Performance measurement of police forces at the local level: A non-parametric mathematical programming approach

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A R T I C L E   I N F O

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A B S T R A C T

The paper attempts to measure the relative efficiency of police activities in the Slovenian police at the local level. As the state allocates a relatively large amount of budget funding to police operations and more than one-quarter of public employees is employed in the police, the efficient use of limited public funds is even more important. In particular, a three-stage Data Envelopment Analysis (DEA) technique is presented and then applied to measure the relative efficiency of police-work-related data for selected police units at the local level (i.e., police stations (PSs)) in 2010 with additional controlling for external (environmental) factors. The results of the DEA empirical analysis reveal that approximately 80% of the observed PSs are inefficient relative to their peers. More detailed analysis also shows that, in general, PSs with more than 50 posts occupied are on average less efficient. To some extent, the differences in efficiency scores are a consequence of external factors which the management of police stations cannot influence, yet they are even more a result of better governance and organized and police work. Thus, the presented methodology and obtained efficiency results can be a valuable tool in the hands of police management when deciding how to optimally allocate the limited public resources.

1. Introduction

It is impossible to envisage a modern state without an efficient and effective public and/or state administration. The latter should ensure that politics corresponds to the (social) needs of the citizens and advocates a managerial approach to efficiency and effectiveness. An efficient and effective government accomplishes everything that the citizens want – efficiency (the rational use of budget funds), quality (the provision of legal services at the right time and at the right place, responsiveness, equality) and effectiveness (ensuring freedom, peace and safety as well as attaining the most important goals). One of public sector management’s key tasks is to ensure that the functioning of administrative bodies at all levels is public, responsible and reasonable, with an emphasis on attainment of the set goals (Verbit, 2009). In this respect, the introduction of a new way of managing the public sector requires a clear definition of the goals of the functioning, a detailed allocation of funds and the development of indicators to measure the efficiency and effectiveness of the public sector.

Like the whole state administration, the Slovenian police should necessarily join the process of adjusting to modern trends in the public sector. Nowadays, the global financial and economic crisis offers an additional window of opportunity for deep structural reforms of the police since police activity is a cornerstone of all other institutions of the rule of law, freedom and security; without the police service there can be no development, democracy, economic progress or social and legal equality. Slovenia does not have a modern system for objectively monitoring the state of security as well as the performance, efficiency and quality of the police’s work, particularly at the local level (Klun, & Setnikar-Cankar, 2013; Pevcin, 2013). Therefore, the main aim of the presented empirical study is to obtain additional expert backgrounds and guidelines for the streamlining and rationalizing the work of local police in Slovenia.

The police service is important budget user1 and clearly a relatively centralized part of the state administration in Slovenia. The legislative solutions differ by country, but in most countries the police are organized hierarchically. In Slovenia, police organizations can be defined at three levels: local (Police Stations), regional (Police Directorates) and national (the General Police Directorate). Each of these levels of the structural organization of the police has its own characteristics that facilitate comparisons (Aristovnik, Seljak, & Mencinger, 2013). The main focus of the paper is on the local level where police officers most often have direct contact with people.

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1 The state allocates a relatively large amount of budget funding to police operations (e.g., in 2010 the Republic of Slovenia allocated about EUR 330 million to the police, accounting for 3.1% of total budget expenditure) and a large share of public employees work in the police (i.e., 8989 employees, accounting for 26.3% of state administration staff in Slovenia in 2010).
which is why their activities are the most visible. However, the organi-
zations at the local level are relatively small and the value of the
related indicators is strongly influenced by individual extraordinary
events, which makes a reliable comparison even more complicated.
Moreover, the autonomy of these units is relatively low as all re-
sources (money, people and technical equipment) are usually allo-
cated at higher regional levels. Nevertheless, there is some degree
of flexibility when it comes to the allocation of financial, technical
and human resources at the local level. In this respect, police activity
at the local level (i.e., the level of Police Stations (PSs) in Slovenia)
appears to be the appropriate level for measuring relative efficiency.

