COMPARATIVE STATIC ANALYSIS OF TARIFFS IN PARTIAL EQUILIBRIUM MODEL: SMALL COUNTRY CASE

***Hrvoje Jošić*[1] & *Mislav Jošić*[2]**

UDC / UDK: 339.453
JEL classification / JEL klasifikacija: F10, F13
Review / Pregledni rad
Received / Primljeno: July 9, 2015 / 9. srpnja 2015.
Accepted for publishing / Prihvaćeno za tisak: November 25, 2015 / 25. studenoga 2015.

Summary

According to standard economic theory, imposition of import tariffs in a small country always leads to suboptimal allocation of resources and generates irretrievable losses for the society. Nevertheless, governments often decide to impose tariff measures in order to balance the budget or to retaliate against protectionist trade policy of their trade partners. This paper gives some insight into the microeconomic aspects of tariff imposition by analysing changes in consumers' welfare, producers' welfare and net welfare of the society. In addition to that, detailed geometric and algebraic analysis was carried out in order to elucidate the conditions under which tariff imposition can be beneficial for the government by introducing the maximum revenue tariff. Furthermore, prohibitive tariff and autarchy equilibrium associated with it was tackled in detail. In order to assess the net effects of import tariff imposition, the partial equilibrium model was used with several propositions being formulated from the linearised model based on a small country assumption. Finally, the propositions were carefully elaborated with special emphasis on changes in initial parameters.

Key words: *trade policy, dead-weight loss, maximum revenue tariff, optimum welfare-tariff, small country.*

[1] Hrvoje Jošić, Ph. D., Postdoctoral Fellow, Faculty of Economics and Business Zagreb, University of Zagreb, E-mail: hjosic@efzg.hr.
[2] Mislav Jošić, Ph. D., Research Economist, Croatian National Bank, E-mail: mislav.josic@gmail.com. The views expressed in this paper are the author's personal views and not necessarily those of the institution in which he is employed.

1. INTRODUCTION

The analysis of tariff imposition is of great importance for consumers, producers, but also for the government that sets the trade policy and actively participates in international trade in goods and services. A small country is usually considered as a price taker and as such cannot change the terms of trade set by the rest of the world. Under the small country assumption, the standard economic theory posits that restricted international trade is always considered as the second best solution with tariffs being preferred as opposed to quotas. In line with this statement we will try to clarify under what conditions tariff imposition can be beneficial for the government, what affects consumers' and producers' surplus and how resources reallocate under price changes. In their international economics textbooks, Krugman and Obstfeld (2009, pp. 188-192) and Salvatore (2007, pp. 250-254) often discuss the costs and benefits of a tariff in a small country by utilising the partial equilibrium model but do not go into details about how certain changes in supply and demand parameters, as well as changes in prices, affect partial or total welfare. Moreover, the geometrical analysis of tariffs in a partial equilibrium model often heavily relies on the assumption of constant supply and demand elasticities, which we will alleviate in our model in order to gain some new insight into the nature of tariff imposition. Some other authors, such as Fan and Fan (2005) dealt with the elasticity issue of supply and demand in the presence of imperfect competition such as a monopoly, while Clarke and Collie applied it on the Bertrand duopoly case.

In his early papers Johnson (1951) argued that a country's welfare can be partially analysed by introducing the term maximum revenue tariff and optimal-welfare tariff. While the optimal-welfare tariff implies the use of zero-tariff rate in order to minimise society costs, maximum revenue tariff is considered to be dependent on many factors, such as the country size, world price of traded goods and supply and demand elasticities. In order to shed light on the tariff induced effects we will utilise the partial equilibrium model while analysing aforementioned effects. Our model of tariff effects will be applied on a small country case, i.e. a situation in which the world price is given exogenously. Our microeconomic analysis will heavily rely on Dupuit's triangles and Harberger's (1971) welfare analysis backed up with some basic algebra understanding.

The goal of the paper is to geometrically and algebraically show how certain parametric changes in the linearised model can influence the welfare of particular participants (consumers, producers and the government) in international trade. Furthermore, several findings regarding the maximum revenue tariff and optimal welfare tariff in a small country case will be carried out in the form of propositions.

2. TARIFF IMPOSITION USING PARTIAL EQUILIBRIUM MODEL: SMALL COUNTRY CASE

The analysis of tariff imposition in the following text uses the partial equilibrium model in order to assess welfare gains and losses on the supply and demand side as well as the change in government revenues. We will use linearized supply and demand functions when analysing the small country case.

