Assessing the Level of Effectiveness of the Public Bicycle Share (PBS) System in Nanjing through Public Policy Evaluation from a citizen's perspective

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Abstract

The public bicycle share (PBS) scheme has been booming over the past two decades in China as a public policy. However, the low usage of PBS in some cities raised concerns. To evaluate whether PBS policy is still necessary for Chinese cities, an evaluation method is needed. This study aimed to assess the level of effectiveness of PBS policy in China. Goal-attainment model was adopted to assess the extent that PBS policy achieved its goal. Data were collected by a questionnaire survey in Nanjing. This study is innovative since there is a research gap about PBS from the policy aspect. The result has shown that PBS policy in PBS policy in Nanjing achieved a high level of effectiveness in providing green travel to citizens while achieving a low level of effectiveness in solving “the last kilometre” problem.

Contents

1. Introduction

With China's accelerating urbanisation process, a growing number of people are now living in urban areas. Between 2000 and 2020, 3 million people emigrated to Nanjing, increasing the total population from 5.5 million to 8.5 million (Nanjing Bureau of Statistics, 2020). The limited urban land availability and the growing urban population make it difficult to build the necessary public transport infrastructure providing efficient and high -quality support. The growing number of vehicles also result in consequences of traffic jam and air pollution (Jia et al., 2017a). By 2020, the Nanjing municipal government had constructed ten metro lines and one light rail. Public transportation can provide citizens with enough transportation support on transfers at big stops; however, the "last kilometre" problem, travel between home to metro stations still remains for the majority of citizens (Lin & Jiang, 2013).

Under such circumstances, the Nanjing municipal government adopted Public Bicycle Sharing (PBS) system. It is defined as the networks of public use bicycles distributed around a city for use at low cost, bicycles can be picked up at any self-serve bike stations and returned to any other bike stations (Department for City Planning New York, 2009), to provide green travel for citizens and solve the last kilometre problem since 2015 (Nanjing Municipal People's Government, 2015).

However, whether PBS systems are effective is still in debate. In 2021, some PBS systems in China were withdrawn from the market as they have a low usage rate (Sina, 2021). If PBS system is effective, why do few people use it? The low usage rate of PBS could have a connection with the appearance of the new kind of stationless bicycle-sharing systems such as *Mobike* and *Hellobike* (Sohu, 2017). These bicycle-sharing systems have a similar function as PBS and have the advantage of being stationless. Meanwhile, Nanjing PBS is still in the running. Is Nanjing PBS effective under this circumstance?

The effectiveness evaluation of PBS policy in Nanjing has been so far studied to a limited extent to our knowledge (Nanjing Municipal Government, 2018). What percentage of citizens use PBS, and do citizens use it merely for travel between metro stations and home or for other purposes? The case study of Nanjing may provide practical experiences and valuable references for Nanjing and other Chinese cities to improve their PBS policy.

1.1. Background information

This section contains four categories of information about Nanjing PBS. It begins with the current situation of PBS, followed by the two reasons why PBS is needed, and the last is the challenge of the new kind of stationless bicycle-sharing system.

1.1.1. The construction of PBS is popular around the world, especially in China

As an environment-friendly vehicle system, PBS has been popular worldwide for the past decade, evidenced by over 800 systems by 2013 (Larsen, 2013). PBS system has been developed for four generations since the construction of the first PBS, which is called "white bikes" in Amsterdam (Mátrai & Tóth, 2016a). At present, PBS has come to the fourth generation, i.e., the complex, integrated system, featured with access to mobile devices, free, real-time information provision and large-scale integration with different systems (Mátrai & Tóth, 2016).

In 2008, Hangzhou became the first city in China to put PBS system into practice

as a fourth-generation system (Zhiyan Consulting, 2018). Afterwards, a large number of first- and second-tier cities in China started their own PBS construction. By the end of 2016, more than 400 cities had implemented PBS, most of which were fourth-generation systems (Zhiyan Consulting, 2018). PBS system has more than 2,000 stations and 100 thousand bicycles in Nanjing. 1.3 million citizens registered in PBS system in total. In the first half of 2018, bicycles in Nanjing were used more than 19 million times (Nanjing Municipal People's Government, 2018).

1.1.2. The fast-growing number of population and motor vehicles has raised traffic problems

With China's urbanisation process, a growing number of people leave rural areas and pursue lives in cities for better infrastructure and job opportunities (Zhang & Song, 2003). From 2000 to 2020, 3 million people emigrated to Nanjing, making 8.5 million by the end of 2020. Regarding age structure, the population aged between 15 and 64 was 6.5 million, accounting for 75.9% (Nanjing Bureau of Statistics, 2020). The high proportion of the population between 15 and 64 means the proportion of people with active demand for public transportation accounts for the main proportion. The mass quantity of the growing population also brought a considerable number of motor vehicles. By the end of 2019, 2.8 million motor vehicles have been registered in Nanjing in total. Such a quantity of motor vehicles caused frequent traffic jams and severe air pollution. In 2020, Nanjing ranked as the 8th of the "top 10 most traffic jam cities" (Gaode Map, 2020). In order to create a better traffic environment for citizens, Nanjing municipal government has established a series of measures, such as limiting the vehicles from other cities passing through one main bridge and one tunnel in Nanjing; however, such attempts did not have positive outcomes as expected (Huang, 2019). New methods should be employed to solve the traffic problem more efficiently and effectively.

1.1.3. The need for solving the last kilometre problem

In urban public transportation, the last kilometre, also known as "the last mile", indicates the distance between the final destinations and the public transportation points. Public transportation cannot take users directly home. They have to use travel alternatives (e.g., subway, walk, and taxi) to reach their final destinations (Lin & Jiang, 2013). At this distance, public transport sometimes can no longer take citizens to their destinations; instead, citizens have to take alternative options, i.e., walk, cycling or taxi. The last kilometre problem brought inconvenience and extra travel costs to citizens, leading to chaos of illegal vehicles.

In the past decades, vehicle numbers in China have kept increasing stably. According to State Statistics Bureau (2015), There were only 2 million vehicles in 1978, while this number significantly increased to 0.163 billion in 2015, with an annual growth rate of 12.6%. The rapidly growing population causes traffic problems, such as traffic jams, environmental pollution, and excessive energy consumption. Therefore, the so-called "public transport priority policy" is carried out in China to solve various issues generated by overwhelming vehicles. Thus, the development of urban public transportation grows fast with diverse travel alternatives, including PBS, bus, metro and tram, which gradually shifted toward a multi-mode public transportation system. However, the issue of the last kilometre remains.

1.1.4. The pressure from the new kind of stationless bicycle-sharing system

Shortly after Nanjing implemented PBS policy, a new kind of stationless bicycle-sharing system, *Mobike, ofo, Hellobike* appeared in Nanjing (Sohu, 2017). By the end

of 2018, there were in total of thirty-eight thousand sharing bicycles in Nanjing (Chen, 2018).

This new kind of bicycle-sharing system has the most similar function to PBS and even has the advantage of having no stations, which gives the new system more flexibility. This advantage is reflected in the numbers; thirty-eight thousand stationless bicycles and fifty-thousand PBS bicycles (Chen, 2018). In some cities in Jiangsu province, the local PBS has been withdrawn from the market. Meanwhile, stationless bicycle-sharing systems are still in use (Sina, 2021). It would be questioned whether PBS still has the necessity to exist.

1.2. Research aim

Based on the current status of PBS in Nanjing and the state-of-art of PBS research, this thesis aims to investigate its effectiveness. In this context, effectiveness is considered as “to what extent the goal is achieved” (Fischer, 1995) of PBS system in Nanjing. In this section, the general research question and sub-research questions are first formulated, then social and scientific importance are introduced.

1.2.1. Research questions

The primary research question is formulated according to the research aim: "What is the level of effectiveness of PBS in Nanjing?". Based on this main research question, two sub-questions are constructed as follows:

1. What is known in the literature about the factors influencing the effectiveness of PBS policy?
2. What is the goal of PBS in Nanjing?
3. What are the usage characteristics of PBS in Nanjing?

1.2.2. Social relevance and importance

Social relevance and importance refer to the outcomes and consequences of research and for different stakeholders. The research of PBS system is of vital theoretical importance concerning improving the urban transportation system. As a supplement to public transport, PBS plays an important role in the daily traffic of the citizens, not only for solving the last one-kilometre problem but also for travel for entertainment and sports. Moreover, sustainable transport systems, such as PBS, are crucial for achieving climate change objectives in an increasingly urbanized and connected world advancing knowledge on sustainable and resilient urban systems (Abduljabbar et al., 2021). This research reveals the characteristics of PBS from different perspectives, including users, bikes, and the dynamic interactions between users and bikes, which can contribute to the research concerning PBS, multi-level public transportation and intensive urban planning. It is specifically meant for metropolitan areas with dense populations and limited land availability.

Research of PBS can focus on different aspects, for example, the distribution of the stations (Zhang et al., 2016), the system's user satisfaction (Maioli et al., 2019) or the system's health influence (Fuller et al., 2013). Meanwhile, this research studied PBS from the policy aspect. PBS system could have different functions in urban areas, but, as a public policy, to what extend did PBS system achieve the policy goal? This research was aimed at evaluating the effectiveness level of the Nanjing PBS system in the policy aspect. As an empirical case study, the research outcomes are expected to benefit different stakeholders as follows: (1) researchers: considering there is not much research about PBS in Nanjing, identifying the characteristics in Nanjing can serve as references for researchers for future relevant local studies; (2) Nanjing municipal government: the identified spatial-temporal characteristics of PBS may guide

government to optimise the resource distribution (e.g., re-distribute bikes to stations who need more bikes in the morning, set up/cancel bike stations according to users' requirements and daily maintenance). The research also helps to explore the specific role of PBS in users' daily traffic, which avails framing the future public transportation policy; (3) users: the users may use it as references for travel plans (e.g., avoid traffic peaks and stations with insufficient bike volume).

1.2.3. Scientific relevance and importance

Scientific relevance and importance refer to the extent this research can fill the knowledge gap on a specific topic and benefit the science of today and the future. First, as mentioned before, PBS in Nanjing has not been fully understood, especially regarding the policy evaluation aspect. Second, this research builds a self-defined overarching conceptual framework, which has not been used before. Third, concerning methodology, on the one hand, the questionnaire is tailor-made for the research purpose and is able to reveal how PBS is evaluated by its users. The neutral perspective and full coverage of the questionnaire enhance the scientific robustness of this research. On the other hand, different evaluation methodologies, namely both public policy evaluation and user satisfaction evaluation, are brought together to evaluate PBS. They have their own emphasis, and the potential can be fully used. The combination of different evaluation methodologies may provide references to researchers regarding how to comprehensively evaluate a social policy that may have a significant societal impact.

1.3. Outline

After the introduction chapter, Chapter 2 consists of the academic theory of public policy evaluation. The content of the Nanjing PBS policy is introduced in Chapter 3. In Chapter 4, the methodology for this case study is outlined. In Chapter 5, the questionnaire survey results are discussed, and the sub-questions are addressed. The final Chapter—Chapter 6 addresses the central research question and concludes. A discussion rounds off this thesis.

2. Theory

This chapter discusses theories about PBS and public policy evaluation, and finally, the unified approach is chosen. This study focuses on the policy evaluation of a specific domain (PBS). Therefore, PBS is first introduced. It helps to understand the case study better. Also, as this case study is based on the public policy evaluation theory, the relevant study in this research field is introduced in the second section. The third section is the conceptual framework based on the literature review in the first two sections. In the last section, a concluding remarks summary of the whole chapter.