The rest of the paper is organized as follows. The next section
presents and briefly discusses previous studies that have influ-
enced the present work. The methodology and some data regarding
the selection of the input and output measures for use in a three-
stage DEA model are then presented. The empirical results
obtained from the DEA assessment are set out and discussed in
the fourth part of the paper. The paper concludes with a summary
of the findings regarding the use of DEA to improve the perform-
ance of police stations in Slovenia.

2. Literature review

In the last decade the estimation of police efficiency has been
the subject of many studies related to the evaluation of public
sector performances. Regarding the performance of police depart-
ments, we can distinguish between the terms efficiency as provid-
ing the police service with the least costs, and effectiveness as
achieving the police’s objectives (Verschelde & Rogge, 2012). De-
spite some limitations on evaluating police efficiency, a number
of studies evaluating the efficiency of police performance employ-
ing DEA methodology can be found. Namely, specification of the in-
puts and outputs when measuring the performance of the police
using DEA is relatively hard to determine due to subjectivity in
the selection of variables and conditioned influence by a variety
of demographic and socio-economic factors, which are beyond
the control of police authorities (Akdogan, 2012; Verma & Gavir-
eni, 2006; Verschelde & Rogge, 2012). Further, the literature re-
veals that studies on the efficiency aspect of police performance
based on the DEA framework focus on the country or regional level
and at the local level, respectively.

For instance, Thanassoulis (1995) was the first to apply the DEA
methodology to measure the performance of police efficiency at
the regional level. The research included 41 police forces in Eng-
land and Wales. It analysed three outputs (number of violent
crimes, burglaries, and other crimes’ clear-ups) against four inputs
(number of employed officers in each force, number of violent
crimes, burglaries, and other recorded crimes). In this research
the author identified some apparent weaknesses in the account-
ability of performance due to omitted external factors, which may
lead to dissimilarities in the identification of efficient perfor-
ance units and their comparison with other peers. In this context,
Drake and Simper (2005) mitigated the limitation bias on relative
efficiency scores and rankings by including environmental, socio-
economic, and demographic variables in their comparative
analysis. With a two-stage procedure the authors verified that the
exclusion of external factors may lead to inaccurate efficiency
scores with respect to some police units of analysis. Further, some
authors, such as Gorman and Ruggiero (2008) analysing police effi-
ciency in the United States, and Wu, Chen, and Yeh (2010) evaluat-
ing the performance of the police in Taiwan, confirmed that the
omission of external environmental factors may distort the effi-
ciency measures of each unit when evaluating the police’s per-
formance. In contrast, Sun (2002) and Carrington, Puthucheary,
Rose, and Yaisawarng (1997) disputed the significant impact of
environmental and socio-economic variables on efficiency rank-
ings in most police departments.

Although a substantial number of studies apply the DEA meth-
ology to measure the performance of the police in terms of effi-
ciency at the national level, e.g., Thanassoulis (1995), Drake and
Simper (2000, 2003, 2005) for the United Kingdom, Nyhan and
Martin (1999), Gorman and Ruggiero (2008) for the United States,
India, Aristovnik et al. (2013) for Slovenia, Hu, Tung, Shieh, and
Lo (2011) for Taiwan, there is a lack of studies concentrating on
an analysis of the efficiency of police performance at the local level
of the organizational structure in the police sector (Akdogan, 2012;

