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Improving the Sustainability of Individual, Motorised Transport by Implementing E-government System

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Abstract

Present day's world is dominated by a set of problems that affect almost all aspects of people's lives (e.g. energy crisis, labor shortages, inflation, etc.). These challenges also have a major impact on transport through its institutional-economic-social interactions. The institutional environment also has a significant impact on the transport system, due to the two-way nature of the systemic interactions. This makes it particularly important to examine the transport aspect of the digitalization of procedures in public administration institutions. The research develops a methodology to quantify the transport energy savings and to increase the sustainability of mobility by developing SMART solutions already applied in public administration, which is presented through a case study in Hungary.

Keywords

sustainable transport, e-government, digital administration, energy crisis, private transport, SMART solutions

1 Introduction

All sectors are trying to find appropriate solutions to mitigate the problems that are dominating our lives today. In transport, there is a proliferation of alternative propulsion vehicles (Lakatos et al., 2024). Methodologies has been developed to optimise the operation costs (Qiu et al., 2023), energy management (Zsombok, 2024), and charging procedures (Gao et al., 2024) as well as possibilities (Csonka et al., 2020) and risks (Yildiz et al., 2024). Using environmental friendly vehicles (Matijošius et al., 2022) reduces the level of global greenhouse gases (Al-lami and Török, 2025), Also the optimization of transport needs should be done to reduce the number of road accidents (Ghadi et al., 2018) and increase the level of road safety (Ötvös et al., 2025). This can be achieved, among other aspects, through the continuous development and expansion of eGovernment functions (Álvarez-Herranz and Martínez-Ruiz, 2012).

Many researches are available in the field of e-government. Most of the recent studies were carried out in Asia and the Middle East, as well as in India and Pakistan, regarding the European Union the researches have been made between 2005-2015.

In a general manner, an index was developed to measure the quality of e-government services and the results show a partial correlation between the quality of e-government service and trust in government (Myeong et al., 2014). Furthermore Khanna et al. (2021) explored the potential of Blockchain technology (combines cryptography and distributed computing to provide a multiparty consensus algorithm to securely exchange value) as an enabler for e-governance in smart cities. On the basis of a comprehensive literature review, they identified four key areas of e-governance wherein Blockchain can provide monumental advantages. Moreover Nam (2022) proposed the Data Envelope Analysis (DEA) method to present a method of improving Information and Communications Technology (ICT) network readiness between countries and derived the ICT network's readiness competency level and strategic plan by comparing each country for efficient ICT operation of e-governments. Xia (2017) found that open data have a positive impact on the government's transparency, moreover E-participation has a positive impact on the offline political participation and the level of liberty. A binary logistic

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regression model has been used to determine the profile of e-government users (Rodriguez-Hevía et al., 2020). Kaye (2011) thinks that improving the e-governance system requires the development of a global system of governance, that does not seek to throw away all of the principles or mechanisms that have been developed over time.

