

Economic Benefits of Construction Waste Recycling Enterprises under Tax Incentive Policies

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Abstract

To further explore the development of construction waste recycling enterprises and promote the recycling of construction waste resources in China, a system dynamics model of the economic benefits of construction waste recycling enterprises is established using the system dynamics method and taking the tax incentive of the Guangzhou Municipal Government as an example. The economic benefits of construction waste recycling enterprises are analyzed from the perspective of the total cost, total revenue, and total recycling amount. The results of the MATLAB simulation and numerical analysis show that: (1) By simulating the effects of different taxes such as value-added tax (VAT), education surcharge, urban construction tax, and enterprise income tax on the economic benefits of construction waste recycling enterprises, it is found that when tax incentives reach 70%, the VAT favorable policies bring the highest gains, followed by enterprise income tax, whereas favorable education surcharge policies and urban construction tax have the least impact on economic benefits. (2) Taking the monetary subsidy of the Guangzhou municipal government as an example, it is estimated that the total revenue of construction waste recycling enterprises will increase by 33.56% annually in 2030. When the new production technology is adopted, the Return On Investment (ROI) will reach 46.8% in 2030 compared to previous technological improvement. In the simulation scenario, the ROI will be 42.2%, which has a good incentive effect on the cost control of enterprises. (3) Increasing the available power to VAT and corporate income tax can improve the profitability of construction waste recycling enterprises in China; however, tax incentive policy will no longer be the main factor affecting the benefits of enterprises when a certain time is reached. (4) It is suggested that the government improves the relevant tax laws incentive policies, increase tax incentives, and add equipment tax incentive policies, actively change the tax mode, and increase indirect tax models to improve the economic benefits of enterprises. The research results provide a decision-making reference for the government to formulate laws and policies related to the economic benefits of construction waste recycling, promote the development of the construction waste recycling industry, the development of new industries, such as waste recycling and treatment, and the formation of industrial chains, to achieve the strategic goal of sustainable development.

1 Introduction

In recent years, China's continuous urbanization progress has been accompanied by a large amount of construction waste increasing annually, which not only consumes many resources but also seriously burdens the ecological environment (Zhao et al. 2010). According to statistics, it is estimated that 1.3 t and 0.3 t of construction waste will be produced for each 1 m² of demolition and 1 m² of new construction. The total amount of construction waste produced annually in China is about 1.55–2.4 billion tons, accounting for 30–40% of the total amount of urban waste (Zheng et al. 2017). Such an enormous amount of waste will cause severe environmental pollution if it is not disposed of reasonably, and its potential value is developed and used (Wang et al. 2018).

Construction waste recycling is the most effective way to dispose of construction waste. The national and local governments have issued corresponding policies and regulations to support the development of

the construction waste-related treatment industry and encourage enterprises to recycle waste(Huang et al.2018). In 2017, the Ministry of Housing and Construction put forward in the *Code Conditions for Construction Waste Resource Recycling Industry* to set up a "threshold" for enterprises engaged in recycling construction waste resources to meet the corresponding qualification requirements, and to make it clear that the resource recycling utilization rate of enterprises engaged in construction waste resources recycling should reach more than 95% (MOIAIT and MOHAC,2017). In the same year, the Central Government of China proposed in *Several Opinions on Further Strengthening the Management of Urban Planning and Construction* that a construction waste recycling system should be established within approximately five years (CGOC,2016).The Shanghai Municipal People's Government stipulates that the principles of reduction, resource utilization, harmlessness, and "who produces and who bears the responsibility for treatment" shall be applied to the disposal of construction waste and supports such enterprises as the use of products for construction waste recycling in accordance with the guidance of industrial development(Ding et al.2014). Shenzhen Housing and Construction Bureau makes public 42 comprehensive utilization enterprises and publishes information on the main types of recycled building materials and catalogs of applicable engineering parts(Wang et al.2018). The Guangzhou government has introduced two forms of subsidies for construction waste disposal (CMC, GCHURCC, GCBF,2015): 1) subsidies for construction waste disposal at 2 yuan/t according to the actual construction waste use in recycled building materials; 2) subsidies of 3 Yuan /m² per month for the production land of enterprises eligible for subsidies combined with their production scale. However, the poor implementation effect of relevant policies issued by the state and local governments and the inadequate implementation of some policies, such as the two subsidy policies implemented in Guangzhou, has led to low awareness and low motivation for active recycling of construction waste recycling enterprises(Liu et al.2020; Liu et al.2019). Therefore, it is essential to strengthen the economic incentive for these enterprises. Nevertheless, in most studies on construction waste recycling, the main focus is on subsidies and fines, and the tax incentives for the enterprises are of less concern, highlighting the need to study tax incentives for the enterprises(Calvo et al.2014).

Germany, Japan, the UK, and other countries have formulated and promulgated a series of policies, laws, and regulations on the recycling of construction waste, among which a central idea has always been followed: to classify waste in the early stage for subsequent treatment (Ajayi et al.2017; Alwan et al.2017; Galvez-Martos et al.2018). All enterprises involved in recycling construction waste have stipulated their responsibilities and obligations, requiring the construction waste producers to dispose of the waste they produce themselves; otherwise, they will be punished as stipulated, together with the producers of illegal landfilling or those who incinerate construction waste. In some policies, the goal of recycling construction waste within a certain period is also clearly defined. Rewards and compensation will be given to those enterprises that achieve the goals to motivate them and to promote the development of related subjects in the entire industrial chain so that they can work together to achieve the required goals of construction waste recycling and the green environmental development. In China, as the output of construction waste increases annually, the government has promulgated macro-policies on the management of construction waste and formulated economic policies on the management of

construction waste in practice(Wu et al.2017). However, most of them are mainly in the form of penalties, charges, and discounts, which makes it difficult to motivate enterprises to recycle construction waste. In addition, the ambiguity of the tax incentive policy-makes the implementation of economic policy measures less effective.

Therefore, the following questions are put forward from the perspective of construction waste recycling enterprises: (1) how do tax incentive policies affect the development of construction waste recycling enterprises? (2) What kind of tax incentive policy can reduce the cost and increase the income of enterprises for recycling construction waste more effectively, and (3) how much tax incentive can maximize the economic benefits of the enterprises for recycling construction waste to play the maximum role of incentive policy? In this study, a system simulation model of construction waste recycling enterprises is constructed, and the interrelationship between model factors is analyzed using the system dynamics method. A causal cycle diagram and flow chart of the economic benefits of construction waste recycling enterprises are established to verify the validity of the model and carry out simulations. Enterprise economic benefit simulations under different tax policies incentive, such as VAT and enterprise income tax, is carried out to compare, analyze, and determine the best tax incentive policy.

2. Literature Review

2.1 Recycling management of construction waste resources

It is necessary to classify construction waste before recycling, which can not only reduce environmental pollution, resource waste, social, and environmental impact but also produce more benefits through efficient recycling. Domestic and foreign scholars have carried out various studies and analyses on the classification and management of construction waste. Dupre (2014) proposed that construction waste classification should be a prerequisite before it can be reused or recycled. Wang (2010) and others took Shenzhen as an example to identify six key success factors affecting the on-site classification of construction waste, namely human resources, recycling material markets, waste classification capability, better management, site space, and construction waste classification equipment. Huang et al. (2002) proposed an on-site classification process for mechanical equipment according to the off-site classification and sorting construction waste method in Taiwan.

