Measuring efficiency in the Croatian customs service: a data envelopment analysis approach

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Abstract

The concept of efficiency in the public services is more complex than the concept of efficiency in the private, profit-oriented sector. Consequently, the measurement of efficiency in the public services is very complex and implies more effort in the identification of relevant outputs and inputs. One of the segments of the public service system in the Republic of Croatia is the Customs Administration, which is an important regulator of Croatian international trade and freight traffic, and also a significant tax authority. This research is focused on determining the relative efficiency of regional organizational units of the Customs Administration on the basis of its most relevant inputs and outputs. Conclusions were made by the processing of data obtained directly from the Customs Administration by using the method of data envelopment analysis. The results obtained, in the end, indicate the need to establish new and different territorial organizational structure for the Customs Administration.

Keywords: efficiency, public services, customs service, inputs, outputs, data envelopment analysis, Croatia

1 INTRODUCTION

Organizational design is aimed to contribute to the efficient fulfilment of organizational goals. Thus, efficiency means "doing things right", and it is an essential factor for the existence and success of the organisation (Hodge, Anthony and Gales, 2003). However, although the importance of efficiency is recognized, its measurement in public organizations is more complex than in the private sector. In economics, there are two definitions of efficiency (Flynn, 1997):

– *Productive efficiency* is measured by the average cost of producing goods and services.
– *Allocative efficiency* is measured by the extent to which the economic system produces that mix of goods and services that reflects people's preferences as expressed by their consumption decisions.

Productive efficiency means the organizational ability to achieve maximum output with a given quantity of input. Whereas in the private sector inputs and outputs are expressed in financial terms, identification of inputs, and, especially, outputs in the public sector is much more complex.

In many cases in the public sector, *effectiveness*, which can be defined *as capacity to achieve goals*, gains a greater importance than efficiency (Pusić, 1999). Economic actors seek to structure their relationships – their firms – as efficiently as possible, and the economic system as a whole operates to weed out those that fail. Political actors, on the other hand, are typically not concerned with efficiency in the usual economic sense, and the political system clearly does not weed out the inefficient (Williamson et al., 1995). The political system is oriented primarily to the achievement of goals defined in the political process, regardless of the cost-benefit ratio.

In the public services there is no direct correlation between revenues and expenses (Von Mises, 2005). Public services spend financial resources, collected mainly in the taxation process. In the other hand, tax and customs revenues are not "products" of the administration, because their source is in legislation, not in tax and customs administration activities.

The assessment of the performance of the public sector has long been a topic of interest to economists, public administration scholars and management scientists (Fox, 2002). It is partly motivated by the challenge of agreeing on an appropriate definition of performance in the public sector. Furthermore, it partly derives from the proclaimed consequences of the different competitive conditions, objectives and constraints facing public sector managers and specific ownership structures in the public sector. At the end, even when agreement on how to specify the services being provided is reached, the services are frequently unpriced, and conventional measuring techniques do not provide opportunities to evaluate the effectiveness.

Different approaches concerning data and methodological framework have been used for measuring efficiency (Mandl, Dearx and Ilzkovitz, 2008). Recently, an approach based on the concept of *efficiency frontier* has been applied. This approach could be implemented by applying multiple methods. The first of these methods is *parametric*, the frontier functions of which require the *ex-ante* definition of the functional form of efficient frontier. On the other hand, *non-parametric* methods construct an efficiency frontier using input/output data for the whole sample following a mathematical programming method.

A number of international researches have been conducted dealing with the assessment of the productivity or efficiency of the public sector (Boyle, 2006). Some of the studies have examined the productivity of government and compared the productivity of whole public sectors of different countries. In one such study Afonso, Schuknecht and Tanzi (2003) have carried out an international comparison of public sector efficiency based on the public sector performance (PSP) and efficiency (PSE) indicators. These indicators comprise a composite and seven sub-indicators. Four of them are "opportunity" sub-indicators that take into account administrative, education and health outcomes and the quality of public infrastructure and those that support the rule of law and a level playing-field in a market economy. Three other indicators reflect the standard "Musgravian" tasks for government: allocation, distribution and stabilization. After defining indicators, the efficiency is measured via the non-parametric frontier technique.

Other studies focus on sectors and may be country-based or oriented to an international sectoral comparison. Aristovnik (2009) compared the public spending efficiency in health care and education in the new EU member states and Croatia by applying and comparing the results of two non-parametric methods. These two sectors are often the object of research aimed at determining efficiency in the pu-

blic sector. In addition, in the literature there are a number of investigations into local government efficiency and the efficiency of other segments of the public sector, such as infrastructure, security or social care.

On the other hand, at the micro level, productivity measurement in the public sector can also take place at the level of the organization and from a "bottom up'' or service-user perspective (Boyle, 2007). The World Bank has adopted this approach with regard to assessing some aspects of the effects of regulation with the development of their Doing Business database, where three indicators from the database are particularly relevant to the assessment of public administration quality and productivity. These indicators are: (1) taxes that companies must pay in a given year, and the administrative burden associated with paying taxes; (2) procedures required for business in the construction industry to build a standardised warehouse; and (3) the steps that an entrepreneur must take to incorporate and register a new firm.

Customs services have developed their own systems to measure efficiency. The European Commission has established its Measurement of Results (MoR) project for the customs services of member states. Work on measuring the results of customs activities performed by member states is underway and the results achieved enable member states to compare their performance to the Community standard and act to improved customs operations where necessary. However, no model has yet been presented to enable a comprehensive assessment of efficiency in customs services, either in Croatia or at the international level.

This paper is concentrated on research into the relative efficiency of the Croatian Customs Service's organizational units. For this purpose, dimensions of customs service efficiency, and relevant inputs and outputs were identified. Data have been collected directly in the Croatian Customs Service, and Data Envelopment Analysis is used for the purpose of data processing and quantifying relative efficiency.

2 DIMENSIONS OF CUSTOMS SERVICES' EFFICIENCY

Radical changes within international relations and economy, new scientific and technological developments and the strengthening of civil society, have irretrievably changed the relations between society and public services, and responsibility criteria in public sector. Dynamic organizational environment and pressures on public spending have increased the sensitivity of the public services to achieving effectiveness and efficiency, with a permanent commitment to serving the public interests and respect for democratic norms achieved.

In such conditions customs administrations, being relevant regulatory operators in international trade and goods movements, accept more important and complex tasks. To begin with, customs administrations are expected to facilitate and accelerate international trade and transport. Furthermore, they are expected to manage

and control supply chains and protect the economy and society. Such tasks and recent processes of the world business system demand additional elasticity and flexibility of customs administrations' organizational structures, while quality planned and implemented organizanional changes are becoming one of the basic factors of their long-term success. Due to the need for harmonization with the European customs and excise system and trends in international trade and transport, the Croatian customs service is now one of the first public administrative organizations in Croatia to have implemented significant organizational changes.

Customs services' roles are changing in a global, changing world, but there is wide agreement about their main tasks. Thus, modern customs services are expected to increase public revenues, provide domestic producers with protection, provide supply-chain security, prevent the importation of prohibited or unsafe imports and combat the trade of narcotics through implementation of laws that are in line with World Trade Organization commitments (De Wulf et al., 2005). According to the missions of modern customs services, it is possible to determine their main tasks as follows: *protection* of national and/or European *financial interests*, *protection and advancement of international trade*, *protection of society* on national and international levels.

The mission of the Croatian customs service (Carinska uprava, 2010) is harmonized with these goals, and includes *collecting public revenues by creating efficient and economic customs procedures, the strengthening of customs controls and protecting the interests of the Republic of Croatia and its citizens*.

From the main functions of the customs service derive relevant outputs, which must be known for measuring efficiency. On the other hand, according to the definition of efficiency as *output-to-input ratio*, it is important to determine the main inputs of the customs service.

2.1 PROTECTION OF FINANCIAL INTERESTS

One of the most important functions of the modern customs service is *taxation*, i.e. the protection of financial interests. Although customs revenues are decreasing due to the liberalization of international trade and reduction of tariffs, customs services still retain an important role in financing public needs. Therefore, measuring revenue leakages gives information to customs services about effectiveness and efficiency in collecting taxes. The core indicators used to identify slack in revenue generation include:

– collected taxes on imports compared with potential revenue collection to identify the "gap",
– share of total imports exempted from taxes,
– fraud in recording valuation, weight or rules of origin.

Customs duties and taxes are obligations prescribed by legislation, and represent a relevant imposition to obligors. That is the reason that some private sector organizations permanently search for new forms to reduce or evade tax obligations. The most important categories of customs duty evasion during the import of goods are (Đurđević, 2006):

– *smuggling of goods over borders* – the most common form of customs duty evasion, which means taking a certain kind of commodity without declaring it to the competent customs service,
– *fraudulent declaration of information relevant to customs* – given that the amounts of customs duties that importers have to pay depend on a great many features of goods, such as kind, quality, quantity, country of origin, value, etc., this is the basis for manipulation by reporting false information.

By administrative capacity development, a customs service reduces the risk of customs and tax evasion. Conversely, by implementation and enforcement of customs and tax legislation, a customs service creates the conditions for the operations of public administration as a whole and the realization of projects that are financed from state budget.

Customs and taxation procedures impose particular expenses on the tax payers. These expenses are called *costs of customs clearance and taxation*, which consist of (Bratić, 2004):

– *administrative costs of customs clearance and taxation* – costs of customs administration arising from the tax and customs legislation implementation and enforcement,
– *compliance costs* – costs of tax payers that arise from customs and tax compliance, i.e. costs incurred by procedures and a customs administration's demands.