Regarding the European Union, an index (Digital Economy and Society Index – DESI) was created to summarize indicators on Europe's digital performance and tracks the progress of EU countries. The European Commission has been monitoring Member States' digital progress through the DESI reports since 2014, as well as the permoance of the road traffic (Mansouri Kaleibar and Krmac, 2024). The methodology of the index is based on dimensions as Human capital, Connectivity, Integration of digital technology and Digital public services. The last dimension is equal to e-Government (European Commission, 2022). Based on the researches it can be stated that technology is used as a strategic tool to modernize structures, processes, regulatory frameworks, human resources and the culture of public administrations to provide better government, but e- Government needs to be more knowledge-based, user-centric, distributed, and networked (Centeno et al., 2005). Torres et al. (2005) defined two findings: first shows that, the issue is no longer whether government is online, but in what form and with what consequences; second shows that the transition to e-government seems to be following a more or less predictable development process, albeit with different speeds between countries and within the cities of each country. Lupu and Lazăr (2015) states (by examining EU and Non-EU states) that increasing the use of e-government will reduce corruption. It should be stressed that the introduction of the technology will only reduce low level corruption, i.e. it will prevent the transfer of bribes in the preparation of various documents (e.g. passports). Guijarro (2007) conceptualize a two-phase interoperability roadmap. A first phase would consist of enabling interoperability; second phase facilitates the alignment of the administrative procedures with the technical systems. It is validated by Xin et al. (2022). Pina et al. (2009) examined the trends of e-government in transparency, openness and hence accountability in European Union and noticed the progress in the application of ICTs and increasing EU local government concern for bringing government closer to citizens and for giving an image of modernity and responsiveness. Yera et al. (2020) analysed the e-Government adoption or practical use of e-Government across Europe by using the level of e-readiness of a country (e.g. the frequency of buying goods over the Internet or the education level) traces the development of e-government and its applications across Europe, exploring the effects of information and communication technology (ICTs) upon political action and processes. Van Rossum and Dreessen (2007) examined a range of concepts and topics underpinning e-government in Europe (UK, France, Germany, Denmark, The Netherlands, Portugal, Greece, Slovenia, Hungary, and Estonia): the degree to which e-government translates into genuine reform of government and public administration the dual role of the EU as both a provider of e-government through its own internal activities and also as a facilitator or aggregator in the way it seeks to engender change and promote its ethos in member states across the EU cyberterrorism and its use both by terrorists and governments to pursue political agendas. Ardielli and Halásková (2015) ranks all of the European Union states based on a criteria-method (e-government indicators - User Centric Government, Transparent Government, Citizen Mobility, Business Mobility, Key Enablers, Online Service Index, E-Participation Index, Individuals Using Internet and Enterprises Using Internet) and finds that Hungary places in the "below-average country" category.

In Hungary Szeróvay (2011) finds that while the site provides a wide range of information and services, some work still needs to be undertaken in order to make it more user-friendly. Szilágyi and Szilágyi (2009) states that there is much room for improvement in the field of mobile/electronic services in Hungary, but there are successful services too, the SMS-based services become more and more popular. Based on the research of Aranyossy (2018), the results imply that the Hungarian government can further increase the usage of e-government services by influencing effort expectancy, trust of internet, facilitating conditions, user experience or habits.

The quality of Romanian cities' official websites was measured using five critical criteria of website quality or performance: personal data security, usability, content, services, and citizen participation. They find that the improvements of websites have been incremental rather than transformational (Gavriluță et al., 2022). structured equation modeling (SEM) and Amos were used to interpret quantitative research results regarding e-government services which showed that values are strongly correlated with expectations about others' efforts. An invaluable feature of e-government services is their simplicity of use. In Iraq the unified theory of acceptance and use of technology (UTAUT) is applied and extended to study citizens' behavior regarding e-government services, which showed that there were statistically significant differences in the demographic characteristics of age, educational level excluding gender, and behavioral intention to use e-government services (Zeebaree et al., 2022). In The Netherlands government officials and citizens are not motivated by the promise of technology but by frames that connect technological opportunities to the production of public value (Meijer, 2015).

Regarding the Middle-East, in case of Pakistan, Zahid and Haji Din (2019) made the decompose theory of planned behavior (DTPB) model which results indicated that trust and its antecedents (economic bonds, social bonds, and structural bonds), attitude and its antecedents (performance expectancy, effort expectancy), subjective norms and their antecedents (mass media influence, family influence), perceived behavioral control and its antecedents (self-efficacy) have significant and positive effect on intention. Ullah et al. (2021) investigated the role of e-governance in combating COVID-19 by integrating the implications of the China–Pakistan Economic Corridor.

Due to Asia, in Korea, five complementary factors have been identified to account for this success (Turner et al., 2022). They are the legacy of the developmental state in defining government's role in economic development; the impact of democratization on the nature of e-government services and provision; the shock impact of the Asian Financial Crisis that led to accelerated e-government development; the creation and maintenance of an effective policy process; an effective system of public administration. Choi (2015) emphasises that the commitment of leadership, cultural adaptability, and procedural intermediation is needed for performance-oriented e-governance in Northeast Asia.

Examing the Indian e-governance system Addo and Senyo (2021) found that advancing e-governance for development by showing how digital identity might enable inclusion. Goel et al. (2012) defined the risks of developing e-governance through a case study Haryana Urban Development Authority.