In the Portuguese context, Barros (2007) conducted a two-stage
DEA analysis on 33 Lisbon police precincts to measure and com-
pare the technical and technological efficiency change in total pro-
ductivity from 2000 to 2002. In particular, in the first stage the
research evaluated DEA efficiency scores considering eight inputs
(number of police officers, cost of labor, cars, other costs, theft
crimes, burglary crimes, car robbery crimes, and drug crimes)
and six outputs (clear-ups of theft and burglary, clear-ups of stolen
cars, clear-ups of drug related crimes, raids, stop operations, and
minor offences). The second stage employed a Tobit model to con-
trol for external factors by regressing socio-economic determinants
with the efficiency scores obtained in the first stage. The research
provides benchmarks for enhancing the efficiency performance of
precincts and identification of external (socio-economic) factors
causing the deterioration of the operations of organizational units.
In the same vein, García-Sánchez (2009) evaluated the efficiency
of local police in Spain regarding public and road safety using the DEA
methodology. Moreover, application of the procedure prior to the
analysis reduces the subjectivity in the statistical selection of vari-
bles by measuring the impact of each activity in the proposed area
on the overall performance of the police. However, in contrast with
previous studies, the purpose of our empirical study is to evaluate
the efficiency of police performance at the local level, which may
be crucial for identifying the strengths and weaknesses of local po-
lice departments’ performances.

3. Methodology and preliminary data review

To examine the relative efficiency of local police units in Slove-
nia, we use a non-parametric technique that has recently started
to be commonly applied to public sector efficiency analysis, i.e.,
Data Envelopment Analysis (DEA). DEA is a non-parametric frontier
estimation methodology originally introduced by Charnes, Cooper,
and Rhodes (1978) who built on the work of Farrell (1957) and oth-
er. It is a linear programming-based methodology that has proven
to be a successful tool in measuring relative efficiency. It computes
the comparative ratio of outputs to inputs for each unit, with the
score between 0 and 100. A decision-making unit (DMU) (in our case
a police station) with a score of less than 100 is inefficient compared
with the comparative ratio of outputs to inputs for each unit, with the
score between 0 and 100. A decision-making unit (DMU) (in our case
a police station) with a score of less than 100 is inefficient compared
to other units. It is used to identify best practices and is increasingly
becoming a popular and practical management tool. DEA was ini-
tially used to investigate the relative efficiency of non-profit orga-
nizations, but now its use has spread to hospitals, schools, banks, and
network industries, among others (Avkiran, 2001).

To measure efficiency, DEA is the choice here because it does not
require us to specify the functional form or distributional forms for
errors. In essence, it is more flexible than the parametric ap-
proach. Further, DEA has been extensively used to measure public
sector efficiency in many countries by a host of researchers, like
Ouellette and Vierstraete (2004), Verma and Gavirneni (2006),
Hauner (2007), or Adam, Delis, and Kammes (2011) who point
out that DEA is so popular because it is easy to draw on diagrams
and easy to calculate. Apart from the above reasons, DEA is employed here because it is more reliable for measuring technical efficiency as it can be applied to multi-input and multi-output variables. As an example, consider a situation that has \( F \) police stations, with each having \( M \) inputs and \( N \) outputs. Let \( X_j^f \) be the level of input \( j \) at police station \( f \) and let \( Y_k^f \) be the level of output \( k \) at police station \( f \). Without loss of generality, it will be assumed that the inputs and outputs are defined in such a manner that lower inputs and higher outputs are considered better. The relative efficiency of police station \( f \), denoted by \( w_f \), is computed by solving the following linear programme (Verma & Gavirneni, 2006):

Maximize \( w_f = \sum_{k=1}^{N} \theta_k Y_k^f \)  
Subject to:

\[
\sum_{i=1}^{M} \lambda_i X_i^f \leq \sum_{k=1}^{N} \theta_k Y_k^f, \quad \forall f = 1, \ldots, F
\]

\[
\sum_{k=1}^{N} \theta_k Y_k^f - \sum_{i=1}^{M} \lambda_i X_i^f \leq 0, \quad \forall f = 1, \ldots, F
\]

\[
\lambda_i, \theta_k \geq 0
\]

