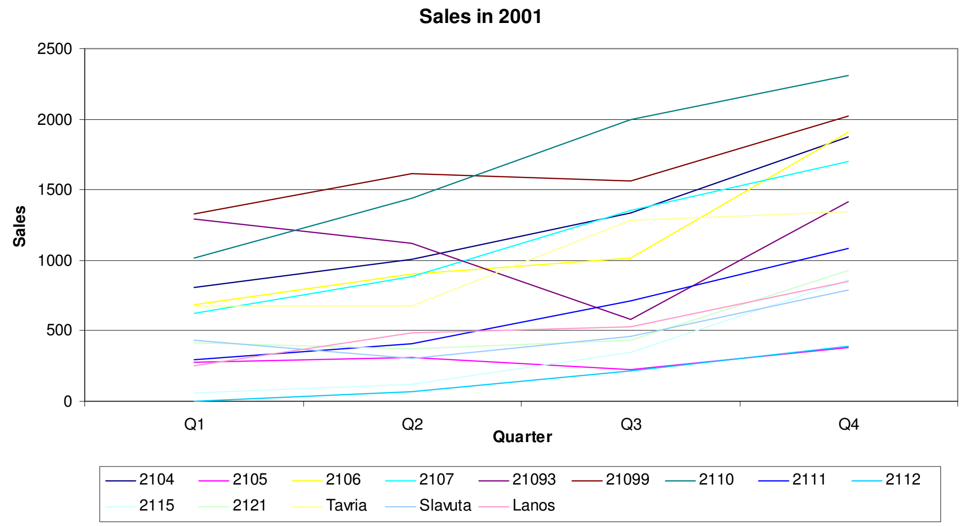

Figure 3. Sales Dynamics

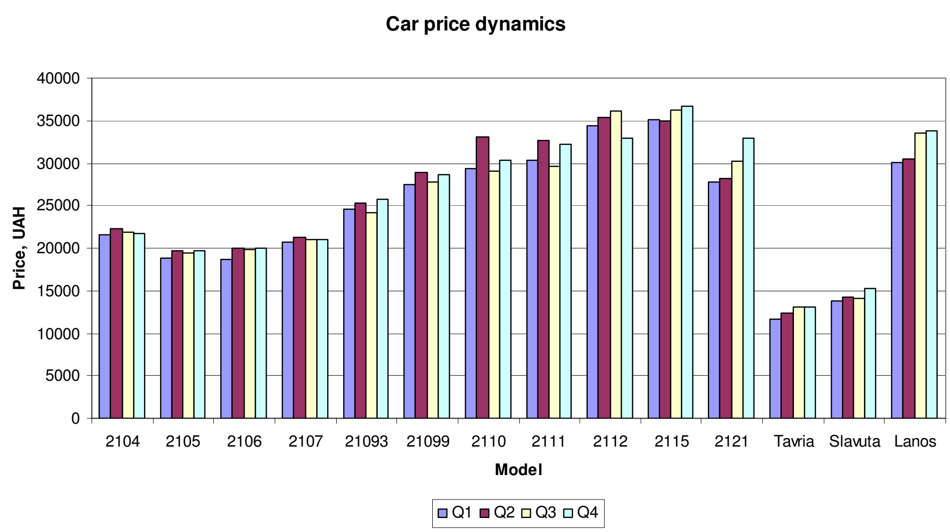

Figure 4. Price Dynamics

Having examined the data, it is clear that it may provide sufficient basis for estimation of the demand system. However, caution should be exercised in dealing with all of the peculiarities of the data set presented in this chapter.

Chapter 6

EMPIRICAL ESTIMATION

To provide a thorough analysis of welfare consequences of the duty imposition it is necessary to estimate market demand, market supply, and market equilibrium. Further I shall present the review of the existing literature concerning these elements in the context of international oligopoly prevailing in the Ukrainian automobile market.

6.1 Model of Market Demand

The estimation of demand for automobiles started from the seminal contribution of Chow (1957). He uses a special case of a multiperiod, multiasset model that examines utility maximizing household faced with the choice between a car and a variety of other goods. The key finding of Chow's work is that automobile demand is income elastic. At the same time, as pointed out by Hess (1977), the theoretical model of Chow is overly simplified due to the omission of the explicit consideration of the depreciation of the assets. In fact, the only two variables included into his equation were relative car prices and real income. Hence, as Hess claims, the estimation of Chow yields inconsistent estimates of the demand elasticities due to the problem of omitted variables.

Hess (1977) offers a different technique that represents a further development of Chow model. He introduces the concept of user cost of capital in demand estimation and develops a full-scale multiperiod, multiasset theoretical framework for his model. The starting point of the model specification adopted by Hess is, again, the assumption of utility maximizing household. He studies four alternative theoretical settings: single-asset, single-period; single-asset, multiperiod; multiasset, single-period and multiasset, multiperiod. On the basis of his theory Hess builds the model of utility optimization, which results in the following demand equation for automobiles:

$$A_t^d = \phi(\frac{u_{a,t}}{P_t}, \frac{u_{d,t}}{P_t}, \frac{u_{h,t}}{P_t}, u_{m,t}, W_{h,t}, W_{n,t}),$$

where:

- $u_{j,t}$ is a user cost of capital for automobiles (*j=a*), other durables (*j=d*), housing (*j=h*), and real money balances (*j=m*) at time period *t*;
- $W_{h,t}$ is a real human wealth at time period *t*;
- $W_{n,t}$ is a real nonhuman wealth at time period *t*.