As source waste reduction is also one of the main impact stages that determine the generation of construction waste, relevant scholars have conducted studies on reducing construction waste in the design stage. Baldwin (2009 and 2008), Poon (2007), and Zhang (2012) proposed that rational design is an effective way to reduce the generation of C&D waste. Osmani et al. (2008) surveyed British architects' perceptions of reducing construction waste and concluded that waste management is not a priority at the design stage and that construction waste is mainly generated during construction. Li et al. (2015) investigated the attitudes and behaviors of architects to reduce construction waste through structural equation modeling and taking Shenzhen as an example and found that they have positive and significant effects on reducing construction waste. Yuan (2014) and others put forward corresponding policy

suggestions based on sorting and summarizing the landfill laws and regulations of Sichuan, Chongqing, Shaanxi, Yunnan, Guizhou, and Guangxi provinces, and summarizing the five aspects of construction waste landfill laws and regulations system, supervision departments, facility planning, charging standards, and penalty intensity, which can provide a reference for policy planning for construction waste management.

2.2 Economic benefits of construction waste recycling

When recycling construction waste, economic measures are an important factor affecting management activities, and the government can play an effective role in implementing economic measures. At present, most cities in China have formulated an economic incentive policy for construction waste. By contrast, less research has been done on tax incentive policies, resulting in poor implementation effects, illegal dumping and landfilling, difficulty in motivating enterprises for recycling construction waste and promoting the competitiveness of recycling products in the market, and reducing the construction waste recycling utilization. Therefore, it is necessary to encourage recycling management activities of construction waste through economic measures, such as penalties and subsidies, to reduce the generation of construction waste, eliminate illegal dumping and landfilling, and improve the comprehensive utilization level of waste.

In terms of economic incentives, Tam (2008) found through surveys and interviews with enterprises that the pilot waste management plan in Hong Kong has a great impact on the production efficiency of construction enterprises. They concluded that on-site recycling and waste reduction are the foremost effective measures to implement the management plan, while high indirect costs and low incentives for economic measures are the main obstacles to implementing the plan. In terms of punishment measures, some scholars believe that charging waste fees, according to the polluter-pays principle, can effectively reduce the generation of waste, and the level of comprehensive waste utilization can be improved by collecting appropriate construction waste fees, setting reasonable fee standards, formulating effective policy management, and implementing economic incentive policies within a certain range of functions. Begum (2006) and others studied the economic feasibility of construction waste reduction by considering the economic factors in the process of construction waste generation, composition, classification, and recycling, based on case studies, and using a cost-benefit analysis method. They also verified that economic means play a positive role in construction waste reduction. Calvo et al. (2014) introduced two policies and measures of economic incentives and tax penalties to eliminate illegal filling and stimulate the construction waste demand. They also constructed a simulation model of a recycling management system of a construction waste enterprise and evaluated the influence of government on enterprise behavior in a construction waste aggregate recycling system so that Spain can achieve the overall goal of 30% recycling utilization of construction waste in a shorter time. Duran et al. (2006) established a potential decision-making model to assess the economic feasibility of creating a market for construction waste recycling based on potential decision-making models for waste producers and waste aggregate users, and proposed three possible construction sites in Ireland that could benefit from economies of scale, and concluded that market-oriented tools are the best choice for policymakers. Jia (2017) and

others integrated the advantages of three single policies through a combination of fees, fines, and subsidies. They believed that the higher the subsidies and penalties, the better, and that the reasonable range of penalties is 250-350 yuan/t and 25-35 yuan/t.

3.3 Literature survey or review

Worldwide scholars have made abundant achievements in research on recycling enterprises of construction waste, involving various aspects, such as life cycle management and reduction management from the policy perspective, and fee subsidies, fee plans, and input-output from the economic benefit perspective. However, from current research, there is little research on the incentive effect of a tax incentive policy on enterprises engaged in recycling construction waste from the micro-level perspective. Most of these studies focus on the economic cost of construction waste management and pay less attention to the economic cost of enterprises. Besides, there are many discussions on economic subsidies or penalties, and there is a lack of research on tax incentive policies for construction waste recycling enterprises. In addition, there is a lack of quantitative research on the tax revenue of construction waste recycling enterprises and insufficient empirical research on the incentive effect of tax incentive policies on enterprises. The development of construction waste recycling enterprises cannot do without government tax incentive policy, which will be the focus of this paper.

3. Methodology And Data

System dynamics is a theoretical method put forward by Professor Forrester in 1958, which combines information theory, system theory, and computer simulation, in which a comprehensive model is established, including system structure, causal relationship, and feedback cycle[36]. Moreover, system dynamics have been widely used in transportation systems, project management, building design, and operation because of its advantages in simulating complex social systems.

The construction waste recycling system studied in this paper is a complex system with a multidisciplinary, complex workflow, and dynamic environment. The system dynamics method can better simulate the characteristics and operation process of the economic benefit system of the construction waste recycling enterprise.

3.2 Sources of data

Data are mainly from literature reviews, official statistics, and estimates. Official statistics include statistical yearbooks and conference reports, and estimates include regression analysis. For example, the data of "total output of construction waste," "construction area of construction waste," "demolition area of construction waste" mainly come from official statistics.

Because many variables are involved in the determination of variable parameters in the model, regression analysis can be used to estimate the parameters, and the non-linear relationship can be described by

tables and logic functions in VENSIM software. The main parameters in the model are listed in Appendix A.

4. A System Dynamics Model for Cost-benefit Analysis of Construction Waste Management

The economic benefit model of construction waste recycling enterprises constructed using the system dynamics Vensim software is as shown in the causal cycle diagram in Fig. 2 and the stock-flow diagram in Fig. 3. It consists of three subsystems: waste generation and management subsystem, waste recycling subsystem, and construction waste enterprise economic benefit evaluation subsystem, which are connected into a whole system and interact with each other. In the subsystem of generation and disposal of construction waste, the generation process, classification, collection, and landfill of construction waste is introduced, which can simulate the output of construction waste in the process of construction, demolition, and decoration. In the subsystem of recycling and construction waste utilization, the total amount of recycled construction waste can be simulated. In the subsystem of the economic benefit of construction waste, the cost that affects the enterprise and the expected income that can be obtained are described and the impact of tax incentives on the economic benefit of enterprises for recycling waste. In this study, the cost of construction waste recycling enterprises is mainly composed of construction cost, recovery cost, and operating cost, and revenue is composed of sales revenue, additional revenue, and government funding support.

The loop in Figure 4 is a positive feedback loop, which means that the increase (or decrease) of any initial parameter in the loop will enhance the effect of this increase (or decrease) through a series of parameters in the loop; on the contrary, the negative feedback weakens the effect. The increase in total waste recycling will lead to the aggravation of the impact of recycling waste. At this time, the supervision (rules) will increase and gradually mature the market for waste recycling, which will reduce the total cost of waste recycling enterprises, and then increase the sales revenue and total revenue of waste recycling enterprises, resulting in the increased motivation of recycling enterprises and the ratio of waste recycling, thus increasing the total amount of waste recycling. Hence, the total amount of waste recycling will increase after a series of parameters in Loop 1, in which tax incentives will promote the total amount of waste recycling.

4. Simulation Results And Discussion

4.1 Parameter sensitivity test

Sensitivity testing of models mainly includes two aspects: first, to test whether the model is affected by minor changes in individual parameters; second, to change the parameters within a reasonable range to observe the behavioral changes of the model. If the fluctuation caused by parameter change is reasonable, it means that the parameter value is not sensitive, i.e., the parameter estimation is reasonable, and the sensitivity test is passed.

Sensitivity Test 1: By setting the government subsidy to 5 yuan, the simulation results of noise seed 1234 are now observed when the government subsidy is between 0 and 10, and the number of fluctuation model simulations is 200. Fig. 5 (a) clearly shows that when government subsidies fluctuate between 0 and 10, the total income effect is small.