The basic idea of this approach is that, through the use of weights \( \lambda \) and \( \theta \), the sets of inputs and outputs are converted into a single ‘virtual input’ and a single ‘virtual output’. The ratio of the virtual output to the virtual input determines the efficiency associated with the police station. In addition, when the efficiency of a police station is being computed the weights are determined in such a way that its virtual input is set equal to 100. The resulting virtual output for that police station determines its relative efficiency. Due to the presence of multiple measures of performance, each police station would like to choose weights that put it in the best light and this linear programming formulation does just that. That is, when solving for police station \( f \), the weights chosen are those which result in that police station receiving the highest efficiency possible. Any other set of weights would only result in the police station having a lower efficiency rating. In order to complete the analysis, \( k \) linear programmes (one each for a police station) need to be solved and the relative efficiencies of the police stations can be tabulated. The technique is therefore an attempt to find the ‘best’ virtual unit (police station) for every real unit (police station). If the virtual unit is better than the real one by either making more output with the same input or making a similar output with less input, then we say that the real unit is inefficient. Thus, analysing the efficiency of \( N \) real units becomes an analysis of \( N \) linear programming problems.

As the efficiency of a police station in transforming inputs into outputs is also influenced by external environmental factors, which are usually beyond its control, a three-stage approach is employed here to obtain a measure of net technical efficiency. This approach estimates efficiency scores with the original DEA programme using only the discretionary inputs (i.e., controlled inputs). This produces a measure of the total inefficiency of the different police stations comprising contributions from both the non-discretionary (i.e., uncontrolled) variables and from non-measurable management inefficiency. Subsequently, a regression analysis is used in the second stage to decompose both of them. Therefore, exogenous variables \( (Z_j) \) are explanatory variables and the dependent variable is the first-stage efficiency score \( (w_f) \) (McCarty & Yaisawarng, 1993):

\[ w_f = f(Z_j, \beta_i) + u_f \]

This regression can be estimated by ordinary least squares (OLS), although the use of a Tobit regression is more widespread since the dependent variable (the efficiency score) is actually bounded between 0 and 1 (McCarty & Yaisawarng, 1993). From the value of the estimated coefficients it is possible to identify the influential variables and their sign (positive or negative) and also to weigh the importance of each external variable in the efficiency estimate. Further, the initial efficiency scores can be directly corrected in order to include the influence of the external variables (Cordero, Pedraja, & Santín, 2009). In the third stage, DEA² will be conducted using the discretionary and non-discretionary input indicators. In most cases, the indicators showing the external factors had a negative sign due to the negative influence, which is why a translation was performed. One of the more common methods for eliminating the problems of non-positive values in DEA involves adding a sufficiently large positive constant to the values of the input or output that has the non-positive number (Sarkis, 2007). The reason for performing the translation so as to achieve non-negative data is that the DEA software packages typically require this condition (Pastor & Ruiz, 2007).

In the majority of studies using DEA the data are analysed cross-sectionally, with each DMU – in our case a police station – being observed only once. Nevertheless, data on DMUs are often available over multiple time periods. In such cases, it is possible to perform DEA longitudinally where each DMU in each time period is treated as if it were a distinct DMU. However, in our case we use data for the last available year (2010), when 128 (local) organization units existed in Slovenia (Ministry of Interior, 2011). As the DEA methodology requires the maximum comparability of the analysed units, we decided to analyse only those 76 units that are named ‘police station’ (the smallest unit employed 17 staff and the largest 141). The selected organisational units are mutually comparable in terms of activity as their areas of operation are identical (something similar was done by Drake and Simper (2005)).³

The data come from the Ministry of the Interior database (for summary statistics, see Table 1) and the program used for calculating the relative efficiency scores is the Frontier Analyst 4.0 software. The following indicators of inputs and outputs were selected for the observed areas of police work at the local level (also see Table 1)⁴:

- Three (discretionary) inputs. These are inputs over which a police organization has some control. The first selected input indicator is the number of occupied employment posts, as commonly used in many previous empirical studies (see Diez-Ticío and Mancebon, 2002; Drake and Simper, 2002; García-Sánchez, 2009). Similarly, material resources (e.g., equipment) are also frequently included as inputs when police efficiency is measured (see Carrington et al., 1997; Diez-Ticío and Mancebon, 2002; García-Sánchez, 2009). In our analysis, we therefore include two ICT equipment indicators expressed as the number of work stations and police vehicle radio stations.