The equation is then estimated using macrolevel data for the United States taking the following proxies:

$$u_{j,t} = P_{j,t} - (1-\delta_j)P_{j,t}(1+\rho^*_{j,t})/(1+i) \qquad (j=a,d,h)$$

and $u_{m,t} = \frac{i}{(1+i)}$, where:

- $P_{j,t}$ is a price of good *j* at time period *t*;
- δ_j is a fraction of real human wealth in total wealth at time period *t*;
- i is an interest rate;
- $\varrho^*_{j,t}$ is an anticipated rate of inflation as of the time period *t*. $\varrho^*_{j,t}$ was approximated by adaptive expectations model to be $\varrho^*_{j,t} = \eta_t \varrho_{j,t} + (1-\eta_t)\varrho^*_{j,t-1}$.

The findings of Hess support the hypothesis that multiperiod, multiasset setting is the most adequate framework for car demand estimation, and also provide much lower estimate of income elasticity and claim the high importance of substitution effects.

An alternative approach to the estimation of demand for cars was developed by Johnson (1978). Her major innovation is the claim that a consumer gets utility not from a durable good itself, but rather from the flow of services provided by this good. In her estimation Johnson assumes that the implicit rental prices derived from the purchase prices of new and used cars and the market interest rate are representative of the user cost of services provided by a car. The empirical part of Johnson's study comprises the estimation of two models: a superior goods model and the demand for car services in general. The superior goods model consists of the following two equations:

$$\log N_M(t) = \alpha_{0M} + \alpha_{1M} \log c^a(M,0,t) + \alpha_{2M} \log c^a(M,1,t) + \alpha_{3M} \log Y(t) + \varepsilon_M(t)$$

$$\log c^a(M,1,0) = \beta_{0M} + \beta_{1M} \log c^a(M,0,t) + \beta_{2M} \log S_M(t) + \beta_{3M} \log Y(t) + u_M(t)$$

where:

$N_M(t)$ is the demand for new automobile services measured in make-M equivalents at time period t;

$c^a(M,j,t)$ is an implicit rental price of new ($j=0$) and used ($j=1$) automobile services at time period t;

$Y(t)$ in an income of a decision making unit (household) at time period t;

$S_M(t)$ is a quantity of used car services measured in one-year-old make-M service equivalents at time period t.

The demand for car services in general is estimated as follows:

$$\log A_M(t) = \gamma_{0m} + \gamma_{1m} \log c^a(M,0,t) + \gamma_{2m} \log Y(t) + v_M(t)$$, where

$A_M(t)$ is the total quantity of automobile services.

The major contribution of Johnson is the explicit recognition of heterogeneity of the services across different car makes and across new and used cars. She also provides an explanation of unsatisfactory estimates of income elasticity found in the earlier papers that used aggregate data for estimation. The problem was found to be a violation of Hicks aggregation conditions that resulted in biasedness of the estimates. With the ex-ante rental prices used as appropriate aggregation weights the estimation of Johnson demonstrated the robustness not achieved in the earlier works.

While the demand estimation using aggregate data was technically easier to perform, and the data were more available, the quality of such estimates was called into question. The main problem was that the techniques used for demand estimation were highly sensitive to the measurement error in both dependent and independent variables. An example of an attempt to deal with this problem is Brester and Wohlgenant (1993). In the context of food demand estimation they propose to use simultaneous equations approach that incorporates both wholesale and retail markets to deal with the endogeneity problem. Further elaborating this topic, Lewbel (1996) finds that under most circumstances not only OLS, but also 2SLS and traditional GMM correction still yield inconsistent results. This results from a measurement error being present not only in a dependent variable, but also in independent variables. Hence, he proposes a special method of correction for measurement error in demand estimation equations using a variation of the GMM methodology.

A conceptually different branch of automobile demand estimation appeared in the end of 1970s, when the theoretical basis and computing power for disaggregate analysis became more available. This approach exploits discrete choice models, mostly multinomial or nested logit, in conjunction with macrolevel data on the population weights to estimate market demand for cars. A representative of the early works in this area is Lave and Train (1979). They investigate the impact of 10% excise tax on the market shares of different car types, and find own price and income elasticities consistent with the previous aggregate level studies. Another example of the estimation of demand from microlevel data is Nolan (2001). Although the estimation of determinants of car ownership decision is not the primary goal of her study, the estimation itself is quite instructive. The author uses Irish Household Budget Survey data and probit estimation to model the decision of purchasing a car. The exact model specification looks like the following:

$$Own_i = probit(\sum_{j=1}^{3}\alpha_j Y_i^j + \sum_{j=1}^{3}\beta_j AD_i^j + \sum_{j=1}^{2}\gamma_j CH_i^j + \delta_1 FEM_i + \delta_2 AP_i + \delta_3 S_i + \delta_4 W_i + \sum_{j=3}^{6}\varphi_j D_{i,j} + \sum_{j=1}^{2}\theta_j ED_{i,j})$$

where:

Own_i is a dummy for *i*-th household owning a car;

Y_i is the income of *i*-th household;

AD_i is the number of adults in *i*-th household;

CH_i is the number of children in *i*-th household;

FEM_i is a dummy for the head of *i*-th household being female;

AP_i is a dummy for *i*-th household residing in an apartment;

S_i is a dummy for *i*-th household residing in a semi-detached house;

W_i is a dummy for at having at least one working member aged 15+ in the *i*-th household;

$D_{i,j}$ is a dummy that takes the value of 1 if the head of the *i*-th household is between 10*j* and 10(*j*+1) years old;

$ED_{i,j}$ is a dummy for the head of *i*-th household possessing only primary school education ($j=1$) or only secondary school education ($j=2$).