In Canada, Allen et al. (2001) examined that Government must produce a new "culture" in order to harness the enormous potential of digital government. Pathak et al. (2007) developed that e-Governance can help not only in weeding out corruption but also in the establishment of sounder government citizen relationships in Ethiopia.

As the literature research shows, on the one hand, there is only a few research available regarding the transportation aspects of e-government in the European Union, and on the other hand, the currently operating e-government system is based on an unbroken arc of development that began in the past, but since 2015, technology has developed so rapidly that e-government has not followed this change. For this reason, the integration of the latest technological possibilities is missing, especially in Hungary.

The new technologies also have affects to the transport, because more available online administrative services can result less mobility demands. This research explores the interaction between e-government and transport from the perspective of how digitally executable administrative procedures affects the performance and energy demand of the transport system.

2 Methodology

The methodology developed examines the relationship between the development of e-government system elements and transport using a complex approach. The structure of the model and the interrelationships between the elements are shown in Fig. 1.

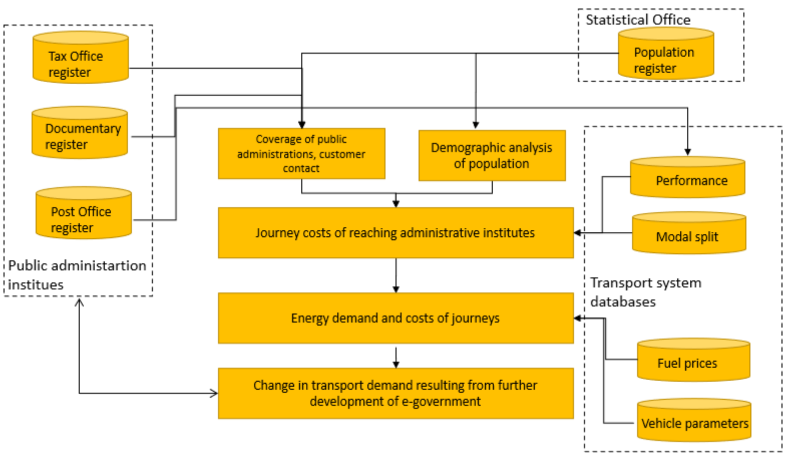

Fig. 1 Structure of the methodology (own source)

The following notations are used in the methodology:

- i – territorial units [–]
- j – public administration institution [–]
- $M_{i,j}$ – number of official working days in a year for j administrative institutions i territorial unit [day/year]
- $m_{i,j}$ – average official working time in j administrative institutions i territorial unit [hour/day]
- $n_{i,j}$ – number of customers served simultaneously regarding j administrative institution i territorial unit [persons]
- $W_{i,j,\max}$ – theoretical, maximum, annual performance of j administrative institution i territorial unit [persons/year]
- $\eta_{i,j}$ – the number of transactions per resident per year regarding j administrative institution i territorial unit [case/year]
- L_i - number of inhabitants in i territorial unit [persons]
- $N_{i,j}$ – number of j administrative institution in i territorial unit [pieces]
- $r_{i,j}$ – radius of covered area in i territorial unit by j administrative institution [km]
- T_i – maximum theoretical annual performance of journeys to j administrative establishment in territorial unit i [km/year]
- $W_{\text{journey},i,j}$ – Percentage of population aged 65 and over in total society by i territorial unit [%]
- φ_i – Population per i territorial unit corrected for the proportion of the population aged 65 and over [persons]
- $L_{i,corr}$ – area of i territorial unit [km^2]
- γ_i – share of individual motorised transport in modal split in i territorial unit [%]
- $W_{PrT,\text{journey},i,j}$ – the theoretical maximum annual performance of journeys to j administrative establishment by private motorised transport in territorial unit i [km/year]
- $W_{PrT,\text{journey}}$ – the theoretical maximum annual performance of journeys to all administrative establishment in all territorial unit [km/year]
- $E_{PrT,\text{journey}}$ – the theoretical maximum annual energy demand for journeys to all administrative establishments in all territorial unit [l/year]
- $F_{\text{fuel,average}}$ – average fuel consumption of an individual motorised vehicle [l/100 km]
- C_{fuel} – world fuel prices [€/l]
- $C_{PrT,\text{journey}}$ – the theoretical maximum annual energy cost of journeys to all administrative establishments in all territorial unit [€/year].

