Empirical Study on Urban Waterlogging Data Governance Model Based on DID

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Abstract. In this paper, 11 communities in Xiqing District of Tianjin are selected as the research objects. According to the data and information of drainage network during 2010 - 2020, the effect of urban waterlogging control after the application of data management model in 2016 is tested by using double check difference method. The empirical results show that the implementation of data governance model has a positive effect on reducing the vulnerability of urban drainage network and can improve the governance efficiency; It is advisable to take the fragility of urban drainage network as an important parameter in urban waterlogging control.

Keywords: urban waterlogging; data governance; DID.

1. Introduction

The continuous influx of urban population, the pressure of urban operation is increasing, and there are many problems such as population expansion, traffic jam, energy shortage, extreme weather, environmental degradation, etc., and the fragility of cities related to economy, environment, population and infrastructure is highlighted. Among them, waterlogging is a serious problem, which has a huge negative impact on residents’ lives, lives and property safety. If serious waterlogging occurred in Wuhan in 2016, besides natural disasters, it is worth pondering on man-made disasters. After investigation, it was found that the long-term construction mode of underground after ground, low drainage design standard and untimely release of early warning information contributed to the waterlogging. On the one hand, it exposes the fragility of urban drainage facilities, on the other hand, it reflects that there are management loopholes such as unscientific construction planning, untimely disaster information processing and inaccurate decision-making in the main body responsible for the implementation and operation management of urban drainage network. Therefore, an accurate understanding and in-depth study of the vulnerability of urban waterlogging will help alleviate urban waterlogging and carry out urban governance. In July 2015, "Opinions of the State Council on Strengthening Urban Infrastructure Construction" pointed out that "urban infrastructure is the material basis for the normal operation and healthy development of cities, and plays an important role in improving the living environment, enhancing the comprehensive carrying capacity of cities, improving the operational efficiency of cities, steadily promoting new urbanization and ensuring the comprehensive construction of a well-off society in 2020". The National Comprehensive Disaster Prevention and Mitigation Plan (2016-2020) puts special emphasis on "improving the resilience of urban buildings and infrastructure, and the resilience and fortification level of lifeline projects." Therefore, in order to achieve this goal, it is urgent for the
decision-makers of urban management to formulate evaluation criteria for urban flood resistance and establish an effective governance system.

At present, China has not yet formed a framework system of macro-control, dynamic monitoring and real-time early warning in the risk management of urban drainage network. Most of the methods to control urban risks are to combine disaster historical data with expert experience to formulate early warning limits, and then start emergency response according to the situation to reduce the consequences of disasters. However, only relying on disaster data is not enough to support the judgment of the current pipeline network foundation state. That is to say, it is obviously not scientific and reasonable to implement the treatment without the relevant data of urban drainage system, and the participation in technical management is not enough, so it is impossible to accurately put forward systematic improvement measures and planning schemes. Obviously, it is imperative to explore an accurate governance model. In this paper, a model of "data-diagnosis-data-governance" is proposed, that is, to diagnose the vulnerability of urban drainage system by integrating urban municipal data, geographic data and meteorological data, and to implement "data governance" symptomatic. Its advantage lies in the introduction of efficient Internet thinking and full consideration of the application of urban big data, which is conducive to the establishment of a data-oriented and active defense risk early warning system for urban drainage networks; It is conducive to the realization of interest integration and information sharing among urban management departments, forming a scientific and efficient governance model, and providing scientific decision-making tools and program support systems for urban planning, construction, operation and management; It is conducive to the realization of collaborative governance among government departments under disaster scenarios.

2. Research area and Methods

2.1. Study area
Xiqing District of Tianjin is selected as the study area, with a total area of 570km² and a resident population of about 700,000. The terrain is low and flat, with the highest in northwest, lower in southeast and lowest in middle. There are 3 first-class rivers, 10 second-class rivers and a district-level medium-sized reservoir that can accommodate 30 million cubic meters. It has jurisdiction over 4 streets and 7 towns, with an average annual rainfall of 585 mm. The urban drainage pipe network in the area is composed of different pipe diameters and drainage pipes A community was selected from each street and town as a representative, with a total of 11 research objects.

2.2. Data resources
The data involved in this research come from Tianjin Statistical Yearbook (2010-2020), China Statistical Yearbook (2010-2020), etc., and some of the data are obtained through in-depth field investigation and access to archives. The missing data of individual years are obtained by trend extrapolation and other methods. The main reference specifications include: Code for Urban Drainage Engineering Planning, Code for Outdoor Drainage Design, Code for Urban Flood Control Planning and Technical Guide for Sponge City Construction-Construction of Rainwater System for Low Impact Development, etc.

