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INCENTIVE COMPATIBLE MECHANISM DESIGN OF CUSTOM POLICY FOR COMPLEX SOCIAL CHOICE FUNCTION

The paper focuses on the design of state customs policy as to unique foreign product for traditional simple and proposed complex social choice functions. The comparative analysis of both models demonstrates the advantages of the complex function, which considers the welfare of domestic consumers. The proposal for state policy of reducing customs duty for unique foreign product under incentive compatible mechanism design is substantiated.

Keywords: social choice function; customs policy; consumer surplus; social welfare.

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РОЗРОБКА УЗГОДЖЕНОГО ЗА СТИМУЛАМИ МЕХАНІЗМУ МИТНОЇ ПОЛІТИКИ ДЕРЖАВИ ДЛЯ КОМПЛЕКСНОЇ ФУНКЦІЇ СУСПІЛЬНОГО ВИБОРУ

У статті досліджено митну політику держави щодо унікальної іноземної продукції для традиційної простої і запропонованої складної функції суспільного вибору. Порівняльний аналіз обох моделей виявив переваги складної функції, в якій враховано добробут вітчизняних споживачів. Обґрунтовано необхідність зниження митної ставки для унікальної іноземної продукції при розробці узгодженого за стимулами механізму митної політики держави.

Ключові слова: функція суспільного вибору; митна політика; надлишок споживачів; суспільний добробут.

Форм. 10. Табл. 4. Рис. 7. Літ 13.

Віталій Н. Кобець

РАЗРАБОТКА СОГЛАСОВАННОГО ПО СТИМУЛАМ МЕХАНИЗМА ТАМОЖЕННОЙ ПОЛИТИКИ ГОСУДАРСТВА ДЛЯ КОМПЛЕКСНОЙ ФУНКЦИИ ОБЩЕСТВЕННОГО ВЫБОРА

В статье исследована таможенная политика государства по отношению к уникальной иностранной продукции для традиционной простой и предлагаемой сложной функций общественного выбора. Сравнительный анализ обеих моделей показывает преимущества сложной функции, в которой учтено благосостояние отечественных потребителей. Обоснована необходимость снижения таможенной ставки для уникальной иностранной продукции при разработке согласованного по стимулам механизма таможенной политики государства.

Ключевые слова: функция общественного выбора; таможенная политика; таможенная ставка; излишек потребителей; общественное благосостояние.

Introduction. The search for effective ways of state budget replenishment by means of indirect taxes in the course of international trade requires the introduction of flexible customs duties for foreign producers of unique products. To achieve this, we need a new approach to take into account the goals of all the participants of such bargaining process.

Literature review. Mechanism is a mathematical structure, modelling an institute and determining the set of rules, regulating actions of participants and determining the ways of transforming participants' strategies into final results under a given

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communication system. A mechanism implements the given objective function, realizing it on participants types space (Hurwicz and Stanluy, 2006). In other words, mechanism transforms the actions' profile into a social result.

Mechanism structure includes (Figure 1):

1. Social choice function or SCF (demonstrates final result required by the whole society). SCF is a composition of messages and result (Maskin, 2009).

2. Implementation mechanism (realization of SCF by the payoffs function and allocation function).

3. Revelation principle of participants' types (allows conveying true information to social planner) (Archibald, 2005).

4. Motivation mechanism (intended to create conditions for participants to reveal true information on their types through signals) (Narahari, 2009).

The examples of complex agents are state authorities, transnational corporations, social organizations, society etc.