Administrative costs are measured as a share in total revenues, or share in GDP, and largely depend on the efficiency of the customs service. On the other hand, compliance costs cannot be precisely measured, and they are subject to estimation.

Costs of customs clearance and taxation have a negative impact on international trade intensity, which could slacken the economic growth of a particular country (Verwaal and Donkers, 2001). Partly, customs service could make an impact on those costs by simplifications and using electronic customs procedures.

The Croatian customs service collects three main categories of public revenues: (1) customs duties, (2) excises, and (3) value added tax imposed on imported goods. The total share of public duties levied by the Croatian customs service is over 30%. That indicates the great importance of the customs service in protecting the financial interests of the Republic of Croatia.

2.2 PROTECTION AND IMPROVEMENT OF INTERNATIONAL TRADE

Participation in international trade has become one of the key factors in the international competitiveness of nations. Conditions in the business environment in past decades have changed under the influence of (OECD, 2003):

- *relevant growth of trade volume* – as the result of elimination of tariffs and other barriers to trade, i.e. consequence of trade liberalization,
- *growth of trade complexity* – under the influence of globalization, many different countries organize production of commodities, and many of them have concluded treaties that regulate international trade flows,
- *increased speed of trade* – information technology and technological development in general allow the application of "just in time" production, which requires fast and seamless cross-border movement of goods.

Such conditions set up new challenges and demands on the customs services. They are responsible for effective and efficient border management to facilitate trade, and thus become major contributors to the international competitiveness of nations (De Wulf et al., 2005). Customs services should not be a "brake", but their own organizational structures have to respond to the challenges. As a result of their activities stakeholders expect safer, more reliable and faster progress of international trade, together with reduced transactional costs for the business community. In other words, customs services have to *protect and improve international trade,* which includes: international trade managing, facilitating, and monitoring.

International trade managing implies adjustment and processing of prescribed customs procedures relating to commodities that are objects of cross-border traffic, considering their categories, kinds, qualities, quantities, values, purposes, and other relevant features. That also includes cooperation between customs services and the trading community, i.e. implies consultations regarding treatment of commodities and efficient processing of customs procedures. A customs service is a "partner to the economy" and it could often lead companies to recognize where their weak points are, where the chains of communication are interrupted and how customs procedures can be simplified and accelerated and thus made even more cost-effective (Federal Ministry of Finance, 2002).

International trade facilitating is one of the topics on which the World Trade Organization and World Customs Organization put a great deal of emphasis. The term "trade facilitation" is defined by WCO as *the simplification and harmonization of international trade procedures*, where procedures are *the activities, practices and formalities involved in collecting, presenting, communicating and processing data required for the movement of goods in international trade* (Grainger, 2004). This implies adapting processes and procedures to the requirements of international trade, reducing the number of physical controls of shipments, simplification and acceleration of customs procedures. In order to protect and improve

international trade the International Convention on the simplification and harmonization of Customs procedures was adopted. It established principles for simplification and harmonization of customs procedures in order to develop international trade and exchange and support international cooperation. The Convention aims to:

– eliminate the divergence between the customs procedures and practices of contracting parties that can hamper international trade and other international exchanges,
– meet the needs of international trade and the customs for facilitation, simplification and harmonization of customs procedures and practices,
– ensure appropriate standards of customs control,
– enable the customs services to respond to major changes in business and administrative methods and techniques.

Trade facilitation is an important issue in both emerging and developed economies as it can contribute to export growth, improve the competitiveness of a country's goods and services in the global market, attract foreign direct investment and increase the participation of small and medium size enterprises in international trade (United Nations, 2002).

In a dynamic economy, the *time* needed for foreign trade transactions greatly affects the competitiveness of companies. Therefore, customs services strive to shorten the time of customs procedures in order to reduce transactional costs. Contemporary business conditions require the development of simpler procedures that reduce time and efforts to file the customs declarations. One of the effective responses is the implementation of procedures at the final destination of commodities or at the recipient's place of business. In addition, customs services perform external audits, which enable some controls, once conducted at the customs offices, to be processed when commodities are already cleared.

Information technologies and modern monitoring devices enable simplification and acceleration of customs procedures. They allow the speeding up of physical controls and faster data exchange between customs and other participants in international trade.

International trade is conducted according to certain rules that are imposed by national and international regulations. However, some participants do not respect the mentioned rules, and thus unfairly achieve more favourable positions in the international market. To prevent this, modern customs services monitor international trade. Thus, they inhibit and prevent illegal conduct and the avoidance of the obligations prescribed by various regulations. There is an evident growth of opportunities for illegal conduct caused by the increased volume, speed and complexity of international trade. Therefore, customs services have to improve their

monitoring methods and techniques, in order to protect and advance international trade.

2.3 PROTECTION OF SOCIETY

In contrast to the pursuit of facilitating and accelerating international trade, customs services decide if goods may be imported, exported, or passed through certain countries in transit on the basis on the national and international regulations. Even in times of extensive foreign trade liberalization, restrictions are necessary for, inter alia, protecting security interests. So, in addition to the acceleration of customs procedures, modern customs services at the same time prohibit, or stop the entry of certain commodities. They also carry out a "stop function" when goods are exported that may not be exported to certain countries, such as countries that are at war, or countries against which international sanctions have been taken.

Public health and safety have become fundamental issues in every country. Considering the position of the customs services, through their presence at frontiers and the control of movement of goods, they represent the first line of defense against organized crime and other forms of threats to the society. The safety of society can be increased if potential threats are identified as early as at the border-crossing stage (Norwegian Customs and Excise, 2005). Customs services have built up a unique body of knowledge concerning international trade and commerce. They have the competence, methods and access to information that can contribute to reducing the risk connected with crossing of frontiers. Thus, protection of society is carried out by:

- combating every form of smuggling, especially smuggling of drugs, explosive substances and endangered plant and animal species,
- surveillance of the movement of harmful and toxic waste,
- surveillance of the traffic in strategic civil and military products, radioactive materials and the cultural heritage,
- performing surveillance and protection of seas,
- supporting the combat against illegal migration and unlawful employment.

Customs services' activities, inter alia, enforce legislation related to the quality of life such as the fields of health care and the environment. In addition, greater emphasis is placed on the goods and substances that can be used for terrorist purposes.

Effective controls prevent the entry of goods that do not meet quality standards for the market of certain country. Thereby, consumers are protected against consuming low quality commodities. On the other hand, producers are protected of unfair competition. Customs services are also involved in combating counterfeited products trafficking (Federal Ministry of Finance, 2002). In cooperation with trademark owners, the customs services confiscate and destroy counterfeited pro-

ducts. Thus, customs services protect consumers from inferior quality products that could endanger human health, while at the same time protecting the economy from financial damage.

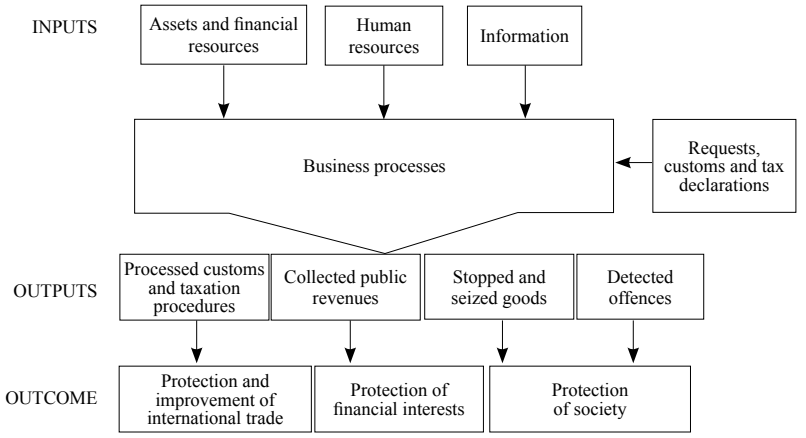
By the implementation of various international conventions considering public health, environment and quality of life, customs services obtain not only national, but international and even global dimensions. Thus, they must have the administrative capacity to identify shipments that contain certain prohibited goods or products that could endanger human safety.

2.4 INPUTS AND OUTPUTS OF THE CUSTOMS SERVICES

From the functions described it is possible to recognize the social purpose of the customs services. In other words, by meeting the main functions, customs services achieve their *outcome* that represents an *impact on society of a particular public sector activity* (Smith, 1996). Thus, outcome is different from the *output* which indicates *quantity of the good or service provided*, without reference to its broader social impact. While outcome measurement is closely tied up with the concept of effectiveness, measuring outputs refers to efficiency.

Customs service use inputs similar to those of other organizations. In general, human and financial resources, assets and information can be highlighted. By business processes it transforms various types of requests and customs and tax declarations submitted by different persons and entities into specific outputs. These are processed tax and customs procedures, collected public revenues, detected offences, seized and stopped goods, as shown in figure 1.

FIGURE 1
Model of efficiency of customs service



Source: Author.

Human resources are the basis for building strategy of organization, and all other resources arise from their activities (Marušić, 2001). Their skills, capabilities, quality and ethics are among the most important determinants of organizational efficiency, including customs services. In other words, human resources are the basis of the administrative capacity of every customs system, and they are the most important and unavoidable factor that affect all aspects of customs service's organization.

Financial resources are needed to achieve the preconditions for the purchase of necessary assets and other material resources and the recruitment of human resources in customs service. In Croatia, financial resources for the customs service are provided by the state budget.

Assets and material resources are constituted by different kinds of buildings and equipment such as information technology and office equipment, vehicles, vessels, aircrafts, detection equipment, etc. that customs officers use for the fulfilment of their tasks. The most important detection devices are x-ray scanners, particle detection instruments, densimeters, radioactive material detection instruments, endoscopes, etc. These detection devices are a great support to customs officers in performing their controls.