Supply and demand functions are given algebraically as follows:

$$p(q) = a + bq \tag{1}$$

$$p(q) = c - dq \tag{2}$$

where $a,b,c,d > 0$.

Let there be a small country that cannot affect world prices importing goods at the world price p_w:

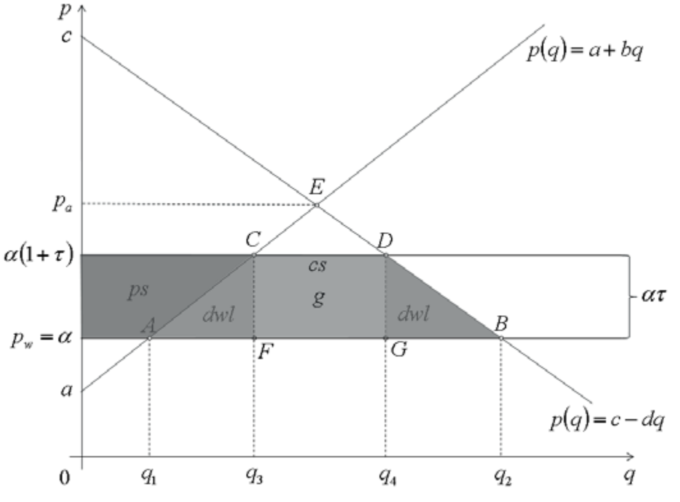
$$p_w = \alpha + \beta q \tag{3}$$

where $\beta = 0$ and $\alpha > a$ which defines the constant world price in a small country such that

$$p_w = \alpha \tag{4}$$

Let's assume that the small country imposes a tariff on all imported goods from the rest of the world by applying an *ad valorem* tariff rate τ, where $\tau > 0$. The imposition of an import tariff does not change the world price α, while the price for domestic consumers, domestic producers and the government increases by $\alpha\tau$ or τ percent. An increase in domestic price from α to $\alpha(1 + \tau)$ leads to an increase in producer surplus (*ps*), decrease in consumer surplus (*cs*) and generates government revenues (*t*). As the result of suboptimal allocation of production factors, dead-weight loss (*dwl*) arises as a net change in the country's welfare as shown in Figure 1.

Figure 1: Tariff imposition in a small country by using partial equilibrium model



Source: authors' contribution

Quantities produced and consumed are q_1 ... q_4 such that $q_1 < q_3 < q_4 < q_2$. Inserting prices in supply and demand functions from (1) and (2) yields the following quantities:

$$q_1 = \frac{\alpha - a}{b} \tag{5a}$$

$$q_2 = \frac{c - \alpha}{d} \tag{5b}$$

$$q_3 = \frac{\alpha(1+\tau) - a}{b} \tag{5c}$$

$$q_4 = \frac{c - \alpha(1+\tau)}{d} \tag{5d}$$

From the quantities q_1 ... q_4 derived in (5a) to (5d) the following changes in producer surplus and consumer surplus arise:

$$ps = q_3[\alpha(1+\tau) - \alpha] - \frac{\alpha\tau(q_3 - q_1)}{2} \tag{6a}$$

when (6a) sorted out results in (6b):

$$ps = \frac{\alpha\tau(2\alpha - 2a + \alpha\tau)}{2b} \tag{6b}$$

A very similar transformation applies for changes in consumer surplus:

$$cs = q_2[\alpha(1+\tau) - \alpha] - \frac{\alpha\tau(q_2 - q_4)}{2} \tag{7a}$$

when (7a) sorted out results in (7b):

$$cs = \frac{\alpha\tau(2c - 2\alpha - \alpha\tau)}{2d} \tag{7b}$$

Government revenues (*g*) and dead-weight loss (*dwl*) can be expressed as a function of τ without using quantities and prices as shown in (8c):

$$g = (q_4 - q_3)[\alpha(1+\tau) - \alpha] \tag{8a}$$

$$g = \alpha\tau(q_4 - q_3) \tag{8b}$$

Inserting q_3 and q_4 into (8b) results in (8c):

$$g = \alpha\tau\left(\frac{a-\alpha(1+\tau)}{b} + \frac{c-\alpha(1+\tau)}{d}\right) \tag{8c}$$

Dead-weight loss (*dwl*) is defined as the sum of all welfare changes due to suboptimal allocation of resources on the supply and demand side upon tariff imposition. It is calculated as follows:

$$dwl = \frac{(q_3-q_1)[\alpha(1+\tau)-\alpha]}{2} + \frac{(q_2-q_4)[\alpha(1+\tau)-\alpha]}{2} \tag{9a}$$

when sorted out results in (9b):

$$dwl = \frac{(\alpha\tau)^2\left(\frac{1}{b}+\frac{1}{d}\right)}{2} \tag{9b}$$

According to the expression (9b), two propositions can be stated regarding the dead-weight loss creation upon the changes in tariff rate τ and parameters *b* and *d*.