2.3. Evaluation index of vulnerability of urban drainage system
The vulnerability of urban drainage system is a comprehensive and comprehensive assessment of the status of urban drainage system. By consulting relevant data and visiting relevant governments for investigation, the evaluation index system of vulnerability of urban drainage system is constructed from three aspects, such as the exposure, sensitivity and resilience of urban drainage system, as shown in Table 1.
Table 1. Evaluation Index of Vulnerability of Urban Drainage System

| Factor classification          | Measurement index                                | Properties of indicators |
|--------------------------------|--------------------------------------------------|--------------------------|
| Exposure of urban drainage system | A1 water surface rate                           | (+)                      |
|                                | A2 Soil permeability coefficient                 | (+)                      |
|                                | A3 Urban Permeable Ground Rate                  | (+)                      |
|                                | A4 Green coverage rate                          | (+)                      |
|                                | A5 Rainstorm intensity                         | (-)                      |
|                                | A6 Rainfall duration                            | (-)                      |
|                                | A7 Population density                           | (-)                      |
| Sensitivity of urban drainage system | A8 Discharge capacity of rainwater inlet     | (+)                      |
|                                | A9 Pipe diameter                                | (+)                      |
|                                | A10 Pipeline slope                              | (+)                      |
|                                | A11 Roughness coefficient of pipeline           | (-)                      |
|                                | A12 Pipe age                                    | (-)                      |
|                                | A13 Setting height of water outlet              | (-)                      |
|                                | A14 Density of drainage pipe network            | (+)                      |
|                                | A15 Laying rate                                 | (+)                      |
| Restoration of urban drainage system | A16 Financial input ratio of drainage network | (+)                      |
|                                | A17 Number of rainwater pumping stations        | (+)                      |

2.4. Models
The DID model is mostly used to evaluate the policy effect. If a policy is not fully rolled out, but selectively implemented, the policy effect can be judged by comparing the differences between the groups affected by the policy and the groups not affected by the policy. But the premise is that the policy should meet the exogenous requirements, that is, the policy should be implemented by randomly selecting objects, and the endogenous reaction caused by some policies should be avoided as far as possible in the selection of samples. Before using the double difference method, it is necessary to satisfy the randomness of the occurrence time of policy shock, the randomness of the selection of treatment group and control group and the assumption of parallel trend.

In the model construction, we take the current situation of urban drainage system after the implementation of data governance measures as the experimental group and the control group before the implementation. We use two dummy variables to group the samples, treat variable is used to distinguish the experimental group from the control group, treat=1 indicates the experimental group, treat=0 indicates the control group, year variable is used to distinguish the sequence of policy occurrence time, year=1 indicates that the urban drainage system is in the data governance pilot and after, and year=0 indicates that the urban drainage system is before the pilot. As the sample used in this paper is microscopic data at the level of drainage pipe network, in order to control the differences of research objects and time differences, we adopt the bidirectional fixed effect model of panel data, which is specifically set as follows:

$$ y_{it} = \beta_0 + \beta_1 \text{treat}_{it} \cdot \text{year}_{it} + \beta_2 + \beta_3 t + \beta' X + \varepsilon_{it} \quad (1) $$

Among them, $y_{it}$ is the interpreted variable, $X$ is the control variable, $\beta_1$ is the individual fixed effect, $\beta_t$ is the time fixed effect and $\varepsilon_{it}$ is the error term. The key variable of the model is $\text{treat}_{it} \cdot \text{year}_{it}$, which is the cross term between the experimental group and the pilot time, and its coefficient $\beta_1$ is the data governance policy effect coefficient that we care about. The reason for this is as follows:

As for the following double difference model,
For the experimental group, the difference before and after the experiment is estimated as follows

\[ y_u = \beta_0 + \beta_1 \text{treat}_u + \beta_2 \text{year}_u + \beta_3 \text{year}_u + \epsilon_u \]  

For the experimental group, the difference before and after the experiment is estimated as follows

\[ E(Y|X, \text{treat} = 1, \text{year} = 1) - E(Y|X, \text{treat} = 1, \text{year} = 0) = \beta_1 + \beta_3 \]  

Among them, \(\beta_3\) is a time factor, which plays a role in both the experimental group and the control group, so the estimation of formula (3) cannot accurately describe the policy effect of “data governance”, and the interference of time factor should be removed in the next step.

For the control group, the difference before and after the experiment is estimated as follows

\[ E(Y|X, \text{treat} = 0, \text{year} = 1) - E(Y|X, \text{treat} = 0, \text{year} = 0) = \beta_3 \]  

Estimating (4) is exactly the time effect that (3) cannot be separated, so the results obtained from (3) - (4) are that some common factors affecting the two groups are removed by differential re-differential, and the net effect of “data governance” is obtained.