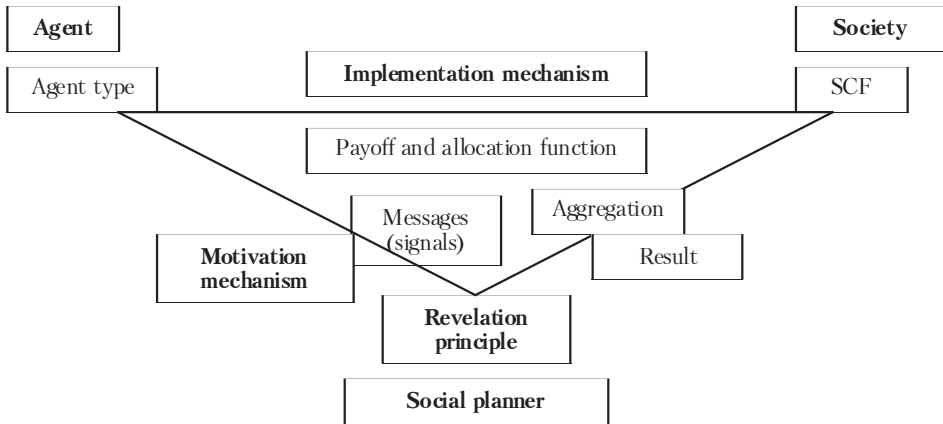


Figure 1. Mechanism design for a social choice function, compiled by the author according to (Kobets, 2013)

Mechanism can enforce cooperation rules, when participants accomplish actions, violating fixed rules (Bergemann and Stephen, 2005). The two extremes of mechanisms types are centralized (planned system) and decentralized (such as competitive market), continuum numbers of other mechanisms between them.

The decentralized mechanism (saving confidentiality mechanism) implies the private expenditure on collection and verification of information reliability (Dilip, 2006).

Reasons and tasks of mechanism design are demonstrated in Table 1.

Table 1. Reasons and tasks of mechanism design, constructed by the author

Reasons of new mechanism introduction	Mechanism tasks
- revelation of unsatisfactory activity aspects of the current economic systems or institutes (market failures such as information asymmetry, monopoly, externalities etc.); - advantage only for certain participants (lobby, non-transparency allocation, corruption schemes) under the existent economic system	- validating social choice function with characteristics, required by society; - developing incentive compatible conditions for participants to reveal their true types (reservation price, costs etc.); - providing implementation process of a social choice function by means of chosen mechanism (direct or indirect)

Mechanism design is connected with information theory, incentive theory and bounded rationalities (Figure 2).

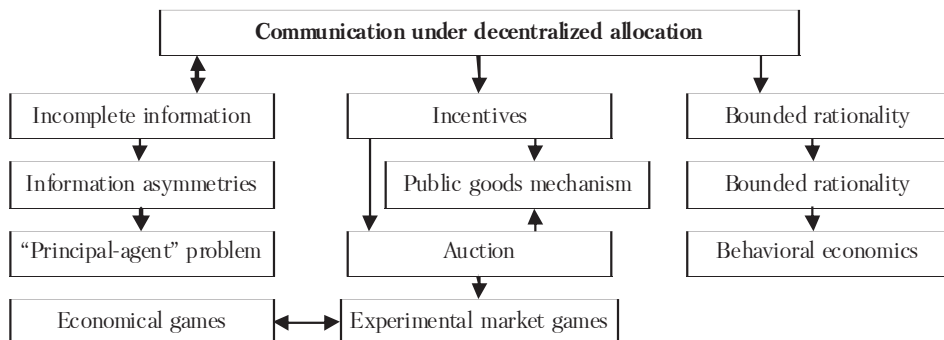


Figure 2. **Integration of mechanism design in economic science,**
compiled by the author according to (McFadden, 2009)

The *direct mechanism* provides a direct transfer of truthful private information on the types of the agents conveyed to social planner (unrealistic mechanism). The *indirect mechanism* creates a motive, which makes it more profitable for the agents to open true information, than to conceal or distort it (more realistic mechanism) (Myerson, 2008). Actions of indirect mechanism can reveal the true type in contrast to direct mechanism, where revealed types may be misreported (Nisan et al., 2007). Mechanism designer can restrict consideration of equilibrium with only true types (Roth, 2002).

The parties involved in custom mechanism are social planner (government) and agents (payers of customs tax). Mechanism designer (planner) is aware of: (i) class of environments, for which the mechanism should be developed; (ii) desired criterions for SCF (Izmailkov et al., 2008).

Problem statement. The aim of the paper is to elaborate an incentive compatible mechanism of customs policy for simple and complex social choice functions grounding the size of the customs duty for unique foreign product under maximization of a customs receipt.

Key findings and discussion. SCF maps types space for customs house (average costs of production for importers) in results space (custom receipts). The participant type (average costs) defines its message (invoice cost of goods), which affects the final result (custom receipts).