Proposition 1: *An imposition of a tariff in a small country increases dead-weight loss with the square of the tariff rate.*

Total net loss of a country's welfare depends on four variables: world price α, *ad valorem* tariff rate τ and the slopes of supply and demand functions which depend on parameters *b* and *d*. Dead-weight loss increases with the square of the tariff rate which can have a significant negative impact on the country's welfare, mainly on consumers that bear the whole burden of tariff imposition.

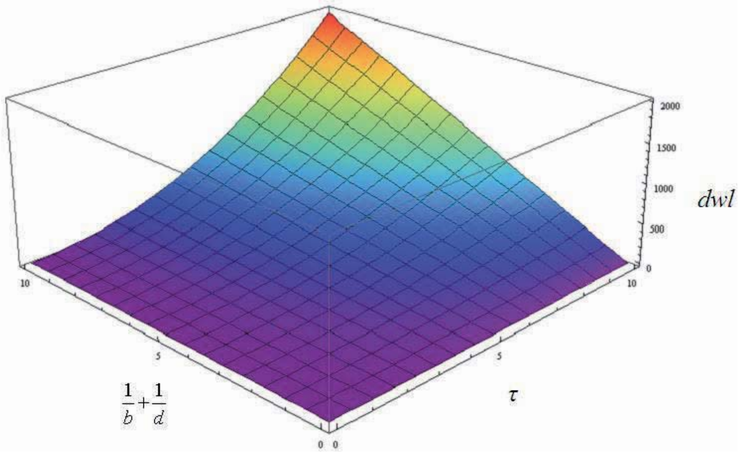
Proposition 2: *An increase in the slope of supply or demand decreases dead-weight loss.*

Any increase in parameters *b* and *d*, *ceteris paribus*, leads to a decrease in dead-weight loss. Conversely, if the supply and demand functions are more horizontally inclined[3] the dead-weight loss is higher.

Graphical presentation of dead-weight loss in a small country, holding world price α fixed is shown in Figure 2.

[3] This is equal to an increase in the sum of inversed values of parameters *b* and *d*.

Figure 2: Dead-weight loss as a function of τ and parameters b and d



Source: authors' contribution

As seen from Figure 2, dead-weight loss strictly increases the function of tariff rate τ(right axis) and decreases the function of slopes b and d (left axis).

From the expression (8c) it is possible to determine the maximum revenue tariff rate τ^* that maximises government revenues at g^*. Let's assume that a government is facing two adverse problems. The first one is to maximise tariff revenues, and the other one is to minimise welfare losses for a country. The aforementioned problem is defined as an optimisation problem given in the following form:

$$\begin{aligned} &\text{maximize } g(\tau) \\ &\text{minimize } dwl(\tau) \\ &s.t.\ \alpha,a,b,c,d > 0 \end{aligned} \tag{10a}$$

An appropriate Lagrange function (Λ) is constructed:

$$\begin{aligned} &\Lambda(\tau,\lambda) = g(\tau) + \lambda \cdot dwl(\tau) \\ &\Lambda(\tau,\lambda) = \alpha\tau\left(\frac{a-\alpha(1+\tau)}{b} + \frac{c-\alpha(1+\tau)}{d}\right) + \lambda\left[\frac{(\alpha\tau)^2\left(\frac{1}{b}+\frac{1}{d}\right)}{2}\right] \\ &1.\ \frac{\partial\Lambda}{\partial\tau} = 0 \Rightarrow \alpha\left(-\frac{\alpha}{b}-\frac{\alpha}{d}\right)\tau + \left(\frac{1}{b}+\frac{1}{d}\right)\alpha^2\lambda\tau + \alpha\left(\frac{a-\alpha(1+\tau)}{b} + \frac{c-\alpha(1+\tau)}{d}\right) = 0 \\ &2.\ \frac{\partial\Lambda}{\partial\lambda} = \frac{(\alpha\tau)^2\left(\frac{1}{b}+\frac{1}{d}\right)}{2} = 0 \end{aligned} \tag{10b}$$