In the knowledge society *information* is a very important input. The basis on which to obtain quality information is a quality information system capable of collecting and processing large amount of data in order to select those that are important for the direction of the customs service's resources.

Figure 1 shows that the customs service has got more relevant outputs, and for the purposes of this research were selected as follows: processed customs and tax declarations, collected public revenues, value of stopped and seized goods, and detected offences according to the law.

Processed customs and tax declarations are a direct indicator of executed procedures, regardless of the value of a foreign trade transaction. It is simple and reliable indicator of customs service's load and capacity, because every submitted declaration requires the implementation of a certain procedure, regardless of the value, category and quantity of goods that are the object of procedure.[1]

Nominal amount of collected revenues indicates how much and what form of public revenues a certain customs service has collected during a defined period. This is one of the main indicators of a customs service's performance, which is pointed out by almost every customs service. It indicates a customs service's administra-

[1] Certainly, in the cases of *risky shipments* that are selected in risk management process, levels and methods of control may vary, i.e. such declarations need to be checked more. That implies that the customs service has to employ more resources in processing such declarations.

tive capacity to collect public revenues, and implies its importance for state budget.

Value of stopped and seized goods is an indicator of a customs service's capacity for the recognition of dangerous goods, endangered species or goods that may be used for purposes that harm society. The capacity to detect prohibited or restricted goods is one of the most important issues of customs service performance.

Customs service enforces national and international legislation. The main legal fields in which customs service has got a great role are customs legislation, taxation, trade regulation, money laundering and legislation that regulates specific issues of safety. In the present conditions, many subjects in the customs procedure, in order to achieve advantages, take some actions that do not comply with the legislation. Furthermore, some subjects or organizations are always engaged in criminal activities. Therefore, the ability to detect irregularities in customs procedures ensures that all functions of customs service are accomplished. Thus, the *number of detected offences* is a comprehensive indicator related to all the previously described functions of a customs service.

3 DEFINITION OF EFFICIENCY: A DATA ENVELOPMENT ANALYSIS APPROACH

Data envelopment analysis (DEA) so named because it "envelops" observations in order to identify a "frontier" that is used to evaluate observations representing the performances of all of the entities that are to be evaluated (Cooper, Seiford and Tone, 2006).

In case of one input and one output, efficiency could be mathematically displayed as *output-to-input ratio*. This ratio is adequate for organizations the efficiency of which depends solely on quantitative indicators. However, public services deal with more than one input and output, and such a ratio is not appropriate.

Uses of data envelopment analysis have involved a wide range of different kinds of entities that include not only business firms but also government and non-profit agencies. The starting point of DEA is the general definition of efficiency called "Pareto optimality" which is as follows: *Pareto optimum is a welfare maximum defined as a position from which it is impossible to improve anyone's welfare by altering production or exchange without impairing someone else's welfare.* Thus, efficiency of a decision making unit (DMU) in DEA is as follows: *the performance of a DMU is efficient if and only if it is not possible to improve any input or output without worsening any other input and output*.

DEA defines the ratio between all weighted relevant outputs and inputs, so it could be presented by following equation (Šegota, 2003):

$$efficiency = \frac{\sum_{r=1}^{s} u_r y_r}{\sum_{i=1}^{m} v_i x_i}$$

where:

y_r – *amount of output r,* x_i – *amount of input i,*
u_r – *weight assigned to output r,* v_i – *weight assigned to input i,*
s – *total number of output r,* m – *total number of input i.*

Weighted output-to-input ratios of similar DMUs are mutually compared based on of equivalent inputs and outputs. In such way, it is possible to perceive the extent to which one DMU is close to the achievement of its production possibilities, i.e. to obtain information if particular a DMU is efficient when it is compared with similar DMUs.

This non-parametric methodology, as application of linear programming, combines information about relevant organizational inputs and outputs and forms a simple measure of efficiency without prior identification of input and output weights.

4 DATA ENVELOPMENT ANALYSIS MODELS

Data envelopment analysis was initially introduced by Charnes, Cooper and Rhodes in 1978. They proposed the basic DEA model, which was named the CCR model. Since the very beginning of DEA studies, various extensions of the CCR model have been proposed. Some representative extensions of he CCR model are the BCC (Banker-Charnes-Cooper) model, the "Additive model", models with restricted multipliers, etc.

Besides, many DEA models could be input and output oriented. The objective of *input-oriented* models is to minimize inputs while producing at least the given output levels. On the other hand, *output-oriented* models attempt to maximize outputs while using no more than the observed amount of any input. This paper will consider CCR, BCC and NCN input-oriented models.

4.1 CCR MODEL

CCR model represents the measure of efficiency which is obtained as the *maximum of weighted outputs-to-weighted inputs ratio*. To obtain values for the input weights v_i and output weights u_r as variables, the following fractional programming problem needs to be solved (Cooper, Seiford and Tone, 2006):

$$(FP_0)\ max\ \theta = \frac{u_1 y_{10} + u_2 y_{20} + \ldots + u_s y_{s0}}{v_1 x_{10} + v_2 x_{20} + \ldots + v_m x_{m0}} \qquad (1)$$

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subject to:
$$\frac{u_1 y_{1j} + u_2 y_{2j} + \ldots + u_s y_{sj}}{v_1 x_{1j} + v_2 x_{2j} + \ldots + v_m x_{mj}} \leq 1 \quad (j = 1,\ldots,n) \tag{2}$$
$$v_1, v_2, \ldots v_m \geq 0 \tag{3}$$
$$u_1, u_2, \ldots u_s \geq 0 \tag{4}$$

where:
n – total number of DMUs,
m – equivalent inputs,
s – equivalent outputs.
(v_i) $(i = 1,\ldots, m)$ – input weights,
(u_r) $(r = 1,\ldots, s)$ – output weights,

The constraints mean that the ratio of "virtual output" vs. "virtual input" should not exceed 1 for every DMU. The objective is to obtain weights u_r *and* v_i that maximize the ratio of DMU_0 of the DMU being evaluated. By virtue of the constraints, the optimal objective value θ^* is at most 1. This is based on the assumption that DMU is inefficient if it cannot be efficient in spite its own choice. On the other hand, if optimal value $\theta^* = \max \theta = 1$, the DMU is efficient.

Optimal value θ^* does not depend on the units of measurement of the DMU's inputs and outputs if these units are the same for all DMUs (Neralić, 1992).

Presented fractional program (FP_0) could be replaced by the following linear program (LP_0):

$$(LP_0)\ max\ \theta = \mu_1 y_{10} + \ldots + \mu_s y_{s0} \tag{5}$$

subject to:
$$v_1 x_{10} + \ldots + v_m x_{m0} = 1 \tag{6}$$
$$\mu_1 y_{1j} + \ldots + \mu_s y_{sj} \leq v_1 x_{1j} + \ldots + v_m x_{mj} \quad (j = 1, \ldots, n) \tag{7}$$
$$v_1, v_2, \ldots, v_m \geq 0 \tag{8}$$
$$\mu_1, \mu_2, \ldots, \mu_s \geq 0 \tag{9}$$

DMU_0 is CCR-efficient if $\theta^* = 1$ and here there exists at least one optimal (v^*, u^*) with v^* i u^* greater than zero. Otherwise, DMU_0 is CCR-inefficient. CCR-inefficiency means that $\theta^* < 1$ or $\theta^* = 1$ and at least one element of (v^*, u^*) is zero for every optimal solution of (LP_0).

When DMU_0 has $\theta^* < 1$, then there must be at least one constraint or DMU in (7) for which the weight (v^*, u^*) produces equality between the left and right sides since otherwise θ^* could be enlarged.

Based on the information about DMUs' performances, DEA forms *the efficient frontier*. CCR-efficient DMUs lie on the efficient frontier, and they compose the *reference set* or *peer group* to the inefficient DMUs. The set of such $j \in \{1,\ldots,n\}$, is

$$E_0^{'} = \left\{ j : \sum_{r=1}^{s} u_r^* y_{rj} = \sum_{i=1}^{m} v_i^* x_{ij} \right\} \tag{10}$$

The subset E_0 of $E_0^{'}$, represents *reference set*, and the set spanned by E_0 is the *efficient frontier*. At the same time, (v^*, u^*) obtained as an optimal solution for (LP_0) results in a set of optimal weights for the DMU_0. The ratio scale is evaluated by:

$$\theta^* = \frac{\sum_{r=1}^{s} u_r^* y_{r0}}{\sum_{i=1}^{m} v_i^* x_{i0}} \tag{11}$$

From (5), the denominator in (11) is 1 and hence

$$\theta^* = \sum_{r=1}^{s} u_r^* y_{r0} \tag{12}$$

Variable v_i^* is the optimal weight for the input unit *i,* and variable u_r^* is the optimal weight for the output unit *r*. These variables determine the relative contribution of x_{i0}, and y_{r0} to overall value of θ^*.

Assuming *semipositivity* (Cooper, Seiford and Tone, 2006), arranging the data sets in matrices $X = (x_j)$ and $Y = (y_j)$ *production possibility set P* could be defined by

$$P = \{(x, y) | x \geq X\lambda, y \leq Y\lambda, \lambda \geq 0\}, \tag{13}$$

where λ is the semipositive vector in R^n.