2.1. Literature review

2.1.1. PBS

In this section, PBS's appearance is first introduced to have a general view of PBS. Then the definition of PBS is given, and three PBS characteristics are summarised based on different definitions of PBS. Relevant studies of PBS are introduced in the last part, as some of the studies may be helpful for this case study.

Why PBS appears

As the urbanisation process progress, a growing number of people are now living in urban areas. By 2050, "every week, more than a million people are being added to the cities (West, 2011)." Cities determine how the vast majority of the world's people will live in the future. The problem of urban transportation is exponentially growing with the increase of urbanisation (Mátrai & Tóth, 2016). In the past two decades, Public Bicycle System has appeared in many urban areas and shown rapid growth worldwide. Amsterdam's "white bicycles" were the first bicycle-sharing system in the 1960s (Wang et al., 2009). Until 2001 only five systems existed in large cities around the world, while in 2012, this number of Public Bicycle Systems increased by over 400 (Larsen, 2013). In 2014 the number climbed to over 800 (Ricci, 2015). In China, by the end of 2016, more than 400 cities had implemented PBS (Zhiyan Consulting 2018).

Definition of PBS

Public bicycle sharing (PBS) is also called a bicycle-sharing system or public bicycle scheme (Shaheen et al., 2011). Fishman et al. (2013) defined PBS as "Contemporary bike share programs refer to the provision of bicycles to enable short-term rental from one docking station to another". European Cyclists' Federation (2013) defined it as "short-term urban bicycle rental schemes that enable bicycles to be picked up at any self-serve bicycle station and returned to any other bicycle station, which makes bicycle-sharing ideal for A-to-B trips". Mátrai and Tóth (2016b) used the following definition: "Public Bike Sharing (PBS) system is a new kind of alternative public transport service, which is an extension of the conventional public transport system. However, this service can provide users flexibility, like private transport options. PBS systems provide public bikes for free or a minimal fee in frequently used urban spaces. The system can be used for one-way trips by anyone."

Characteristics of PBS

As the definitions show above, PBS has unique characteristics compared to traditional public transportation. Three characteristics of PBS can be concluded: fixed stations, low cost and short-distance travel (Shaheen et al., 2010).

PBS system usually contains fixed bicycle stations for borrowing and returning bicycles. To use PBS, people need to register and obtain their user’s card. Each time he uses these bicycles, he must tap the card on the card reader on the docking pole. Then, one bicycle is released from the pole. The same methods must be applied when returning the bike to the docking station (J. Zhao et al., 2014).

In general, public transportation is costly in Europe, in which 9 out of 10 cities

with the highest cost are in Europe (Jessica Dillinger, 2017). Taking the Dutch public transportation system as an example, a single-trip bus ticket of Dutch Syntus Company costs at least 2.45 euros (*Tarieven 2022 Syntus Twents*, 2022), and a Rotterdam 2-hour Transport ticket costs 4 euros (*Public Transport Tickets Rotterdam*, 2022). In contrast, renting an OV-fiets (rental bike operated by the Dutch railway company) for 24 hours only costs 4.15 euros (*OV-Fiets*, 2022). This phenomenon may be partly explained by the urban scale of the population using public transportation – the more the population, the lower the price. France is also one of the countries which maintain a high-quality PBS called Vélib. Their advertising-based system makes low prices possible: a one-day pass ticket costs 1 euro and a weekly pass 5 euros (*Where to Rent a Bike in Paris*, 2022). The price is significantly lower.

Regarding the situation in China, a large-scale public transportation system is extensively available and provides stable services. The price may vary between city and city; in general, public transportation is affordable and cheap. For example, one single-way bus ticket in Nanjing is 2 yuan (approximately 0.29 euro or 0.33 US dollar) (*Nanjing Public Bus - Baidu Pedia*, 2021). The price is even lower when it comes to PBS - the first hour is free of charge, and 1 yuan (approximately 0.14 euro or 0.16 US dollar) is charged for every hour after the first hour (J. Zhao et al., 2014). In most scenarios, the users are free of charge if they use PBS for short-term travelling.

"PBS helps people move from one transit station to another and enhances connections with other public transit modes" (Karki & Tao, 2016a). Typically for short-term travel between one to five kilometres (Bauman et al., 2017). PBS is a supplement to traditional public transportation such as the metro or bus because metro stations and bus stations cannot cover every community and provide equal accessibility to every citizen. Li et al. (2009) defined three main usage scenarios of PBS:

The first scenario is connecting other public transport. Citizens sometimes have a long way to get to the bus stop or the metro stations from home or vice versa. On this occasion, PBS has the advantage of flexibility. Citizens don't have to wait and take a long walk because PBS stations are close to the residential areas. The second scenario is short-term travel near home. Citizens may work near their homes or go to the supermarket for everyday demands. The third scenario is the use of tourist attractions. In the tourist attractions, as most people are tourists from other places, they can hardly bring a bike there, and most drive their car or take public transportation such as train or bus. There is a problem with the travel within the tourist attractions for these tourists. Public bicycles provide an irreplaceable choice here. With public bicycles, tourists do not have to transport bicycles for long-distance. They only need to borrow and return to the tourist attractions.

The current state-of-the-art of PBS

The current state-of-the-art of PBS is introduced in the following paragraphs. In this case study, we studied the effectiveness of PBS through the policy evaluation aspect. Meanwhile, this effectiveness could possibly be measured by indicators, such as turnover rate (Zhao et al., 2014), and user satisfaction (Gatian, 1994). The relevant studies of PBS can provide a broader view for the studying of PBS evaluation.

There has been abundant research on PBS since it rose in the late 1990s (Karki & Tao, 2016b). For PBS in different cities and countries, Li et al. (2019) determined that PBS in Nanjing, China has a tidal phenomenon during the workday: the usage peak from 6 to 9 am and from 4 to 6 pm. While at the weekend, the usage is frequently in the middle of the day. In terms of PBS's impact, Hosford et al. (2019) conducted a study in 8 cities around the world and concluded that PBS could contribute to increasing the cycling population. Fraser and lock (2011) concluded that PBS might be a solution for

both public health and the environment. In terms of user perception, Maioli et al. (2019) use the SERVPERF tool to study which factors influence user satisfaction in Brazil. Karki and Tao (2016b) concluded that PBS has a "low participation for women, migrant workers, low-income families, informal jobholders and less educated people" in Suzhou, China.

In the aspect of the system's effectiveness, according to the author's best effort, there is only one paper studying PBS's effectiveness. Zhao et al. (2014) evaluated the effectiveness of PBS by measuring the turnover rate. In this paper, the turnover rate is measured by the rate of the city's daily use of public bicycles to the number of public bikes in the city. The higher the rate, the more effective the system is. Moreover, according to Marco and Cinzia (2010), in the urban public transport domain, the effectiveness of the public transportation system can be measured in different aspects: economic dimension, adherence to objectives and customer viewpoint. The economic dimension is measured by "the extent of service consumption" (Giuliano, 1981). Adherence to objects is measured by "the extent to which an object has been achieved" (Gleason & Barnum, 1982). Customers' viewpoint is measured by "effectiveness for users: service quality" (Hensher & Prioni, 2002). These domain-specific studies may provide references to the effectiveness study for PBS.

The "last kilometre" problem is one of the main problems that PBS is meant to address(Liu et al., 2012). The "last kilometre" problem is defined as "the provision of travel service from a public transportation node to a home or workplace ("last mile") or vice versa ("first mile")" (Wang & Odoni, 2014). Wang and Odoni (2014) conduct a study to approximate the performance of a "last kilometre" transportation system by dividing the system into the supply side and demand side. Liu et al. (2012) took Beijing PBS for a study and revealed failure reasons when solving the "last kilometre" problem. Fan et al. (2019) studied how PBS changed people's "last kilometre" travel mode.

Generally, most current studies on the bicycle-sharing system focus on the system itself rather than viewing the system from a policy perspective. However, the research from the two perspectives is different. The research on PBS system can focus on the environment function, health function, etc. Meanwhile, the policy perspective focuses on how PBS reached the policy goal. For example, if the policy goal is to solve the “last kilometre problem”, then we need to study how did PBS solve the “last kilometre problem” and to what extend did the policy goal achieved.

2.1.2. Public policy evaluation

In this section, the definition of public policy evaluation is first discussed to understand better the origin and development of public policy evaluation. Secondly, the development of public policy evaluation is discussed. Different models of public policy evaluation are discussed, and the proper model for this case is chosen.

The government is faced with increasingly complex problems as the world becomes unstable and unknown. Policymakers face unpredictable and various outcomes when making policies, as citizens have different perspectives and values towards different outcomes based on their varying cultures and interests (Vedung, 2017). Although the government has used a number of the nation's resources to meet society's needs, discontent and opposition never disappear (Nachmias, 1979). However, policymakers are responsible for improving citizens' living environment and meeting their needs. Though there are difficulties, policymakers still need to make proper policies with high uncertainty and limited data. In the 1930s, more policymakers strived to look for alternatives and tools aiming to improve the effectiveness of public policy and avoid the subjective bias of the policymakers. These tools are called public policy evaluation (Nachmias, 1979).

The definition of public policy evaluation can be various. Public policy evaluation often means public policy analysis, while public policy evaluation emphasises the evaluation progress rather than explaining why they exist (Nagel, 2002). Quade (1972) defined public policy evaluation as "a systematic approach to supporting policymaking in the public sector." Walker (2000) defined public policy analysis as "a rational, systematic approach to making policy choices in the public sector. It is a process that generates information on the consequences that would follow the adoption of various policies." Nachmias (1979) defined public policy evaluation as "the objective, systematic, empirical examination of the effects ongoing policies and public programs have on their targets in terms of the goals they are meant to achieve." The abovementioned three definitions showed nuanced differences regarding the specific details, as the definition of public policy evaluation can vary according to different dimensions.

There are two dimensions for dividing public policy evaluation: the evaluation stage and the evaluation methods (Zhao, 2014). The definition of public policy evaluation varies according to three evaluation stages: formative evaluation, process/implementation evaluation, and outcome/effectiveness evaluation (Figure 1). Formative evaluation is used before the full implementation to ensure the program's feasibility. Process/implementation evaluation checks whether the program is implemented as planned. Outcome/effectiveness evaluation is used to assess the program's effectiveness by examining whether the program achieves the expected outcomes.

