

Is the digital reform of governmental services a good way to address climate change? Case Study of Market Surveillance E-infrastructure

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Abstract. With the growth of global warming, climate risk management has become an urgent task in the world. The digital reform of government service, known as the e-government, integrates information and communication technology into the structure of governments to promote administrative openness and citizen engagement through high-quality public services. This study compared the ecological and economic performance of e-government services with traditional offline government services. The time consumption, carbon emissions, and cost spending for each identified service touchpoint were estimated using the Green-computing-based Performance Assessment method. The simulation under the AnyLogic environment was applied. The results show that e-government services are the most efficient, ecological, and economical. The stakeholder analysis revealed that enterprises contribute the most time, cost consumption, and carbon emissions. Although the e-government undertook more carbon emissions and costs than the traditional mode, comparing with enterprises, the overall contributions from government are negligible.

Keywords: E-government, Ecological performance assessment, Green-computing-based assessment.

1. Introduction

Climate change and its effects have intensified recently [1]. With the growth of global warming, reducing carbon emissions and climate risk management has become an urgent task in the world. E-government integrates information and communication technology (ICT) into the structure of governments [2] to promote administrative openness and citizen engagement, provide high-quality public service, and boost governments' efficiency [3]. In the digital era, the positive opinion indicated that building digital climate-resilient infrastructure will contribute to sustainable development goals (such as the Net Zero target) and safeguard our societies and economies [4]. The Global e-Sustainability Initiative, representing a worldwide network of IT companies, claimed that digitalization can achieve a significant 20% reduction in global carbon emissions [5]. However, the opposite voice claims that ICT has significantly exacerbated environmental pollution, with the rebound effect of information technology being a significant contributor [6]. The research aims to investigate whether the digital reform of government services should be promoted to adapt to climate change.

2. Research Method

2.1 Research Framework

Figure 1 shows the comprehensive research framework. A new company registration case from market surveillance was first applied to compare the performance of e-governmental services (M1)

and traditional governmental services (M2). Onsite observation was first conducted. Two governmental service modes were identified: the service blueprints, key stages, and touchpoints for e-government and traditional governmental services. The time consumption, carbon emissions, and costs were estimated using the green-computing method mentioned in the following. Hence, the ecological, efficient, and economic performance were assessed and compared.

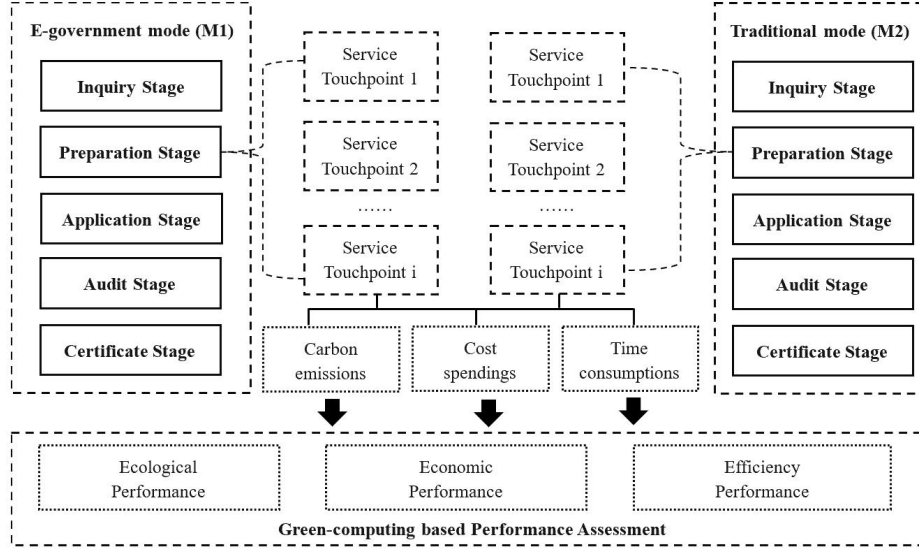


Fig. 1. The research framework

2.2 Data collection

The collected data is based on onsite observation and time measurement. To understand key service stages and touchpoints, the author played a role in a new enterprise applicant and experienced the whole procedures of both e-government and traditional governmental services. Meanwhile, experts working in relevant positions were consulted to validate the identified procedures. The time consumption, the type of energy used, the quantity of applied equipment and resources, and unit cost were collected for each governmental service touchpoint.