Sensitivity test 2: by setting the model building waste collection ratio to 0.86, the simulation results of the noise seed 1234 are now observed when the government subsidy fluctuates between 0.72 and 1.00, and the number of times of the model is 200. Figs. 5 (b)–(d) clearly show that the ratio of building waste collection has a stable impact on the total amount of building waste collection, the amount of building waste resource utilization, and the total revenue, which can make the affected amount appear as a wideband chart, but the sensitivity of the value is not high and stable, so the parameter value passes the sensitivity test.

4.2. Extreme condition test

When extreme condition 1 is selected, the waste sorting ratio is 0, which means that no sorting is carried out when building waste is disposed of. Therefore, the total amount of waste to be sorted is 0. When extreme condition 2 is selected, the parameter is set to 1, indicating the choice of the way to sort and dispose of waste. In this case, the total amount of waste sorting is the largest, which is expected to reach 1,611,660 tons by 2019. The current segment in Fig. 6 shows the waste sorting ratio under normal conditions. Under normal conditions, the estimated amount of waste sorting in 2019 is 728,520 tons, between the two extreme conditions, which shows that the simulated amount of waste sorting is of practical significance and that the simulation results are consistent with the actual situation.

4.3 Result analysis

At present, the government implements tax incentive policies for construction waste recycling enterprises, including a favorable VAT policy, a favorable enterprise income tax policy, a favorable urban construction tax policy, and a favorable additional education fee policy. In this paper, taking Guangzhou City in the Pearl River Delta as an example, the tax incentive policies of construction waste recycling enterprises are simulated systematically. The effects of different tax preferences on the income and ROI of construction waste recycling enterprises are analyzed.

4.3.1 VAT favorable policy

Because of the implementation of the tax system of "replacing business tax with value-added tax" in the construction industry, the tax rate has risen sharply from the original lower 3% to 11%. Therefore, the tax incentive policies for construction waste recycling enterprises are mostly in favor of VAT. The favorable VAT treatment will greatly reduce the cost expenditure of construction recycling enterprises, and to a certain extent, will also promote construction recycling enterprises to actively recycle waste and improve the total amount of waste recycling.

As shown in Figs. 7 (a)–(d) above, in the current simulation scenario, when VAT reaches up to 8,520,000 yuan by 2030, increasing VAT favorable policies will reduce the total tax paid by enterprises, and the reduction of the total tax paid is evident. In 2030, the total estimated cost is 509 million yuan. When favorable policies are + 10%, the operating cost is 496 million yuan, a decrease of 2.55% year on year. When favorable policies are + 30%, the operating cost is 472 million yuan, a decrease of 7.27% year-on-year. When favorable policies are + 70%, the operating cost is 423 million yuan, a decrease of 16.89% year-on-year. In 2030, the predicted ROI is 42.27%. When the VAT Favorable policy was + 10%, the ROI was 45.77%. When the VAT favorable policy was + 30%, the ROI was 53.3%. When the VAT favorable policy is + 70%, the ROI is shortened to 8 years at 70.97%. Therefore, when the government adopts favorable policies for enterprise VAT, the economic benefits of enterprises have significantly improved, which is conducive to the development of enterprises. The simulation results of MATLAB on the ROI in Fig. 8 (b) show that the assets of the enterprise are negative from the beginning of its operation in 2007 until 2016, and profits are made in 2017 with an ROI period of 10 years. The ROI increases quickly in the medium term and tends to be flat in the later period. Therefore, the graph shows a smooth surface. With the year-on-year growth, the greater the value-added tax incentive, the faster the ROI, so there is an evident growth trend for the enterprises' economic benefits.

4.3.2. Favorable tax on enterprise income tax

In our country, enterprise income tax is a direct tax paid based on the final operating income of the enterprise, which can specifically adjust the redistribution of social wealth and meet the special requirements of social security. However, for direct tax, taxpayers cannot easily transfer the tax burden to others. Therefore, a favorable tax on enterprise income tax provides tax exemption to taxpayers directly in the distribution link, which is beneficial to reducing the tax burden of enterprises, encouraging enterprises to strengthen management and increase efficiency to generate income.

The above figure shows that income tax will reach 4.6 million yuan in 2030, in the current simulation scenario. The favorable increasing income tax policy will significantly reduce the total tax amount of enterprises and change the ROI. In 2030, the predicted income tax is 4.6 million yuan. When the favorable policy is + 10%, income tax will be 4.14 million yuan; when the favorable policy is + 30%, the tax will be 3.22 million yuan; when the favorable policy is + 70%, the tax will be 1.38 million yuan; in 2030, ROI will be 42.27%, when the favorable tax policy is + 10%, the ROI will be 43.85% when the favorable tax policy is + 30%, the ROI will be 47.12% when the favorable tax policy is + 70%, the ROI period will be shortened to 9 years at 54.124%. Therefore, when the government adopts favorable policies for enterprise income tax, the economic benefits of enterprises have significantly improved, which is conducive to the development of enterprises. By importing the system dynamics model and calculation formula and data into MATLAB, as shown in Figure 10(b), a three-dimensional picture can be obtained more intuitively. The z-axis corresponding to the same color is the same, that is, the rate of the ROI is the same. With the growth of years, the more favorable power of enterprise income tax, the higher the rate of ROI. The simulation results in the ROI show that the greater the government's favorable power to corporate income tax, the

faster the ROI increases in the medium term and tends to be flat in the later period. Therefore, the graph shows a smooth surface, so it has a certain growth trend for the economic benefit of the enterprise.

Fig. 11 shows that increasing the favorable education surcharge policy will reduce the education surcharge, but the total tax reduction is not obvious because the proportion of education surcharge in the total tax is relatively small. In 2030, the projected education surcharge is 255,600 yuan. When the favorable policy is + 10%, education surcharge is 230,100 yuan; when the favorable policy is + 30%, education surcharge is 178,900 yuan; when the favorable policy is + 70%, education surcharge is 76,700 yuan. As shown in the MATLAB diagram in Fig. 12 (b), the ROI does not change significantly with the preferences increase over the years because the education surcharge is discounted based on VAT. The simulation results in the ROI show that the higher the favorable rate of corporate income tax applied by the government to the enterprise the slower the ROI will increase in the medium term without significant change, so there is no evident growth trend for the economic benefit of the enterprise.

Fig. 13 shows that in the current simulation scenario, the urban construction tax is 596,600 yuan by 2030. Reducing total tax by increasing the favorable policy for urban construction tax is not evident because the proportion of construction tax to total tax is not obvious. In 2030, the urban construction tax is forecasted to be 255,600 yuan. When the favorable policy is + 10%, education surcharge is 230,100 yuan; when the favorable policy is + 30%, education surcharge is 178,900 yuan; when the favorable policy is + 70%, education surcharge is 76,700 yuan. As shown in the MATLAB diagram in Fig. 14 (b), the ROI did not change significantly with the increase in the annual favorable rate. Because the urban construction tax is favorable based on VAT, it has little change. The simulation results in the ROI show that the greater the Favorable rate of corporate income tax applied by the government to the enterprise, the slower the ROI will increase in the medium term without significant change, so there is no evident growth trend for the economic benefit of the enterprise.

4.4 Comparison of different tax policies

By comparing four different taxes—enterprise income tax, value-added tax, education surcharge, and urban construction tax—under the condition of 70% favorable force, this study analyzes which tax has the highest impact on construction waste recycling enterprises to provide suggestions for the government to formulate a favorable tax system for enterprises.

As shown in Figs. 15 and 16, the favorable tax policies are compared and discussed in terms of 70% preference. The benefit from favorable policies of VAT is the highest, with the total amount of tax paid in 2030 being 7.41 million yuan. As government policies have favorably granted income tax, the increase in the favorable policy situation of income tax is lower than that of VAT. The total amount of tax paid in 2030 is 1075.68 yuan. The benefit from favorable policies of education surcharge and urban construction tax is not evident. The benefit of favorable VAT policies is the highest, with an expected ROI of 70.97% in 2030; the second highest is the situation of favorable policies of the income tax, with an ROI of 54.12% in 2030; and 42.92% and 43.81%, respectively, for favorable policies of the education surcharge and the urban construction tax.