McCarthy (1996) uses microlevel approach to test whether the problems of aggregate level models persist on the disaggregate level. In particular, he concentrates on the inclusion of vehicle quality variables into the specification. On the basis of the multinomial logit model applied to new vehicle buyers survey of 1989 he concludes that the inclusion of vehicle quality variables does not have significant effect on the results.

The two approaches of market demand estimation have their strengths and weaknesses. The studies that use aggregate industry data involve few computational problems and are able to model the endogeneity of prices through the estimation of a reduced form equation. However, as Berry (1994) shows, for a reduced form to exist a set of restrictive assumptions must be imposed on the functional form of the demand system. This results in a counterintuitive substitution patterns as reflected in the cross price elasticities of demand. Further, the aggregate level models fail to take into account the heterogeneity of consumers.

The studies that use disaggregate consumer data allow for a high degree of product differentiation and for explicit consideration of consumer heterogeneity. Furthermore, microlevel estimation overcomes the problem of price endogeneity by assuming an individual household to be a price taker in the market. However, such studies ignore the supply side effects and the market equilibrium considerations. Hence, while the microlevel estimation ideally fits the purpose of modeling individual demand, it is clearly inadequate for forecasting purposes. Therefore, as an amalgamation of the two types of models the "mixed" models appeared, combining the strengths of the two approaches. These studies either use disaggregate data in conjunction with the macrolevel model, or aggregate data and a microlevel model.

A representative of such "mixed" models of the U.S. automobile market is Goldberg (1995), who studies the welfare consequences of "Voluntary Export Restriction" trade regime set for the Japanese cars in the U.S. She uses nested logit model to estimate aggregate demand for cars. The main advantage of such estimation is that it allows for explicit inclusion of an outside good, which overcomes a problem of unintuitive substitution patterns inherent in many alternative formulations. Also, nested logit enables the researcher to explicitly model the stages of consumer's choice in the framework of transactions approach. The complete model is too complex to replicate it here, but the key idea can be illustrated with the help of the decision-making tree (see Figure 5).

On each node of the tree the decision is modeled with the help of a multinomial logit model that is governed by household-specific and/or car-specific characteristics.

Further, the author applies the first order conditions for Bertrand oligopoly setting to the estimated demand, and by doing this explicitly incorporates producers into the model.

Another example of "mixed" estimation with the large data set is Berry, Levinsohn and Pakes (1998). They use four types of data: on U.S. households; on the vehicle attributes; on the first choice vehicles; and on substitution patterns to model the demand system. The authors use the methodology of modeling the utility maximization process similar to that applied by Goldberg (1995), but increase the complexity of the decision tree by adding the nodes for second vehicle choice. Given the richness of the data, they are able to model complex substitution patterns and obtain a very good descriptive quality of the model. The estimation technique they use is a variation of GMM, since the estimation of the full model using maximum likelihood method is computationally infeasible.

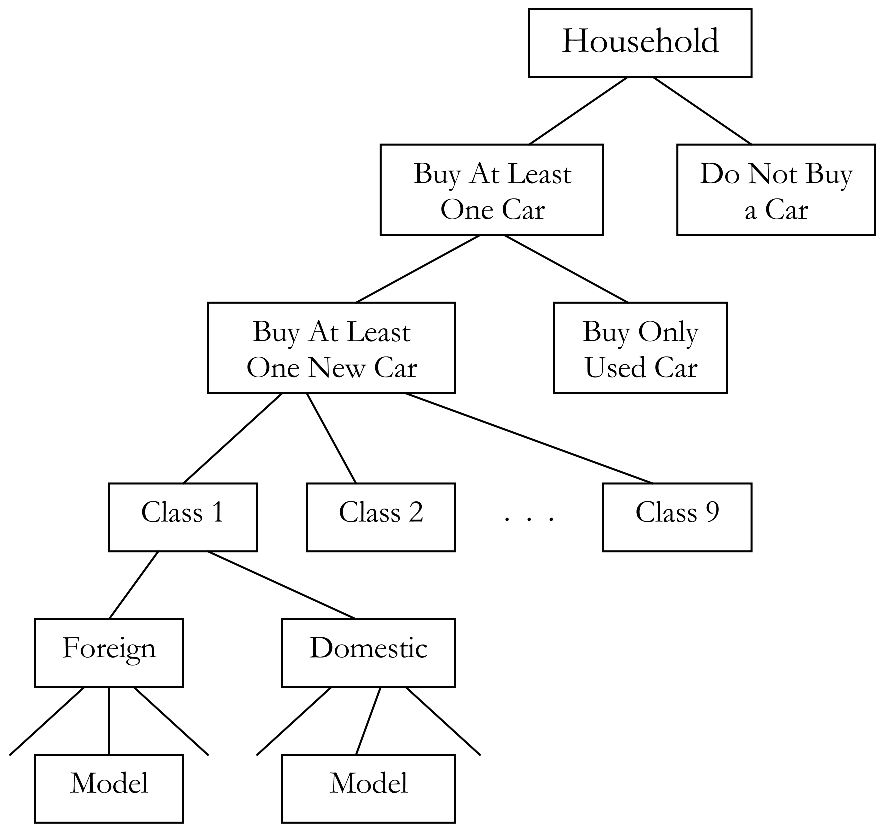

Figure 5. Decision tree.