This gives two solutions to the problem expressed in (10a):

$$\tau_1^* = 0 \tag{11a}$$

$$\tau_2^* = \frac{ad - \alpha b + bc - \alpha d}{2\alpha(b+d)} \tag{11b}$$

If the government decides to pursue a free trade policy without tariffs ($\tau_1^* = 0$), then the dead-weight loss is minimised. Zero tariff policy in the context of changes in national welfare represents an optimum-welfare tariff in a small country. An alternative to a free trade policy is tariff imposition at tariff rate τ_2^* that leads to the maximisation of government (tariff) revenues with the presence of welfare costs. The following conclusions can be summarised in the form of propositions.

Proposition 3: *Government revenues from tariff imposition in a small country are maximised if there exists a maximum revenue tariff rate* $\tau^* = \frac{ad - \alpha b + bc - \alpha d}{2\alpha(b+d)}$, *where world price is* τ *and a,b,c,d are supply and demand parameters.*

If a maximum revenue tariff rate τ_2^* is inserted into (8c) then maximum tariff revenues are given as follows:

$$g^* = \frac{(bc + ad - b\alpha - d\alpha)^2 \left(\frac{a - \alpha\left(1 + \frac{bc + ad - b\alpha - d\alpha}{2(b+d)\alpha}\right)}{b} + \frac{c - \alpha\left(1 + \frac{bc + ad - b\alpha - d\alpha}{2(b+d)\alpha}\right)}{d} \right)}{4(b+d)^2 \alpha} \tag{12a}$$

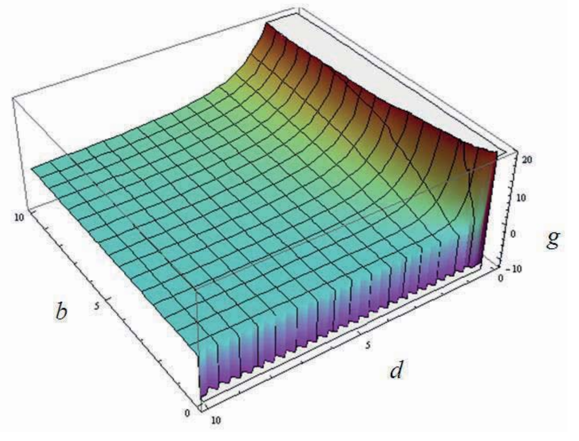
Simplified expression (12a) results in (12b):

$$g^* = \frac{[d(a-\alpha) + b(c-\alpha)]^3}{8bd(b+d)^2 \alpha} \tag{12b}$$

Proposition 4: *Government revenues from tariff imposition in a small country are maximised when* $g^* = \frac{[d(a-\alpha) + b(c-\alpha)]^3}{8bd(b+d)^2 \alpha}$ *and* $\tau^* > 0$, *where* τ *is the world price and a,b,c,d are supply and demand parameters.*

Graphical presentation of government revenues in a small country resulting from a tariff imposition is shown in Figure 3. For the purposes of graphical demonstration the following variables are held constant ($\alpha = 2$, $a = 1$ and $c = 10$) while $b, d \in [0,10]$.

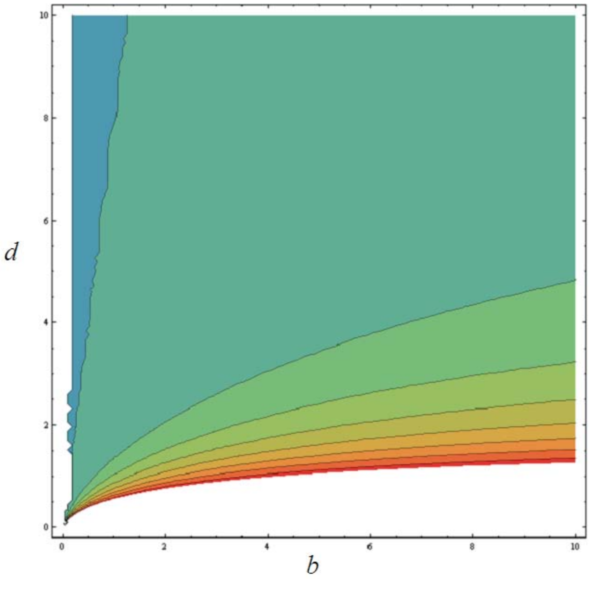
Figure 3: Government revenues as a function of parameters *b* and *d*



Source: authors' contribution

On a two dimensional plane, level curves are shown in Figure 4 as a contour plot of the revenue function *g*.