By comparing these typical tax favorable policies for construction waste, it is clear that China currently provides a great deal of support for construction recycling enterprises in waste disposal. As a tax-favorable policy, VAT brings the greatest economic gain to enterprises, followed by enterprise income tax, and favorable policies for education surcharge and urban construction tax have the least impact. When the government strengthens VAT and corporate income tax incentives for recycling enterprises, it encourages enterprises to increase their motivation for recycling construction waste. The economic benefits of enterprises for recycling construction waste are also significantly improved, which is reflected in the upward trend of the curve. The results show that the stronger the government's VAT favorable policy on construction waste recycling enterprises, and the stronger the government's favorable corporate income tax policy on construction waste recycling enterprises the higher the economic benefits of enterprises.

5. Conclusions

The recycling of construction waste is an important link in the disposal of construction waste and the key to saving resources, saving energy, and reducing emissions in the construction field. As a result, research on construction waste recycling has become an urgent task in the economic development, urban renewal, and construction of our country. In this study, from the perspective of construction waste recycling enterprises, the method of combining qualitative and quantitative system dynamics was adopted by taking Guangzhou City as an example to study the economic benefits of construction waste recycling enterprises and stimulate the effects on these enterprises under different favorable tax policies. The following conclusions were drawn:

(1) Tax incentive policies will effectively improve the economic benefits of enterprises. The government implements four tax incentive policies for construction waste recycling enterprises, including VAT, income tax, education surcharge, and urban construction tax. The simulation results show that such incentives can reduce the cost of recycling enterprises, improve the total income and investment return of recycling enterprises, and then improve the motivation of enterprises for recycling, and greatly improve the total amount of waste recycling.

(2) VAT brings the most obvious economic benefits, followed by income tax, education surcharge, and urban construction tax, which help enterprises improve economic benefits, but not as much as VAT and income tax. As income tax has been favored by the government policy, the effect of the income tax incentive policy situation is lower than the gains brought by VAT, and the gains brought by education surcharge preference and urban construction tax preference are relatively insignificant, thus increasing the VAT incentive can effectively improve the economic benefits of enterprises.

(3) The sensitivity simulation of different tax incentives shows that for the government's VAT favorable policy on construction waste recycling enterprises, the higher the favorable power the higher the economic benefits of enterprises, i.e., the higher the ROI. For the favorable corporate income tax policy issued by the government on construction waste recycling enterprises, the greater the favorable power,

the higher the economic benefit of enterprises. When the tax incentive is 70%, the benefit from favorable policies of VAT is the highest, with an expected ROI of 70.97% by 2030. As income tax has been freely granted by government policies, the benefit of favorable income tax policies is lower than that of VAT, with an expected ROI of 54.12%. The benefits of favorable policies on education surcharge and urban construction tax are relatively insignificant, and the expected ROI is 42.92% and 43.81%, respectively. The greater the tax incentive for enterprises, the higher the economic benefits of enterprises, and the more active the enterprises are in recycling to alleviate the environmental and social problems caused by construction waste.

The research results of this study can improve the incentive policy theory of recycling construction waste, provide a decision-making reference for the government to formulate relevant laws and policies on recycling and economic benefits of construction waste, and promote the development of the construction waste recycling industry. However, the paper still has the following deficiencies: (1) The scope of the study is not broad enough. There are many enterprises involved in the industrial chain of construction waste disposal, such as construction, demolition, decoration transportation, and landfill in the upstream, and some downstream enterprises. The focus of this paper is only on the study of the economic benefits of construction waste recycling enterprises in the upstream industry, while other enterprises still need to be studied. (2) Because the conclusion of this study is conditional and the time limit of the simulation was set to 2030, the conclusion is valid for a certain period. There is a need to further study as to whether the tax incentive policy issued by the government for recycling construction waste helps enterprises increase their economic benefit or goes on the market because their economic benefit will not increase further after reaching the peak value.

Declarations

Authors' contributions Jingkuang Liu contributed to the conception of the study and contributed significantly to analysis and manuscript preparation. Engqing Gong performed the data analyses and wrote the manuscript. Xuotong Wang contributed to the conception of the study and helped perform the analysis with constructive discussions.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Research involving human participants and/or animals Not applicable

Ethical approval and consent to participate Not applicable

Consent to publish The authors consent to publish.