A different type of "mixed" approaches uses the aggregate data for the sales of a particular car make to derive its inferences. This approach was pioneered by Berry et al. (1995) who demonstrated its application to the automobile market of the United States. Their model enables to use widely available product-level data and aggregate consumer data to model the demand system. An example of a study that uses the techniques developed by Berry et al. is Goldberg and Verboven (1999). They use aggregate data for sales of different car models in the European countries, but explicitly model utility maximization for a group of consumers. Therefore, albeit conditional on the assumptions made, this type of model provides an opportunity to avoid the estimation of a large number of cross-elasticities implicit in the aggregate model estimation.

As can be seen from this short review, the microlevel models in conjunction with some elements of macrolevel analysis proved to be the most successful in the modeling of demand systems. However, due to the limitations of the data I am forced to use the macrolevel model.

6.2. Estimation of Demand System

The demand system is estimated on the basis of the data described in Chapter 5. The natural choice of the estimation technique given the nature of the data set is panel data estimation.

As the theoretical part of this study suggests, the demand system to be estimated is:

$$\begin{aligned} Q_D &= a_D - b_D P_D + c_D P_F \\ Q_F &= a_F - b_F P_F + c_F P_D \end{aligned} \qquad (28)$$

However, to come to a model that can be estimated and make the best use of the data set at hand, the theoretical model has to be modified to make the demand equation applicable in a broader context that just the sample period. After the estimation, the econometric model will be transformed into a form (28) required by the theory.

Here are the adjustments made in the econometric model:

- Despite the assumptions of the model, the cars are heterogeneous, and for the purpose of empirical estimation I need to incorporate the influence of all price changes into the estimation procedure. Clearly, putting the prices of all vehicles into a model is not feasible, mostly because of a severe multicollinearity that will occur. Therefore, I will construct an index that would represent the price of the substitute cars and put it into regression equation. The most reasonable price index seems to be the sales-weighted average of prices of the substitute cars. The substitutes for Russian cars would be Ukrainian ones and vice versa.

- I would like to use the estimated demand system for different years, and therefore need to take into account the change in the population of Ukraine and in its income. The former will be accomplished by stating the model in per capita terms, and to account for the latter I will explicitly introduce income into regression equation

- The data at hand is a very particular "three-dimensional" panel, that is, it has one temporal dimension, and two cross-sectional dimensions: across regions of Ukraine and across the types of cars. Hence, to reduce the impact of heterogeneity across the car type dimension I will put vehicle-specific dummies into the model. Vehicle-specific dummies are also expected to reduce the possible correlation between regressors and residuals.

- Another issue that needs to be resolved is the apparent seasonality in the demand for cars. To accommodate it, I will insert three quarter-specific dummies into the model.

On the basis of the considerations outlined above, the complete model to be estimated is given by (29). Each equation is to be estimated separately.

$$\begin{aligned}
\hat{Q}_{Dijt} &= \hat{a}_D + \hat{b}_D P_{Dijt} + \hat{c}_D \overline{P}_{Fijt} + d_D Income_{it} + \sum_{t=2}^{4} \delta_{Dt} Q_t + \sum_{j=13}^{14} \rho_{Dj} D_j + u_i^D + e_{ijt}^D \\
\hat{Q}_{Fijt} &= \hat{a}_F + \hat{b}_F P_{Fijt} + \hat{c}_F \overline{P}_{Dijt} + d_F Income_{it} + \sum_{t=2}^{4} \delta_{Ft} Q_t + \sum_{j=2}^{11} \rho_{Fj} D_j + u_i^F + e_{ijt}^F
\end{aligned} \tag{29}$$

where: $\hat{Q}_{Dijt}$ and $\hat{Q}_{Fijt}$ represent sales of cars per 1000 people of population (indexed by *i*=region, *j*=car type and *t*=quarter). The distinction is made between foreign cars (F) that range from i=1 to i=11, and domestic cars (D) that range from i=12 to i=14.

P_{Dijt} and P_{Fijt} are the own prices of car *i* in region *j* in quarter *t*.

$Income_{it}$ is a per capita income in region i in quarter t, as proxied by the average wage.

Q_t are quarter-specific dummied.

D_j are vehicle-specific dummies.

$\overline{P}_{Dijt}$ and $\overline{P}_{Fijt}$ are the price indexes of substitutes for domestic and foreign cars constructed as described above.

Both equations were estimated using random effects model. The estimation was performed using Stata 7.0. Estimation results are summarized in Table 3 and Table 4. Estimation output is presented in Appendix A.

Note that since the market is an oligopoly, there is no supply curve per se, and therefore the endogeneity is not a problem here from the theory point of view. Specification tests for random effects model, namely Hausman test and Breusch and Pagan LM test, suggest that the model was correctly specified. The relevant test statistics are summarized in Table 5, and the output is presented in Appendix

A. In the Hausman test, the null hypothesis of no bias in the random effects estimates cannot be rejected even at 10% level of significance. The Breusch and Pagan LM test indicates the presence of individual-specific effects in the data; hence pooled OLS estimators would be inappropriate.