3. Results

3.1. Descriptive statistics of variables

This paper focuses on the effect of urban drainage system data management on urban waterlogging. The economic development data at the urban level mainly comes from China Urban Statistical Yearbook, Tianjin Statistical Yearbook and Tianjin Xiqing Yearbook from 2010 to 2020. Some missing data are analogized with reference to relevant policies and regulations. The descriptive analysis of each variable is shown in Table 2

| Variable  | Variable declaration       | Observations | Mean  | Standard deviation | Min  | Max  |
|-----------|----------------------------|--------------|-------|--------------------|------|------|
| vdn       | Vulnerability of drainage network | 110          | 14.15 | 0.79               | 0.36 | 0.78 |
| wp        | Water surface rate         | 110          | 9.20  | 0.57               | 3.52 | 9.47 |
| spc       | Soil permeability coefficient | 110          | 0.75  | 0.07               | 0.91 | 3.55 |
| ups       | Urban Permeable Ground Rate | 110          | 0.12  | 0.28               | 0.21 | 0.48 |
| gc        | Green coverage rate        | 110          | 0.11  | 0.14               | 0.14 | 0.47 |
| ri        | Rainstorm intensity        | 110          | 0.48  | 0.11               | 136  | 189  |
| dr        | Rainfall duration          | 110          | 0.62  | 0.25               | 1.52 | 9.44 |
| pd        | Population density         | 110          | 0.14  | 0.08               | 2.76 | 4.31 |
| dcr       | Discharge capacity of rainwater inlet | 110  | 0.01  | 0.03               | 20.00| 50.00|
| calibre   | Pipe diameter              | 110          | 1.13  | 0.51               | 344  | 589  |
| pg        | Pipeline slope             | 110          | 0.54  | 0.31               | 0.15 | 0.52 |
| rcp       | Roughness coefficient of pipeline | 110 | 0.47  | 0.16               | 0.91 | 3.11 |
| tu        | Pipe age                   | 110          | 0.31  | 0.25               | 1.50 | 9.50 |
| swo       | Setting height of water outlet | 110         | 0.11  | 0.13               | 0.24 | 1.36 |
| ddp       | Density of drainage pipe network | 110        | 0.25  | 0.18               | 6.38 | 8.46 |
| lr        | Laying rate                | 110          | 0.38  | 0.09               | 0.81 | 0.95 |
| fdn       | Financial input ratio of drainage network | 110 | 0.14  | 0.34               | 10.25| 35.68|
| mlp       | Number of rainwater pumping stations | 110     | 0.67  | 0.29               | 4.00 | 8.00 |

3.2. Empirical results

In this part, we used the full sample data from 2010 to 2020 and the data from 2016 to 2020 to make an empirical analysis on the implementation of data governance measures to improve the governance efficiency of urban drainage network. We are concerned about whether the time node and the data governance policy effect coefficient \(\beta\) proposed by the implementation of the data governance measures
in the results are significantly positive. If it meets the forecast, the implementation of this measure has a positive effect on reducing the vulnerability of urban drainage network. Table 3 shows the basic regression results, and the $\beta$ coefficient in column (2) is significantly positive, indicating that the implementation of data governance measures has a significant positive effect on the governance of urban waterlogging. In column (2), we added water surface rate, soil permeability coefficient, urban permeable ground rate, greening coverage rate, rainstorm intensity, rainfall duration, population density, rainwater inlet discharge capacity, pipe diameter, pipeline slope, pipeline roughness coefficient, pipe age, outlet setting height, drainage pipe network density, laying rate, drainage pipe network financial investment ratio, and the number of rainwater pumping stations as control variables, and controlled the fixed effect and time fixed effect.