For construction of a model describing the cooperation between foreign producers and consumers under custom house tax policy we assume:

- n foreign firms produce a homogeneous product, which is supplied to domestic market and has no domestic analogues (e.g., foreign cars);
- there is quantitative Cournot competition between firms;
- cost functions of all firms and domestic market demand function are linear on quantities;
- the information on average costs of foreign firms and domestic market demand is uniformly distributed between *all* participants (foreign producers, domestic consumers and government).

Participants' objective functions are presented in Table 2.

Table 2. Participants' objective functions, constructed by the author

PARTICIPANTS	OBJECTIVE FUNCTIONS
Foreign producers	Profit of producer i : $\pi_i^F = (1-t) \times P \times q_i - v_i \times q_i \xrightarrow{q_i \geq 0} \max, i = 1, \dots, n$
State (Ministry for Incomes and Duties of Ukraine)	Tax proceeds to state budget is: $B = t \times P_f \times \sum_{i=1}^n q_i$
Domestic market	Function of domestic demand is $P = b - c \times Q = b - c \times \sum_{i=1}^n q_i$

Custom Receipts Model Construction for a Fixed Customs Duty. After the profit maximization we obtain the optimal value of foreign producer sales (custom duty $0 < t < 1$):

$$q_j = \frac{1}{(n+1) \times c} \times \left(b - \frac{(n+1) \times v_j - n \times \bar{v}}{1-t} \right), j = 1, \dots, n, \tag{1}$$

where $\bar{v} = \frac{\sum_{i=1}^n v_i}{n}$ – the average product cost of all foreign producers. Summing up the amounts of goods produced by every firm we receive the total amount of unique product:

$$Q = \sum_{j=1}^n q_j = \frac{n \times ((1-t) \times b - \bar{v})}{c \times (n+1) \times (1-t)}. \tag{2}$$

Budget customs receipts maximization.

Theorem 1. Government has to hold a single customs duty on a unique product of foreign producers on the level of $t = 1 - \sqrt{\frac{\bar{v}}{b}}$ for maximization of customs receipts under fixed tariff policy in the short-run period for simple social choice function.

Proof of this result follows from the maximization of budget receipts: $B = t \times P_f \times Q \xrightarrow{q_i \geq 0} \max$. From the expression $B = t \times P_f \times Q$ we define that the equilibrium (maximal) custom receipt will be equal to:

$$B^* = \frac{n \sqrt{b} \times (\sqrt{b} - \sqrt{\bar{v}})^2 \times (\sqrt{b} - n \sqrt{\bar{v}})}{c \times (n+1)^2}. \tag{3}$$

Dependence between the equilibrium of customs duty and customs receipts is shown in Figure 3.

Mechanism design for complex social choice function for a single customs duty. In the long-run period invoice cost of commodity will change according to the equilibrium price dynamics of a given unique foreign goods at home market. It requires the adjustment of invoice cost of commodity P and custom duty t correspondingly. In the short-run period invoice cost P is unchanged.

Now we combine the formulas above for the optimal indices under single custom duty as in Table 2 (Table 3).

From Table 2 we rewrite the expressions for optimal quantity and price as follows:

$$Q = \frac{n \times b}{c \times (n+1)} - \frac{n \times \bar{v}}{c \times (n+1) \times (1-t)};$$