Table 3. Estimation of the Demand for Domestic Cars

Coefficient	Value	S.E.
$\hat{a}_D$	.0102186	.0216842
$\hat{b}_D$	-1.20e-06*	5.11e-07
$\hat{c}_D$	7.06e-07	6.43e-07
d_D	.0000643*	.000022
δ_{D2}	-.001179	.001684
δ_{D3}	.0042675*	.0017516
δ_{D4}	.0085593*	.0023234
ϱ_{D13}	-.0134109	.0102374
ϱ_{D14}	-.0207165*	.0092607

* significant at 5%

Table 4. Estimation of the Demand for Foreign Cars

Coefficient	Value	S.E.
$\hat{a}_F$	.0161923*	.0065776
$\hat{b}_F$	-1.08e-06*	1.98e-07
$\hat{c}_F$	1.02e-06*	2.30e-07
d_F	.000045*	.0000174
δ_{F2}	-.0002256	.0012174
δ_{F3}	.0020573	.0012698
δ_{F4}	.0108957*	.0015832
ϱ_{F2}	-.0215388*	.0017522
ϱ_{F3}	-.003739*	.0017447
ϱ_{F4}	-.0020629	.0017084
ϱ_{F5}	-.0000978	.0017992
ϱ_{F6}	.0121614*	.0020886
ϱ_{F7}	.0152438*	.0024534
ϱ_{F8}	-.0028238	.002618
ϱ_{F9}	-.0056046	.0034081
ϱ_{F10}	-.0025134	.0032992
ϱ_{F11}	-.0050801*	.0023148

* significant at 5%

Table 5. Specification Tests

Equation	Test	Statistic	P-value
Demand for domestic cars	Breusch-Pagan	219.66	0.0000
	Hausman	11.50	0.1748
Demand for foreign cars	Breusch-Pagan	810.52	0.0000
	Hausman	2.03	1.0000

Next it is necessary to recover the parameters of the function in the form given by (28). To do this, one needs data on the population of Ukraine and on the average wage at the national level. These data are presented in Table 6.

Table 6. Selected Demographic Indicators

Indicator	2001	2002	2003
Average wage per month, UAH	305.02	431.58	415.49
Population of Ukraine, thousand people	48672.8	48202.5	47879.4

Substituting the values of the parameters into the estimated equations and aggregating over time and over car types, the demand equations are obtained as in Table 7.

Table 7. Demand Equations

Year	Demand for cars	a_i	b_i	c_i
2001	Domestic	12383	0,935	0,550
	Foreign	48059	2,313	2,184
2002	Domestic	13832	0.925	0.544
	Foreign	50615	2.291	2.163
2003	Domestic	13542	0,919	0,541
	Foreign	49894	2,275	2,149

This completes the estimation of the demand functions, which gives the key parameters of the model. Now it is appropriate to turn to the results and predictions of the theoretical model.

C h a p t e r   7

EMPIRICAL RESULTS

Given the theoretical model described in Chapter 4, and the estimated demand system in Chapter 6, it is possible to provide an empirical assessment of the model and give policy recommendations. But first the remaining parameters of the model need to be calculated.

Further Calibration of the Model

The first exercise that must be done with the model prior to running any optimization procedure is calibration. Part of the calibration has already been done in Chapter 6, and another part is still to be done. The parameters that one needs to determine to implement the model are:

1) The demand equations – estimated in Chapter 6.

2) The marginal cost of the domestic firm (AutoZAZ), MC_D, is calculated on the basis of the firm's balance sheet. According to the assumptions of the model, marginal cost is constant (at least in the relevant range of production), and hence may be approximated with the help of an average cost. More precisely, due to the presence of fixed and quasi-fixes costs marginal cost is supposed to be below average cost. I will assume that $MC_D = 0.80AC_D$. Clearly, 80% is an ad hoc number, but it does allow for the presence of fixed costs, and, thus, approximates the difference between average and marginal costs in a reasonable manner. Further, it is a common practice to resort to such approximations when the actual data are not available (Goldberg, 1995). Average cost is equal to the cost of

sales divided by the total number of vehicles produced, $MC_D = AC_D = \frac{290263000}{14810} = 18890.29$ hryvnas. So $MC_D = 0.80 AC_D = 15112.23$. This reflects the balance sheet data for the year 2001. Later information is not currently available.

3) The marginal cost of the foreign firm (AutoVAZ), MC_R, is calculated on the basis of its balance sheet as well. Again, marginal cost is assumed to be constant (at least in the relevant range of production), and hence may be approximated with the help of the average cost: $MC_R = 0.80 AC_R$. $AC_R = \frac{91549000}{767313} = 119.311$ thousand rubles. The exchange rates prevalent in the year 2001 were 31.14 RUR/USD and 5.33 UAH/USD. Hence, bringing the estimate of marginal cost to the same base currency, $MC_R = 0.80 AC_R = 0.80 \times 119.311 \times \frac{5.33}{31.14} \times 1000 = 16337.28$ hryvnas.

4) Since the composition of Russian exports to Ukraine is shifted toward low-priced models, the transfer price of the foreign cars, MC_F, is calculated as 80% of the average revenue of AutoVAZ for the year 2001. Clearly, 80% is somewhat ad hoc number, but it seems to be not too far from the actual value. Average revenue is in turn approximated as total revenue from sales divided by the number of units sold. And again, this value should be brought to the same base currency, i.e hryvna. $AR_F = \frac{112\,843000}{767313} \times \frac{5.33}{31.14} \times 1000 = 25167.24$ hryvnas. This yields: $MC_F = 25167.24 \times 0.80 = 20133.79$ hryvnas.

5) There was no import tariff for Russian cars in 2001, therefore t=0.

6) The marginal cost of public funds parameter, η-1, was taken from Ballard et al. (1985). The average value they report, η-1=0.3 is used in further calculations. However, it is important to note that the estimation of the marginal cost of public funds parameter was done for the US economy. In Ukraine as in the transitional economy the efficiency of the taxation system is likely to be below that of the United States, which would make fiscal argument in favor of an import tariff even stronger, and the optimal level of tariff even higher. In fact, if the marginal cost of public funds parameter were zero, the optimal tariff would be -6% and turn into an import subsidy (see Table 12).