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Figures

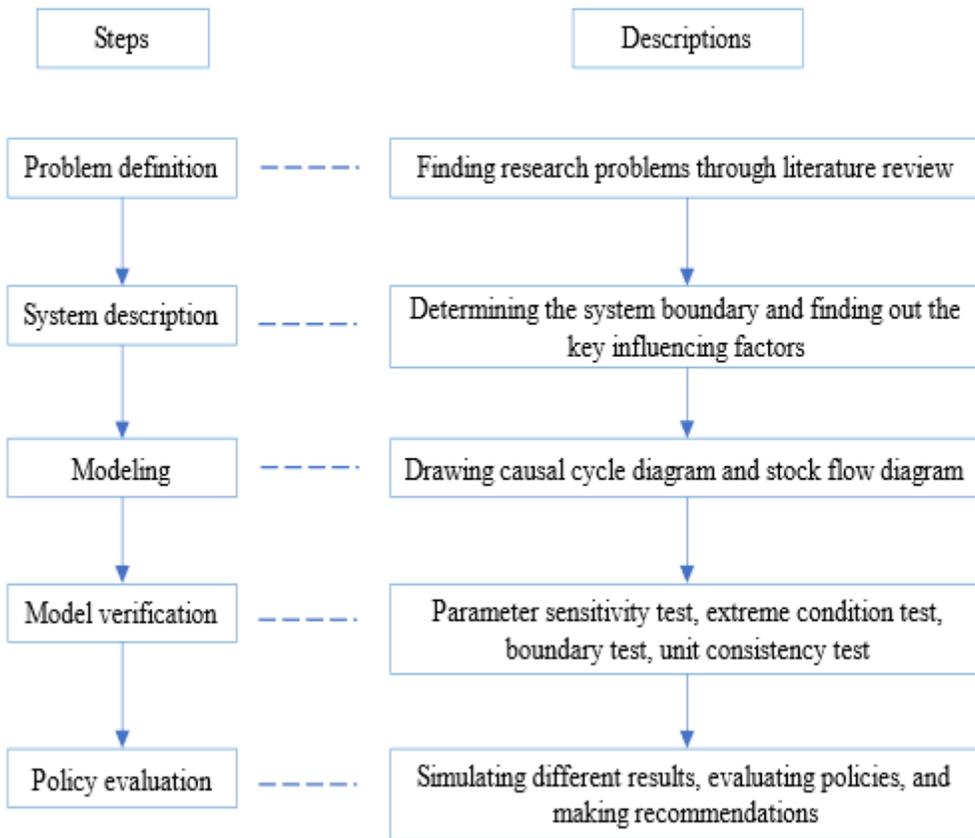


Figure 1

Flow chart of system dynamics

Figure 4

Main cause and effect relationships

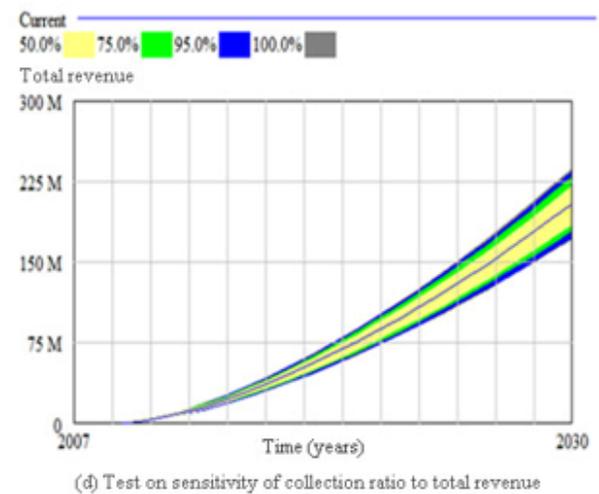
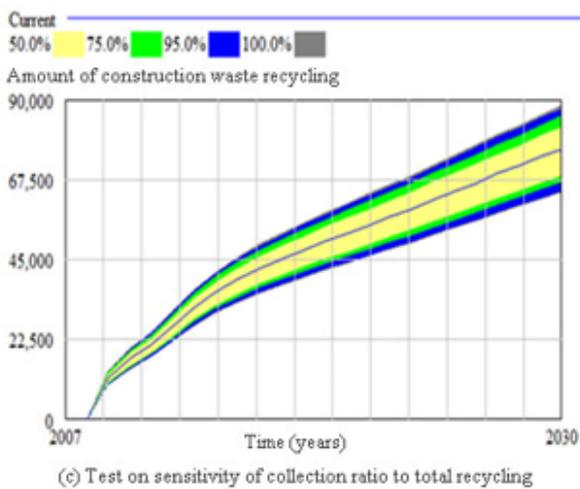
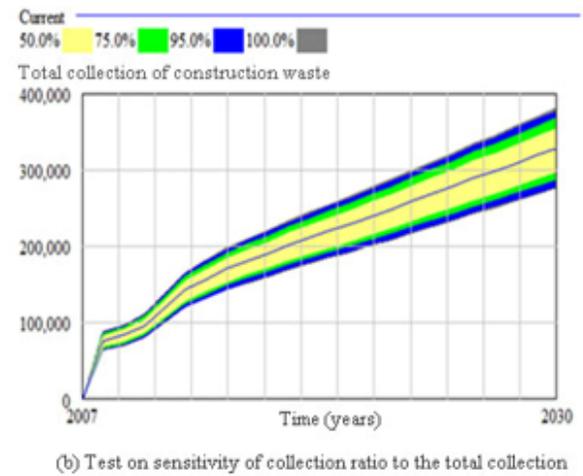
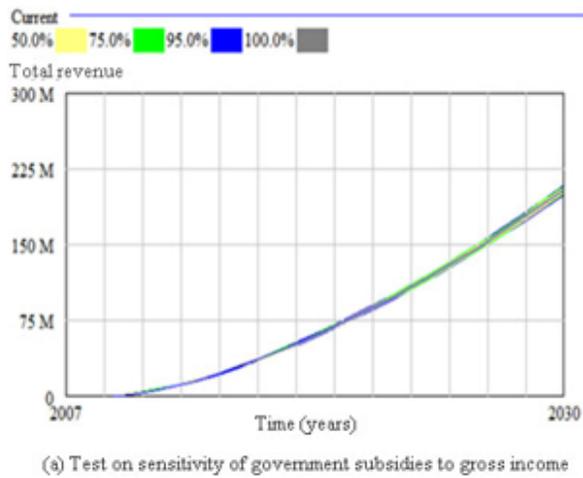


Figure 5

Parameter sensitivity test

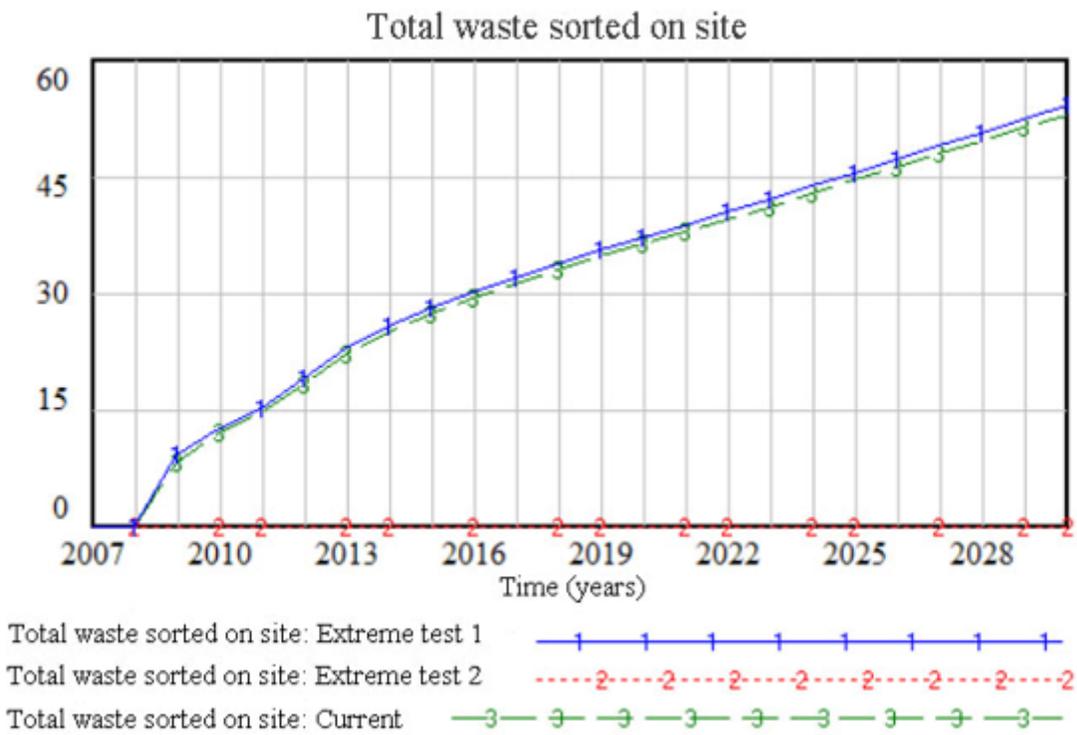
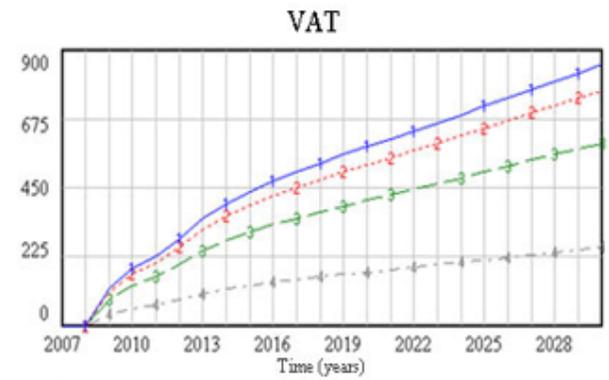