2.3 Method of Green-computing based Performance Assessment

To estimate the carbon emissions, the carbon emission accounting method for public utilities published by the Chinese government was applied in this research. The total carbon emission is the sum of consumptions of fuels, electricity, and thermal energies. Thus, the equation is shown as Eq (1).

$$E_{\text{total}} = \sum_{i=1}^n (AD_i \times EF_i) + \sum_{i=1}^n (T_{st} \times E_{ac} \times EF_e) \quad (1)$$

Where E_{total} is the total carbon emissions, the unit is tCO₂; AD_i is the consumption of fossil fuels within the statistical interval, the unit is t; EF_i is the emission factor of type I fuel, the unit is tCO₂/GJ; T_{st} is the time consumptions of each service touchpoint, the unit is h; E_{ac} is the average electricity consumption of a computer per hour, the unit is MWh, and EF_e is the coefficient of carbon emissions in certain regions, the unit is tCO₂ /MWh; i is the type of fossil fuel.

The cost accounting mainly comes from electric charges, transportation fees, printing fees, and charges for the working time, see Eq (2).

$$C_{\text{total}} = \sum_{j=1}^m (C_{\text{electricity}} + C_{\text{transportation}} + C_{\text{printing}} + C_{\text{labor}}) \quad (2)$$

Where C_{total} is the total cost that should be estimated, the unit is RMB Yuan; $C_{\text{electricity}}$ is the electric charge, which is the production of the unit electricity price, and the total energy

consumption, the unit is RMB Yuan. $C_{\text{transportation}}$ is the transportation fee, the unit is RMB Yuan; C_{printing} is the printing fee, the unit is RMB Yuan; and C_{labor} is the charge for the working time loss, which is the production of the unit labor cost loss and the time consumption, the unit is RMB Yuan; j is the j -th identified service touchpoint.

2.4 Simulation

AnyLogic® was applied to simulate the e-government and the traditional government service scenarios through Unified Modeling Language. Figure 2 displayed a fragment of the governmental service blueprint simulated via the AnyLogic environment. The model elements represent identified service touchpoints with the setting values of resource consumption, energy, time, and labor—the parameters aligned with each resource type regarding the Green-computing-based Performance Assessment method. The simulation was set as 2000 days. For each day, 192 enterprise applicants were designed according to the onsite consultancy. As a result, accumulative carbon emissions and costs of M1 and M2 for 2000 days were obtained for analysis.

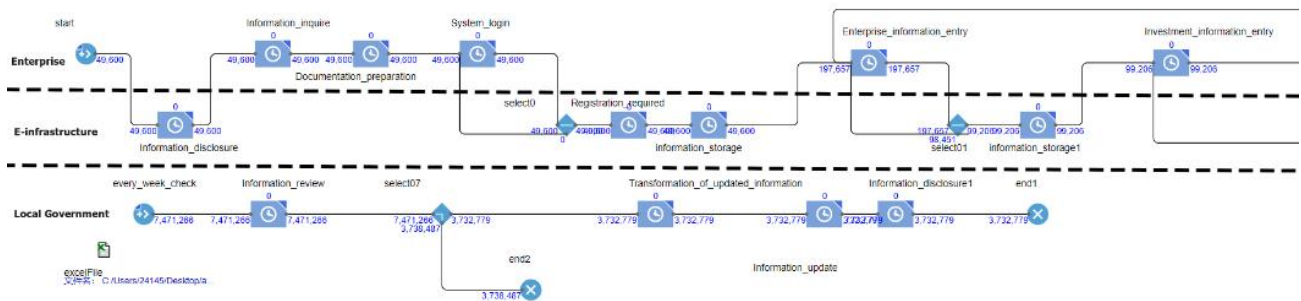


Fig. 2. Fragment of e-government service blueprint simulated via Anylogic®

2.5 Data analysis

Descriptive analysis and comparative analysis were introduced. The normal distribution of the generated data from the simulation was tested. Mean and standard deviation were obtained, and the accumulative values were predicted. The paired t-test is further applied to investigate the difference between e-government and traditional government services.