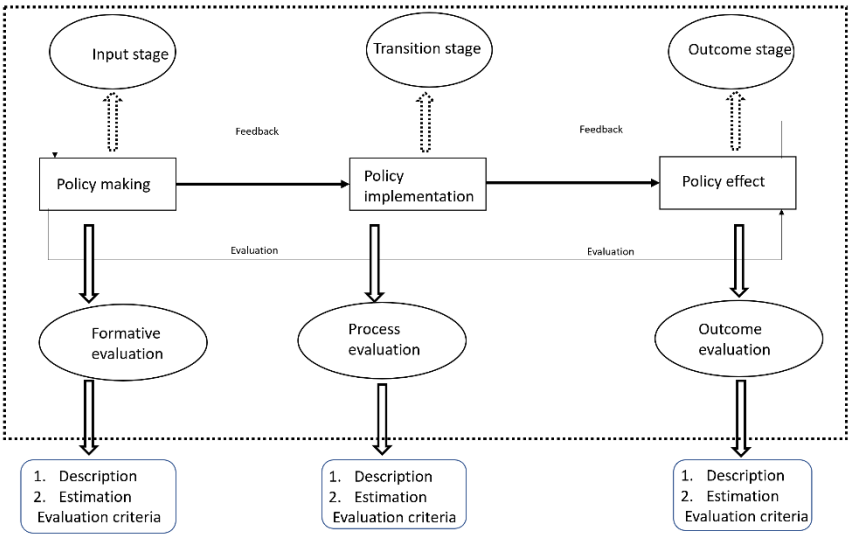


Figure 1 Logical framework for the classification of public policy evaluation (Zhao, 2014)

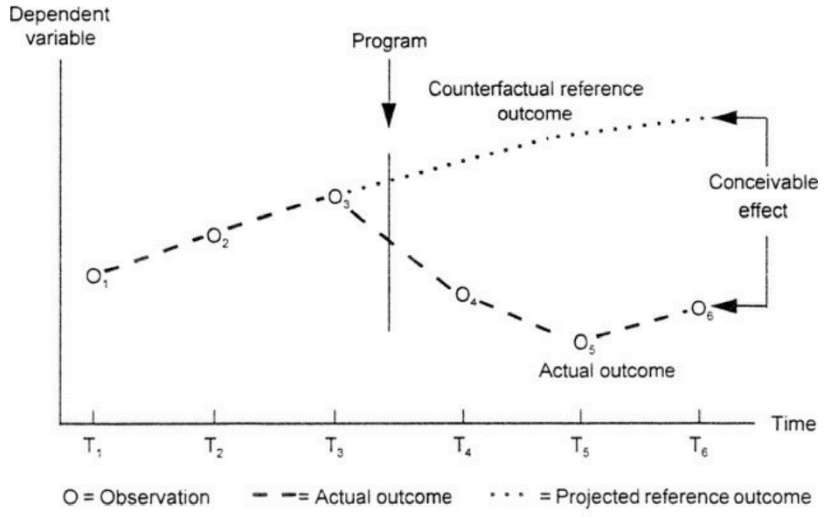
Similarly, evaluation methods vary as well. According to Zhao (2014), evaluation methods can be divided into positivism and post-positivism. The evaluation theory of positivism takes the efficiency, benefit, effect and sufficiency of policy results as the basic value orientation, which adheres to the combination of demonstration and technology, and applies qualitative evaluation methods such as cost-benefit analysis, multiple regression .analysis, public opinion survey research, operations research and system analysis (Howlett et al., 2009). Meanwhile, Post-positivism emphasises the combination of fact and value, adheres to the unification of technical standards and social and political standards of value, and combines the evaluation methods of

empirical analysis with the evaluation methods of normative analysis (Howlett et al., 2009). Emphasis should be placed on applying economic and technical standards in evaluating policy results and applying political, social, and legal standards in the policy plan and policy implementation practice (Zhao, 2014).

Referred to the definitions noted above, this article defines public policy as a course of actions created and enacted in response to public and real-world problems (Rinfret, Scheberle & Pautz, 2018). It is meant to realise three functions: social public management or service, political control and class rule, and the balance and adjustment of social interest relations (Zhao, 2014).

During the development of public policy evaluation, different researchers gave different classifications. In the following paragraphs, Theodoulou and Kofinis's and Vedung's classifications are discussed, and the proper type is chosen for carrying on this case study. Theodoulou and Kofinis (2004) defined four types of public policy evaluation: process evaluation, impact evaluation, outcome evaluation and cost-benefit evaluation. According to Nachmias (1979), process evaluation is to examine "whether a particular policy or program is implemented according to its stated guidelines." To be specific, process evaluation evaluates policy through real-time tracking or monitoring of the process and related outputs of the project implementation. The project objectives and expected benefits set by the previous project are met, and then the project can continue and be completed within the framework of a monitoring function system(Vedung, 2017).

As Nachmias (1979) noted, impact Evaluation is to examine "the extension to which a policy causes a change in the intended direction." Impact evaluation not only describes or measures the existing effect but also the function of the intervention (Figure 2). It answers the question of "What contingencies (causal factors, operating causal forces) — the intervention included—explain the results? (Vedung, 2017)" to be more simplified, as (Centers for Disease Control and Prevention, 2015) noted, "it



assesses program effectiveness in achieving its ultimate goal".

Figure 2 The impact Problem in Counterfactual Terms (Vedung, 2017)

Outcome evaluation is frequently referred to by institutions and foundations, and such organisations emphasise social welfare. It assesses the effectiveness of a project in producing change. For example, the project focuses on how much of a difference the

project achieves, namely the "before-after" effect (Theodoulou & Kofinis, 2004).

Cost-benefit evaluation, as known as cost-benefit analysis (CBA), is widely adopted in both the private and public sectors and for a diversity of projects. It is an approach used to understand the economic welfare impacts of a project by comparing its total costs with its benefits, using a common metric (in most time it is monetary units); then, decisions can be made based on the comparing results in the means of total benefits less total costs, i.e., whether there is eventually a net benefit or cost, while also taking into account the temporal dimension and uncertainties (Theodoulou & Kofinis, 2004).

Vedung (2017) divided policy evaluation into three models: effectiveness models, economic models and professional models (Figure 3). Effectiveness models: effectiveness models is used for "addressing only the result of alternative interventions"(Vedung, 2017). It can be divided into a goal-attainment model, side-effects model, goal-free evaluation model, comprehensive evaluation model, client concerns model and stakeholder concerns model. Goal-attainment model address the problem of “are the result in accord with program goals?” (Vedung, 2017); the side-effects model is used to address those unintended important set of side effects; goal-free evaluation is used to “discover whatever impacts the intervention has produced” (Vedung, 2017); comprehensive evaluation evaluate not only the goal but also implementation and planning; client concerns model address the problem of whether the program satisfies client concerns; stakeholder concerns model focuses on the issues or concerns of those people who are involved in the policy.

Economic models can be divided into productivity models and efficiency models. It "integrates cost and effectiveness aspects of public interventions"(Vedung, 2017). "It takes productivity maximisation to be the standard of good performance for public interventions (Vedung, 2017)." In other words, economic models measure the ratio of outputs to inputs in public policy. The difference between the two models is that effectiveness models only address the interventions without considering costs, while economic models only address the integrated cost and pay no attention to the intervention itself (Vedung, 2017). Professional models imply that "members of a profession are entrusted with evaluating other members' performances concerning the profession's criteria of merit and quality standards of performance". The professional model evaluates the policy indirectly. The most used professional model is the peer-review approach: submitted articles are subjected to peer review to decide whether they ought to be accepted for publication"(Vedung, 2017).

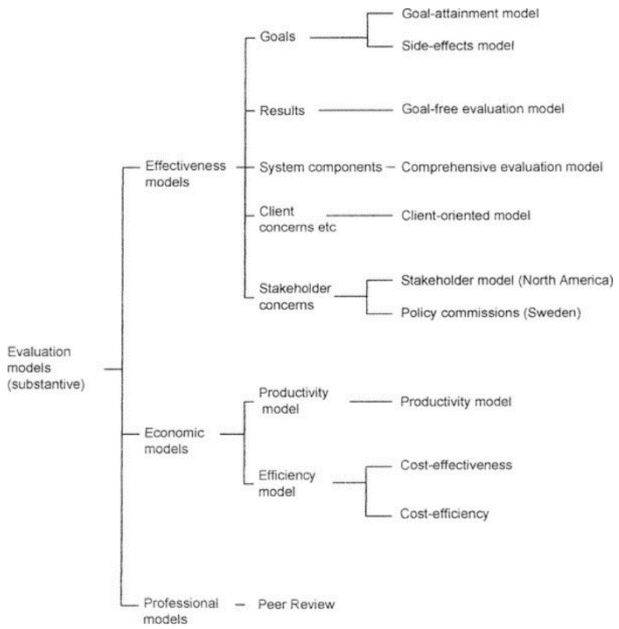


Figure 3 Vedung's classification of public policy evaluation models (2017)

According to Theodoulou and Kofinis's classification (2004), this case study of Nanjing PBS policy applies to the impact evaluation, as this case study is about examining the extent to achieving the final goal. While according to Vedung (2017), this case study applies to the goal-attainment model. As Vedung (2017) noted, the "goal-attainment model address the key question: is the result in accord with program goals?" This is in accord with the research aim: To what extent did PBS policy achieve its goal?

Facts in public policy are the external objective facts that make decisions (Yulong, 2017). Decision-makers use these facts to determine the problem and make decisions. In policy evaluation, objective description and judgement are always necessary. These elements consist of measurable indicators that can reflect quantitative value, ratio relations, and statistical results of the past, present and future (Zhang, 2010). Analysing these objective descriptions and judgments can help evaluators understand the causal relations in policies and thus evaluate the effectiveness of policies(Yulong, 2017).

According to Guba and Lincoln (1989), public policy evaluation has developed in four stages. The first and second generations of policy evaluation are based on analysing objective facts.

The first generation is the measurement generation, which emerged in the early 20th century and was mainly influenced by two situational factors (Guba & Lincoln, 1989). The first is the rise of behaviourism in social science, which emphasises quantitative research methods. The second is the motivation of the scientific management movement for testing behaviour. In measurement, the role of the evaluator was technical (Nachmias, 1979). Policymakers in measurement generation were expected to know instruments well; therefore, variables could be measured well.

The second generation is the description (Guba & Lincoln, 1989). This generation emphasises a description of the advantages and disadvantages of explicit goals. Evaluation is a process of detecting the consistency between goals and behaviours, and the significance of evaluation is to compare the difference between expected results and actual results (Nachmias, 1979).

Meanwhile, individuals have different value preferences and will have other value evaluation criteria on the same policy. Even the same individual's choice will change based on different periods, social environments, problems, and tasks (Zhang, 2010). Considering the importance of value, the third-generation evaluation is called

judgement evaluation (value-based). Just as Dunn (2018) noted, if the evaluators take their value criteria as the public's accepted value standards, he uses quantitative research methods such as questionnaire survey and random sampling. This evaluation's utility in guiding policy practice is minimal. Therefore, the third generation of policy evaluation, the judgment evaluation model, appeared in the mid-1960s (Guba & Lincoln, 1989). Unlike the first and second generations, judgment evaluation concentrates on " judgment" rather than measurement and description. Weber argues that the dimension of "judgment" contained in the evaluation should not be ignored and that policy evaluation, in addition to its function of measurement and description, is an effort to reach some judgment (Weber, 2002). As a revision of the previous two generations of evaluation, the judgment-oriented evaluation model argues that the performance of policies and the policy objectives should be viewed as problematic and need to be evaluated (Nachmias, 1979).

An excellent example of the difference between fact-based and value-based evaluations is Barro's (1999) research. In this research, Barro concluded that equal income in developing countries could stimulate economic growth while there is a trade-off in wealthy countries. Although this research gave a rigorous conclusion, the article still drew criticism as it ignored the poor people's desire for equity in wealth distribution (Zhang, 2010). This example indicated Fischer's (1995) theory: if the evaluation is judged as reasonable, then fact and value should be considered. This is also the main idea of the next-generation evaluation.

The fourth generation of policy evaluation is responsive and constructivist (Guba & Lincoln, 1989). As Guba and Lincoln (1989) noted, the first three generations of policy evaluation have three pervasive problems: a tendency toward managerialism, failure to accommodate value-pluralism, and overcommitment to the scientific paradigm. An alternative approach was proposed to avoid these problems, i.e., responsive and constructivist evaluation. The "Responsive" here means the new approach to cooperating with the stakeholders. In the first three generations, the parameters and boundaries are decided before the evaluation, while in the fourth generation, parameters and limits are accomplished through negotiations between clients and evaluators.

Moreover, the responsive evaluation does not only respond to the stakeholder's view once. It will also respond to the view in the following processes, as stakeholders have different interests and claims in different positions and at different times. The "Constructivist" means the reconstruction of a paradigm. As Guba and Lincoln (1989) noted, although the normativity of the paradigm makes practitioners do research "without the necessity of long existential or epistemological considerations", it also has a weakness in that research is hidden in the unquestioned assumptions of the paradigm.