CCR model could be expressed in vector-matrix notation by the following linear program:

$$(LP_0) \quad \max_{v,u} uy_0 \tag{14}$$

subject to

$$vx_0 = 1 \tag{15}$$
$$-vX + uY \leq 0 \tag{16}$$
$$v \geq 0, u \geq 0 \tag{17}$$

The corresponding dual program (DLP_0) is

$$(DLP_0) \quad \min_{\theta,\lambda} \theta \tag{18}$$

subject to

$$\theta x_0 - X\lambda \geq 0 \tag{19}$$
$$X\lambda \geq y_0 \tag{20}$$
$$\lambda \geq 0 \tag{21}$$

Dual linear program (DLP_0) has a feasible solution $\theta = 1$, $\lambda_0 = 1$, $\lambda_j = 0$ ($j \neq 0$). Optimal value θ, denoted by θ^*, is not greater than 1. Due to the semipositive assumption for the data, the constraint (20), forces λ to be non-zero, and from constraint (19) θ must be greater than zero. Hence, $0 < \theta^* \leq 1$.

To define *input excesses* $s^- \in R^m$ and output shortfalls $s^+ \in R^s$, and identify them as "slack" vectors the following need to be solved

$$s^- = \theta x_0 - X\lambda \tag{22}$$

$$s^+ = Y\lambda - y_0 \tag{23}$$

with $s^- \geq 0$, $s^+ \geq 0$ for any feasible solution (θ, λ) of dual linear program (DLP_0).

To discover possible input excesses and output shortfalls, the following two-phase LP problem needs to be solved. In a *first phase,* a dual linear program needs to be solved. If objective value is θ^*, by the duality theorem of linear programming, it is equal to the optimal objective value of linear program (LP_0) and is the CCR-efficiency value. In a *second phase*, knowing optimal values of θ^*, it is possible to solve the following linear program (λ, s^-, s^+) as variables:

$$\max_{\lambda, s^-, s^+} axo = es^- + es^+ \tag{24}$$

subject to

$$s^- = \theta x_0 - X\lambda \tag{25}$$

$$s^+ = Y\lambda - y_0 \tag{26}$$

$$\lambda \geq 0,\ s^- \geq 0,\ s^+ \geq 0$$

where $e = (1,...,1)$ a vector of ones, so that $es^- = \sum_{i=1}^{m} s_i^-$ and $es^+ = \sum_{r=1}^{s} s_r^+$.

The second phase finds a solution that maximizes the sum of input excesses and output shortfalls while keeping $\theta = \theta^*$. Objective term in (24) could be replaced with any weighted sum of input excesses and output shortfalls such as:

$$\omega = \omega_x s^- + \omega_y s^+ \tag{27}$$

where the weights ω_x and ω_y are positive row vectors. This may result in different optimal solution for the second phase, and the objective term in (24) will identify some nonzero slacks with inefficiency, if and only if a nonzero value is obtained when the objective in (24) is replaced with (27). If an optimal solution (θ^*, λ^*, s^{-*}, s^{+*}) of the two linear programs satisfies $\theta^* = 1$ and is zero-slack, then the DMU_0 is called CCR-efficient. Otherwise, DMU_0 is called CCR-inefficient.

For an inefficient DMU_0 will be defined its reference set E_0 based on the max-slack solution as obtained in two-phase linear program by

$$E_0 = \{j|\lambda_j^* > 0\}\ (j \in \{1,...,n\}) \tag{28}$$

An optimal solution can be expressed as:

$$\theta^* x_0 = \sum x_j \lambda_j^* + s^{-*} \tag{29}$$

$$y_0 = \sum_{j \in E_0} y_j \lambda_j^* - s^{+*} \tag{30}$$

where $j \in E_0$ means the index j is included in the set E_0. This can be interpreted as follows:

$$x_0 \geq \theta^* x_0 - s^{-*} = \sum_{j \in E_0} x_j \lambda_j^* \tag{31}$$

$$y_0 \leq y_0 + s^{+*} = \sum_{j \in E_0} y_j \lambda_j^* \tag{32}$$

The gross input improvement Δx_0 and output improvement Δy_0 can be calculated from:

$$\Delta x_0 = x_0 - (\theta^* x_0 - s^{-*}) = (1 - \theta^*)\, x_0 + s^{-*} \tag{33}$$

$$\Delta y_0 = s^{+*} \tag{34}$$

Finally, the *CCR-projection* that represents the formula for input and output improvement, can be expressed by:

$$\hat{x}_0 = x_0 - \Delta x_0 = \theta^* x_0 - s^{-*} \leq x_0 \tag{35}$$

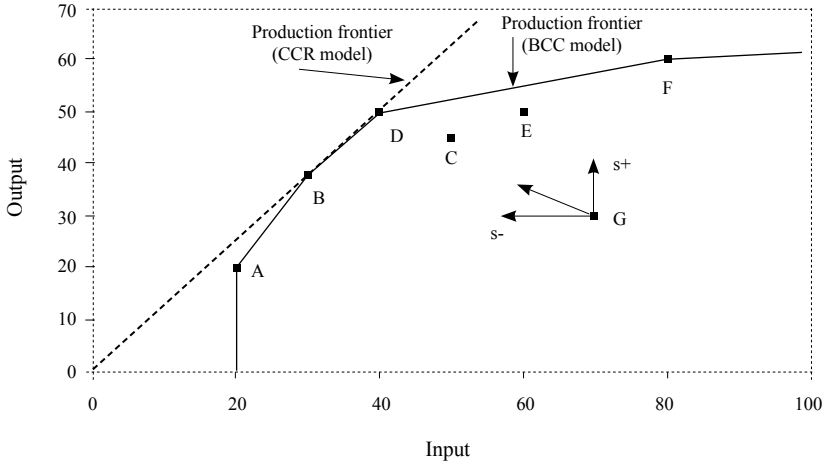
$$\hat{y}_0 = y_0 - \Delta y_0 = y_0 + s^{+*} \leq y_0 \tag{36}$$

Improved activity $(\hat{x}_0, \hat{y}_0)$ projects analyzed DMU_0 in reference set E_0 and every nonnegative combination in set E_0 is efficient.

4.2 BCC MODEL

The CCR model is based on the assumption of constant returns to a scale of activities. Banker, Charnes and Cooper modified the CCR model by adding a constraint for the calculation of the variable returns-to-scale. The new model is called the BCC model. The main differences between two models are presented in figure 2.

FIGURE 2
Differences between CCR and BCC models



Source: Cooper, Seiford and Tone (2006).

Banker, Charnes and Cooper defined the production possibility set P_B by:

$$P_B = \{(x, y) | x \geq X\lambda, y \leq Y\lambda, e\lambda = 1, \lambda \geq 0\} \tag{37}$$

where $X = (x_j) \in R^{m \times n}$ and $Y = (y_j) \in R^{s \times n}$ are a given data set, $\lambda \in R^n$ and e is row vector with all elements equal to 1. The BCC model differs from the CCR model only in adjunction of the condition $e\lambda = \sum_{j=1}^{n} \lambda_j = 1$. Together with the condition $\lambda j \geq 0$, for all j, this imposes a convexity condition on allowable ways in which the observations for the n DMUs may be combined.

The input-oriented BCC model evaluates the efficiency of DMUs by solving the following linear program:

$$(BCC_0) \min_{\theta_B, \lambda} \theta_B \tag{38}$$

subject to

$$\theta_B x_0 - X\lambda \geq 0 \tag{39}$$
$$Y\lambda \geq y_0 \tag{40}$$
$$e\lambda = 1 \tag{41}$$
$$\lambda \geq 0 \tag{42}$$

where θ_B is a scalar.

Corresponding dual program of this linear program (BCC_0) is:

$$\max_{v,u,u_o} z = uy_o - u_o \tag{43}$$

subject to

$$vx_0 = 1 \quad (44)$$

$$-vX + uY - u_0 e \leq 0 \quad (45)$$

$$v \geq 0,\ u \geq 0 \quad (46)$$

In previous program, scalars z i u_0 may be positive, negative or zero, and u_0 is a dual variable associated with constraint $e\lambda = 1$, which represents a variable that does not appear in the CCR model.

The primal program (BCC_0) is solved in *two-phase procedure*. In the first phase, θ_B is minimized, and, in the second, the sum of the input excesses and output shortfalls is maximized, keeping $\theta_B = \theta_B^*$.

DMU is *BCC-efficient* if optimal solution (θ_B^*, λ^*, s^{-*}, s^{+*}) for (BCC_0) satisfies $\theta_B^* = 1$ and has no slack ($s^{-*} = 0$, $s^{+*} = 0$). Otherwise, it is *BCC-inefficient*.

For a *BCC-inefficient* DMU it is possible to define *reference set* E_0 based on the optimal solution λ^* by:

$$E_0 = \{ j \mid \lambda_j^* > 0 \}\ (j \in \{1,...,n\}) \quad (47)$$

If there are multiple optimal solutions, it is possible to choose any one to find that:

$$\theta_B^* x_o = \sum_{j \in E_o} \lambda_j^* x_j + s^{-*} \quad (48)$$

$$y_o = \sum_{j \in E_o} \lambda_j^* y_j - s^{+*} \quad (49)$$

Thus, formula for improvement via *BCC-projection* is expressed as follows:

$$\hat{x}_o \Leftarrow \theta_B^* x_o - s^{-*} \quad (50)$$

$$\hat{y}_o \Leftarrow y_o + s^{+*} \quad (51)$$

This results in improved activity ($\hat{x}_0, \hat{y}_0$) which is *BCC-efficient*.

4.3 BON-CONTROLLABLE VARIABLE (NCN) MODEL

CCR and BCC are basic DEA models and after the initial applications, models have been extended and adjusted to specific situations. Thus, new models were defined with characteristics customized to satisfy specific research needs.