3. Results

3.1 Comparative analysis of e-government and traditional government services

Figure 3a shows the accumulative carbon emissions and costs of e-government and traditional government services. It indicated that M1 (1170.616 tCO₂) generates less carbon emissions in total than M2 (2910.28 tCO₂). The enterprise contributes the most carbon emissions in M1 (1106.33 tCO₂) and M2 (2751.270 tCO₂). The national MSA contributes the carbon emissions in M1 (0.6994 tCO₂) and M2 (0 tCO₂). Local MSA generates more carbon emissions in M2 (159.01 tCO₂) than in M1 (61.89 tCO₂).

As for the costs, Figure 3b indicates that M1 (1.5E+08 RMB Yuan) costs less than M2 (2.29E+08 RMB Yuan). The enterprise contributes the most costs in M1 (1.4E+08 RMB Yuan) and M2 (22.3E+08 RMB Yuan). The national MSA contributes the cost in M1 (1.084E+05 RMB Yuan) and M2 (0 RMB Yuan). Local MSA generates more costs in M1 (8.307+06 RMB Yuan) than in M2 (4.247E+06 RMB Yuan).

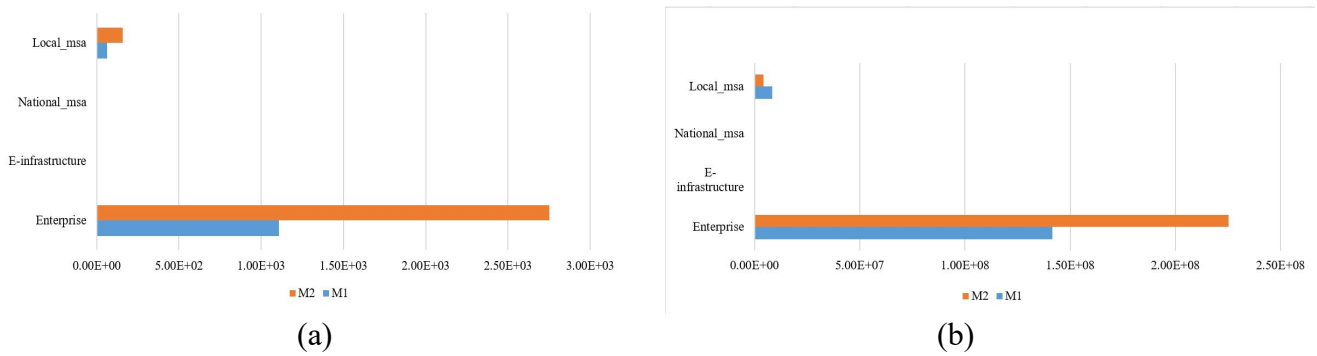


Fig. 3. Carbon emissions (a) and cost spending (b) regarding two governmental service modes

The accumulative carbon emissions and cost spending were calculated to compare the differences between M1 and M2. Table 1 shows the paired T-test results. The enterprise in the M1 scenario contributes less carbon emissions than M2 with a significant paired difference of $-8.22\text{E}+02$ (S.D. is $4.75\text{E}+02$; $p < 0.0001$). The local MSA in the M1 scenario contributes less carbon emissions than M2 with a significant paired difference of $-4.86\text{E}+01$ (S.D. is $2.80\text{E}+01$; $p < 0.0001$). As for the costs, the enterprise in the M1 scenario spends less costs than M2 with a significant paired difference of $-4.19\text{E}+07$ (S.D. is $2.42\text{E}+07$; $p < 0.0001$). However, the local MSA in the M1 scenario spends more costs than M2 with a significant paired difference of $2.03\text{E}+06$ (S.D. is $1.17\text{E}+06$; $p < 0.0001$).