² All of the empirical results in the empirical part of the paper will be related to DEA with an input orientation, allowing for constant returns to scale (CRS). An input orientation focuses on the amount by which the input quantities used can be proportionally decreased without changing the output. We choose input orientation as we assume that police management has a significant influence on input allocation. Indeed, the chosen orientation is the one that best reflects the actual circumstances – it is vital to establish on which element (input, output) managers have the strongest impact (Coelli, Prasada Rao, & O’Donnell, 2005).

³ The following were excluded from the 128 police organisations in Slovenia: border police stations, air police stations, railway police stations, service dog handler stations and traffic police stations (these only operate in the area of traffic).

⁴ A potential limitation of DEA is the sensitivity to proper variable selection. Improper variable selection or omitting relevant variables and/or including irrelevant variables will lead to a biased measurement. Moreover, it is also known that the sample size needs to be large relative to the number of inputs and outputs to prevent the classification of efficiency by default. Therefore, the careful selection of an appropriate set of variables is necessary for a reliable efficiency measurement (Ruggiero, 2005).
- Three (non-discretionary) inputs. This group of indicators represents the burdening of police stations with individual types of events on which the organization largely has no effect. These input indicators are criminal offences, violations of public order regulations, and road accidents. Most previous empirical analyses discussed such inputs as controlled or included them directly in the model (see Akdogan, 2012; Barros, 2006; Drake and Simper, 2005). We decided to include them in the second phase of the analysis (Tobit analysis) because, as mentioned earlier, the police stations cannot influence them. Moreover, for the selection of non-discretionary input indicators the first criterion was substantive and the second statistical, although it should be emphasized that the selection of indicators was largely influenced by the data availability.

- Five outputs. The selection includes those activities performed by individual police stations as part of their (legally prescribed) responses along with some results as a consequence of their activities. We included in the model one ‘desirable’ output (solved criminal offences) and four outputs for which the smallest possible values were desired (‘undesirable outputs’). A monotonically decreasing transformation is applied to the undesirable outputs and then adapted variables are viewed as outputs (Hua & Bian, 2007; Zhu, 2009).

Thus, the selected output indicators are solved criminal offences, road accidents involving minor and serious injuries, average response time of police patrols and use of instruments of restraint and warning shots.

- Solved criminal offences is a commonly used efficiency indicator of the functioning of the police (see Barros, 2006; Diez-Ticio and Mancebon, 2002; Drake and Simper, 2002).

- Road accidents involving injuries. In the area of traffic, we usually monitor reactions to a situation in the traffic (number of recorded traffic accidents, number of traffic offences, number of alcohol intoxication tests etc.). We took a step further and focused on the consequences of traffic accidents and/or the weight of traffic accidents in an area. In road traffic, different indicators of the consequences of traffic accidents are used to measure efficiency, including the number of casualties or serious injuries (Pritchard, Culbertson, Malm, & Agrell, 2009). Similarly, when measuring efficiency in the area of criminal offences the number of murders and the number of crimes committed were considered (Gorman and Ruggiero, 2008).

- Average response time of police patrols has been used frequently is some previous studies (see for instance Drake and Simper, 2002; Pritchard et al., 2009).

- Use of instruments of restraint and warning shots. The police are a state authority which in specific cases has the right to use coercive measures. The use of coercive measures may also result in injuries to citizens and police officers. Therefore, the frequency and scope of these acts must be studied, along with the behavior of both sides and the environment in which the events took place (Alpert & Dunham, 2004). Therefore, this indicator can be used to reveal both the response of the police (due to police officers’ reactions) and the level of reputation of the police in the public, given that the frequency of use of coercive measures is supposed to have a strong influence on public opinion about the police.

In order to show the relationship between the different variables used, we estimated Pearson’s coefficient. The correlations between the theoretical input and output variables proposed for our empirical analysis are given in Tables 2 and 3 where it can be seen, with

### Table 1
Input/output indicators for police activities at the local level in Slovenia (in 2010) – descriptive statistics.