$$P = \frac{b}{n+1} + \frac{n \times \bar{v}}{(n+1) \times (1-t)}$$

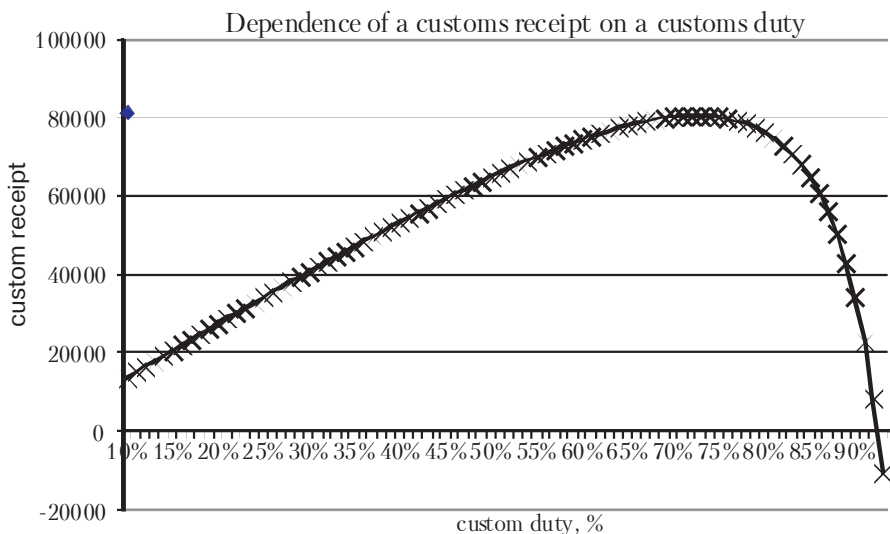


Figure 3. Laffer curve – dependence between customs receipts and a customs duty ($n = 10, b = 40, v = 5.25, c = 0.01, P = 24.04, t = 73\%$), constructed by the author

Table 3. Optimal indices for a customs policy under a single customs duty, constructed by the author

Indices	Optimal value
Sales quantity of foreign producer j , units	$q_j = \frac{1}{(n+1) \times c} \times \left(b - \frac{(n+1) \times v_j - n \times \bar{v}}{1-t} \right), j = 1, \dots, n$
Total sales quantity of foreign unique product, units	$Q = \frac{n \times ((1-t) \times b - \bar{v})}{c \times (n+1) \times (1-t)}$
Product price, UAH	$P = \frac{(1-t) \times b + n \times \bar{v}}{c \times (n+1) \times (1-t)}$
Profit of foreign producer j , UAH	$\pi_j^B = (1-t) \times P \times q_j - v_j \times q_j, j = 1, \dots, n$
Custom receipts, UAH	$B = t \times P \times Q$

Theorem 2. Government has to hold a single customs duty on a unique product of foreign producers on the level of $t^* = 1 - \left(\sqrt[3]{-\frac{g}{2} + \sqrt{D}} + \sqrt[3]{-\frac{g}{2} - \sqrt{D}} \right)$ for maximization of custom receipts under fixed tariff policy in the long run for simple social choice function, where $p = \frac{(n-1) \times b \bar{v} + n \times \bar{v}^2}{b^2}, g = -\frac{2n \bar{v}^2}{b^2}, D = \sqrt{\frac{g^2}{4} + \frac{p^3}{27}}$.

Proof. In the long run invoice cost P is variable just as market price. After substitution of price and total sales functions in custom receipts expression from Table 3 we obtain B as a function of t and after algebraic transformation we get:

$$b^2 \times (1-t)^3 + (n-1) \times b\bar{v} \times (1-t) - n\bar{v}^2 \times (1+t) = 0. \quad (4)$$

The domain of function (4) is interval (0;1]. Solution of this equation can be determined by means of Cardano formula $x = u_0 + w_0$, where

$$u_0 = \sqrt[3]{-\frac{g}{2} + \sqrt{D}}; w_0 = \sqrt[3]{-\frac{g}{2} - \sqrt{D}}; D = \sqrt{\frac{g^2}{4} + \frac{p^3}{27}}. \quad (5)$$

In general we get equilibrium value of single custom duty, under which custom receipts will maximize:

$$t^* = 1 - \left(\sqrt[3]{-\frac{g}{2} + \sqrt{D}} + \sqrt[3]{-\frac{g}{2} - \sqrt{D}} \right). \quad (6)$$

Q.E.D.

The software used for the investigation of equilibrium state of market participants for numeric example is "Maple" and "MS Excel".

Example 1. Let $b = 1, n = 2, v_1 = 0.47, v_2 = 0.53$, then for equation (4) we obtain $x^3 + x - 1 = 0$. Under Cardano formulas we get $u_0 = 1.0118, w_0 = -0.3295$. And $x = 0.6823$ or $t^* = 0.3177$ (31.77%).

For the given equilibria the rate of custom receipts is demonstrated on Figure 4.