CCR and BCC models are based on the assumption that all inputs and outputs can be varied at the discretion of DMU management. However, in certain cases there may exist "non-discretionary variables", that are not subject to management con-

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trol, but also need to be considered. There are a few approaches to the problem of non-discretionary, or non-controllable variables. For purpose of this research, one approach will be presented. That is the *NCN model*, which can be expressed as follows:

$$(NCN) \quad \min_{\theta,\lambda} \theta \tag{52}$$

subject to

$$\theta x_o^C \geq X^C \lambda$$
$$y_o^C \leq Y^C \lambda$$
$$x_o^N = X^N \lambda \tag{53}$$
$$y_o^N = Y^N \lambda \tag{54}$$
$$L \leq e\lambda \leq U$$
$$\lambda \geq 0.$$

In this model a matrix-vector formulation is used in which X^C and Y^C refer to matrices of "controllable" variables and x_o^C, y_o^C refer to the corresponding vectors of observed values for the DMU_0 being evaluated. On the other hand, matrices X^N and Y^N refer to data on the non-controllable variables that are to be evaluated relative to the vectors x_o^N, y_o^N for the same DMU. The last constraint imposes an upper bound U, and a lower bound L, on the variable choices with $e\lambda = \sum_{j=1}^{n} \lambda_j$.

The NCN model represents an extension of CCR and BCC models and it evaluates relative efficiency including one or more non-controllable variables. Under the influence of constraint (53), CCR and BCC scores can be different than NCN scores for the same data. Hence, production possibility sets may be modified, too. Finally, the NCN-projection of non-controllable variable is the same as the original data.

5 THE ASSESSMENT OF A RELATIVE EFFICIENCY OF CROATIAN CUSTOMS SERVICE'S ORGANIZATIONAL UNITS

The organizational structure of the Customs Administration of the Republic of Croatia is based on a territorial division. There are 17 regional organizational units, i.e. customs houses. In this study DMUs are customs houses. They are established in the economic and transport hubs considering the scope, structure and flow of goods, and other economic interests. All customs houses have the same administrative powers, duties and tasks related to the implementation of customs procedures and taxation within their territorial jurisdiction.

5.1 CHOICE OF DEA MODEL, THE SELECTION OF INPUT AND OUTPUT AND EFFICIENCY ASSESSMENT

As can be seen before, the Customs Administration has several inputs and outputs which increases the complexity of assessing its effectiveness. No evident priority can be assigned to any output of the customs service. The reason is that all functions of customs service are very important and the ranking of outputs is not rational.

When creating the model for the assessment of efficiency using DEA methodology, it is necessary to take into account several elements. In this study, these elements are the orientation of the model, differences in returns-to-scale that DEA models assume and the number of analysed inputs and outputs. Anyway, in order to obtain reliable results, it is necessary to know the characteristics of business processes of the analysed DMUs.

At the beginning, it is necessary to define the orientation of the model, i.e. make a choice between input, output or input-output (mixed) oriented models. Given the time of this study, and the needed rationality in using inputs, for this research, the most suitable are input-oriented models. In addition, because of the expected accession of Croatia to the European Union, rationalization of inputs is already required.[2]

DEA models assume constant or variable returns-to-scale. It is not possible to determine reliably which models are more suitable before the analysis, because the real characteristics of returns-to-scale are not known. This is the reason why authors of DEA recommend the application of both, constant and variable returns-to-scale models. When the results of both models coincide to a large extent, it is proper model that assumes constant returns-to-scale. Otherwise, a more suitable model is that which assumes variable returns-to-scale.

One of the limitations of DEA is the total number of inputs and outputs that can be included in the analysis. Specifically, it is advisable for the number of analyzed DMUs to be at least three times greater than the sum of inputs and outputs included in the analysis (Cooper, Seiford and Tone, 2006). Therefore, one of the main problems is the selection of relevant inputs and outputs that depict the best way the business processes of the analyzed DMUs. Based on previously conducted research, for this study the following inputs and outputs were selected:

a) Inputs:

- *Number of employees* – employees are the most important resource and a fundamental factor of the administrative capacity of each customs house and have a great impact on quality of service.
- *Costs* – costs are an exact and systematically studied variable and as such represents a suitable and relevant input for analysis[3].

[2] One of the expected implications of accession of Croatia to the European Union is reduction of number of employees due to inclusion Croatian customs territory in European customs union and the disappearance of borders between Croatia and the EU.

[3] The analysis included all costs of customs houses. Part of total costs, such as salaries, is not classified by customs houses and is recorded in the Head Office of the Customs Administration. For this reason, that part of the total costs is estimated for every customs house, based on total number and professional qualifications of employees. Such an estimation will ensure the correct application of DEA.

b) Outputs:

– *Collected public revenues* – as in other countries, public revenues represent a relevant measure of achievement of the function of protecting the financial interests of the Republic of Croatia.

– *Number of processed customs declarations* – represents the number of completed customs procedures as a reliable indicator of load and capacity of the customs houses in performing the function of promotion of international trade.

– *Number of detected offences* – the most reliable measure of prevented abuses in the meeting of financial obligations and in international commerce and trade, thereby resulting in the execution of a function of protecting the safety of society.

Table 1

Inputs and outputs of customs houses

Customs house (DMU)	Inputs		Outputs		
	Number of employees	Costs (million kuna)	Number of customs declarations (thousand)	Public revenues (million kuna)	Number of offences
Zagreb	478	68.6	1,070.3	20,524.1	1,666
Koprivnica	76	11.5	40.8	910.2	223
Osijek	179	26.0	121.9	713.6	315
Rijeka	340	46.4	242.2	5,368.9	415
Pula	197	28.4	107.4	3,548.3	146
Split	285	40.3	99.5	1,481.6	450
Ploče	146	19.9	57.5	187.7	126
Zadar	75	11.0	24.5	895.1	90
Šibenik	63	9.4	13.2	535.7	22
Dubrovnik	145	19.6	7.4	83.7	362
Varaždin	285	41.6	370.7	2,411.0	675
Krapina	166	23.2	260.7	3,628.6	438
Slavonski Brod	154	23.4	123.2	308.2	308
Virovitica	44	6.6	15.3	74.8	77
Vukovar	266	37.7	136.2	466.6	758
Otočac	52	7.6	15.7	16.6	65
Karlovac	87	9.3	60.3	643.4	114

Source: Internal data of the Croatian Customs Service.

Between all inputs and outputs, the *number of processed customs declarations* could be observed as a *non-controllable variable*. In fact, customs declarations are submitted by importers or exporters of goods and their number depends on international trade activity in a particular customs region. Therefore, the decisions of a particular customs house cannot affect the number of customs declarations submitted. However, this output should not be omitted from the analysis because it is an indicator of load and capacity of customs houses.

For the purposes of this study, inputs and outputs of customs houses from 2008 will be analysed. 2008 was the year when the Croatian economy had not yet been hit by the world financial crisis and the last year when Croatian GDP grew. In addition, outputs were at the highest levels in the history of Croatian Customs Service. Data were collected directly in Croatian Customs Administration.

Table 2

Relative efficiency of customs houses and reference sets (NCN-I-C model)

No.	DMU	Score	Rank	Reference set (lambda)	
1	Zagreb	1	1	Zagreb	1
2	Koprivnica	1	1	Koprivnica	1
3	Osijek	0.5626	13	Zagreb	0.0841
				Koprivnica	0.3759
				Vukovar	0.1197
4	Rijeka	0.6061	11	Zagreb	0.1687
				Koprivnica	0.2989
				Pula	0.4604
5	Pula	1	1	Pula	1
6	Split	0.5563	14	Zagreb	0.0529
				Koprivnica	0.2931
				Dubrovnik	0.3873
				Vukovar	0.2061
7	Ploče	0.2833	17	Zagreb	0.0452
				Vukovar	0.0670
8	Zadar	1	1	Zadar	1
9	Šibenik	1	1	Šibenik	1
10	Dubrovnik	1	1	Dubrovnik	1
11	Varaždin	0.7054	9	Zagreb	0.3229
				Koprivnica	0.6142
12	Krapina	0.7934	8	Zagreb	0.2360
				Vukovar	0.0591
13	Slavonski Brod	0.6307	10	Zagreb	0.0873
				Koprivnica	0.7287
14	Virovitica	0.5949	12	Zagreb	0.0016
				Koprivnica	0.3003
				Vukovar	0.0098
15	Vukovar	1	1	Vukovar	1
16	Otočac	0.4231	16	Zagreb	0.0051
				Koprivnica	0.1160
				Vukovar	0.0403
17	Karlovac	0.5316	15	Zagreb	0.0517
				Vukovar	0.0368

Source: Author's calculation.

Data from table 1 were analysed using "DEA Solver LV 3.0". Data were processed in two analyses, i.e. two models were applied. The first one was NCN input-oriented with constant returns-to-scale (NCN-I-C), and the second was NCN input-oriented with variable returns-to-scale (NCN-I-C). In table 2 the results calculated by applying NCN-I-C model are shown.