Generally, public policy evaluation research starts firstly by collecting data from individuals; then it considers the nonhuman factors in the second generation; in the third generation, it leads the evaluations to judgement (the evaluation's value and its worth). In the fourth generation, to avoid the defect of the previous evaluation, responsive and constructivist evaluations were put forward (Guba & Lincoln, 1989).

2.1.3. Summary

Previous research on PBS focused more on the system itself, for example, the distribution of the stations (Zhang et al., 2016), the system's user satisfaction (Maioli et al., 2019) and the system's health influence (Fuller et al., 2013). Meanwhile, there are few studies investigating PBS from the policy aspect. PBS system could have different functions in urban areas, but to what extent did PBS system achieve the policy goal as a public policy? To fill this research gap, this study aimed to evaluate the effectiveness

level of the Nanjing PBS system in the policy aspect.

From previous research on public policy evaluation, it can be concluded that public policy evaluation theory development has gone from fact-based evaluation (positivism) to value-based evaluation and to the combination of fact and value evaluation— value-pluralism (Guba & Lincoln, 1989). Just as Fischer (1995) noted: "the contemporary empirical approach to policy evaluation is constructed on the foundations of positivism". The evaluation of public policy should consider the facts and the value, and the judgment of value should be based on the fact (Yulong, 2017). Dunn (2018) also noted that facts and values are interdependent. The realise of value is an important component of public policy evaluation. From these viewpoints above, it can be concluded that public policy evaluation tends to be pluralistic. It integrated different evaluation methods to make it more adaptive and objective (Gao, 2008). Public policy evaluation should take value pluralism to consider the value of different groups and pursue the integration of facts and values. In this case study, PBS policy is related to both the interests of the government and the citizens. The value of this case study can be measured by both the value of the government and the value of the citizens. And the citizens can also be divided into different groups, such as low-income and high-income. Different groups of people have different interests, and the choice of different values can directly affect this case study's evaluation result. Just like Barr's (1999) example mentioned in the previous paragraph, he ignored the poor people's desire for wealth distribution equity when he concluded that the equalisation of income in wealthy countries could lower economic growth. In this case study, the Nanjing citizens' interests are valued. Because PBS did not serve specific groups of people, it did not serve only the wealthy or the poor; it did not serve only men or women. It is a public transport service, and it serves every citizen.

2.1.4. Addressing sub-question 1

As shown in the literature review above, the goal attainment model, which is defined as “are the result in accord with program goals?” (Vedung 2017), is selected as the research model for this case study. Therefore, sub-question 1: What is known in the literature about the factors influencing the effectiveness of PBS policy? can be answered, by using this model. The factors that influence the effectiveness of PBS policy are PBS policy’s goals. If the result is in accord with the goal, then the policy achieved effectiveness; if the result is not in accord with the goal, then the policy did not achieve effectiveness.

2.2. Conceptual framework

The conceptual framework is an intuitive representation of the causality between independent and dependent variables. It reveals expected relationships between the variables. In this section, the conceptual framework for each of the sub-goals is formulated. Both models and literal explanations are given to give a clear view. Considering PBS is a public transport service that serves every citizen, the conceptual framework is constructed according to all Nanjing citizens' interests.

The goal of PBS is stated in Nanjing Municipal Government's Public bicycle development work programme (Nanjing Municipal People's Government, 2015) "To provide green travel for citizens and solve the 'last kilometre' problem." This objective can be split into two sub-goals:

Subgoal 1: To provide green travel to citizens

Subgoal 1 is "to provide green travel to citizens". Tian et al. (2019) noted that PBS is a green travel mode. If people use PBS, they are doing green travel. Meanwhile, if people do not use PBS, then the goal is not achieved. PBS cannot achieve green travel with only bicycles without the use of the users. Therefore, the evaluation of this sub-goal of "providing green travel to customers" needs to check if people are using this service. In other words, the more people use PBS, the high level of green travel PBS achieve. Therefore, the first hypothesis is formulated:

H_{1a}: The more PBS service is used, the higher level of green travel is achieved.

Meanwhile, the citizen's use of PBS system can be determined by one or more factors, for example, Xu et al. (2021) pointed that altruism has a positive effect on citizens' pro-environmental behaviour. Bokhari (2005) revealed that higher user satisfaction can lead to higher system usage amounts. In this study, user satisfaction is adopted as the factor that influences citizens' PBS usage amount (Figure 4). Hypothesis 1b is therefore formulated:

H_{1b}: The more the users are satisfied with the system, the more the users will use the system (Bokhari, 2005).

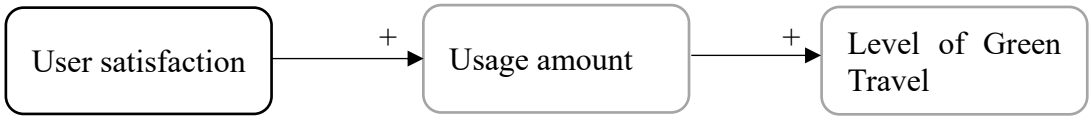


Figure 4 Intervening model hypothesis 1

The relations of the variables are shown in the graph, 'user satisfaction is the independent variable, and 'level of green travel' is the dependent variable. "usage amount" in this relation plays the act of intervening variable. This means the high level of 'user satisfaction cannot directly lead to a high 'level of green travel', 'user satisfaction' positive influences' use', then 'use' has a positive influence on the 'level of green travel'.

Subgoal 2: To solve the last-kilometre problem

Subgoal 2 is "to solve the last-kilometre problem" (Nanjing Municipal People's Government, 2015). The last kilometre problem is defined as "the provision of travel service from a public transportation node to a home or workplace ("last mile") or vice

versa ("first mile")" (Wang & Odoni, 2014). The definition shows that the last kilometre means a specific use of PBS, which is from the transportation hub to home or vice versa. Therefore, the sub-goal is evaluated by the ratio of the citizens that use PBS to travel between transportation hubs to their homes. The second hypothesis is formulated:

H_{2a}: The more users use PBS, and the more users use PBS for "the last kilometre" purpose, the higher fit for the "last kilometre" problem is achieved.

Figure 5 shows the relationship between the interaction and the intervening model.

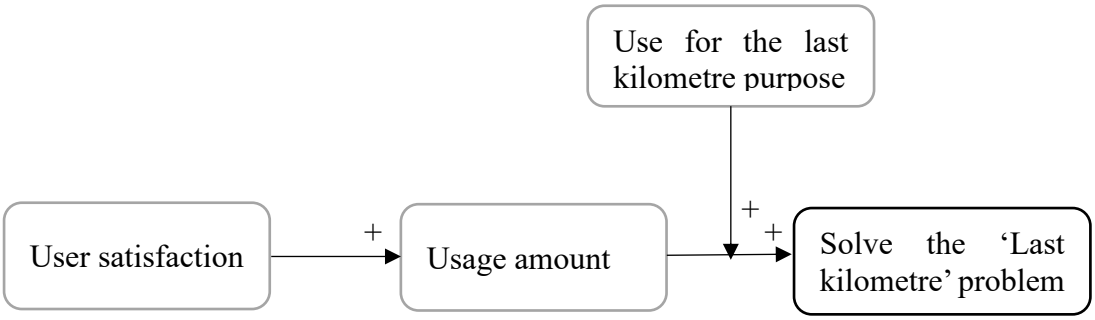


Figure 5 Interaction and intervening model for hypothesis 2

With the literature review and the conceptual framework, the three sub-research questions can be answered and revised. For the first sub-question "What is known in the literature about the factors influencing the effectiveness of PBS systems?" Zhao et al. (2014) evaluated the effectiveness of PBS by measuring the turnover rate. Marco and Cinzia (2010) noted that the effectiveness of the public transportation system could be measured in different aspects: economic dimension, adherence to objectives and customer viewpoint. For the second sub-question, "What is the goal of PBS in Nanjing?" As it was stated in Nanjing Municipal Government's Public bicycle development work programme (Nanjing Municipal People's Government, 2015), PBS policy is "to provide green travel for citizens and solve the 'last kilometre' problem." The third sub-question, "What are the usage characteristics of PBS in Nanjing?" is not appropriate, as two models have been built to show the interaction and intervening relation between variables.

Following the theoretical discussion presented in this chapter, the central question is formulated as : "To what extent did the PBS policy in Nanjing achieved its goal? " with the following derived sub-questions:

1. What is known in the literature about the factors influencing the effectiveness of PBS policy?
2. What is the goal of PBS in Nanjing?
3. What is the user satisfaction level of PBS in Nanjing?
4. To what extend do users use PBS for the 'last kilometre' problem?

The two new sub-questions are posed based on the interaction and intervening model. Meanwhile, these models are framed based on theories only. To apply these models into practice, an empirical study is needed. In the next chapter, the Nanjing PBS policy's content is discussed in detail.

3. The content of PBS policy in Nanjing

This chapter introduces the content of PBS policy in Nanjing. In the first section, the study area— Nanjing- is first introduced, and in the next, the characteristic of PBS in Nanjing is described. The policy's goal is identified in the second section, and two key concepts, "green travel" and "last kilometre problem", are introduced to better understand this policy.

3.1. Nanjing and its PBS

Nanjing is chosen as the study area of this thesis. It is the capital city of Jiangsu Province and one of the megacities in China[1] (National Statistics Bureau, 2021). Geographically, Nanjing is located on the Yangtze River Delta and provides essential economic, political, and transportation functions in the East China region (Figure 6). Until 2020, this city covers an administrative area of 6,587 km^2 with a total population of 7.22 million (Nanjing municipal bureau statistics, 2021; Nanjing Public Transportation Group, 2022).

Figure 6 The study area map of Nanjing (Nanjing municipal bureau statistics, 2021)

Currently, different public transportation modes are available within Nanjing, including bus, subway, and PBS. PBS was first introduced to Nanjing in 2013 to achieve two goals, namely (1) solving the last kilometre problem and (2) green travel. The Nanjing public bicycle company, a subsidiary of the state-owned Nanjing public transportation group, operates it. As of February 2020, NPB had 53,200 bikes and 1500 stations in operation (Hua et al., 2021). The most significant difference between PBS and other sharing bike systems operated by private companies lies in the dock. As shown in Figure 7, PBS bicycle has a dock unlocked by a smart card, while another bicycle is dockless and free of parking place restrictions.

[1] Cities with a population of more than 5 million and less than 10 million are called megacity in Chinese context.

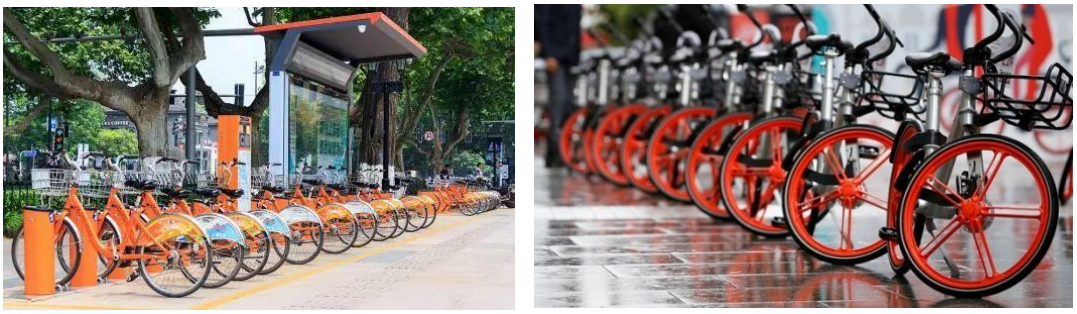


Figure 7 The comparison of Nanjing PBS (left) (soho, 2017) and dock-less sharing bicycle run by private companies (right) (Ren, 2018)

3.2. Goals

The goal of PBS policy is stated in Nanjing Municipal Government's Public bicycle development work programme (Nanjing Municipal People's Government, 2015), which is: "To provide green travel for citizens and solve the 'last kilometre' problem."