<table>
<thead>
<tr>
<th>Name of Indicator</th>
<th>N</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Inputs (discretionary)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Posts occupied</td>
<td>76</td>
<td>17</td>
<td>141</td>
<td>53.0</td>
<td>32.9</td>
</tr>
<tr>
<td>IT equipment (number of work stations)</td>
<td>76</td>
<td>9</td>
<td>45</td>
<td>19.6</td>
<td>9.5</td>
</tr>
<tr>
<td>Police vehicle radio stations (number)</td>
<td>76</td>
<td>3</td>
<td>53</td>
<td>13.1</td>
<td>9.2</td>
</tr>
<tr>
<td><strong>Inputs (non-discretionary)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Criminal offences (number)</td>
<td>76</td>
<td>101</td>
<td>7,688</td>
<td>1,086.9</td>
<td>1,575.5</td>
</tr>
<tr>
<td>Violations of public order regulations (number)</td>
<td>76</td>
<td>84</td>
<td>3,039</td>
<td>520.6</td>
<td>483.6</td>
</tr>
<tr>
<td>Road accidents (number)</td>
<td>76</td>
<td>29</td>
<td>1,503</td>
<td>276.8</td>
<td>278.5</td>
</tr>
<tr>
<td><strong>Outputs</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Solved criminal offences (number)</td>
<td>76</td>
<td>37</td>
<td>3,798</td>
<td>521.6</td>
<td>659.7</td>
</tr>
<tr>
<td>Road accidents involving serious injury (number)</td>
<td>76</td>
<td>0</td>
<td>51</td>
<td>11.4</td>
<td>9.8</td>
</tr>
<tr>
<td>Road accidents involving minor injury (number)</td>
<td>76</td>
<td>15</td>
<td>970</td>
<td>124.6</td>
<td>141.3</td>
</tr>
<tr>
<td>Average response time of police patrols (in minutes)</td>
<td>76</td>
<td>9.53</td>
<td>475</td>
<td>97.7</td>
<td>89.7</td>
</tr>
<tr>
<td>Use of instruments of restraint and warning shots (number)</td>
<td>76</td>
<td>1</td>
<td>165</td>
<td>37.5</td>
<td>40.2</td>
</tr>
</tbody>
</table>

Source: Ministry of the Interior, 2011; calculations by the authors.

### Table 2
Correlation coefficients among the inputs.

<table>
<thead>
<tr>
<th></th>
<th>Posts occupied</th>
<th>IT equipment (number of work stations)</th>
<th>Police vehicle radio stations</th>
<th>Criminal offences</th>
<th>Violations of public order regulations</th>
<th>Road accidents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Posts occupied</td>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IT equipment (number of work stations)</td>
<td>0.905*</td>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Police vehicle radio stations</td>
<td>0.761*</td>
<td>0.584*</td>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Criminal offences</td>
<td>0.527*</td>
<td>0.630*</td>
<td>0.024</td>
<td>1.000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Violations of public order regulations</td>
<td>0.669*</td>
<td>0.778*</td>
<td>0.212</td>
<td>0.863*</td>
<td>1.000</td>
<td></td>
</tr>
<tr>
<td>Road accidents</td>
<td>0.480*</td>
<td>0.651*</td>
<td>0.165</td>
<td>0.771*</td>
<td>0.702**</td>
<td>1.000</td>
</tr>
</tbody>
</table>

Source: Ministry of the Interior, 2011; calculations by the authors.

*Correlation is significant at the 15 level (2-tailed).
4. Empirical results

Here we present the empirical application of the three-stage Data Envelopment Analysis (DEA) to assess the relative efficiency of police stations in Slovenia. The most efficient are those PSs which, for instance, solve a higher number of criminal offences or have a lower average response time of police patrols per posts occupied. Namely, we established to what extent the individual inefficient units (PS) would have to reduce their inputs (such as number of posts occupied or work stations) to become just as efficient as the best performing units. The key advantage of such analysis lies in the easier interpretation of the calculations and/or the possibility of defining for each inefficient unit how it could become efficient and by how much it must increase individual types of output.