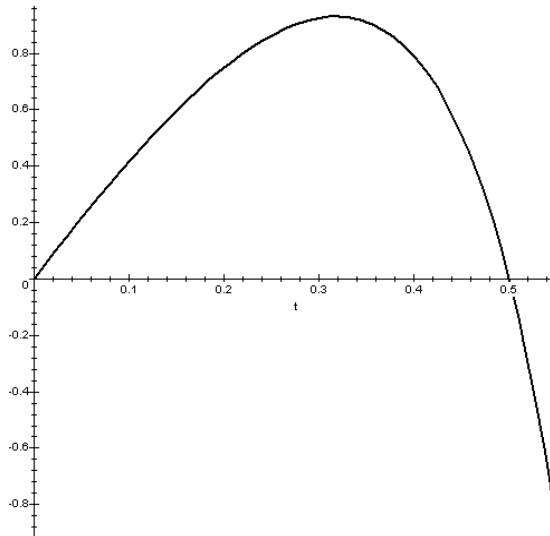


Figure 4. Dependence of a customs receipt function B on a single duty rate, constructed by the author

For $t = 31.77\%$ budget receipts will maximize. Increasing the customs duty is a reason of decreasing unique foreign product sales and rise of domestic prices for consumers (Figure 5).

Consider the impact of a single customs duty dynamics on all participants, such as foreign producers, domestic consumers and state authorities (Table 4). Index PS is foreign firms producer surplus as the total sum of their profits at domestic market. Consumer surplus CS is computed as a triangle area restricted by reverse demand function, price axis and segment normal to price axis (Figure 6). CS can be defined by the formula:

$$CS = \frac{1}{2} \times (b - P(t)) \times Q(t). \tag{7}$$

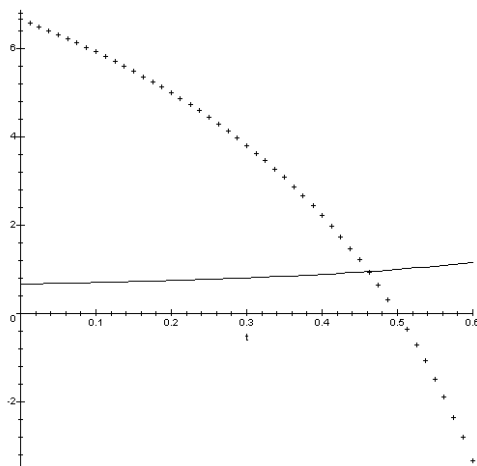


Figure 5. Dependence of sales quantity (pointed graph) and price (line) on a single duty rate, constructed by the author

Table 4. Economic indices dynamics for a customs policy with a single customs duty, constructed by the author

t	q ₁	q ₂	Q	P	π ₁	π ₂	PS	CS	B	SCF
0.10	3.63	2.30	5.93	0.70	0.59	0.24	0.83	0.88	0.42	1.29
0.15	3.45	2.04	5.49	0.73	0.51	0.18	0.68	0.75	0.60	1.35
0.2036	3.22	1.71	4.93	0.75	0.41	0.12	0.53	0.61	0.77	1.38
0.25	3.02	1.42	4.44	0.78	0.34	0.08	0.42	0.49	0.86	1.36
0.3177	2.66	0.90	3.56	0.82	0.24	0.03	0.27	0.32	0.93	1.25
0.35	2.46	0.62	3.08	0.85	0.20	0.01	0.21	0.24	0.91	1.15
0.40	2.11	0.11	2.22	0.89	0.13	0.00	0.13	0.12	0.79	0.91

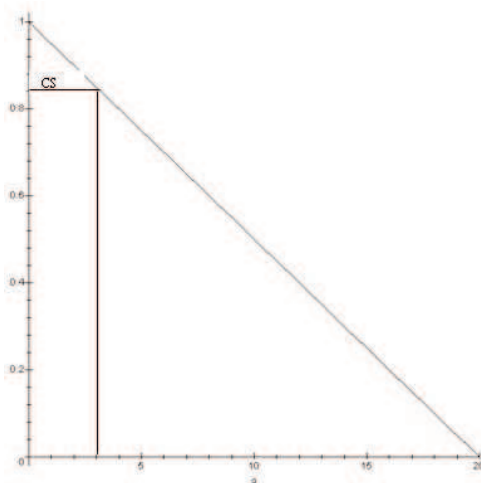


Figure 6. Consumer surplus at a unique product market, constructed by the author

Social welfare of a country is determined as a sum of customs receipts B and consumer surplus CS in the form of desirable social choice function, where not only customs receipts but also consumer interests are taken into account. This approach is new in contrast to the traditional one, where the state takes into account only customs receipts. Incorporation of *consumer surplus* in complex social choice function gives a new tool for researching of state authorities effectiveness, or

$$SCF = B + CS. \tag{8}$$

From Table 4 it can be concluded that after increasing of customs duty the amount of consumption will fall for all domestic consumers. Also the growth of custom duty is a reason for profits decrease for all foreign manufactures of product unique for home market.