3.2.1. Green travel

The idea of green travel originates from green transportation, but it still lacks a uniform or clear definition (Jeon & Amekudzi, 2005; Yang et al., 2017). It has a high overlapping area with terms such as sustainable transportation (*Sustainable Transport: What Is It and Why Is It Important?*, n.d.). Green travel has received great attention due to growing concerns of car and air pollution in the urbanisation process (Jia et al., 2017b). In general, green travel refers to sustainable transportation methods concerning their social and environmental impacts. The greenness of a specific travelling means is largely measured by energy effectiveness and efficiency as well as the environmental and climate impacts of the system (Jeon & Amekudzi, 2005). There are several evaluation criteria for greenness, including the energy source (e.g., electricity or gasoline for cars), the infrastructure used to accommodate the transport (e.g., airways, waterways, and canals), and the vehicles (e.g., aeroplanes and train). The European Union defines sustainable transportation as follows, which can be referred to when defining and promoting green travel(European Conference of Ministers of Transport, 2005):

- Allows the basic access and development needs of individuals, companies and society to be met safely and consistently with human and ecosystem health and promotes equity within and between successive generations.
- It is affordable, operates fairly and efficiently, offers a choice of transport modes, and supports a competitive economy and balanced regional development.
- Limits emissions and waste within the planet's ability to absorb them, uses renewable resources at or below their generation rates and uses non-renewable resources at or below the rates of development of renewable substitutes while minimising the impact on the use of land and the generation of noise.

Green travel provides a positive contribution to the environment, society and economics. For example, renewable energy sources deliver less carbon dioxide and less air-polluted partials, thus slowing the pace of global warming and improving overall air quality. Poor and vulnerable groups can also benefit from green travel due to its flexibility and mobility.

3.2.2. Last kilometer problem

It is a concept that was initially adopted in the field of telecommunication. It indicates the difficulty of connecting individual homes to the main telecommunication networks (Lin & Jiang, 2013). In distribution networks and supply chains, it delivers a similar dilemma – the parcels or people can be efficiently transferred by train, aeroplane, or other transportation ways; however, they can only reach the individual customers by smaller vehicles with an increasing marginal cost. Currently, urban transportation often refers to the challenges of public transportation, e.g., subway and public bus lines, delivering people to their homes. The urban transportation system works efficiently in hierarchical levels. The levels are sorted by time efficiency. The private car is the most convenient and fastest means to reach the destination with the highest monetary cost, associated with negative external consequences such as traffic congestion and air pollution. Walking is the greenest alternative but the embedded time cost is not affordable for urban residents. Public transportation is the alternative solution provided for the majority in a balanced, cost-effective and time-efficient manner. The city is abstracted into nodes in a different hierarchy and thus connected by public transportation, in which people enjoy great convenience. However, the last-mile issue points out the ignored fact that there lacks an effective connection between individual homes to the virtual node of public transportation. People need a more efficient way rather than walking for up to 30 minutes to reach their destination (Balcik et al., 2008).

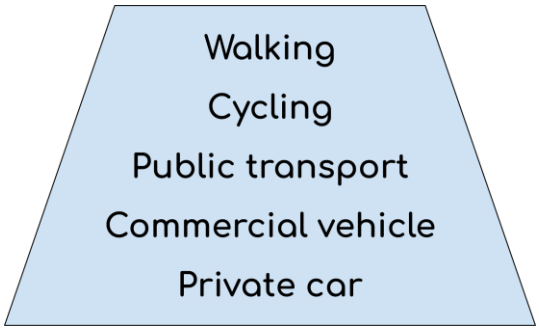


Figure 8 The urban transportation hierarchy pyramid (Leigh, 2019)

3.2.3. Addressing sub-question 2

This chapter introduces the basic information about Nanjing and its PBS. Sub-question 2: What is the goal of PBS in Nanjing? Thus can be answered: "To provide green travel for citizens and solve the 'last kilometre' problem."

Information, especially those numerical values such as population, bicycle numbers etc., may affect the choice of research methods (Babbie, 2015). The next chapter—the methodology chapter addresses the methodology used for this case study.

4. Methodology

The methodology Chapter introduces the choice of research design and justifies the design choice. This chapter describes the overall methodology and introduces the details in different stages. The general design is elaborated first, followed by the data collection and analysis; after that, the author acknowledges the limits of this research and proposes ethical issues which may need concern. This chapter ends with how to maintain validity and reliability.

4.1. Design

In this section, a general design of the methodology is introduced. It is divided into four main steps: the general research design framework is firstly introduced; after this, whether this research is deductive or inductive is identified; based on the result, the choice of the quantitative or qualitative method is made; in the last, the proper research methods are chosen, and it determines the use of primary data or secondary data.

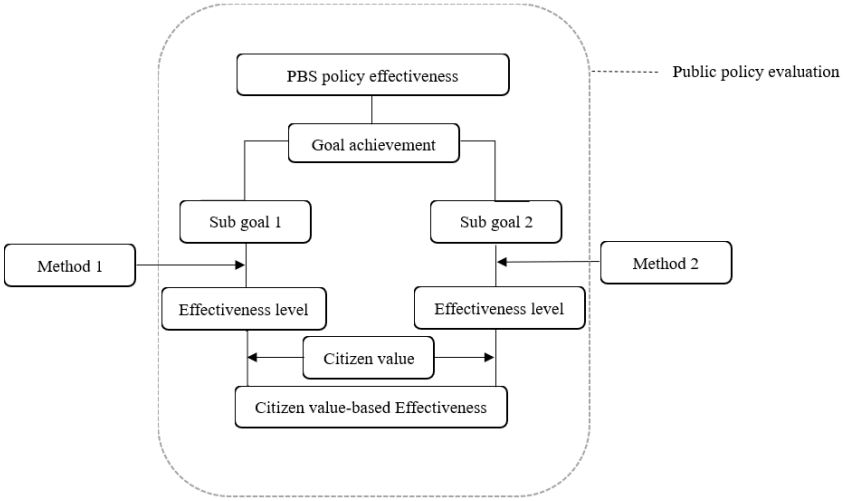


Figure 9 Research framework of PBS case study

The research design in this case study is developed from Vedung (2017) 's goal attainment model. As shown in Figure 7, it measures the policy's effectiveness by examining the extent to which the policy goal is achieved. At the same time, two research methods are also adopted to test the effectiveness level of sub-goals. For subgoal 1, Maioli et al. (2019) 's method of evaluating public bicycle system user satisfaction is adopted. For subgoal 2, users' ratio of usage is used for the last kilometre purpose.

The effectiveness of the Nanjing PBS policy is measured by the extent it achieves the policy goal. This can be divided into sub-goal 1: 'To provide green travel for citizens' and sub-goal 2 'to solve the 'last kilometre' problem'. Two different ways measure those two sub-goals according to the causal relationship in the conceptual framework. For sub-goal 1, a causal relationship is developed between the independent variable "user satisfaction" and dependent variable "level of green travel"; for sub-goal 2, we frame a causal relationship between the independent variable "user satisfaction" and dependent variable "solve the 'last kilometre' problem".

This case study is inductive research. Babbie (2015) noted that a theory can be built or tested from two directions: deductive and inductive. Deductive begin with broad

generalisations and move to specific observations. While inductive begins with moves from specific observations to broad generalisations". Based on the previous chapter, a conceptual framework has been formulated, and it came with two hypothesises. The conceptual framework showing PBS system's effectiveness was measured by user satisfaction and the ratio that users used PBS for the last kilometre use. It starts from the research of a specific part of PBS users to infer the overall characteristics.

Quantitative research is adopted for this case study. According to Becker et al. (2012), quantitative methods "focuses on quantifying the collection and analysis of data". It "promotes the objective empirical investigation of observable phenomena to test and understand relationships" (Becker et al., 2012). While qualitative research is "used to understand concepts, thoughts or experiences. It gathers information through "observations, note-taking, interviews, focus groups (group interviews), documents, and artefacts" (Becker et al., 2012). This case study aims to evaluate the effectiveness of the Nanjing PBS policy by studying users' usage characteristics and satisfaction. In the previous chapters, a conceptual framework has been formed based on the literature. The framework provided an overview of the potential causal relations between the "user satisfaction", "ratio of use for the last kilometre purpose" and two sub-goals. In order to understand the degree that the goal is achieved, "user satisfaction" and "ratio of use for the last kilometre purpose" was intended to be measured by numbers rather than concepts, thoughts or experiences.

The data collection method is an online questionnaire survey. In this case study, the unit of analysis is Nanjing PBS users, which has the number of more than one million (Nanjing Public Bicycle Co, 2022). The quantity is too large to be measured directly. So, the analysis unit and research the observation unit are needed to be defined. Just as Babbie (2015) noted, "survey research is probably the best method to collect original data for describing a population too large to observe directly".

Regarding the time dimension, Babbie (2015) noted two possibillity: cross-sectional and longitudinal studies. Cross-sectional studies observe the sample or cross-section at one point in time. It reflects the sample's characteristics at a specific time. At the same time, longitudinal studies are designed to "observe the same phenomenon over an extended period. This case study aimed to study people's satisfaction level and usage purpose rather than the change in satisfaction and usage purpose over a long period. This case study is a cross-sectional study.

4.2. Data collection

As Babbie (2015) noted, there are two types of sampling methods one is probability sampling, and the other one is nonprobability sampling. Probability sampling is based on the principle of randomisation. Nonprobability sampling means researchers select samples based on subjective judgment. In this case study, probability sampling is not operationalizable because the list of Nanjing PBS users is not available, and thus it is not possible to randomly select or stratify the population. Therefore, nonprobability sampling is adopted to do the research. There are three main types of nonprobability sampling: purposive or judgmental sampling, snowball sampling and quota sampling. Purposive or judgment sampling selects a sample based on knowledge; snowball sampling locates several members of the population first and find other members with the information provided by the first several members; quota sampling selects particular groups of the population (Babbie, 2015). In this case study, snowball sampling is adopted because the research field is in China, which is hard to enter during the COVID-19 period. It is only possible to get in touch with several Nanjing PBS users and ask them to help to find other PBS users online.

The questionnaire survey is made available online, "questionnaire survey star" (wjx.cn). The questionnaire is delivered through the Chinese instant messaging software Wechat. Users deliver the questionnaire to other users through the software. The unit of analysis is all PBS users in Nanjing. The unit of observation is PBS users who take the questionnaires. The time setting is one month before the participants take the questionnaire, as the research currently evaluates PBS system's effectiveness. Participants in this study should be residents of Nanjing, 18 years of age or older. The data is collected on the online questionnaire platform "wjx.cn" and distributed through social software "Wechat". The questionnaire is sent to participants who agreed to participate in the survey and agreed to share their data (anonymously) for academic research (this case study only). The sample number is less than 10 per cent of the population and should be at least 100 to achieve an acceptable error level (de Veaus et al., 2016). In this case study, 100 to 200 (de Veaus et al., 2016) valid responses were collected.

4.2.1. Survey instrument

The questionnaire was designed for two main purposes: the first is to examine the users' usage purpose; the other is to study users' satisfaction level with the system. In order to reach these two purposes, the questionnaire survey is divided into four main parts.

The first part is users' basic information, with two questions to ask for gender and age. The second part is the use of frequency and purpose. This part asks about the main mode of transport, frequency and purpose of use. In the third part, user satisfaction is measured by twenty questions and these questions are divided into four indicators. These indicators are tangibles (T), system availability (SA), efficiency (E) and security/privacy (SP). Each question is rated by users of PBS system service on a five-point Likert scale, ranging from 'strongly disagree' to 'strongly agree'. In the last part, two questions about general satisfaction are asked: "overall, do you consider yourself satisfied with the service provided by the company?" and "Rate your last experiences".