With this goal in mind, we conducted the empirical analysis with the basic data, representing the first stage of the DEA analysis in order to calculate the relative efficiency scores (DEA-I scores) (see Table 4). This stage only includes discretionary inputs (i.e., controlled inputs). The result of this first stage showed the aggregate relative efficiency of the police stations. In the second stage, the effect of the non-discretionary (i.e., uncontrolled) inputs (such as number of criminal offences or road accidents) was separated by using a Tobit regression. The Tobit regression (together with OLS) results are reported in Table 4. The coefficients on the percentage of violations of public order regulations and road accidents both have the expected sign and are significant at the 95% level of confidence. The coefficient on criminal offences is statistically significant but has an unexpected sign. This could be due to the relatively high correlation between criminal offences and violations of public order regulations (0.86) and road accidents (0.77)). In terms of goodness of fit, we see that the equation is statistically significant at the 95% confidence level and $R^2$ is a moderate 0.27. In the third stage, DEA was conducted using both the discretionary and non-discretionary input indicators.

One of the biggest advantages of (input-oriented) DEA analysis is its ability to show the decreases in inputs needed to achieve efficiency. For police managers this is crucial as they obtain a comprehensive and precise picture of the situation of the inefficient police stations. Table 5 displays the results of the average input-oriented local police efficiency indices for each PS in 2010. The average police efficiency score is 78.5, suggesting that the average PS could have achieved the same output using about 21.5% fewer resources.

### Table 3
Correlation coefficients among the outputs.

<table>
<thead>
<tr>
<th></th>
<th>Solved criminal offences</th>
<th>Road accidents involving serious injury</th>
<th>Road accidents involving minor injury</th>
<th>Average response time of police patrols</th>
<th>Use of instruments of restraint and warning shots</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solved criminal offences</td>
<td>1.000</td>
<td>0.676**</td>
<td>0.645*</td>
<td>0.373*</td>
<td>0.830**</td>
</tr>
<tr>
<td>Road accidents involving</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>serious injury</td>
<td>0.676**</td>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Road accidents involving</td>
<td>0.645*</td>
<td>0.658**</td>
<td>1.000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>minor injury</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average response time of</td>
<td>0.373*</td>
<td>0.391**</td>
<td>0.311**</td>
<td>1.000</td>
<td></td>
</tr>
<tr>
<td>police patrols</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Use of instruments of</td>
<td>0.830**</td>
<td>0.579**</td>
<td>0.596**</td>
<td>0.175</td>
<td>1.000</td>
</tr>
<tr>
<td>restraint and warning</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>shots</td>
<td></td>
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</tbody>
</table>

Source: Ministry of the Interior, 2011; calculations by the authors.

** Correlation is significant at the 1% level (2-tailed).

The empirical results show that PS Ribnica is the least efficient police station from an input perspective, indicating it is the only police station wasting more than half (56.1%) of its resources. For instance, according to its relatively poor outputs/outcomes PS Ribnica should reduce its posts occupied (by almost 69%), number of work stations (by around 56%) and police vehicle radio stations (by almost three-quarters) in order to become efficient (see Table 6). In other words, this particular PS has large reserves in its resource use since more efficient use could be translated into better performance. Slightly better organization units are PS Brežice, PS Rače and PS Podlehnik. However, they are still wasting just over half of their resources. These poor efficiency performers share the same characteristics as they use, in general, a relatively high (above-average) quantity of inputs for (mostly) below-average outputs/outcomes.