With the values of the parameters in place, it is time to test the model for consistency, to check whether it describes the initial conditions reasonably well, given the actual values of parameters.

Consistency Check

Plugging the values of parameters found on the calibration stage into equations (7)-(10) and (12)-(16) yields the following results (see Table 8):

Table 8. Consistency Check on the Model

Parameter	Model 1	Model 2	Actual Data (2001)
Transfer price, MC_F	20,135[1]	33,039	20,135
Quantity supplied by importers, Q_F	30,974	17,473	39720
Quantity supplied by domestic firm, Q_D	6,423	8,450	8095
Price charged by importers, P_F	30,180	38,706	26369[2]
Price charged by the domestic firm, P_D	24,134	26,981	19230[2]

1 In this model transfer price is treated as exogenous, and hence the figure represents the actual transfer price.

2 Weighted average of car prices, with weights represented by sales of a particular car type.

On the basis of the visual inspection of Table 8 it seems that among the two models the Stackelberg model with fixed transfer price fares better when faced with the actual data. Also, the performance of the model lies within a reasonable 30% range of the actual figures. However, it should be noticed that the model consistently predicts higher prices and lower quantities than actually observed. This may be an indication of more intense competitive pressures than those currently present in the model and that may become a focus for further research on the topic. The competitive pressure may in part come from the domestic assembly plants that produce AutoVAZ cars in Ukraine. In the year 2001 their output was small enough so that the pressure on the main market actors was quite mild. But these plants have become more active in the year 2002, when the tariff was first introduced. Another factor that was omitted from the model and that could also contribute to the more severe competition is 5% fringe of the other Russian car brands sold in Ukraine.

Optimal Level of Tariff

Now I may use the theoretical models to calculate the optimal level of the tariff. On the technical side, to provide an estimate of the optimal tariff, I use the solver implemented in Microsoft Excel to solve numerically the first-order conditions for social welfare maximization given by equations (26) and (27) in Chapter 4. The results of optimization are given in Table 9. Clearly, both models suggest that there should be a positive import tariff in place. However, the values of the optimal tariff suggested by the two models are quite different. And, since Model 1 seems to describe the market better, the level of the optimal tariff should probably have been around 25% in 2001.

Table 9. Optimal Tariff Calculation for 2001

Parameter	Model 1	Model 2
Transfer price (MC_F)	20,134	23,165
Quantity supplied by importers (Q_F)	25,628	11,847
Quantity supplied by domestic firm (Q_D)	7,225	9,295
Price charged by importers (P_F) UAH	33,556	42,259
Price charged by the domestic firm (P_D) UAH	25,261	28,167
Optimal tariff (t), %	25.4	65.8
Tariff revenue (TR), UAH	130,956,784	180,675,643

As a more relevant exercise, consider an import tariff being imposed in the year 2003. An important assumption has to be made, though. The preferences of consumers must be treated as time-invariant. Then, taking current values of average wage and population and following the procedure similar to that described in Chapter 6, I calculate the parameters of the demand function. Assuming that no significant technological innovations have been introduced either in AutoVAZ, or in AutoZAZ, the marginal costs stay at the level of 2001. Given these assumptions, the results of optimal tariff calculation are given in Table 10.

Table 10. Optimal Tariff Calculation for 2003

Parameter	Model 1	Model 2
Transfer price (MC_F)	20,134	23,580
Quantity supplied by importers (Q_F)	27,617	12,716
Quantity supplied by domestic firm (Q_D)	7,999	10,236
Price charged by importers (P_F) UAH	34,850	44,417
Price charged by the domestic firm (P_D) UAH	26,533	29,728
Optimal tariff (t), %	27.9	70.6
Tariff revenue (TR), UAH	154,948,830	211,636,012

As can be seen from Table 10, the tariff rates remained almost unchanged. Somewhat surprising is the fact that the optimal level of the tariff predicted by the model (27.9%) is almost identical to that announced as a policy target by Ukrainian Prime Minister (28%). One might become suspicious about the magnitudes of the sales values predicted by the model. They seem to be a bit too low to fit the actual data. An explanation here may stem from the fact that in the year 2002 with the temporary import tariff in place some people could have postponed the purchase of a car until the tariff is cancelled. According to the information of Auto-Consulting company, this "postponed demand" for AutoVAZ cars constituted about 10000 units. Another explanation is the marketing campaign launched by AutoZAZ. These two facts could have induced consumers to buy more cars than it was predicted by the model, which is in some sense a long-run equilibrium value.

On the basis of theoretical model, it is also possible to assess the welfare impact of the temporary tariff imposed in the second half of 2002. In doing these calculations I abstract from the distortions caused by the temporary character of the tariff, and only focus on the distortions resulting from the tariff per se. The calculations on the basis of 2002 demand are presented in Table 11.

Table 11. Social Welfare Assessment

Indicator	**No tariff (0%)**	**Actual Tariff (31.8%)**	**Optimal Tariff (28.2%)**
Social Welfare, UAH	863.74 mln	889.03 mln	889.44 mln

As the analysis of Table 11 suggests, the tariff was actually welfare-improving, and in terms of welfare was very close to the optimal level. However, one should treat this result with the grain of salt due to the losses caused by the forced intertemporal substitution in consumption.