These three parts make up the 28 questions of the questionnaire in total. The original version of the questionnaire is shown in Appendix 1. The translated version was in Chinese and translated into English by the author.

Table 1 Questionnaire breakdown (Maioli et al., 2019)

Part1 Basic information
Gender
Age
Part2 Use frequency and purpose
Main mode of transport
Frequency
Purpose of use
Part3 User satisfaction
Tangibles
System availability
Efficiency
Security/privacy
Part4 General satisfaction
Overall satisfaction
Rate the service

4.3. Data analysis

A quantitative statistical analysis is conducted to analyse the data gathered from the online questionnaire survey. Statistical software 'IBM SPSS statistics 26' is the analysis software. The analysis is divided into two main parts:

The first part is to analyse the user satisfaction level. The analysis is conducted in four steps: The first step is data selection. Data is selected, and participants who did not meet the requirements are removed from the sample. Outliers are selected and excluded from the sample also. The second step is to formulate a frequency table for the questionnaire survey. A general view of the frequency table's usage characteristics and user satisfaction can be seen. The third step is linear regression analysis. In order to identify the extent each indicator effect user satisfaction, this study constructs a multiple linear regression model. All 20 questions in Part3 are independent variables, and general satisfaction (GS) is the dependent variable. As De Veaus et al. (2016) noted, R square can show the portion that the independent variable can explain the dependent variable in a regression model. In this case, 20 indicators in questions in the third part are taken as independent variables, and user satisfaction is taken as the dependent variable to test how the indicators can explain user satisfaction.

The second part is to analysis the usage frequency and purpose. Three questions in Part 2 of the questionnaire survey are designed to study the frequency and purpose: Question one: “What is your main mode of transport for short travel?” Question two: “How often do you use PBS service?” and Question three: "Purpose of use?" Three frequency tables are used to show the ratio of each question.

4.4. Limits of the research design and research method

The research design limits are mainly the following three parts: temporal validness, spatial validness, sample size, and statistics. First, the temporal validity of the evaluation is restricted to 2022. This questionnaire studies user satisfaction using tangibles, system availability, efficiency and security/privacy indicators. These indicators focus on the system rather than the external environment's effect. The results may not apply to the past or the future. In analogy, the validity is restricted within Nanjing city. Lastly, regarding the statistics, snowball sampling is a kind of non-probability sampling. The representativeness of the samples extracted is poor, and generally, it is not necessary to infer the overall characteristics.

4.1. Ethical issues

The research proposal was submitted to the BMS Ethics committee before the data collection. The data-collecting procedure started after the approval. Also, any changes or modifications of the data collection were made after the reapplication is approved.

Participants volunteered for the study participant in this research and were free to join or withdraw at any time. Also, the research was conducted only after the participants were informed consent. Every participant was required to read the informed consent form and tap the “yes” button to ensure they knew the goal, benefits and potential risks before participating in the research. The survey asked for no name and personal data such as ID. Once participants participated in the research, the data were anonymised to ensure no one could link those data to individuals. The data storage was also secured by encrypting the hard drive and having regular data backup on the cloud service.

4.2. Validity and reliability

Validity refers to the accuracy of the specific measure(s), i.e., whether the results really represent what is supposed to be measured(Babbie, 2015). Validity can be divided into content validity, criterion validity and construct validity. Content validity access

whether the research method covers all aspects of the concept. In this case study, the level of green travel and the level of solving the 'Last kilometre' problem are used to measure the effectiveness level. The level of green travel is measured by user satisfaction, and the ratio of use for the last kilometre purpose measures the level of solving the 'Last kilometre' problem. Content validity is fulfilled. Criterion validity assesses whether the indicators are used correctly. The measurement of user satisfaction is based on Maioli et al.'s (2019) work of the SERVPERF tool for public bicycle sharing. The tool is widely used to evaluate various types of services (Maioli et al., 2019). Construct validity is to make sure the method matches the construct. In this case study, user satisfaction is measured by the existing study, mainly based on Maioli et al.'s (2019) measurement of user satisfaction for bicycle-sharing services. The ratio of usage for the last kilometre purpose measures the level of solving the 'last kilometre' problem. To make sure this method matches the construct, the questionnaire's options are well designed to ensure that only taking PBS bicycle from home to the metro station and bus stop within 5 kilometres and vice versa are identified as the last kilometre use.

Reliability refers to the consistency of the specific measure(s), i.e., whether the results are reproducible under the same conditions(Babbie, 2015). In this case, the following measures are used to maintain reliability: (1) Internal Consistency. Participants are asked to answer their satisfaction for four different subitem satisfaction of the system: tangibles, system availability, efficiency and security/privacy, and at the end of the survey, participants are asked to give a general satisfaction of PBS service if the result between the subitems and the general satisfaction has an obvious difference, this piece of data is considered as invalid. In addition, more than a hundred participants are expected to participate in this case study. The obvious outliers are analysed and removed before the data analysis. (2) Test-Retest Reliability. This case study is conducted during China's COVID-19 pandemic. The lockdown policy could affect people's access to PBS, and the government's policy could affect this study. Meanwhile, in the questionnaire design, the impact of external circumstances should be minimized on the research. This questionnaire studies user satisfaction using tangibles, system availability, efficiency and security/privacy indicators. These indicators focus on the system rather than the external environment's effect.

5. Results

This chapter contains the results of the questionnaire survey, which can be divided into three parts. The first part is the descriptive analysis of answers, which offers an overview of participants' satisfaction levels in different dimensions. For example, which dimension has significantly low user satisfaction and has significantly high user satisfaction? The second part addresses which factors influence user satisfaction mostly through a multiple regression model, and the third part addresses what proportion of the users use PBS for the "last kilometre" purpose.

5.1. Descriptive analysis

Descriptive statistical analyses, including age, gender, and overall satisfaction of different genders and ages, are shown below to have an overall review.

Table 2 Descriptive analysis of samples (n=67)

		Count	Column N %
Gender	Male	23	34%
	Female	44	66%
Age	<18	0	0%
	18-25	10	15%
	26-30	32	48%
	31-40	20	30%
	41-50	3	4%
	51-60	1	1%
	>60	1	1%

A total of 69 participants responded to the online questionnaire, two responses with a short answer time (less than 70 seconds) are removed. This research is conducted based on 67 samples. As shown in Table 2, 34% of the respondents are male and 66% are female. The age distribution is concentrated in middle age and young people. The online survey may partially explain this result that the young group is more approachable online.

Table 3 Overall satisfaction in different genders

*Gender * Overall satisfaction Crosstabulation*

% within Gender

		Overall satisfaction					
		Strongly dissatisfied	Unsatisfied	No idea	Satisfied	Very satisfied	Total
Gender	Male	0.0%	13.0%	13.0%	60.9%	13.0%	100%
	Female	4.5%	4.5%	0.0%	63.6%	27.3%	100%
Total		3%	7.5%	4.5%	62.7%	22.4%	100%

Table 3 shows the participants' satisfaction levels in different genders. Both genders tend to be generally satisfied with PBS service, as 62.7% of people chose "satisfied". Meanwhile, 4.5% of the female are strongly dissatisfied with PBS service.

The gender and overall satisfaction cross table show that female has a slight trend to be more polarized than male. For the category of very satisfied, female (27.3%) surpasses male (13.0%); while in the category of strongly dissatisfied, female (4.5%) surpasses male (0.0%) as well.

Table 4 Participants' satisfaction level in different age groups

			Overall satisfaction					
			Strongly dissatisfied	Unsatisfied	No idea	Satisfied	Very satisfied	Total
Age	18-25	Count	0	1	0	6	3	10
		% within Age	0.0%	10.0%	0.0%	60.0%	30.0%	100.0%
	26-30	Count	0	2	0	22	8	32
		% within Age	0.0%	6.3%	0.0%	68.8%	25.0%	100.0%
	31-40	Count	1	2	3	12	2	20
		% within Age	5.0%	10.0%	15.0%	60.0%	10.0%	100.0%
	41-50	Count	1	0	0	0	2	3
		% within Age	33.3%	0.0%	0.0%	0.0%	66.7%	100.0%
	51-60	Count	0	0	0	1	0	1
		% within Age	0.0%	0.0%	0.0%	100.0%	0.0%	100.0%
	>60	Count	0	0	0	1	0	1
		% within Age	0.0%	0.0%	0.0%	100.0%	0.0%	100.0%
Total		Count	2	5	3	42	15	67
		% within Age	3.0%	7.5%	4.5%	62.7%	22.4%	100.0%

Table 4 shows participants' satisfaction levels in different age groups. The majority are satisfied with PBS service, as only two are strongly dissatisfied and five for unsatisfied, accounting for approximately 10.5% of the total. Participants in the group "26-30" seem to have the highest satisfaction level, with 68.8% satisfied and 25.0% very satisfied. 18-25 ranks second, with 60.0% voting for satisfied and only one for unsatisfied. 31-40 ranks third, with 60.0% satisfied and 10.0% very satisfied. The samples in the remaining groups are limited, so they are not discussed there.

5.2. User satisfaction

In this section, the statistical result of user satisfaction is interpreted in two parts. The first part is the interpretation of the multiple regression model. Three factors are selected to illustrate which and how different dimensions influence the overall users' satisfaction. The second part is the verification of the assumptions for the multiple regression model. There are five assumptions, namely linear assumption, independence assumption, normality assumption, equal variance assumption and no multicollinearity assumption, before implementing a multiple regression model. The multiple regression model can be valid only if all the assumptions are satisfied.

Table 5 Descriptive analysis of the overall user satisfaction

	N	Mean
Overall satisfaction with PBS service	67	7.88
Rate the last time you used PBS service	67	7.51
Valid N (listwise)	67	

Table 5 shows the mean of the overall user satisfaction and the score for the last time use of PBS. The mean of overall user satisfaction of PBS for the 67 responses is 7.88; the mean of the score that the 67 responses last time use of PBS is 7.51.

Table 6 The descriptive analysis of answers

	Overall satisfaction				
	Strongly disagree	Disagree	No idea	Agree	Strongly agree
	Row %	Row %	Row %	Row %	Row %
T1	1%	21%	16%	51%	10%
T2	3%	18%	15%	58%	6%
T3	4%	31%	10%	48%	6%
T4	7%	24%	10%	52%	6%
T5	12%	27%	7%	46%	7%
T6	12%	25%	13%	40%	9%
SA7	3%	7%	27%	34%	28%
SA8	4%	18%	19%	42%	16%
SA9	7%	16%	9%	40%	27%
SA10	3%	19%	16%	36%	25%
E11	4%	16%	10%	49%	19%
E12	3%	16%	10%	52%	18%
E13	3%	19%	18%	40%	19%
E14	3%	12%	3%	57%	25%
E15	4%	24%	4%	49%	18%
E16	3%	4%	22%	46%	24%
E17	3%	10%	16%	42%	28%
SP18	3%	9%	31%	33%	24%
SP19	4%	12%	22%	40%	21%
SP20	1%	4%	10%	51%	33%

a. T: Tangibles, SA: System availability, E: Efficiency, SP: Security/privacy

It was observed that T questions had a lower “strong agree” than other dimensions. T5 (the bikes allowed good drivability) and T6 (the bikes did not present fail during use) have a significantly high “strongly disagree" than other questions. Therefore, T1 (the station was in a good conservation status) T2 (the bikes were well located) T3 (the bikes were in a good conservation status) T4 (the bikes were comfortable) T5 (the bikes allowed good drivability) and T6 (the bikes did not present fail during use) were relevant negative aspects in users’ perceptions. In other words, the users may be more unsatisfied with the tangibility of PBS.