Table 1. Paired T-Test Results

| | | Paired Differences | | | t | df | Sig. (2-tailed) |
|--------|---|--------------------|-------------------|-------------------|--------------------|-------------------|-----------------|
| | | Mean | Std. Deviation | Std. Error Mean | | | |
| Pair 1 | M1_enterprise_carbon - M2_enterprise_carbon | $-8.22\text{E}+02$ | $4.75\text{E}+02$ | $1.06\text{E}+01$ | $-7.75\text{E}+01$ | $2.00\text{E}+03$ | 0.000 |
| Pair 2 | M1_enterprise_cost - M2_enterprise_cost | $-4.19\text{E}+07$ | $2.42\text{E}+07$ | $5.40\text{E}+05$ | $-7.75\text{E}+01$ | $2.00\text{E}+03$ | 0.000 |
| Pair 3 | M1_LMSA_carbon - M2_LMSA_carbon | $-4.86\text{E}+01$ | $2.80\text{E}+01$ | $6.27\text{E}-01$ | $-7.75\text{E}+01$ | $2.00\text{E}+03$ | 0.000 |
| Pair 4 | M1_LMSA_cost - M2_LMSA_cost | $2.03\text{E}+06$ | $1.17\text{E}+06$ | $2.62\text{E}+04$ | $7.75\text{E}+01$ | $2.00\text{E}+03$ | 0.000 |

3.2 Comparative analysis of key governmental service stages

According to Figure 4a, M1 is the most environmentally friendly way for enterprises. During the consultancy stage ($8.49\text{E}+02$ tCO₂ in M2 and $5.66\text{E}+00$ tCO₂ in M1) and application stage ($8.56\text{E}+02$ tCO₂ in M2 and $4.41\text{E}+01$ tCO₂ in M1), M2 contributes much more carbon emissions than M1. The reason for this phenomenon is that enterprises will contribute a lot of carbon emissions in traffic. In Figure 4b, the national MSA in M1 generates much more carbon emission than M2 in the consultancy stage ($4.87\text{E}-01$ tCO₂) and application stage ($2.13\text{E}-01$ tCO₂), which causes the M2 to be more environmentally friendly than M1. Figure 4c shows that the local MSA in M2 generates carbon emission than M1 in all stage.

Figure 4d shows that the e-government mode (M1) is a more economical option for enterprises, which is caused by the high cost of M2 in the consultancy ($5.02\text{E}+07$ RMB Yuan) and application stage ($5.04\text{E}+07$ RMB Yuan). In Figure 4e, the national MSA in M1 consumes more money than M2 in the consultancy stag because the National MSA is not participate in the M2. In Figure 4f, M2

is the most economical way toward the local MSA because M1 costs more money in the stages of audit (2.23E+06 RMB Yuan) and certificate stage (6.08E+06 RMB Yuan).