The methodology developed is based on (public) data from national and governmental databases, of which the following need to be examined.

Customer contact data of public administrations:

- the number of offices available in a territorial unit;
- the size of a territorial unit;
- opening hours of offices, number of working days per year;
- average number of clients served per hour.
- population register data:
- number of people living in a territorial unit;
- age distribution of the population living in a territorial unit.

From these data, a theoretical maximum value Eq. (1) of the specific performance of each institution – per year – can be calculated, assuming that each administrator of each institution is in charge of a case at all times. In practice, this assumption may prove to be correct, as the online booking system shows that all the appointments offered are booked weeks or months in advance.

$$W_{i,j,\max} = M_{i,j} \times m_{i,j} \times n_{i,j} \tag{1}$$

The theoretical maximum value of the specific performance divided by the number of inhabitants gives the average number of transactions per inhabitant per year in each institution, i.e. the mobility indicator for the specific transaction motivation can be determined Eq. (2).

$$\eta_{i,j} = \frac{N_{i,j} \times W_{i,j,\max}}{L_i} \tag{2}$$

The theoretical maximum length of a journey Eq. (3) for administrative purposes can be derived from the size of the area covered by each institution.

$$r_{i,j} = \sqrt{\frac{T_i}{\pi \times N_{i,j}}} \tag{3}$$

In addition to the mobility needs, the specific (annualised) travel performance can be calculated Eq. (4) based on the area covered by each institution by taking into account the length of journeys.

$$W_{\text{journey},i,j} = r_{i,j} \times L_i \times \eta_{i,j} \tag{4}$$

Based on the use of digital devices by demographic groups, the methodology assumes that the older age group (over 65) prefers to use in-person. Thus, this stratum is not calculated in the analysis (i.e. they prefer face-to-face regardless of the penetration of e-government systems), which requires the following Eq. (5) adjustment to the population pattern.

$$L_{i,corr} = L_i \times (1 - \varphi_i) \tag{5}$$

In addition, the mode of transport is also important regarding the journeys, as public transport is used by individuals with a wide range of travel motivations. Therefore, the present methodology examines individual travel by motorised means using the modal split indicator with the Eq. (6) formula.

$$W_{PrT,\text{journey},i,j} = W_{\text{journey},i,j} \times (1 - \varphi_i) \times \gamma_i \tag{6}$$

By summing up the individual sub-elements, it is possible to calculate the transport performance for all administrative institutions, covering several territorial units Eq. (7).

$$\begin{aligned} W_{PrT,\text{journey}} &= \sum_i \sum_j W_{PrT,\text{journey},i,j} \\ &= \sum_i \sum_j \left(\begin{array}{l} \dfrac{N_{i,j} \times M_{i,j} \times m_{i,j} \times n_{i,j}}{L_i} \times \sqrt{\dfrac{T_i}{\pi \times N_{i,j}}} \\ \times L_i \times (1 - \varphi_i) \times \gamma_i \end{array} \right) \end{aligned} \tag{7}$$

The energy demand Eq. (8) and the financial implications Eq. (9) of the administrative journeys are determined by the transport performance, the average fuel consumption of vehicles and the world market price of fuel.

$$E_{PrT,\text{journey}} = \frac{W_{PTU,\text{journey}}}{100} \times F_{\text{fuel,average}} \tag{8}$$

$$C_{PrT,\text{journey}} = E_{PrT,\text{journey}} \times C_{\text{fuel}} \tag{9}$$

The methodology can be used to calculate the energy demand of individual motorised transport for administrative purposes for the whole governmental system, but also for each territorial unit and administrative institution. In other words, the theoretical maximum energy savings that can be achieved by developing and introducing e-government tools can be determined.