SA dimension also has a slightly higher strongly disagree percentage than other dimensions. 18% of the participants strongly disagreed with SA8 (The station system did not fail during use) and 16% with SA9 (The application was compatible with the operating system of my smartphone). System availability (SA) might also negatively influence users’ perceptions.

Participants’ overall satisfaction with PBS is asked in question 21 “Overall, do you consider yourself satisfied with the service provided by the company”? In order to study which of these items (T1-SP20) have relevant to overall satisfaction from a statistical perspective, this study proposes the construction of a multiple regression model, which is used to “determine the strength and character of the relationship between one dependent variable and several independent variables” (de Veaus et al., 2016). Twenty questions (T1-SP20) are independent variables, and overall satisfaction (S21) is the

dependent variable.

5.2.1. Multiple regression model

In this section, the result of the multiple regression model for Nanjing PBS's user satisfaction is interpreted. This section starts with the R square analysis, which shows the degree of fitting.

Table 7 The R square table for the model

				Change Statistics	
Model	R	R Square	Adjusted R Square	df	Sig. F Change
1	.834[a]	.696	.563	46	.000

a. Predictors: (Constant), SP20, T6, SA9, T5, E16, SP19, SA8, E14, T3, SA7, E15, T2, T4, E13, SP18, T1, SA10, E11, E12, E17

b. Dependent Variable: Overall satisfaction

R square is "a statistical measure that represents the proportion of the variance for a dependent variable that is explained by an independent variable or variables in a regression model" (de Veaus et al., 2016). Table 7 shows the R square value is 0.696, which means this model can explain 69.6% of the variation in overall user satisfaction. Meanwhile, according to (de Veaus et al., 2016), when there are multiple independent variables in the model, the R square value increases with the rise in the number of independent variables. Considering that there are 20 independent variables in this model, the R square may have a deviation. Adjusted R square should also be used to make sure the R square value is not effected by the number of independent variables. In the table, the adjusted R square is 0.563, which means 56.3% of the variation in overall user satisfaction can be explained by this model, which is a reasonably good estimation result.

Table 8 The coefficients[a] table for the model

Model		Unstandardized Coefficients		t	Sig.
		B	Std. Error		
1	(Constant)	.530	.476	1.114	.271
	T1	.279	.144	1.943	.058
	T2	-.136	.144	-.943	.350
	T3	.139	.112	1.240	.221
	T4	.165	.118	1.399	.168
	T5	.019	.105	.184	.855
	T6	.060	.093	.647	.521
	SA7	-.076	.105	-.728	.470
	SA8	-.106	.092	-1.154	.254
	SA9	.116	.104	1.108	.274
	SA10	.047	.118	.398	.693
	E11	-.398	.141	-2.822	.007
	E12	.092	.153	.601	.551
	E13	.038	.129	.299	.766
	E14	.297	.143	2.075	.044
	E15	-.106	.121	-.879	.384
	E16	-.087	.125	-.701	.487
	E17	.151	.161	.942	.351
	SP18	-.001	.147	-.008	.994
	SP19	-.085	.118	-.716	.478
	SP20	.491	.172	2.854	.006

a. Dependent Variable: Overall satisfaction
*: significantly significant ($p<0.05$)

As shown in Table 8, E11, E14 and SP20 are statistically significant because their p-values are smaller than 0.05, which means these three variables can interpret overall satisfaction.

5.2.1. Five assumptions for multiple linear regression model

The multiple regression model is valid only when five assumptions are met. These assumptions are linear, independence, normality, equal variance, and no multicollinearity.

Linearity assumption means there exists a linear relationship between the independent variable(s) X and dependent variable(s) Y. This linear relationship can be examined by the scatterplot(s) of X and Y. The 20 scatterplots are shown in appendix. All of the scatterplots are straight enough, which means there is a linear relationship between X and Y.

Table 9 Regression statistics[b] for the model

Model	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	0.696	0.563	0.608	1.973

b. Dependent Variable: Overall satisfaction

Independence assumption means the residuals need to be independent of each other. The Durbin-Watson test usually tests the Independence assumption(Babbie, 2015; de Veaux et al., 2005). The Durbin-Watson statistic has a range from zero to four. If the value is 2, then the residuals are independent of each other. In Table 9, the Durbin-Watson statistic value is 1.973, which is approximately equal to 2. The independence assumption is fulfilled.

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Unstandardized Residual	0.106	67	0.057	0.973	67	0.159

a. Lilliefors Significance Correction

Table 10 Test of Normality

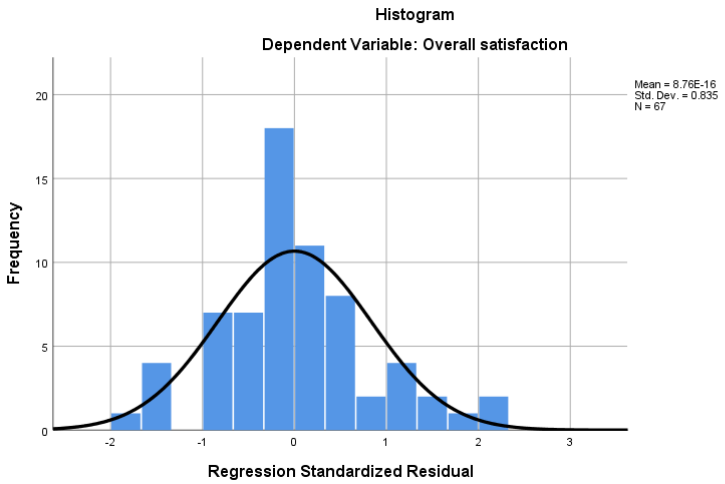


Figure 10 The standadised residual of the model

Normality assumption means the residuals need to be normally distributed. It can be examined by normality test and histogram. Kolmogorov-Smirnova and Shapiro-Wilk tests are usually used for normality tests (de Veaux et al., 2005). When the sample number is less or equal to 50, the Kolmogorov-Smirnova test is more effective; when the sample number is more than 50, Shapiro-Wilk is more effective. In Table 10, the significance of both tests is higher than 0.05, meaning the residual follows the normal distribution. The histogram in figure 10 is reasonably unimodal and symmetric and shows no obvious skewness or outliers (de Veaux et al., 2005).

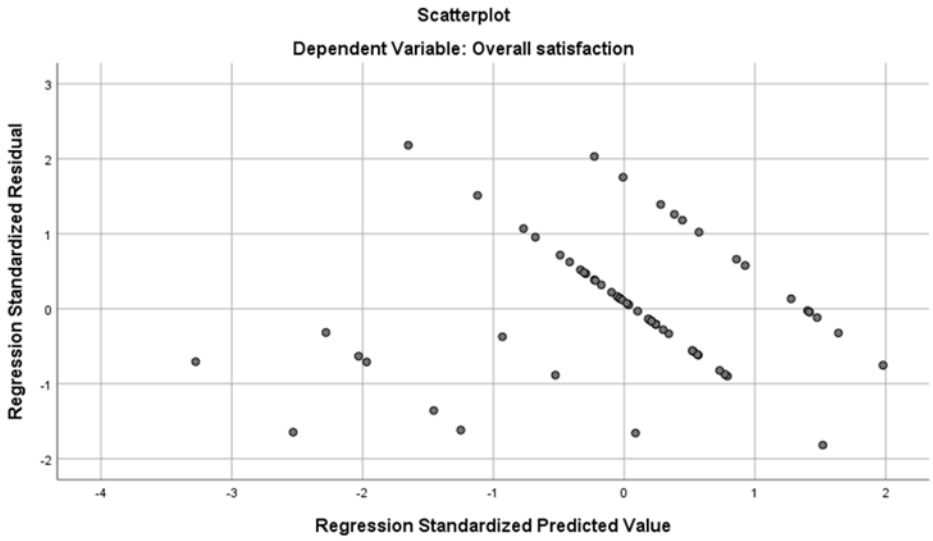


Figure 11 The standardized predicted value of the model

The equal variance assumption is determined to test whether the variance in each group is equal to each other. The scatterplot of regression standardized predicted value and regression standardized residual usually tests it. If the standardized residual did not obviously change with the standardized predicted value, then we can say the equal variance assumption is fulfilled. It can be seen from the Figure 11 that the scatter plot of standardized residuals and standardized predicted values that the scatter fluctuation range of standardized residuals basically remains stable and does not change with the change of standardized predicted values, which can be considered to meet the equal variance assumption.

Table 11 The coefficients[a] table for the model

Model		t	Sig.	Collinearity Statistics	
				Tolerance	VIF
1	(Constant)	1.114	.271		
	T1	1.943	.058	.276	3.620
	T2	-.943	.350	.295	3.392
	T3	1.240	.221	.373	2.684
	T4	1.399	.168	.323	3.099
	T5	.184	.855	.335	2.989
	T6	.647	.521	.433	2.309
	SA7	-.728	.470	.470	2.126
	SA8	-1.154	.254	.540	1.853
	SA9	1.108	.274	.327	3.060
	SA10	.398	.693	.302	3.311
	E11	-2.822	.007	.227	4.404
	E12	.601	.551	.216	4.637
	E13	.299	.766	.276	3.622
	E14	2.075	.044	.264	3.794
	E15	-.879	.384	.278	3.597
	E16	-.701	.487	.401	2.493
	E17	.942	.351	.194	5.161
	SP18	-.008	.994	.242	4.136
	SP19	-.716	.478	.338	2.956
	SP20	2.854	.006	.252	3.967

a. Dependent Variable: Overall satisfaction

No multicollinearity assumption means there should be no independent variable highly correlated with other variables. It is usually tested by VIF statistics. If the VIF value is higher than 10, the variable has a high correlation with other variables (s) (de Veaux et al., 2005). Table 11 shows the result of VIF statistics. All of the results are less than 10. No multicollinearity assumption is fulfilled.

All five assumptions of multiple regression are fulfilled, meaning the multiple regression model can interpret the dataset. The multiple regression model is constructed and interpreted in the next section.

5.3. Do they use PBS for the “last-kilometre” purposes?

In this section, two questions are answered: (1) what kind of transportation do people use when their travel is within 5 km? and (2) which purposes do people use PBS for? Therefore, the position of PBS among other public transportation, as well as the specific purposes for PBS can be identified.

Table 12 shows that only 7.5% of the responses use PBS for their travel within 5 kilometres. It is evident that car (car and online hailing) is still preferred by the majority, accounting for 29.9+14.9% of the total. After that, it is worth highlighting that bicycle sharing takes up a slightly higher share (16.4%) than public bicycles (7.5%) and a significantly higher share than self-owned bicycles (3.0%). It is possibly due to the high flexibility different bicycle-sharing companies hold (e.g., the users do not need to return the bikes to a specific location).

Table 12 Choice of transportation for travel within five kilometers (n=67)

		Count	Column N %
Main transport	Walking	7	10.4%
	Bicycle	2	3.0%
	Online car-hailing	10	14.9%
	Bus	8	11.9%
	Car	20	29.9%
	Motorcycle	4	6.0%
	Public bicycle	5	7.5%
	Taxi	0	0.0%
	Bicycle sharing	11	16.4%

Table 13 shows the different purposes the respondents use PBS for. 13.4% of the responses use PBS for the ride from home to work or vice versa within five kilometres. Only 13.4% of the responses use PBS for the last kilometre purpose. Nearly half (47.8%) use PBS for other purposes within five kilometres, and nearly a quarter (23.9%) for leisure. Besides, 9 out of 69 use PBS for physical activities. This might indicate that the initial assumptions with which the policy has been put into place were not confirmed in practice.