**Table 3.** Effect of data governance measures on vulnerability of urban drainage system

|                  | (1)vdn   | (2)vdn   | (3)Sample of vdn after vdn2016 | (4)Sample of vdn after vdn2016 |
|------------------|----------|----------|-------------------------------|-------------------------------|
| treat$_t$·year$_t$ | 0.0748*** | 0.0337*** | 0.0820***                     | 0.0355***                     |
|                  | -0.00357  | -0.00533  | (0.00321)                     | (0.00524)                     |
| wp               | 0.291***  | 0.0139*** | 0.611***                      | 0.0497***                     |
|                  | (0.00968) | (0.00305) | (0.0635)                      | (0.012)                       |
| spc              | -0.0139***| 0.00338   | -0.00329                      | 0.0232***                     |
|                  | (0.00279) | (0.000279)| (0.012)                       | (0.00391)                     |
| upc              | -0.0190***| 0.0910*** | 0.0316***                     | 0.00942**                     |
|                  | (0.0284)  | (0.00284) | (0.0635)                      | (0.00431)                     |
| gc               | -0.00636* | 0.00338   | -0.00338***                   | 0.0157***                     |
|                  | (0.00341) | (0.000279)| (0.00391)                     | (0.00380)                     |
| ri               | 0.0910*** | 0.0910*** | 0.0316***                     | 0.00942**                     |
|                  | (0.0284)  | (0.0284)  | (0.0635)                      | (0.00431)                     |
| dr               | -0.00338***| 0.00338   | 0.0232***                     | 0.0157***                     |
|                  | (0.000829)| (0.000829)| (0.00391)                     | (0.00380)                     |
| pd               | 0.00168***| 0.00168***| 0.0157***                     | 0.0157***                     |
|                  | (0.000550)| (0.000550)| (0.00380)                     | (0.00380)                     |
| dcr              | 0.00502** | 0.00502** | 0.0233***                     | 0.00720                       |
|                  | (0.0420)  | (0.0420)  | (0.00720)                     |                               |
| calibre          | 0.0577*** | 0.0577*** | 0.0108                        | 0.0122                        |
|                  | (0.0428)  | (0.0428)  | (0.0122)                      |                               |
| pg               | 0.480***  | 0.480***  | -0.0231***                    | 0.00172                       |
|                  | (0.0338)  | (0.0338)  | (0.00172)                     |                               |
| rcp              | 0.415***  | 0.415***  | -0.0180***                    | 0.00316                       |
|                  | (0.0555)  | (0.0555)  | (0.00316)                     |                               |
| tu               | 0.00610** | 0.00610** | 0.000239*                     | 0.000145*                     |
|                  | (0.0409)  | (0.0409)  | (0.000145)                    | (0.00161)                     |
| swo              | 0.00578***| 0.00578***| 0.00448**                     | 0.00161                       |
|                  | (0.0429)  | (0.0429)  | (0.00161)                     |                               |
| ddp              | 0.584*    | 0.584*    | 0.00485*                      | 0.0028                        |
|                  | (0.0405)  | (0.0405)  | (0.0028)                      |                               |
| lr               | -0.0122   | -0.0122   | 0.00968                       | 0.00173                       |
|                  | (0.00172) | (0.00172) | (0.00173)                     |                               |
| fdn              | -0.0125***| -0.0125***| -0.0214***                    | 0.00488                       |
|                  | (0.00164) | (0.00164) | (0.00488)                     |                               |
| mlp              | 0.00569** | 0.00569** | -0.0219***                    | 0.00529                       |
|                  | (0.00271) | (0.00271) | (0.00529)                     |                               |
| Regional fixed  | No        | Yes       | No                            | Yes                           |
| time effects     | No        | Yes       | No                            | Yes                           |
| Constant         | 9.488***  | -4.870*** | 9.611***                      | -3.243***                     |
|                  | (0.000372)| (0.615)   | (0.000481)                    | (1.002)                       |
| Observations     | 110       | 110       | 110                           | 110                           |
3.3. Hypothesis test of econometric model

In order to ensure the accuracy of the estimation results, parallel trend test and placebo test were conducted in this paper. Through parallel trend test, it is found that there are differences in urban drainage management between the experimental group and the control group before or after the pilot project of drainage network data management, and the implementation of this measure has significantly improved the level of urban drainage network management in the pilot community; Through the placebo test, it can be concluded that the random estimated value is distributed near zero and obeys normal distribution, and the data governance effect of the experimental group is real.

4. Conclusions

This paper mainly used the data of urban drainage network in 11 districts of Xiqing District of Tianjin in recent 10 years, and adopted DID model to investigate whether the implementation of data treatment measures will have an impact on the fragility of urban drainage network, and then improved the level of urban waterlogging treatment.

The empirical results show that: (1) the implementation of data governance measures has a significant impact on the vulnerability of urban drainage network, which can promote the implementation of urban waterlogging governance; (2) It is desirable to take the fragility of urban drainage network as an important parameter in urban waterlogging control; (3) The fragility of urban drainage pipe network has a remarkable effect on distinguishing disasters and adopting plans to implement accurate disaster prevention; (4) The fragility of urban drainage network can also provide decision support for daily waterlogging disaster prevention and control in non-disaster emergencies.

However, the data management measures of urban drainage network are still in the initial stage of practice, and various technical support, measures and project promotion need to be improved, which is also the direction and focus of further research by the research group in the future.

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