It should be underlined that the methodology has the following limitations:

- the research does not take into account other costs (e.g. from accidents, road maintenance), including externalities (e.g. emissions), arising from individual motorised transport;
- the methodology is based on data available on the internet. The methodology can be further refined if institution-specific data series (which institution, which specific transaction takes place in which period) are published as public data;
- additional – even personal and sensitive – data collected during the administration (e.g. age, distance of residence from the institution, etc.) are not taken into account, but can be incorporated into the methodology if available;
- the methodology can be improved by taking into account alternative propulsion vehicles (e.g. electric, diesel-electric hybrid, hydrogen, LPG, CNG, CBG). This research is based on the most common petrol and diesel vehicles.

3 Results, case study

The methodology is presented through a case study in Hungary. In the Central European country, the tax office (National Tax and Customs Office) and the government offices (e.g. for preparing documents, applying for social benefits, etc.) are the main administrative institutions with a significant customer flow. The Magyar Posta Zrt. (Hungarian Post Office), which carries out postal operations, also has a high number of customer contacts, but detailed data on this are not available (only in aggregate), so trips related to cheque payments and mailing are not part of this case study.

Certain procedures of both institutions can already be handled electronically (on the magyarorszag.hu website, using the Client Gateway application), which has a significant impact on reducing the need to move. These include:

- the preparation of the annual tax declaration (for all individuals over 18 years of age) and tax operations concerning businesses (annual and quarterly declarations). Before the introduction of digital e-government, the documents required for tax declarations were delivered by Magyar Posta and all individuals and businesses had to post them at the post office, generating a considerable need for transport;
- notification of changes in property (e.g. real estate, motor vehicle), tax assessment;
- enrolments in public education;
- pension administration, etc.

In addition to the hundreds of administrative procedures, many cases can currently only be handled in person or using a special terminal (which is not popular with the public because of its cost). For example:

- producing various documents (identity card, address card, passport, social security card, tax card, etc.);
- administrative tasks following the purchase of a new vehicle (e.g. naturalisation, registration, etc.);
- applying for authenticated documents for various social benefits;
- marriage related administrative formalities.

From the above, it can be concluded that e-government enables the digital management of a large number of administrative procedures, but the number of procedures to be handled in person is still significant, and therefore has a traffic-generating (traffic-attracting) effect. This is also shown by the fact that public administrations are operating at capacity utilisation rates of almost 80%.

Using the methodological calculations, the results for these Hungarian offices are shown in Tables 1 and 2. The opening time of each office varies from day to day, but averages 8 hours per day, for 200 working days per year (national holidays and public holidays and Sundays), with 6 opening windows at the same time.

This results in the following specific annual maximum theoretical performance-outputs (Eqs. (10), (11)) for the Government Offices and the Tax Offices:

$$W_{i,govoffice,\max} = 9{,}600 \text{ h} \quad (10)$$

Table 1 Results of calculations carried out according to the methodology for government offices (own source)

Name of territorial unit	$N_{i,j}$ [pieces]	L_i [persons]	T_i [km²]	$r_{i,j}$ [km]	$W_{journey,i,j}$ [km]	$W_{PTU,journey,i,j}$ [km]
Budapest	28	1,630,320	525	2	23,453	11,194
Pest	33	1,353,891	5,865	8	72,206	34,464
Bács-Kiskun	19	512,280	8,443	12	114,174	54,495
Baranya	15	373,043	4,430	10	93,079	44,427
Békés	18	335,374	5,630	10	95,789	45,720
Borsod-Abaúj-Zemplén	24	654,126	7,247	10	94,117	44,922
Csongrád	14	401,292	4,262	10	94,502	45,106
Fejér	13	425,490	4,358	10	99,167	47,333
Győr-Moson-Sopron	12	465,659	4,208	11	101,425	48,410
Hajdú-Bihar	19	534,219	6,209	10	97,911	46,733
Heves	9	294,475	3,637	11	108,880	51,968
Jász-Nagykun-Szolnok	16	368,848	5,581	11	101,156	48,282
Komárom-Esztergom	10	304,962	2,264	8	81,496	38,898
Nógrád	6	189,895	2,544	12	111,527	53,232
Somogy	15	311,108	6,065	11	108,910	51,983
Szabolcs-Szatmár-Bereg	25	562,184	5,933	9	83,438	39,825
Tolna	10	217,307	3,073	10	94,946	45,318
Vas	13	250,347	3,336	9	86,764	41,412
Veszprém	14	344,905	4,463	10	96,704	46,157
Zala	10	273,691	3,784	11	105,359	50,288