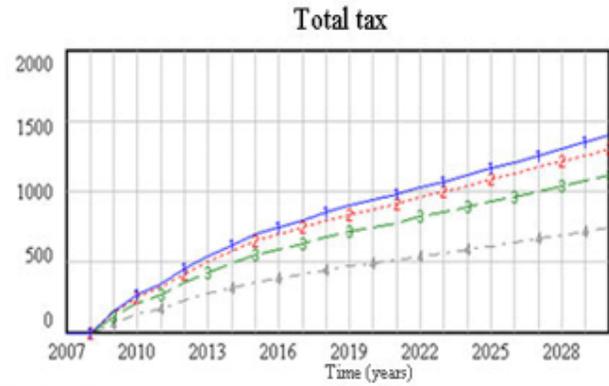
Figure 6

Extreme condition test



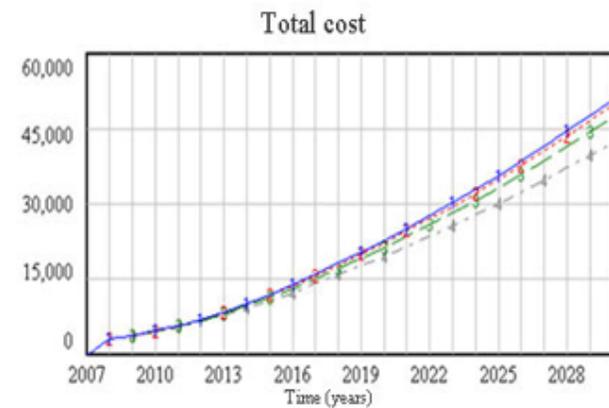
VAT: Current ————
 VAT: Favorable policy for VAT +10% - - - -
 VAT: Favorable policy for VAT +30% ————
 VAT: Favorable policy for VAT +70% - - - -

(a) Under different Favorable policies for VAT



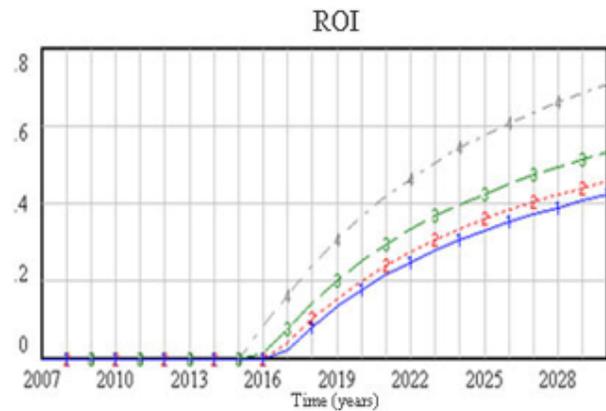
Total tax: Current ————
 Total tax: Favorable policy for VAT +10% - - - -
 Total tax: Favorable policy for VAT +30% ————
 Total tax: Favorable policy for VAT +70% - - - -

(b) Impact on total tax



Total cost: Current ————
 Total cost: Favorable policy for VAT +10% - - - -
 Total cost: Favorable policy for VAT +30% ————
 Total cost: Favorable policy for VAT +70% - - - -

(c) Impact on total cost

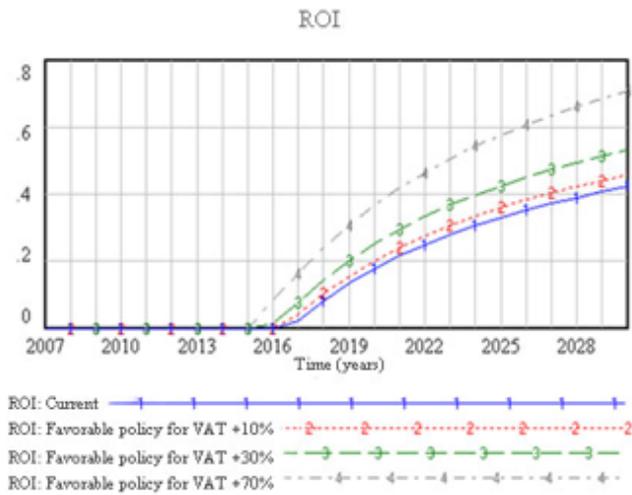


ROI: Current ————
 ROI: Favorable policy for VAT +10% - - - -
 ROI: Favorable policy for VAT +30% ————
 ROI: Favorable policy for VAT +70% - - - -

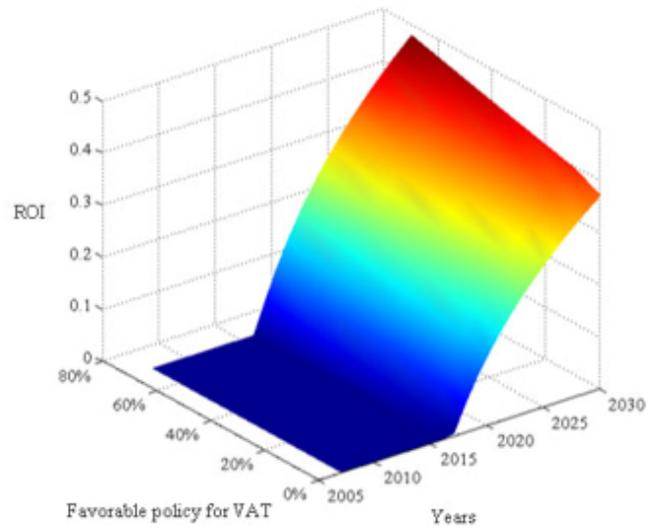
(d) Impact on ROI

Figure 7

Impact of VAT Favorable policies on key variables



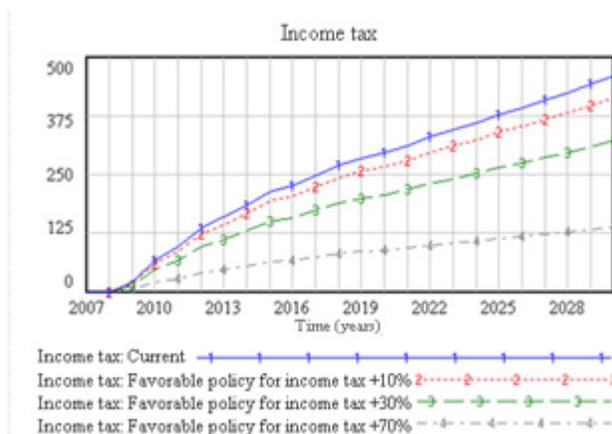
(a) Prediction of ROI in system dynamics



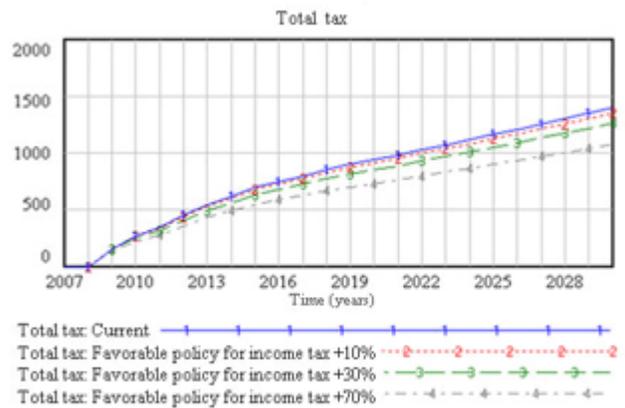
(b) Prediction of ROI based on MATLAB

Figure 8

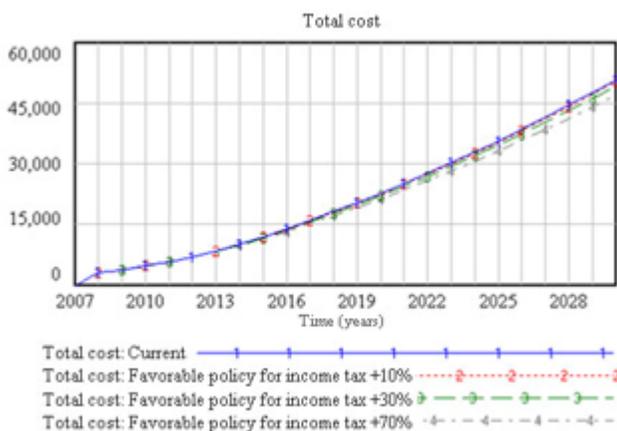
Impact of VAT Favorable policies on key variables