Table 3

Relative efficiency of customs houses and reference sets (NCN-I-V model)

No.	DMU	Score	Rank	Reference set (lambda)	
1	Zagreb	1	1	Zagreb	1
2	Koprivnica	1	1	Koprivnica	1
3	Osijek	0.5899	15	Zagreb	0.0836
				Koprivnica	0.7204
				Virovitica	0.1960
4	Rijeka	0.6088	14	Zagreb	0.1717
				Koprivnica	0.2349
				Pula	0.4149
				Zadar	0.1785
5	Pula	1	1	Pula	1
6	Split	0.5569	16	Zagreb	0.0472
				Koprivnica	0.4247
				Dubrovnik	0.3121
				Vukovar	0.2160
7	Ploče	0.4587	17	Zagreb	0.0400
				Virovitica	0.9600
8	Zadar	1	1	Zadar	1
9	Šibenik	1	1	Šibenik	1
10	Dubrovnik	1	1	Dubrovnik	1
11	Varaždin	0.7114	12	Zagreb	0.3228
				Koprivnica	0.5826
				Virovitica	0.0945
12	Krapina	0.9064	10	Zagreb	0.2326
				Virovitica	0.7674
13	Slavonski Brod	0.6629	13	Zagreb	0.0869
				Koprivnica	0.6363
				Virovitica	0.2768
14	Virovitica	1	1	Virovitica	1
15	Vukovar	1	1	Vukovar	1
16	Otočac	0.8763	11	Zagreb	0.0004
				Virovitica	0.9996
17	Karlovac	0.9996	9	Zagreb	0.0427
				Virovitica	0.9573

Source: Author's calculation.

The table 2 shows that, according to the NCN-I-C model, 7 customs houses were efficient. However, to decide which model is more suitable for the analysis of customs houses, it is necessary to analyze data with the NCN-I-V model, too. Table 3 shows the results calculated by applying the NCN-I-V model.

As can be seen from tables 2 and 3, results calculated using NCN-I-C and NCN-I-V models are largely similar. In such case, it can be concluded that the NCN model with constant returns-to-scale is more suitable for analyzing the business processes of the Croatian Customs Service.

Relatively efficient customs houses appear in the reference set of relatively inefficient customs houses. So, frequency of occurrence in the reference set can be considered as indicator of whether the customs house is a model for other customs houses. Particularly, if a relatively efficient customs house is not a member of any reference set, that means that it is relatively efficient, but it does not appear as a model that should be achieved by the other customs houses. On the other hand, a higher frequency of occurrence in the reference set means a higher probability that it is an example of a good performance. Therefore, table 4 shows the frequency of relatively efficient in the reference set of relatively inefficient customs houses.

Table 4
Frequency in reference set

Reference	Number of occurrences in reference set
Zagreb	10
Koprivnica	7
Pula	1
Zadar	0
Šibenik	0
Dubrovnik	1
Vukovar	7

Source: Author's calculation.

After examining occurrences in inefficient customs houses' references set, it can be concluded that customs houses Zagreb, Vukovar and Koprivnica are the most frequent DMUs in the reference set. This means that mentioned customs houses are models of efficient performance and their scores are targets for the inefficient.

In addition, every inefficient customs house has a specific reference set consisting of relatively efficient customs houses with similar input-output orientations. With the data of the reference set, in order to become efficient, it is possible to identify concrete goals for every inefficient customs house.

Finally, after the identification of the reference set for every inefficient customs house, *NCN projection* will determine inputs that have to be reduced, and outputs

that must be increased. These improvements will project a particularly inefficient customs house in a reference set, and by achieving projected scores, such a customs house will become efficient.

TABLE 5
NCN Projection

Customs house	Employees		Costs (million kuna)		Public revenues (million kuna)		Offences		Declarations (thousand)
	No.	Proj.	Score	Proj.	Collected	Projection	Score	Proj.	Score/Proj.
Zagreb	478	478	68.6	68.6	20,524.1	20,524.1	1,666	1,666	1,070.3
Koprivnica	76	76	11.5	11.5	910.2	910.2	223	223	40.8
Osijek	179	101	26.0	14.6	713.6	2,127.9	315	315	121.9
Rijeka	340	194	46.4	28.1	5,368.9	5,368.9	415	415	242.2
Pula	197	197	28.4	28.4	3,548.3	3,548.3	146	146	107.4
Split	285	159	40.3	22.4	1,481.6	1,833.4	450	450	99.5
Ploče	146	39	19.9	5.6	187.7	958.0	126	141	57.5
Zadar	75	75	11.0	11.0	895.1	895.1	90	90	24.5
Šibenik	63	63	9.4	9.4	535.7	535.7	22	22	13.2
Dubrovnik	145	145	19.6	19.6	83.7	83.7	362	362	7.4
Varaždin	285	201	41.6	29.2	2,411.0	7,187.3	675	675	370.7
Krapina	166	129	23.2	18.4	3,628.6	4,871.7	438	438	260.7
Slav. Brod	154	97	23.4	14.4	308.2	2,455.7	308	308	123.2
Virovitica	44	26	6.6	3.9	74.8	310.2	77	77	15.3
Vukovar	266	266	37.7	37.7	466.6	466.6	758	758	136.2
Otočac	52	22	7.6	3.2	16.6	229.8	65	65	15.7
Karlovac	87	34	9.3	4.9	643.4	1,078.2	114	114	60.3

Source: Author's calculation.

Table 5 presents projections, i.e. desirable inputs and outputs for inefficient customs houses. However, if particular customs houses reduce their inputs to a desirable level, their existence would not be possible. Namely, in particular cases, the projected inputs are so low that they cannot ensure fulfilment of the main customs house tasks. This indicates that the current territorial organizational model of Croatian Customs Administration is unsustainable. Consequently, the number and size of particular customs houses need to be changed.

5.2 SENSITIVITY ANALYSIS

After obtaining the previous results, sensitivity analysis has been implemented to determine the impact of choice of outputs on the final results of analysis. In the first phase, it is performed by replacing the number of detected offences with the *values of goods with which offences were committed*.[4] That output represents an

[4] Hereinafter, an analysis that includes *the number of detected offences* will be called "analysis 1", and analysis which includes *values of goods with which offences were committed* will be called "analysis 2".

expression of value of all goods that are objects of offences, and compared to the total number of detected offences, better expresses the seriousness of irregularities. Remaining outputs and inputs are the same as in the previous analysis.

Table 6

Inputs and outputs of customs houses

Customs house	Inputs		Outputs		
	Number of employees	Costs (million kuna)	Number of customs declarations	Public revenues (million kuna)	Value of goods with offences (thousand kuna)
Zagreb	478	68.6	1,070.3	20,524.1	49,462.8
Koprivnica	76	11.5	40.8	910.2	3,241.5
Osijek	179	26.0	121.9	713.6	1,327.3
Rijeka	340	46.4	242.2	5,368.9	3,394.4
Pula	197	28.4	107.4	3,548.3	3,784.6
Split	285	40.3	99.5	1,481.6	1,951.4
Ploče	146	19.9	57.5	187.7	147,552.5
Zadar	75	11.0	24.5	895.1	76,648.1
Šibenik	63	9.4	13.2	535.7	910.8
Dubrovnik	145	19.6	7.4	83.7	5,260.5
Varaždin	285	41.6	370.7	2,411.0	5,507.3
Krapina	166	23.2	260.7	3,628.6	7,042.4
Slav. Brod	154	23.4	123.2	308.2	2,845.2
Virovitica	44	6.6	15.3	74.8	955.7
Vukovar	266	37.7	136.2	466.6	13,038.0
Otočac	52	7.6	15.7	16.6	57.9
Karlovac	87	9.3	60.3	643.4	3,176.3

Source: Internal data of the Croatian Customs Service.

To process data from table 6, the NCN-I-C model has been applied, because it was assessed in the previous analysis as the model that is most suitable for analyzing the business processes of the Croatian Customs Service. Results calculated by applying the NCN-I-C model are presented in table 7.

TABLE 7

Relative efficiency of customs houses and reference sets (analysis 2)

No.	DMU	Score	Rank	Reference set (lambda)	
1	Zagreb	1	1	Zagreb	1
2	Koprivnica	0.4133	10	Zagreb	0.0296
				Pula	0.0802
				Zadar	0.0192
3	Osijek	0.3040	12	Zagreb	0.1139
4	Rijeka	0.5604	8	Zagreb	0.1776
				Pula	0.4860
5	Pula	1	1	Pula	1
6	Split	0.1584	15	Zagreb	0.0930
7	Ploče	1	1	Ploče	1
8	Zadar	1	1	Zadar	1
9	Šibenik	1	1	Šibenik	1
10	Dubrovnik	0.0521	17	Zagreb	0.0051
				Ploče	0.0340
11	Varaždin	0.5809	7	Zagreb	0.3464
12	Krapina	0.7195	6	Zagreb	0.2435
13	Slavonski Brod	0.3573	11	Zagreb	0.1151
14	Virovitica	0.1597	14	Zagreb	0.0142
				Ploče	0.0017
15	Vukovar	0.2511	13	Zagreb	0.1248
				Ploče	0.0465
16	Otočac	0.1356	16	Zagreb	0.0147
17	Karlovac	0.4212	9	Zagreb	0.0562
				Ploče	0.0027

Source: Author's calculation.

The table shows that, according to NCN-I-C model, in *analysis 2*, there were 5 efficient customs houses. There are important differences from the previous analysis. Specifically, according to the results of *analysis 1*, there were 7 efficient customs houses. Moreover, particular customs houses that were efficient in *analysis 1*, in *analysis 2* were inefficient, as can be seen from the comparison of results of *analysis 1* and *analysis 2*.

TABLE 8

Comparison of results of analysis 1 and analysis 2

No.	DMU	Analysis 1		Analysis 2	
		Score	Rank	Score	Rank
1	Zagreb	1	1	1	1
2	Koprivnica	1	1	0.4133	10
3	Osijek	0.5626	13	0.3040	12
4	Rijeka	0.6061	11	0.5604	8
5	Pula	1	1	1	1
6	Split	0.5564	14	0.1584	15
7	Ploče	0.2833	17	1	1
8	Zadar	1	1	1	1
9	Šibenik	1	1	1	1
10	Dubrovnik	1	1	0.0521	17
11	Varaždin	0.7054	9	0.5809	7
12	Krapina	0.7934	8	0.7195	6
13	Slavonski Brod	0.6307	10	0.3573	11
14	Virovitica	0.5949	12	0.1597	14
15	Vukovar	1	1	0.2511	13
16	Otočac	0.4231	16	0.1351	16
17	Karlovac	0.5316	15	0.4212	9

Source: Author's calculation.