With the growth of custom duties social welfare first rises, then falls. It can be explained as follows: at first consumer surplus falls (due to higher prices) more slowly than budget receipts rise. But near the equilibrium of a customs duty the rise of customer receipts does not compensate for the decrease of consumer surplus.

Because government is to take into account the interests of its own consumers, social choice function has to include not only customs receipts, but also consumer interests (their surplus), which is a new approach in this paper.

Theorem 3. *Government has to hold a single customs duty on a unique product of foreign producers on the level of $t^* = 1 - \left(\sqrt[3]{-\frac{g}{2} + \sqrt{D}} + \sqrt[3]{-\frac{g}{2} - \sqrt{D}} \right)$ for the maximization of custom receipts under fixed tariff policy in the long-run period for complex social choice function, where $p = -\frac{b\bar{v} - n \times \bar{v}^{-2}}{b^2}$, $g = -\frac{n\bar{v}^{-2}}{b^2}$, $D = \sqrt{\frac{g^2}{4} + \frac{p^3}{27}}$.*

Proof (sketch). Consider the social choice function, which takes into account both budget replenishments and consumer surplus:

$$SCF = t \times P(t) \times Q(t) + \frac{1}{2} \times (b - P(t)) \times Q(t). \tag{9}$$

Optimization of social choice function (9) results in:

$$b^2 \times (1-t)^3 - (b\bar{v} - n\bar{v}^{-2}) \times (1-t) - n\bar{v}^{-2} = 0. \tag{10}$$

The equation solving gives the result presented in Theorem 3.

Example 2. For the parameters of the previous Example 1 after the Cardano formulas we have the solution of equation (10): $f(x) = x^3 - 0.5 = 0$, from which $x = 0.7937$ or $t = 1 - 0.7937 = 0.2063$ (20.63%). This result demonstrates that for the maximization of complex social function custom house has to decrease the customs duty in contrast to simple SCF on 11,14%: $\Delta t = 0.2063 - 0.3177 = -0.1114$.

The derived result for complex SCF can be presented by the following graph (Figure 7).

Conclusions. Under the incentive compatible mechanism designs of a customs policy, government is to take into account not only customs receipts to budget, but also the more implicit and simultaneously more important index of home consumers welfare. With the interests of custom house prevailing, domestic consumers will be overpaying for unique foreign product. Support for social welfare means including both budget receipts and consumer surplus in complex social choice function.

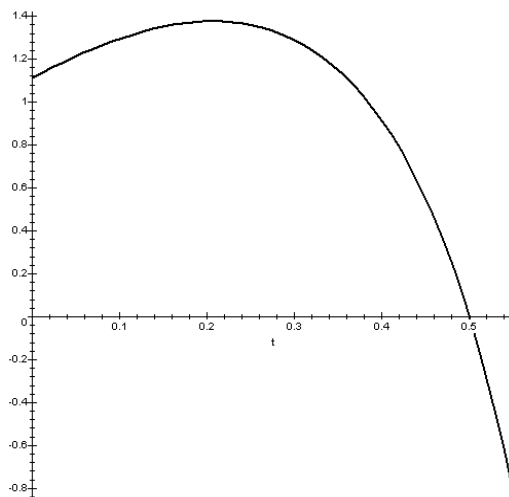


Figure 7. **Dependence of a custom receipt function on a single duty rate, constructed by the author**

Thus, domestic consumer interests being supported, foreign producers of a unique product will also benefit from lower domestic price and increased sales and profits. The rise of consumer welfare and stable budget receipts from a unique foreign product is a preferable alternative over budget receipt maximization, when benefit for one side (customs house) does not consider the needs of home consumers.

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