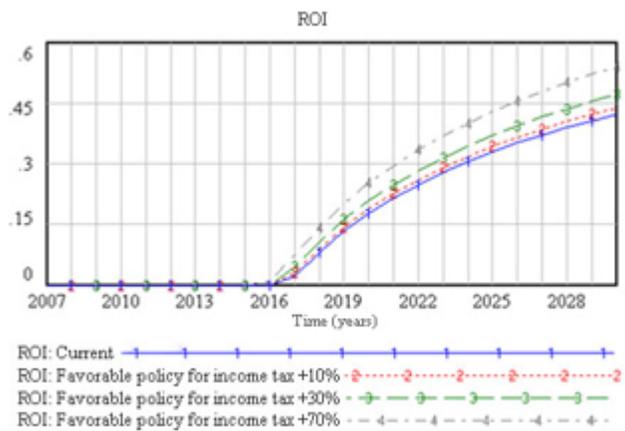
(a) Under different enterprise income taxes



(b) Impact on total tax



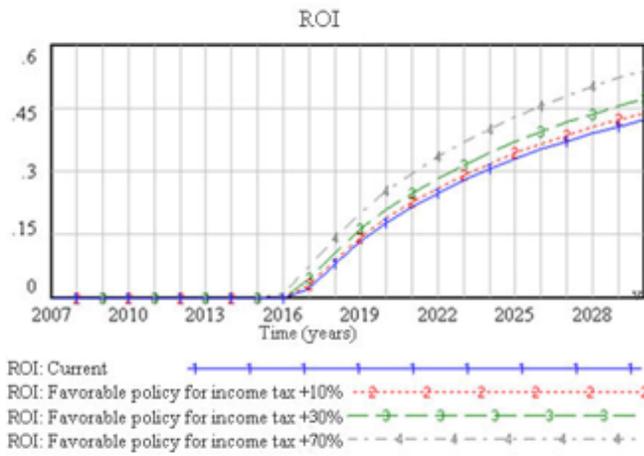
(c) Impact on total cost



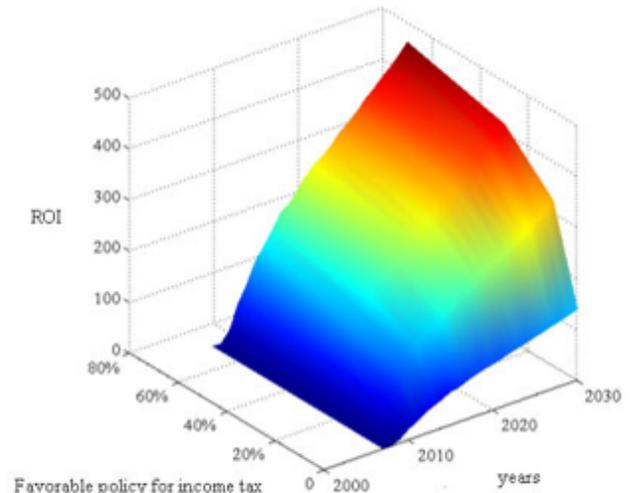
(d) Impact on ROI

Figure 9

Impact of different corporate income tax Favorable policies on ROI



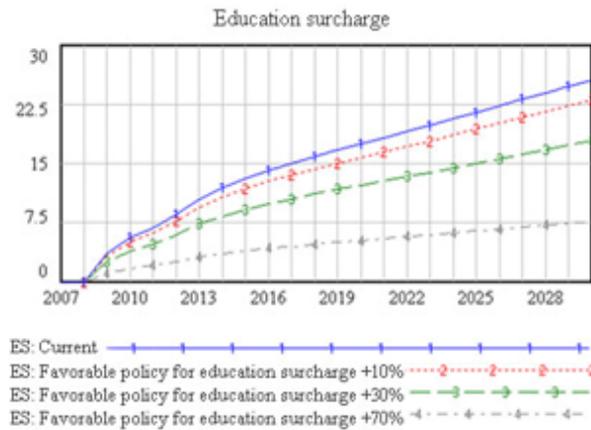
(a) Impact on ROI



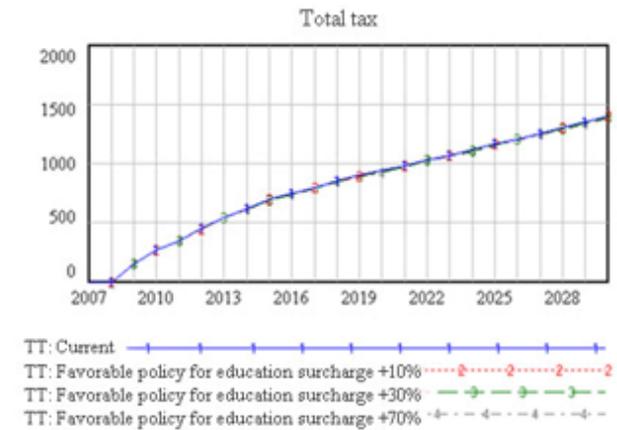
(b) Matlab 3D simulation prediction chart

Figure 10

Comparison of corporate income tax simulation



(a) Under different Favorable policies for education surcharge



(b) Impact of different Favorable policies for education surcharge on total tax

Figure 11

Impact of favorable policies for education surcharge on key variables

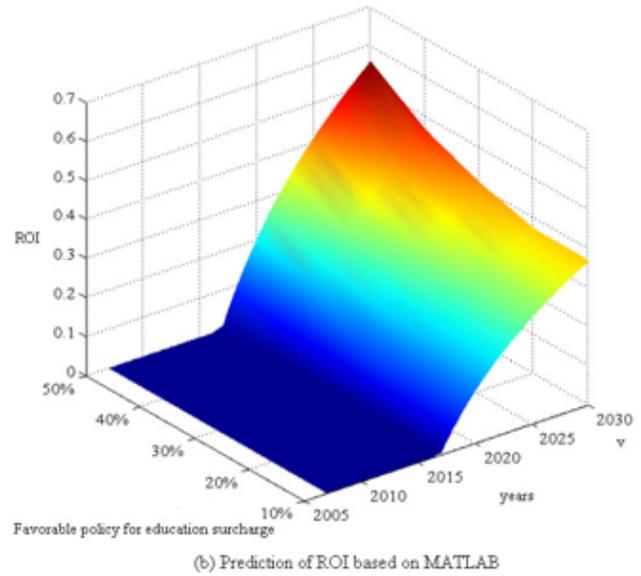
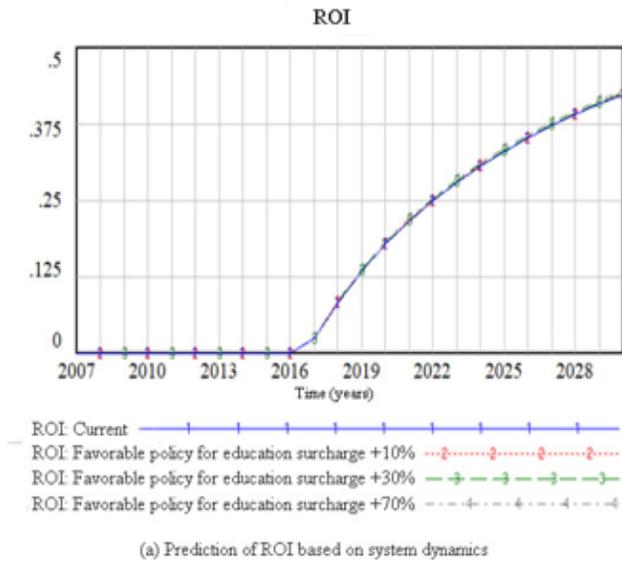