On the other hand, 15 of the 76 selected PSs analysed with our formulation for police efficiency were estimated as efficient in 2010 (see Table 5). Interestingly, some of them were highly inefficient in the first-stage DEA model. For instance, PS Koper has an efficiency score of just 38.2. However, when accounting for environmental (external) factors, PS Koper becomes an efficient organizational unit (the same applies to PS Maribor II). Indeed, PS Koper has significantly above-average unfavourable conditions, for instance in the form of violations of public order regulations (PS Koper: 1374; average: 510) and road accidents (PS Koper: 677; average: 277). In spite of the just presented case of significant improvements of the efficiency scores, when comparing the DEA-I and DEA-III scores the results reveal that external factors generally do not significantly affect the ranking of PSs. Namely, the Spearman correlation of the rankings formed by the first- and third-stage efficiency scores is relatively high (0.71) and always significant at the 1% level. This result has clear implications regarding the forces that shape efficiency scores since superior external factors appear to be less important than sound management. In turn, this reflects the idea that police management has much to gain by observing and implementing the strategies followed by the efficient PSs, in an attempt to improve their own efficiency scores. (see Table 7).

When comparing the frequency of PSs relating to their posts occupied and relative efficiency scores, we find that the best average efficiency scores are noticed in a group of PSs with less than 25 posts occupied (the best performers are PS Logatec, PS Bovec, PS Hrastnik, PS Medvode, PS Dravograd and PS Šentjernej). This group represents almost one-fifth of all PSs and their average efficiency scores have achieved the same output using about 21.5% fewer resources.

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5 The Tobit regression model is used by many researchers due to the fact that the technical efficiency scores obtained from data envelopment analysis are between 0 and 100. A small number of researchers prefer the OLS method (Afonso & Staubyn, 2006; Simar & Wilson, 2003). However, in our case the Tobit and OLS results are very similar.

6 Our results contrast with Drake and Simper (2005), Diez-Ticio and Mancebon (2002), and Corman and Ruggiero (2008) who use different methodologies (and population is a key environmental variable for establishing police force efficiency). However, our results are in line with Carrington et al. (1997) and Sun (2002) who find environmental variables do not significantly contribute to police efficiency; however, these studies omit population as an environmental variable (similarly to ours).
This is not surprising as we would expect that in small PSs employees and equipment are under great pressure and therefore the efficiency is higher. The largest group of PSs is the one ranging from 26 to 50 posts occupied that accounted for more than 40% of all PSs and had an efficiency score of almost 78 (similar efficiency is found in the PSs with more than 75 employees). The least efficient PSs seem to be those with between 51 and 75 employees (e.g., PS Ribnica, PS Cerknica, PS Krško etc.). Police management should therefore particularly focus on the PSs with more than 50 posts occupied as there seems to be a wide range of opportunities to reduce resources via a contraction of observed input usage or, even more realistically, output/outcome augmentation without changing the use of resources.

5. Conclusions

By upgrading previous analyses and extending them to local levels we provided additional insights into the efficiency of police...
work at the level of police stations in Slovenia in 2010. We used the framework of non-parametric methodology, namely a three-stage DEA procedure enabling the inclusion of the effects by external factors. The study established clear differences in assessments of the efficiency of the functioning of police stations. We found that most of the observed PSs are technically inefficient as approximately 80% of the PSs are inefficient relative to their peers. This suggests that there are reserves that would allow a reduction of inputs (costs) via contraction of the observed resource usage. Moreover, further analysis showed that, in general, PSs with more than 50 posts occupied are on average less efficient. Further, the empirical results also indicated that the differences in the assessment of police stations’ relative efficiency are also due to the differences in external factors (e.g., number of criminal offences and road accidents), even though individual PS characteristics are less important than the governance of a PS in determining its performance.

Nevertheless, we must point out a few areas where caution is required. First, our empirical research mainly focuses on quantitative dimensions of outputs and inputs. However, there are other important qualitative dimensions of outputs that were not taken into account; for example, the quality of police work and police officers. It would be desirable to treat these outputs explicitly in our models. Second, the application of the presented technique was hampered by a lack of suitable data and a precise definition of the inputs and outputs, which may influence the empirical results significantly. Finally, it is important to note that our findings are important indicators of the relative efficiency (or inefficiency) of PSs, which can serve as a guide for police management when further investigating how to enhance the performance efficiency of police units.

Acknowledgments

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References