Figure 4: Government revenues contour plot



Source: authors' contribution

The slope of the level curves at any point can be easily calculated as a Marginal Rate of Parameter Substitution (MRPS) expressed as

$$MRPS = \frac{\partial d}{\partial b} \tag{13}$$

MRPS shows all levels of substitutability between supply and demand (*b* and *d)* parameters, while at the same time keeping government revenues fixed along the isorevenue curves. By calculating MRPS, the government can estimate possible implications of supply and demand shift in elasticities so as to keep revenues from tariffs fixed.

A more specific type of tariff rate of great importance in the tariff analysis is the prohibitive tariff τ_p. It leads a country to an autarchy equilibrium at the autarchy price p_a. Prohibitive tariff rate τ_p is determined as follows:

$$\tau_p = \frac{p_a}{\alpha} - 1 \tag{14a}$$

If $p_a = a + b\frac{c-a}{b+d}$, then it is easy to define τ_p

$$\tau_p = \frac{a + b\frac{c-a}{b+d}}{\alpha} - 1 \tag{14b}$$

such that $\tau_{ft} < \tau^* < \tau_p$[4].

As the result of derived expressions, the autarchy proposition can be stated as follows:

Proposition 5: *Autarchy equilibrium exists in a small country only if* $\tau_p = \frac{a + b\frac{c-a}{b+d}}{\alpha} - 1$ *or* $\tau_p = 0$, *where the world price is* α *and a,b,c,d are supply and demand parameters.*

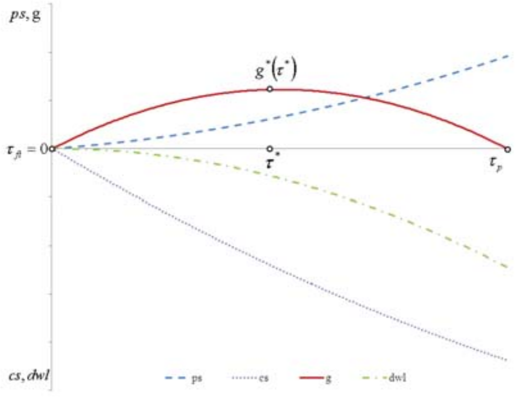
Any further increase in the tariff rate above $\tau_p = \frac{a + b\frac{c-a}{b+d}}{\alpha} - 1$ no longer has an impact on government revenues.

Furthermore, the graphical analysis in Figure 5 shows nonlinear forms of the functions *ps,cs,g* and *dwl* with respect to changes in the tariff rate τ. The following parameters are constant in Figure 5 ($a = b = d = 1$, $c = 10$, $\alpha = 2$), while $\tau \in [0, \tau_p]$. Producer surplus strictly increase the function of τ, while consumer surplus and dead-weight loss strictly decrease the functions with monotonic properties. Government revenues are

4 $\tau_{ft} = 0$ denotes free trade equilibrium with zero tariffs.

maximised at the point g^* with the maximum revenue tariff rate τ^*, while null points $(\tau_{ft} = 0)$ and $(\tau_p, 0)$ represent zero-revenue equilibrium.

Figure 5: Welfare changes upon tariff imposition



Source: authors' contribution

The government, as a policy maker, has two options to choose from: either to pursue a free trade policy with an optimum-welfare tariff rate $\tau^* = 0$ in order to minimise welfare losses, or to maximise its own benefit by introducing the maximum revenue tariff $\tau^* > 0$, thus balancing the budget. The negative side effects of introducing non-zero tariffs are welfare costs to the society due to suboptimal allocation of resources on the supply side and loss of welfare on the demand side because of a negative consumption effect. Any increase in tariff rates in a small country always leads to lower level of country net welfare and unchanged terms of trade, while the quantities of imported goods decrease. In this way, the tariff rate τ acts as a policy variable of the government, but also serves as a powerful tool of resource allocation and income redistribution.

3. CONCLUSION

The aim of this paper was to carry out an in-depth microeconomic analysis into policy driven effects of tariff imposition in a small country. In the first part of this paper we have analytically derived equations through which changes in partial and net country welfare can be calculated. Moreover, the breakdown of welfare costs and benefits has been analysed by using geometrical tools of the partial equilibrium model with the simplest assumption of linearised supply and demand functions.