Figure 12

Comparison of education surcharges simulation

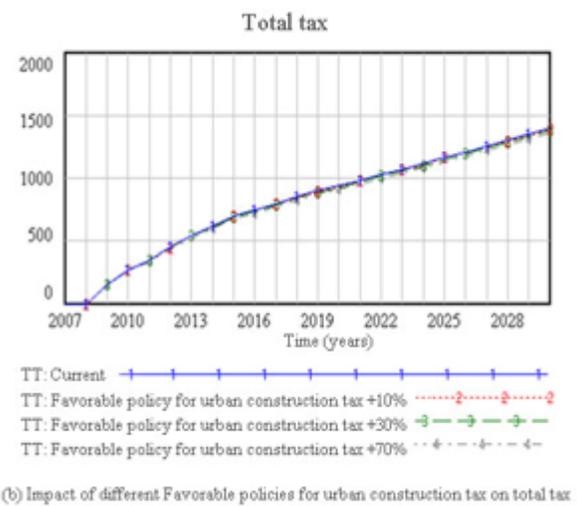


Figure 13

Impact of urban construction tax on key variables

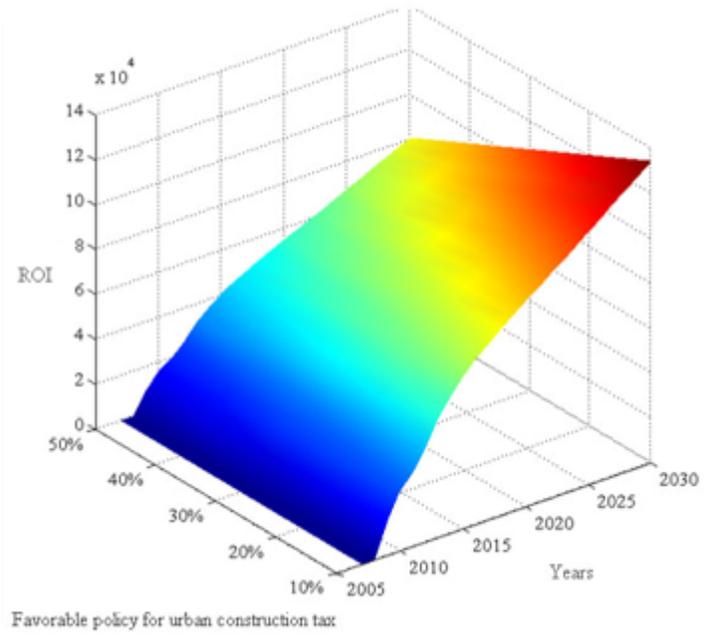
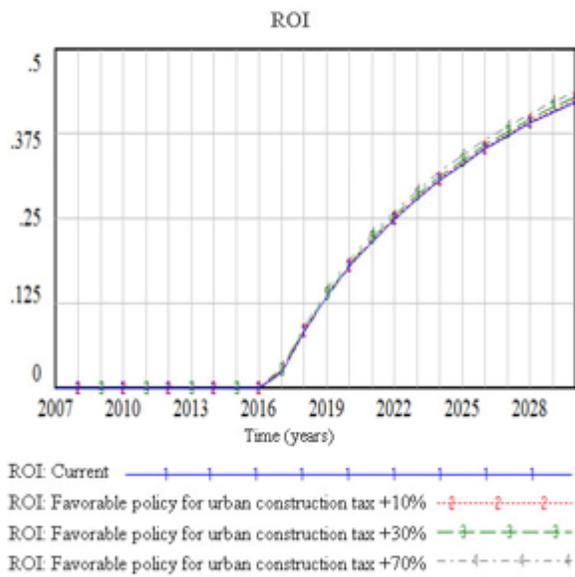


Figure 14

Comparison of urban construction tax simulation

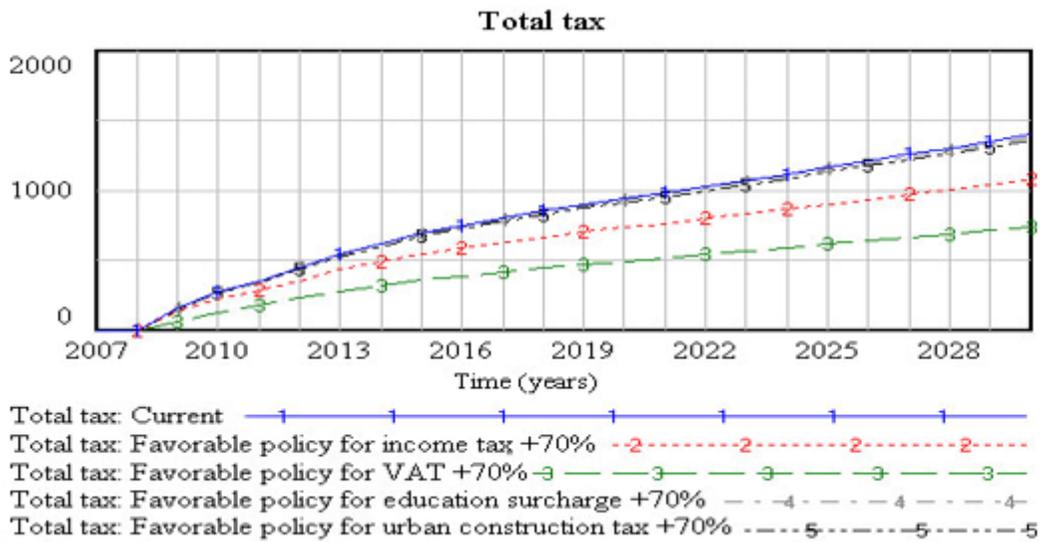


Figure 15

Impact of different tax preferences on total tax

ROI

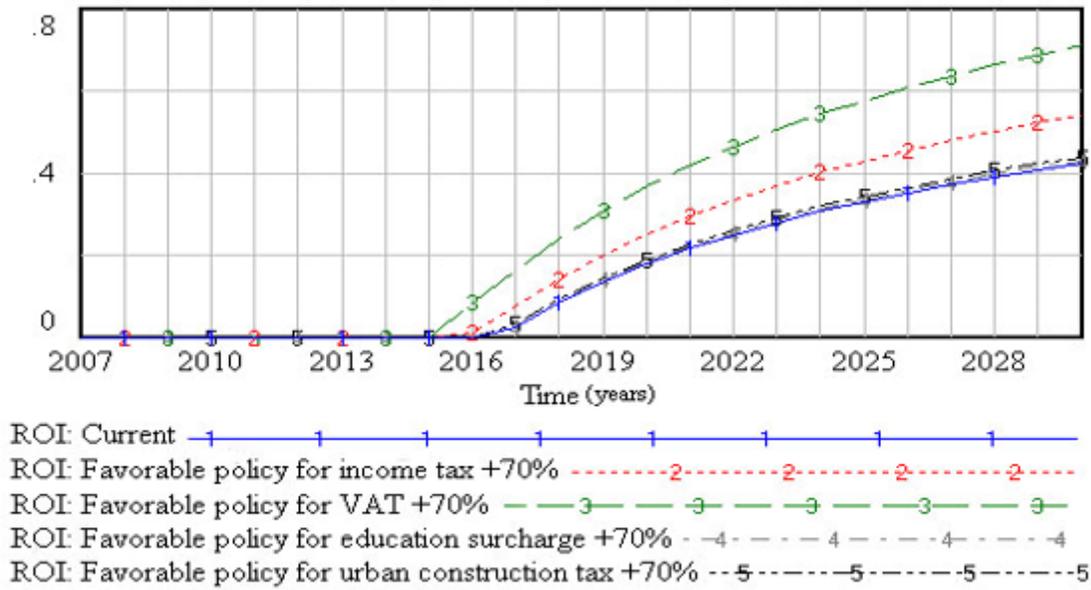


Figure 16

Impact of different tax preferences on ROI

Supplementary Files

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- [AppendixA.docx](#)