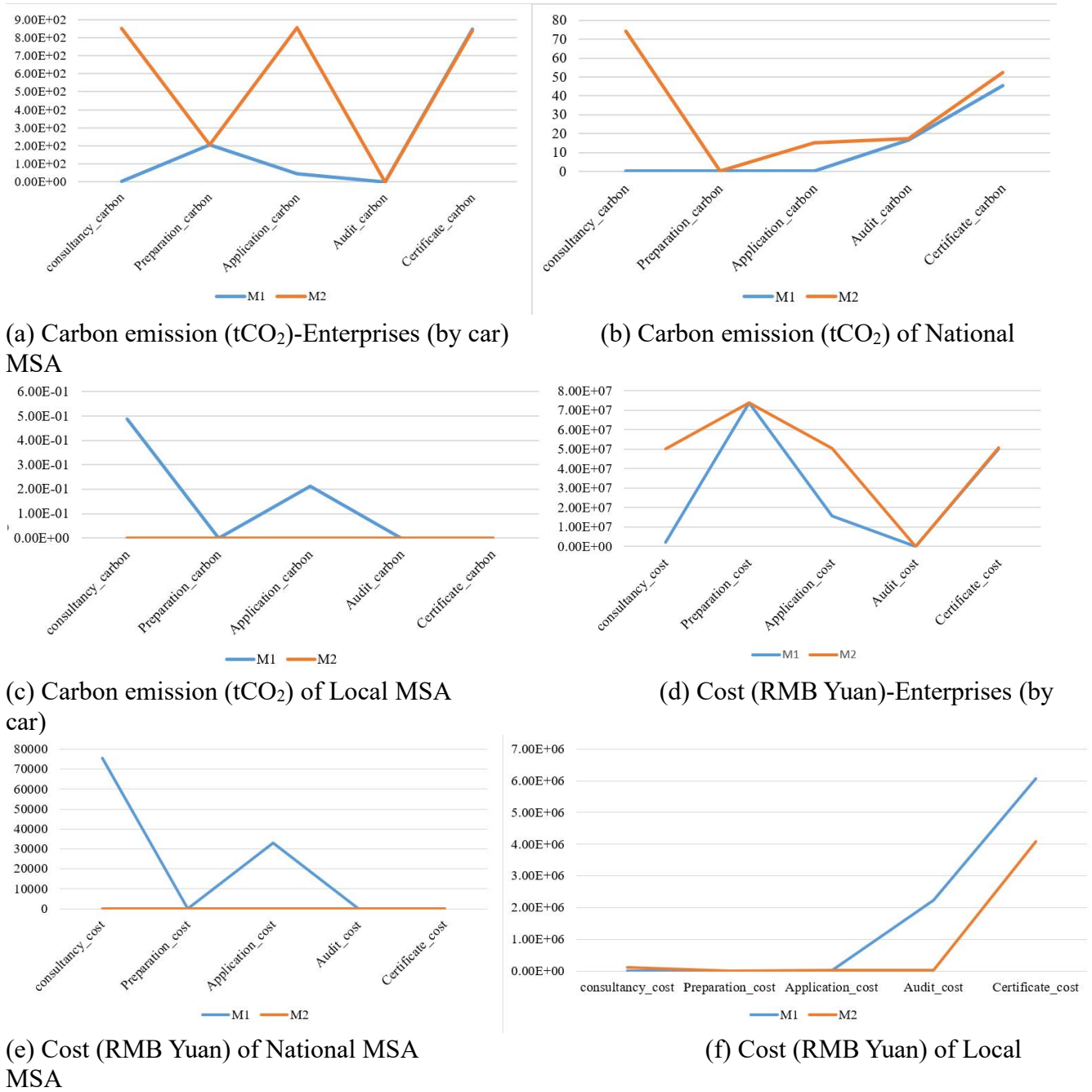


Fig. 4. Carbon emissions regarding different stages

4. Discussion and Conclusion

E-government services are the most efficient, ecological, and economical way. Through this study, the e-government mode is a more efficient, low-carbon, and economical option, which means it can contribute to protecting the natural environment. The most significant reason is that the e-government services do not need traffic, contributing to time consumption, carbon emissions, and costs. The research also indicated that the digital reform of governmental services is a trend to adapt to climate change.

Enterprises contribute the most time and cost consumption and carbon emissions. The enterprise takes the most time and economic cost and contributes the most carbon emissions in e-governmental and traditional offline services. Thus, decreasing enterprises' carbon emissions, cost, and time consumption is still a worthy issue for policymakers to address. For example, Certificates can be made electronically or collected by Courier, reducing unnecessary time, carbon emissions, and financial costs in the certificate stage of M1 and M2.

Although the e-government undertook more carbon emissions and costs than the traditional mode (see Fig 4c, Fig 4e, Fig 4f), comparing with enterprises, the overall contributions from government are negligible (Fig 3).

Acknowledgment

This paper is fund by The Dean's Fund Project of China National Institute of Standardization "Sustainable procurement model, instrument, and standard development for central enterprises" (Project Number:602023Y-10399).

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