It is also instructive to look at the sensitivity of the results to the change in the marginal cost of public funds parameter. As Table 12 indicates, for all of the range of marginal cost of public funds estimates of Ballard et al. (1985), the optimal tariff is positive and increasing. This is the result to be expected: the more value is attached to the revenue collected by the tariff, the higher the optimal tariff is.

Table 12. Optimal Tariff as a Function of Marginal Cost of Public Funds

Marginal cost of public funds	0	0.2	0.4	0.6
Optimal Tariff, %	-5.9	20.2	34.4	43.2

To summarize, the theoretical model developed in the study provides a valuable tool to analyze various aspects of trade policy and to perform economic and policy simulations.

Chapter 8

CONCLUSIONS

In the study I have developed a new theoretical model of international oligopoly. It allows to capture the specifics of Ukrainian automobile market that other theoretical model available in the literature are unable to tackle. Furthermore, it is able to generate testable predictions about the behavior of the key market players and to provide the guidelines for the government in choosing optimal level of the tariff.

As the empirical results of the study suggest, the theoretical model describes the data reasonably well. It predicts the behavior of the market actors in a consistent and intuitively appealing way. The strong point of the model is that it allows for the different evaluation of the tariff revenue and other constituents of the surplus by introducing the marginal cost of public funds. In part, this enables the model to capture the general equilibrium effects of the tariff. A chief drawback of the model is that it probably leaves out some competition that is present in the market and that drives the prices to a lower level than the one predicted by the model. It may be of interest to develop this issue in further research either by introducing a more aggressive form of competition, like mixed price-quantity rivalry, or by including Ukrainian producers of Russian cars in the model once the data becomes available. Another suggestion for further research in terms of the theory is to fit the model in the general equilibrium framework to allow for spillovers from automobile market to related markets.

Other limitations of the paper that suggest directions for further research include:

- Model the market as a multi-product oligopoly with each firm being able to produce a variety of goods
- Re-specify demand system using different functional form, like AIDS
- Explicitly model the behavior of Ukrainian producers of Russian cars as a competitive fringe

The empirical results of the model suggest that price discrimination of Ukrainian importers by the Russian car manufacturer is unlikely to be the case. This is also supported by the fact that Ukrainian imports constitute a negligible part of overall sales of AutoVAZ cars, which makes price discrimination impractical due to arbitrage opportunities.

The welfare-maximizing level of a tariff applied only to imports of Russian cars is 27.9%, which is almost identical to the one announced as a policy target for all cars by the Ukrainian Prime Minister (28%). It is expected to raise approximately 155 million hryvnyas in revenues from Russian car imports. However, the optimality of the tariff is conditional on the marginal cost of public funds in Ukraine being 0.3. With the less efficient taxation system the optimal level of the tariff will be higher. Furthermore, the optimal import tariff will be negative and turn into a 6% import subsidy if the marginal cost of public funds is set to zero.

Abstracting from the distortions caused by the temporary nature of the special tariff imposed on Russian cars in the second half of 2002, the tariff seems to be welfare-improving rather than distortionary. A possible explanation for this fact is that the benefit of the revenue generated by the tariff exceeded its costs in terms of augmenting market imperfections.

Given the limited definition of social welfare function, the conclusions above should be treated with the grain of salt. The formulation of social welfare as it is assumed in the study leaves out any redistributional considerations associated with the tariff and long-run implications of the protectionism.

To conclude, despite its limitations, the theoretical model developed in the study provides a valuable tool for policy analysis and conducting policy simulations in oligopolistic market environments.

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APPENDIX A. ESTIMATION OUTPUT

I. Demand for Domestic Cars

Panel Data Estimation Output

```
Random-effects GLS regression                   Number of obs      =       312
Group variable (i): region                      Number of groups   =        26

R-sq:  within  = 0.4026                         Obs per group: min =        12
       between = 0.3270                                        avg =      12.0
       overall = 0.3645                                        max =        12

Random effects u_i ~ Gaussian                   Wald chi2(8)       =    198.49
corr(u_i, X)       = 0 (assumed)                Prob > chi2        =    0.0000

------------------------------------------------------------------------------
    q_percap |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        pdom |  -1.20e-06   5.11e-07    -2.34   0.019    -2.20e-06   -1.96e-07
        wage |   .0000643    .000022     2.92   0.003     .0000212    .0001075
    pdom_sub |   7.06e-07   6.43e-07     1.10   0.273    -5.55e-07    1.97e-06
 _Iquarter_2 |   -.001179    .001684    -0.70   0.484    -.0044797    .0021216
 _Iquarter_3 |   .0042675   .0017516     2.44   0.015     .0008344    .0077006
 _Iquarter_4 |   .0085593   .0023234     3.68   0.000     .0040055    .0131132
    _Icar_12 |  -.0134109   .0102374    -1.31   0.190    -.0334758    .0066541
    _Icar_13 |  -.0207165   .0092607    -2.24   0.025    -.0388671   -.0025659
       _cons |   .0102186   .0216842     0.47   0.637    -.0322816    .0527188
-------------+----------------------------------------------------------------
     sigma_u |  .00727274
     sigma_e |  .00834085
         rho |  .43190959   (fraction of variance due to u_i)
------------------------------------------------------------------------------
```