Data from the table 8 show that customs houses Zagreb, Pula, Zadar, and Šibenik were efficient according to the results of both analyses. In addition, customs houses Koprivnica, Dubrovnik, Virovitica and Vukovar were efficient according to the results of *analysis 1*, while by the results of *analysis 2*, they were inefficient. On the other hand, Ploče customs house is efficient only according to the results of *analysis 2*.

Table 9 shows the frequency of relatively efficient in the reference set of relatively inefficient customs houses for both analyses.

TABLE 9

Comparison of reference sets (analysis 1 and analysis 2)

Analysis 1		Analysis 2	
Reference	Number of occurrences in reference set	Reference	Number of occurrences in reference set
Zagreb	10	Zagreb	12
Pula	1	Pula	2
Zadar	0	Zadar	1
Šibenik	0	Šibenik	0
Koprivnica	7	Ploče	4
Dubrovnik	1		
Vukovar	7		

Source: Author's calculation.

Following the previous results, there are evident differences in *the reference sets* from *analysis 1* and *analysis 2*. Still, according to results of the *analysis* 2, Zagreb customs house is also the most frequent DMU in the reference set. In addition, Ploče customs house, which, according to results of *analysis 1*, was not efficient, by the results of *analysis 2*, is second most frequent DMU in reference set.

The above indicates that the reliability of DEA results greatly depends on the selection of inputs and outputs. Therefore, good knowledge of business processes and key inputs and outputs of analysed DMUs is crucial for obtaining reliable DEA results.

Finally, as in *analysis 1*, after the identification of a reference set for every inefficient customs house, *NCN projection* will determine inputs that have to be reduced, and outputs that must be increased. Table 10 shows differences between NCN projections of *analysis 1* and *analysis 2*.[5]

TABLE 10

Comparison of NCN projections (analysis 1 and analysis 2)

Customs house	Employees		Costs (million kuna)		Public revenues (million kuna)		Value of goods (thousand kuna)	
	Pr.1	Pr.2	Proj. 1	Proj. 2	Projection 1	Projection 2	Score	Projection
Zagreb	478	478	68.6	68.6	20,524.1	20,524.1	49,462.8	49,462.8
Koprivnica	76	31	11.5	4.5	910.2	910.2	3,241.5	3,241.5
Osijek	101	54	14.6	7.8	2,127.9	2,336.7	1,327.3	5,631.5
Rijeka	194	181	28.1	26.0	5,368.9	5,368.9	3,394.4	10,622.5
Pula	197	197	28.4	28.4	3,548.3	3,548.3	3,784.6	3,784.6
Split	159	44	22.4	6.4	1,833.4	1,908.8	1,951.4	4,600.1
Ploče	39	146	5.6	19.9	958.0	187.7	147,552.5	147,552.5
Zadar	75	75	11.0	11.0	895.1	895.1	76,648.1	76,648.1
Šibenik	63	63	9.4	9.4	535.7	535.7	910.8	910.8
Dubrovnik	145	7	19.6	1.0	83.7	110.5	5,260.5	5,260.5
Varaždin	201	166	29.2	23.7	7,187.3	7,108.9	5,507.3	17,132.3
Krapina	129	116	18.4	16.7	4,871.7	4,998.4	7,042.4	12,046.2
Slav. Brod	97	55	14.4	7.9	2,455.7	2,362.7	2,845.2	5,694.2
Virovitica	26	7	3.9	1.0	310.2	291.3	955.7	955.7
Vukovar	266	66	37.7	9.5	466.6	2,569.3	13,038.0	13,038.0
Otočac	22	7	3.2	1.0	229.8	301.6	57.9	726.7
Karlovac	34	27	4.9	3.9	1,078.2	1,154.7	3,176.3	3,1763

Source: Author's calculation.

[5] *The number of customs declarations* is not shown in the table because it was treated as a non-controllable output. Therefore, projections are equal with the achieved results. Furthermore, for *values of goods with which offences were committed* scores and projection are shown, because these are new data, not analysed in *analysis 1*, making a comparison impossible.

Table 10 presents comparison of projections between results of both analyses. It demonstrates significant differences between the results of *analysis 1* and *analysis 2*. By observing projected inputs, it can be concluded that *analysis 2* initiates more drastic reductions of inputs for all inefficient customs houses. As in *analysis 1*, projected inputs of particular DMUs are so low that they cannot ensure fulfilment of main customs house tasks. Therefore, *analysis 2* additionally confirms the argument arising from *analysis 1*, according to which the current territorial organizational model of the Croatian Customs Administration is unsustainable.

In the next step a sensitivity analysis was performed by removing inputs and outputs one at a time, while others remain included in analysis. The number of detected offences was removed first, collected public revenues second, costs third, and the number of employees was removed the last. After that, an analysis was made of how the efficiency of each DMU varies. The outcome of this analysis can be seen in table 11.

Table 11
Analysis of DMU efficiency variations

No.	DMU	Analysis 1	Omitted output		Omitted input	
		(all outp./inp.)	Offences	Revenues	Costs	Employees
1	Zagreb	1	1	1	1	1
2	Koprivnica	1	0.4079	1	1	1
3	Osijek	0.5626	0.3040	0.5626	0.5577	0.5560
4	Rijeka	0.6061	0.5604	0.3782	0.5708	0.6061
5	Pula	1	1	0.2434	1	1
6	Split	0.5564	0.1584	0.5480	0.5310	0.5553
7	Ploče	0.2833	0.1854	0.2833	0.2665	0.2833
8	Zadar	1	1	0.4011	1	1
9	Šibenik	1	1	0.1019	1	1
10	Dubrovnik	1	0.0241	1	1	1
11	Varaždin	0.7054	0.5809	0.7054	0.7054	0.6963
12	Krapina	0.7934	0.7195	0.7934	0.7717	0.7934
13	Slav. Brod	0.6307	0.3573	0.6307	0.6307	0.6009
14	Virovitica	0.5949	0.1550	0.5949	0.5933	0.5742
15	Vukovar	1	0.2312	1	0.9746	1
16	Otočac	0.4231	0.1351	0.4231	0.4174	0.4161
17	Karlovac	0.5316	0.4166	0.5316	0.39334	0.5316
	Average	0.7463	0.4845	0.5999	0.7301	0.7419

Source: Author's calculation.

In general, after texamining the presented scores, it can be concluded that, in the case of the Croatian Customs Administration, the outcome of DEA is more sensitive to the removal of one of the outputs than to the removal of one of the inputs. Namely, the differences in relation to the analysis from subchapter 5.1 are greater when the analysis omits one of the outputs, than one of the inputs.

By observing individual scores, it was found that only Zagreb Customs House was efficient according to all analyses, regardless of which variable is removed. Other DMU scores, generally, vary depending on the importance of input or output that was omitted from the analysis for a particular customs house. Therefore, sensitivity analysis has shown that the impact of choice of inputs and outputs on the final results of applied DEA model is significant.

6 LIMITATIONS OF THE MODEL AND RECOMMENDATIONS FOR FUTURE RESEARCH

The model applied is one of the few comprehensive models for evaluating the efficiency of customs services and its organizational units, even at the international level. Therefore, as such, it represents a valuable tool in the search for "best practice". However, it has several limitations. Several limitations derive from methodology, i.e. data envelopment analysis. On the other hand, few limitations are related to the model applied and data used.

The first limitation is that the *model applied cannot determine absolute but only relative efficiency*; it can identify organizational units of customs service or customs services as a whole, that are, compared with others, efficient or inefficient. It can also identify units that are members of the reference set and, as such, represent desirable models for particular inefficient units. However, data envelopment analysis does not offer the possibility of determining the maximum possible efficiency of DMUs, i.e. customs houses.

The second limitation is related to the *lack of prognostic value* of data envelopment analysis. It deals with data from the past and determines the necessary steps on the basis of these data. Data envelopment analysis is *ex post* oriented and does not create prognosis.

The *ratio between the total number of analyzed units and the total number of inputs and outputs*, (total number of analyzed units has to be at least three times greater than the sum of inputs and outputs included in the analysis) is a limitation that prevents the comparison of a small number of DMUs. Specifically, this model, with a total of five inputs and outputs cannot be reliably used for the analysis of fewer than 15 DMUs, i.e. customs houses. Sometimes researchers conduct studies for only a few units of the customs service, which is not possible using this model.

Previous limitations appear primarily from data envelopment analysis as a methodology. Moreover, the proposed model has several important limitations related to the inputs and outputs of the customs services used in this research; in this research, on the basis of the main tasks, five inputs and outputs that represent customs services, or their organizational units, in the best way were selected. One of these inputs is the *number of irregularities*, expressed through the number of detected

violations and offenses. When using the total number of customs offences, weights of serious and minor offences are not distinguished. Although it does not mean that for the detection of major irregularities customs services need to invest more energy and resources, serious irregularities should be taken into account and properly evaluated in future researches. For the beginning, it is necessary to determine an adequate criterion of "serious irregularities". Therefore, the inclusion of the *customs value of seized goods the circulation of which is prohibited or restricted* in the analysis could be proposed. Thus, to the analysis would be added the criterion of the customs service's success in detecting the smuggling of commodities such as narcotics, tobacco, alcohol, weapons, and protected plant and animal species. This means that the most relevant, properly valued findings of the customs services would have an impact on the relative efficiency of analyzed DMUs.