Table 2 Results of calculations carried out according to the methodology for tax offices (own source)

Name of territorial unit	$N_{i,j}$ [pieces]	L_i [persons]	T_i [km²]	$r_{i,j}$ [km]	$W_{journey,i,j}$ [km]	$W_{PTU,journey,i,j}$ [km]
Budapest	5	1,630,320	525	6	55,500	26,460
Pest	6	1,353,891	5,865	18	169,338	80,734
Bács-Kiskun	4	512,280	8,443	26	248,837	118,635
Baranya	1	373,043	4,430	38	360,494	171,869
Békés	1	335,374	5,630	42	406,397	193,754
Borsod-Abaúj-Zemplén	8	654,126	7,247	17	163,016	77,720
Csongrád	5	401,292	4,262	16	158,131	75,391
Fejér	6	425,490	4,358	15	145,970	69,593
Győr-Moson-Sopron	4	465,659	4,208	18	175,673	83,754
Hajdú-Bihar	2	534,219	6,209	31	301,781	143,877
Heves	6	294,475	3,637	14	133,350	63,576
Jász-Nagykun-Szolnok	1	368,848	5,581	42	404,625	192,909
Komárom-Esztergom	6	304,962	2,264	11	105,210	50,160
Nógrád	2	189,895	2,544	20	193,170	92,096
Somogy	4	311,108	6,065	22	210,902	100,550
Szabolcs-Szatmár-Bereg	3	562,184	5,933	25	240,865	114,835
Tolna	2	217,307	3,073	22	212,306	101,219
Vas	5	250,347	3,336	15	139,902	66,700
Veszprém	7	344,905	4,463	14	136,761	65,202
Zala	2	273,691	3,784	25	235,590	112,320

$$W_{i,taxoffice,\max} = 9{,}600 \text{ h} \quad (11)$$

Aggregated data on the age structure of territorial units are available in the database of the Hungarian Central Statistical Office, which defines Eq. (12) the proportion of the population aged 65 and over.

$$\varphi_i = 20.45\% \quad (12)$$

The modal-split of private motorised transport can also be defined in national volume Eq. (13).

$$\gamma_i = 60\% \quad (13)$$

Note that for sufficiently detailed data, both the share of the population aged 65 and over and the mobility share of individual motorised transport can be provided by the methodology.

Summarising the theoretical maximum mobility performance values calculated for the Government Office and the tax offices, the theoretical maximum mobility required for the whole system for the administration Eq. (14) is:

$$W_{PrT,\text{journey}} = 2{,}891{,}517 \text{ km/year} \quad (14)$$

Using the world market price of fuel of €1.5 per litre and car fuel consumption of 6 l/100 km, the theoretical maximum energy demand and its cost implications are in Eqs. (15), (16).

$$E_{PrT,\text{journey}} = 173{,}491 \text{ l/year} \quad (15)$$

$$C_{PrT,\text{journey}} = 260{,}237 \text{ €/year} \quad (16)$$

4 Conclusion

The methodology for assessing the transport implications of using e-government tools is generally applicable to any area or country. It can be used to highlight the maximum mobility demand associated with the digital administrative development of a territory or country. In other words, the mobility performance, energy and cost required to carry out administrative tasks is decisive.

The Hungarian case study shows that the cost of the energy needed to journeys is more than 260,000 € per year, only including the cost of the energy needed. Following costs can be included in the further researches to define a more detailed value:

- the cost of travel time;
- the external costs;
- the costs of transport accidents;
- transportation performance regarding digital administration over the age of 65.

Assuming that around € 5 million can be spent on administrative services that are currently only available in person (e.g. car-related issues; document applications), 5% of the investment is recovered only from the mobility energy savings.

Based on the above, the development of e-government tools and the expansion of the range of services available is therefore very important, as it contributes to increasing the sustainability of transport and mitigates the impact of the energy crisis.

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