Hausman specification test

```
Hausman specification test

                ---- Coefficients ----
             |      Fixed       Random
    q_percap |    Effects      Effects       Difference
-------------+-----------------------------------------
        pdom |  -1.20e-06    -1.20e-06        -2.09e-09
        wage |   .0000209     .0000643        -.0000434
    pdom_sub |   5.28e-09     7.06e-07        -7.00e-07
 _Iquarter_2 |   .0007343     -.001179         .0019134
 _Iquarter_3 |   .0065717     .0042675         .0023043
 _Iquarter_4 |   .0123056     .0085593         .0037463
    _Icar_12 |  -.0134525    -.0134109        -.0000416
    _Icar_13 |  -.0207541    -.0207165        -.0000376

    Test:  Ho:  difference in coefficients not systematic

                 chi2(  8) = (b-B)'[S^(-1)](b-B), S = (S_fe - S_re)
                           =    11.50
                 Prob>chi2 =     0.1748
```

Breusch-Pagan LM test

```
Breusch and Pagan Lagrangian multiplier test for random effects:

        q_percap[region,t] = Xb + u[region] + e[region,t]

        Estimated results:
                         |       Var     sd = sqrt(Var)
                ---------+-----------------------------
                q_percap |   .0002029       .014243
                       e |   .0000696       .0083409
                       u |   .0000529       .0072727

        Test:   Var(u) = 0
                             chi2(1) =   291.66
                         Prob > chi2 =     0.0000
```

II. Demand for Foreign Cars

Panel Data Estimation Output

```
Random-effects GLS regression                   Number of obs      =      1144
Group variable (i): region                      Number of groups   =        26

R-sq:  within  = 0.4876                         Obs per group: min =        44
       between = 0.3390                                        avg =      44.0
       overall = 0.4631                                        max =        44

Random effects u_i ~ Gaussian                   Wald chi2(16)      =   1061.67
corr(u_i, X)       = 0 (assumed)                Prob > chi2        =    0.0000

------------------------------------------------------------------------------
    q_percap |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        pfor |  -1.08e-06   1.98e-07    -5.45   0.000    -1.46e-06   -6.90e-07
        wage |    .000045   .0000174     2.59   0.010     .0000109    .0000791
    pfor_sub |   1.02e-06   2.30e-07     4.43   0.000     5.68e-07    1.47e-06
 _Iquarter_2 |  -.0002256   .0012174    -0.19   0.853    -.0026116    .0021604
 _Iquarter_3 |   .0020573   .0012698     1.62   0.105    -.0004315    .0045461
 _Iquarter_4 |   .0108957   .0015832     6.88   0.000     .0077927    .0139987
     _Icar_2 |  -.0215388   .0017522   -12.29   0.000    -.0249731   -.0181045
     _Icar_3 |   -.003739   .0017447    -2.14   0.032    -.0071586   -.0003194
     _Icar_4 |  -.0020629   .0017084    -1.21   0.227    -.0054113    .0012855
     _Icar_5 |  -.0000978   .0017992    -0.05   0.957    -.0036242    .0034287
     _Icar_6 |   .0121614   .0020886     5.82   0.000     .0080677     .016255
     _Icar_7 |   .0152438   .0024534     6.21   0.000     .0104351    .0200524
     _Icar_8 |  -.0028238    .002618    -1.08   0.281     -.007955    .0023075
     _Icar_9 |  -.0056046   .0034081    -1.64   0.100    -.0122843     .001075
    _Icar_10 |  -.0025134   .0032992    -0.76   0.446    -.0089797    .0039528
    _Icar_11 |  -.0050801   .0023148    -2.19   0.028    -.0096171   -.0005431
       _cons |   .0161923   .0065776     2.46   0.014     .0033004    .0290842
-------------+----------------------------------------------------------------
     sigma_u |  .00599869
     sigma_e |  .01224502
         rho |  .19354215   (fraction of variance due to u_i)
------------------------------------------------------------------------------
```

Hausman specification test

```
Hausman specification test

                ---- Coefficients ----
             |      Fixed       Random
    q_percap |    Effects      Effects       Difference
-------------+-----------------------------------------
        pfor |  -1.06e-06    -1.08e-06         2.08e-08
        wage |   .0000624      .000045         .0000174
    pfor_sub |   1.06e-06     1.02e-06         3.74e-08
 _Iquarter_2 |  -.0006635    -.0002256        -.0004378
 _Iquarter_3 |   .0013299     .0020573        -.0007274
 _Iquarter_4 |   .0097727     .0108957         -.001123
     _Icar_2 |  -.0214931    -.0215388         .0000457
     _Icar_3 |  -.0036966     -.003739         .0000424
     _Icar_4 |  -.0020426    -.0020629         .0000203
     _Icar_5 |  -.0001606    -.0000978        -.0000628
     _Icar_6 |   .0120332     .0121614        -.0001281
     _Icar_7 |   .0150572     .0152438        -.0001865
     _Icar_8 |  -.0030336    -.0028238        -.0002099
     _Icar_9 |  -.0059158    -.0056046        -.0003112
    _Icar_10 |  -.0028113    -.0025134        -.0002979
    _Icar_11 |  -.0052459    -.0050801        -.0001657

    Test:  Ho:  difference in coefficients not systematic

                 chi2( 16) = (b-B)'[S^(-1)](b-B), S = (S_fe - S_re)
                           =     2.03
                 Prob>chi2 =     1.0000
```

Breusch-Pagan LM test

```
Breusch and Pagan Lagrangian multiplier test for random effects:

        q_percap[region,t] = Xb + u[region] + e[region,t]

        Estimated results:
                         |       Var     sd = sqrt(Var)
                ---------+-----------------------------
                q_percap |   .0003376       .0183739
                       e |   .0001499        .012245
                       u |    .000036       .0059987

        Test:   Var(u) = 0
                              chi2(1) =   810.52
                          Prob > chi2 =     0.0000
```