In section 2.2 it was found that the duration of customs procedures has become one of the key factors of efficiency of customs services and their tendency should be a maximum shortening of the time required for enforcement of customs procedures. Faster customs procedures reduce the potential costs that are caused to participants in international trade. Therefore, it would be useful to include *the average processing time of customs declarations* in the analysis. Given the increased computerization of customs procedures in contemporary customs services, such data are probably available, but still, are not generally published in annual reports.

One of the questions that this study did not answer, which occupies an important place when discussing the efficiency of customs services, is the problem of *determining the number of undetected irregularities and the size of illegal tax evasion*, as a result of irregular declarations and the smuggling of goods. This research deals with data recorded in Croatian Customs Service. On the other hand, no reliable estimates of proportions of irregularities in areas covered by the Croatian Customs Service exist. The same situation holds true in most other contemporary customs services. For example, customs services have information on how many illegal shipments of cigarettes have been discovered and stopped, but in contrast, they have no reliable information about the number of such shipments that avoided the customs controls and reached the desired destination. The assumption is that customs services in more developed and better regulated countries are more effective in detecting illegal shipments, but this has not been scientifically demonstrated. Hence, at the same time as the analysis of the data available to customs services, and analysis of the "visible", to enhance the reliability of determining the efficiency, it is necessary to explore and evaluate "invisible" items.

7 CONCLUSION

Present conditions of public services' activities are characterised by the development and growth of the global economy, changes within international relations,

new scientific knowledge and technological development and the strengthening of civil society. These factors have radically changed the attitude of society towards the state administration, but also the attitude of public services to issues concerning public interest. Public services are expected to be effective, or to be "solving real problems", and efficient, i.e. "doing things right", with the essential concern for the public interest and respect for the principles of democracy.

Contemporary circumstances in which customs services operate imply new challenges. From the initial, primarily fiscal role, customs services in developed and most other countries, have transformed, or are in the process of transformation into organizations with broader and still very important tasks. Besides fulfilling fiscal tasks, customs services ensure the safety of distribution chains by protecting trade, economy and markets from imports of prohibited goods. In addition, they ensure the unhindered flow of legal goods across national borders and contribute to the international competitiveness of their economies. All these tasks can be summarized in the three basic functions of modern customs service:

– protection of national and/or community financial interests,
– international trade protection and improvement,
– protection of society at national and international levels.

The organizational structure of Croatian Customs Service is characterized by its 17 customs houses, i.e. regional organizational units. Analytical research into the outputs and inputs of the Croatian Customs Service has created the basis for evaluating the efficiency of its organizational units. The Customs Service uses different indicators of efficiency, but these measures are usually partial in character, i.e. represent the ratios of one output and one input. Those measures are very simple to use, but do not give an overview of the overall efficiency of customs services. In contrast, this study is focused on determining the methods and models for evaluating the efficiency of customs services, taking into account all the relevant segments of their operations. Data envelopment analysis is suitable for this. It was developed specifically for measuring the effectiveness of organizations working on a non-profit basis, where it is not possible to determine efficiency from the ratio of output and input prices. It is a quantitative technique for measuring the relative efficiency or productivity of organizations within the same sector, and is used for organizations with multiple outputs and inputs.

During the research, for the purpose of applying specified method, the following steps were implemented:

– identification of inputs and outputs that describe the operations of customs services the best way,
– the selection of inputs and outputs relevant for the assessment of efficiency. For this research, the following were selected as the most relevant: number of staff and expenses as inputs, and collected public revenues, the number of

processed customs declarations and the number of detected irregularities as outputs,
– development of a model for comparative analysis of efficiency,
– application of the model and estimation efficiency of customs houses,
– sensitivity analysis.

Considering the business processes of customs houses and the results obtained by both models, the appropriate model is the NCN input-oriented model with a constant returns-to-scale. The analysed data were collected directly in the Croatian Customs Service.

Several conclusions can be drawn from applying the model to the organizational units of the Croatian Customs Administration. Firstly, it suggests and proves that it is possible to quantify relative efficiency of the customs services. Thus, although it is not profit-oriented and its results cannot be measured in terms of profitability, its outputs in key areas were identified and quantified. Furthermore, the model can be applied to certain foreign customs services to assess the relative efficiency of their organizational units. However, the same model is applicable for the comparison of customs services of different countries as wholes at the international level. Specifically, key inputs and outputs of organizational units, in fact, are identical to those of the entire customs services.

Secondly, irrespective of what the inputs and multiple outputs are expressed in different units, the analysis yielded valid results. This implies that it is meaningful to try to identify and quantify the inputs and outputs of other public services and thus to evaluate their efficiency. Therefore, this research can be used as "guideline" for researching and accessing efficiency in other segments of the Croatian system of public administration. Specifically, data envelopment analysis, with its various models, is suitable for determining the relative efficiency of and for finding the "best practice" of organizations in the non-profit sector.

There are several points where the research has placed its emphasis that deserve further studies. The analysis indicates that the organizational structure of Croatian Customs Administration is inadequate. This stems from the fact that if particular customs houses reduced their inputs to the desirable level, their existence would not be possible, because in particular cases, projected inputs are so low that they could not ensure fulfilment of main customs houses' tasks. Thus, future research should focus on finding and proposing a more adequate organizational structure. Moreover, an additional incentive for organizational change is the imminent entry of Croatian accession to the European Union, which will greatly change the territorial organization of the Croatian Customs Administration.

Sensitivity analysis, in which the number of detected irregularities, as output, was replaced by the values of goods with which offences were committed, has confir-

med the conclusions about the need for organizational changes in the Croatian Customs Service. However, that analysis has changed the composition of the reference set, and certain customs houses that were previously assessed as efficient, have become inefficient, while the other customs house, previously inefficient, has became efficient. Mentioned indicates that data envelopment analysis results depend to a large extent on the choice of inputs and outputs. That is confirmed by the sensitivity analysis carried out by omitting certain inputs and outputs. Therefore, for the application of this method, a good knowledge of the business process of the evaluated organization is required.

Within the known limitations of data envelopment analysis, this research has highlighted the shortcomings arising from the selected inputs and outputs. In fact, the study has detected two relevant outputs, which were not known due to the lack or the inadequate structure of the existing data at the time of research. Certainly, in future research, as outputs, it is necessary to include the customs value of seized goods the circulation of which is prohibited or restricted and the average processing time for customs declarations.

In addition, further efforts should be focused on the quantification of undetected irregularities and the size of tax evasion. Besides the possibility of obtaining a more reliable assessment of efficiency, "the detecting of the undetected" provides an opportunity for quality risk assessment and eventually for increasing overall efficiency and effectiveness.

TABLE A1

Correlation (analysis 1)

	Employees	Costs	Customs declarations	Public revenues	Offences
Employees	1	0.9977	0.8183	0.7661	0.8750
Costs	0.9977	1	0.8270	0.7694	0.8836
Customs declar.	0.8183	0.8270	1	0.9578	0.9281
Public revenues	0.7661	0.7694	0.9578	1	0.8538
Offences	0.8750	0.8836	0.9281	0.8538	1

TABLE A2

Input and output weights (analysis 1)

No.	DMU	V(1) Number of employees	V(2) Costs	U(1) Number of customs declarations	U(2) Public revenues	U(3) Number of offences
1	Zagreb	0.0014	0	0	0	0.0002
2	Koprivnica	0.0132	0	0	0	0.0038
3	Osijek	0.0056	0	0	0	0.0016
4	Rijeka	0	0	0	0	0
5	Pula	0.0051	0	0	0	0
6	Split	0	0	0	0	0.0010
7	Ploče	0	0	0	0	0.0021
8	Zadar	0.0133	0	0	0	0.0038
9	Šibenik	0.0159	0	0	0	0
10	Dubrovnik	0	0	0	0	0.0021
11	Varaždin	0.0035	0	0	0	0.0010
12	Krapina	0	0	0	0	0.0018
13	Slavonski Brod	0.0065	0	0	0	0.0019
14	Virovitica	0.0227	0	0	0	0.0065
15	Vukovar	0	0	0	0	0.0011
16	Otočac	0.0192	0	0	0	0.0055
17	Karlovac	0	0	0	0	0.0044

TABLE A3

Correlation (analysis 2)

	Employees	Costs	Customs declarations	Public revenues	Offences' value
Employees	1	0.9977	0.8183	0.7661	0.0456
Costs	0.9977	1	0.8270	0.7694	0.0394
Customs declar.	0.8183	0.8270	1	0.9578	0.1148
Public revenues	0.7661	0.7694	0.9578	1	0.1302
Offences' val.	0.0456	0.0394	0.1148	0.1302	1

TABLE A4

Input and output weights (analysis 2)

No.	DMU	V(1) Number of employees	V(2) Costs	U(1) Number of customs declarations	U(2) Public revenues	U(3) Value of offences
1	Zagreb	0.0016	0	0	0	0
2	Koprivnica	0.0132	0	0	0	0
3	Osijek	0.0056	0	0	0	0
4	Rijeka	0	0	0	0	0
5	Pula	0.0051	0	0	0	0
6	Split	0	0	0	0	0
7	Ploče	0.0018	0	0	0	0
8	Zadar	0.0066	0	0	0	0
9	Šibenik	0.0159	0	0	0	0
10	Dubrovnik	0	0	0	0	0
11	Varaždin	0.0035	0	0	0	0
12	Krapina	0	0	0	0	0
13	Slavonski Brod	0.0065	0	0	0	0
14	Virovitica	0.0227	0	0	0	0
15	Vukovar	0	0	0	0	0
16	Otočac	0.0192	0	0	0	0
17	Karlovac	0	0	0	0	0

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