According to our findings, several propositions were laid out, where one-to-one causal connection can be carefully observed. Due to the nature of dead-weight loss creation, it is important to understand how the link with tariff rate change works when applied to a small country case. Tariff rate increases lead to the increase in dead-weight loss for the society, but with the square of a tariff rate, thus leading to income redistribution within a country. This also puts pressure on policy makers when deciding about potential trade policy tightening. Elasticities of supply and demand functions also matter significantly, where any increase in supply and/or demand elasticity leads to an increase in dead-weight loss. If the supply function is flatter, most of the burden of sub-optimal resource allocation will be passed onto producers. The same analogy applies to the demand side conditions. Although functions that depict changes in producers' and consumers' surplus possess strictly monotonic preferences, government revenues can be maximised with respect to changes in the tariff rate yielding unique maximum revenue tariff rate τ^* and optimal government revenues g^*. This enables the realisation of maximum budget revenues in the case of insufficient domestic funding, while simultaneously maintaining the social costs at the minimum level. Finally, autarchy conditions are scrutinised up to the point of determining the parametric condition that leads to no-trade equilibrium, i.e. the highest dead-weight losses for the country.

REFERENCES:

1. Clark, R. and Collie. D. R. (2006) "Optimum-Welfare and Maximum Revenue Tariffs under Bertrand Duopoly", *Scottish Journal of Political Economy 53 (3)*, pp. 398-408.
2. Fan, L. S. and Fan C. M. (2005) "On the Welfare Effect of an Equivalent Tariff and Quota", *Economic Issues 10 (1)*, pp. 1-8.
3. Harberger, A. (1971) "Three Basic Postulates for Applied Welfare Economics: An Interpretive Essay", *Journal of Economic Literature 9*, pp 785-97.
4. Johnson, Harry G. (1951) "Optimum welfare and maximum revenue tariffs", *Review of Economic Studies 19*, pp. 28-35.
5. Krugman, P. R and Obstfeld, M. (2009) *"International Economics Theory and Policy 8th Ed."*, Addison and Wesley.
6. Salvatore, D. (2007) *"International Economics 9th Ed."*, Wiley Publishing.

KOMPARATIVNO-STATIČKA ANALIZA CARINA U MODELU PARCIJALNE RAVNOTEŽE: SLUČAJ MALE ZEMLJE

***Hrvoje Jošić*[5] & *Mislav Jošić*[6]**

Sažetak

Prema standardnoj ekonomskoj teoriji uvođenje uvoznih carina u maloj zemlji uvijek vodi k suboptimalnoj alokaciji resursa i generira nepovratne troškove za društvo. Usprkos tome, države često uvode carinske mjere kako bi uravnotežile državni proračun ili uzvratile odmazdom protiv protekcionističkih mjera trgovinske politike njihovih vanjskotrgovinskih partnera. Ovaj rad daje uvid u mikroekonomske aspekte uvođenja carina analizirajući promjene u blagostanju potrošača, proizvođača i neto blagostanju društva. Dodatno, detaljna geometrijska i algebarska analiza provedene su kako bi se razjasnili uvjeti pod kojima uvođenje carina može biti probitačno za državu putem uvođenja maksimalne prihodne carine. Nadalje, prohibitivna carina i autarkična ravnoteža povezani s time bit će analizirani u detalje. Kako bi se procijenili učinci uvođenja uvozne carine korišten je model parcijalne ravnoteže s nekoliko propozicija formuliranih iz lineariziranog modela temeljenih na pretpostavci male zemlje. Konačno, propozicije će biti pomno promotrene s posebnim naglaskom na promjene u početnim uvjetima.

Ključne riječi: *trgovinska politika, gubitak mrtvog tereta, maksimalna prihodna carina, optimalna društvena carina, mala zemlja.*

JEL klasifikacija: F10, F13

[5] Dr. sc. Hrvoje Jošić, Postdoktorand, Ekonomski fakultet u Zagrebu, Sveučilište u Zagrebu, E-mail: hjosic@efzg.hr.

[6] Dr.sc. Mislav Jošić, Ekonomist istraživač, Hrvatska narodna banka, E-mail: mislav.josic@gmail.com. Stavovi iskazani u ovom radu i autorovo osobno mišljenje ne odražava nužno i stajalište institucije u kojoj je zaposlen.