Table 13 The breakdown of the purposes of using PBS (n=67)

		Count	Column N %
Purpose of use	Physical activities	9	13.4%
	A ride from home to work (or vice versa) within five kilometres	9	13.4%
	A ride for other purposes within five kilometres	32	47.8%
	A ride from home to work (or vice versa) more than five kilometres	1	1.5%

	A ride for other purposes more than five kilometres	0	0.0%
	Leisure	16	23.9%

Table 14 The frequency of people using PBS

		Count	Column N %
Frequency	Every day	1	1.5%
	Every weekday	4	6.0%
	Fourth a week	2	3.0%
	Three times a week	5	7.5%
	Two times a week	7	10.4%
	Once a week	4	6.0%
	Less than once a week	44	65.7%

The results in Table Table 14 The frequency of people using PBS The sum of proportion of "every day", "every weekday", "fourth a week", and "three times a week" is 18%, which is close to the result with the proportion of "A ride from home to work (or vice versa) within five kilometres" and"A ride from home to work (or vice versa) more than five kilometres" (13.4%). Both results show that the responses have a low proportion of using PBS for the "last kilometre" problem. Instead, most of the responses use PBS for "the ride for other purposes within five kilometres" and for leisure. The result in Table 13 Table 13 shows the different purposes the respondents use PBS for. 13.4% of the responses use PBS for the ride from home to work or vice versa within five kilometres. Only 13.4% of the responses use PBS for the last kilometre purpose. Nearly half (47.8%) use PBS for other purposes within five kilometres, and nearly a quarter (23.9%) for leisure. Besides, 9 out of 69 use PBS for physical activities. This might indicate that the initial assumptions with which the policy has been put into place were not confirmed in practice.

Table 13 also supports the result. Most (65.7%) of the respondents only use PBS for less than once a week. If they use PBS for the "last kilometre" problem (A ride from home to work or vice versa within five kilometres), they probably will not use PBS for less than once a week.

5.4. Addressing sub-questions 3 and 4

Previous section 5.1 and 5.2 has provided answer for sub-question 3: "What is the user satisfaction level of PBS in Nanjing?" The general user satisfaction is 7.88 out of 10, the citizens are generally satisfied with PBS service. For sub-question 4 "To what extend do users use PBS for the 'last kilometre' problem?" Only 13.4% of the responses use PBS for the last kilometre purpose. Due to the limitation of the sampling method, the result can only represent the group of participants.

6. Conclusion

The general user satisfaction score for the responses is 7.88 out of 10. The user satisfaction score of the responses' last use experience is 7.51 out of 10. Both of the results show a high level of user satisfaction.

As shown in the previous chapter, the use of the SERVPERF tool and multiple regression allows the measurement of user satisfaction in different dimensions (Tangibles, system availability, efficiency and security/privacy) and items (T1-SP20). It was observed that the Tangibles dimension has a lower user satisfaction level, which can be seen from a generally high level of disagreement and a low level of agreement, especially in T5 (the bicycles allowed good drivability) and T6 (the bikes did NOT present fail during use). Thus, PBS company must pay more attention to the bicycles' drivability and quality. The drivability could be related to the braking, the steering or gearing etc. Users may fail to brake in time, find it hard to turn the direction or use too much strength to ride the bicycle. Bicycle failure may also cause annoying problems during use, as PBS stations are far apart from each other if the bicycle breaks down during the ride, the user must walk the bicycle to another station to return it. With the improved drivability, users can ride bicycles much easier and more pleasant. With the improvement of bicycle quality, fewer bicycle failures would happen during use.

A multiple linear regression model makes it possible to determine which factors contribute most to overall user satisfaction. As shown in table 12, E11 (the station/application system interface was easy to use), E14 (it was easy to unlock the bike using the station/application system), and SP20 (I believe the company would not charge me unfairly amounts) have the significantly lower than 0.05, which means E11, E14 and SP20 contribute most to the overall user satisfaction. Meanwhile, it does not mean that other items have no linear relationship with the dependent variable (overall user satisfaction). It means these items almost "contribute nothing to the modelling of a dependent variable after all the other predictor variables are taken into account"(de Veaux et al., 2005). Although the Tangibles (T) dimension has an obviously lower user satisfaction level in descriptive analysis, PBS company should pay more attention to E11, E14 and SP20 as these items contribute most to the overall user satisfaction.

The general user satisfaction shows a level of 7.88, and three items (E11, E14 and SP20) account for 69.6% of that. Meanwhile, to study the effectiveness of PBS policy, the proportion of how much users use PBS for the "last kilometre" problem also needs to be studied.

Table 13 shows that only 7.5% of the responses use PBS for their travel within 5 kilometres. Meanwhile, almost 45% of the responses travel by car within 5 kilometres (14.9% by online car-hailing and 29.9% by car). This result indicates that the proportion of citizens that use PBS for their travel within 5 kilometres is quite low. Table 14 and Table 15 show that only 15% of the respondents use PBS for the ride from home to work (or vice versa), and only 10.5% of the respondents use PBS more than fourth a week. Both Table 12 and Table 13 indicate that the proportion of citizens that use PBS for the "last kilometre" use is low (no more than 15%). Considering that only 7.5% of the responses use PBS for short-term travel, the proportion of the citizens that use PBS for the "last kilometre" is extremely low.

The effectiveness of PBS policy is assessed by achieving two subgoals: subgoal 1: To provide green travel to citizens and subgoal 2: To solve the last-kilometre problem. As stated earlier in Chapter 2, subgoal 1 is measured by user satisfaction and subgoal 2 is measured by the proportion of the users use PBS for the "last kilometre" use. The

questionnaire survey shows that PBS achieved a high score for overall user satisfaction, which is 7.88 out of 10 and a high score for last use experience, which is 7.51 out of 10. In general, the responses are highly satisfied with the Nanjing PBS service. However, in another regard, the usage of PBS for the last kilometre use remained relatively low. Only 7.5% of the responses use PBS for short-term travel, and nearly half of the responses use PBS for other purposes. The main research question can thus be answered: PBS policy in Nanjing achieved a high level of effectiveness in providing green travel to citizens while achieving a low level of effectiveness in solving “the last kilometre” problem.

The conclusion reveals the fact that the PBS policy in Nanjing did not achieve the goal of solving “the last kilometre” problem. Policymakers should concern more about whether the policy solves the problem it was supposed to solve. Based on the analysis, the PBS in Nanjing is a system with high user satisfaction and low usage rate for the “the last kilometre” purpose. Policymakers can research why the citizens choose not to use the PBS for their travel for daily work and how to solve”the last kilometre” problem in a proper way. The regression analysis also recommends the PBS company care more about E11 (the station/application system interface was easy to use), E14 (it was easy to unlock the bike using the station/application system), and SP20 (I believe the company would not charge me unfairly amounts) to make the system has a higher user satisfaction level. The policymakers in other cities can also use this result in newly-built PBS systems.

7. Discussion

Although PBS is widely used in China, little is known regarding its effectiveness in the policy aspect. This present studying applied the goal attainment model and SERVPERF tool to assess the effectiveness of the Nanjing PBS policy. The survey result shows that the user satisfaction level is high. However, the proportion the users who use PBS for “the last kilometre” use remained relatively low.

PBS is part of the public good and serves an important role in the public transportation system, more attention should be paid, and more research on PBS policy effectiveness should be done. This study provided a possible method to evaluate PBS policy and revealed some items that may primarily affect overall user satisfaction. Also, this research gives the government a chance to reconsider the position of PBS in complex public transportation systems which provide different transportation services. Does PBS have an overlapping area with private bicycle sharing? Etc.

However, this study should be interpreted with caution due to the limitation. Due to the lack of relevant research, some other factors that affect usage amount may need to be take into consideration. Moreover, the result should be considered when considering the effect of COVID-19. The result may be affected by the lockdown or other factors caused by COVID-19. Also, the use of snowball sampling can have a potential sampling bias and margin error.

As PBS has been booming In China in the past ten years, it is essential to develop some strategies to assess the effectiveness of PBS programmes. This study's findings could provide useful information and suggestions for Nanjing PBS.

Although the PBS policy in Nanjing did not achieve effectiveness in solving “the last kilometre” problem, the system still achieved high user satisfaction (3.95 out of 5). It is interesting that the policy did not achieve the original goal but still have a good performance for other unanticipated purposes. In this research, users of Nanjing PBS did not use the PBS for transportation from home to work (14.9%) but prefer more to use it for other purposes (47.8%).

The results of this study showed that the Tangibles (T) dimension has the lowest user satisfaction. A PBS system with better-designed stations and bicycles should be encouraged. In the future, on the one hand, the Nanjing PBS company should put more effort into the design and maintenance of PBS bicycles, docks, and station screens. On the other hand, it might also be possible for PBS system to transfer the form from fixed station to stationless, which has the advantages of flexibility and less maintenance workload on fixed stations.

The findings also suggested that PBS company should put more effort into encouraging citizens to use PBS bicycles for short-term travel and adjust PBS system to meet the citizens’ requirement of “last kilometre” use. The government can use the results to optimize their design of PBS. For example, half of the responses did not use it for “the last-kilometre” purpose but for other purposes. The other purposes are also worth to be investigated to help money-wise decision-making. Since sub-goal two is not entirely fulfilled, the government may reconsider the measures to improve the number of people using PBS for last-kilometre purposes. For instance, a survey regarding what kind of factors prevent/enhance people’s preference for using PBS for the last kilometre.

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Appendix

A. Survey items for the questionnaire of bicycle sharing service.

Dimension	Item	Question
Tangibles	T1	The stations were in a good conservation status.
	T2	The bikes were well located.
	T3	The bikes were in a good conservation status.
	T4	The bikes were comfortable.
	T5	The bicycles allowed a good drivability (lightweight, easy to guide, not hard).
	T6	The bikes did NOT present fail during use.
System availability	SA7	The application and/or the system of the stations were in operation at the requested time
	SA8	The station system did not fail during use.
	SA9	The application was compatible with the operating system of my smartphone.
	SA10	The application did not fail during use.
Efficiency	E11	The station/application system interface was easy to use.
	E12	The station/application system responded to commands quickly.
	E13	It was easy to find the information in the station/application system.
	E14	It was easy to unlock the bike using the station / application system.
	E15	It was easy to return the bike using the station/application system.
	E16	The station/application system reported updated information.
	E17	It was easy to pay for the service.
Security/privacy	SP18	I felt safe entering my bank information in the application.
	SP19	I felt safe entering my personal data in the application.
	SP20	I believe the company would not charge me unfair amounts.

B. Questionnaire survey questions

Part1 Basic information

1. What's your gender?
   a. Female
   b. Male
2. What's your age?

Part2 Use frequency and purpose

1. What's your main mode of transport for short travel?
   a. On foot
   b. Bicycle (your own)
   c. Taxi
   d. Bus
   e. Drive
   f. Motocycle
   g. PBS
   h. Didi
   i. Hello bike
2. How often do you use PBS service?
   a. Every day of the week
   b. Every day of the weekday
   c. Fourth per week
   d. Third per week
   e. Twice per week
   f. Once per week
   g. Less than once a week
3. Purpose of use?
   a. Leisure
   b. Short distance (within 5 km) transportation from home to work
   c. Short distance (within 5 km) transportation not from home to work
   d. Long distance (more than 5 km) transportation from home to work
   e. Long distance (more than 5 km) transportation not from home to work
   f. Physical activities

Part3 User satisfaction

1. The stations were in a good conservation status
   a. Strongly disagree
   b. Disagree
   c. No idea
   d. Agree
   e. Strongly agree
2. The bikes were well located
   a. Strongly disagree
   b. Disagree
   c. No idea
   d. Agree
   e. Strongly agree
3. The bikes were in a good conservation status
   a. Strongly disagree
   b. Disagree

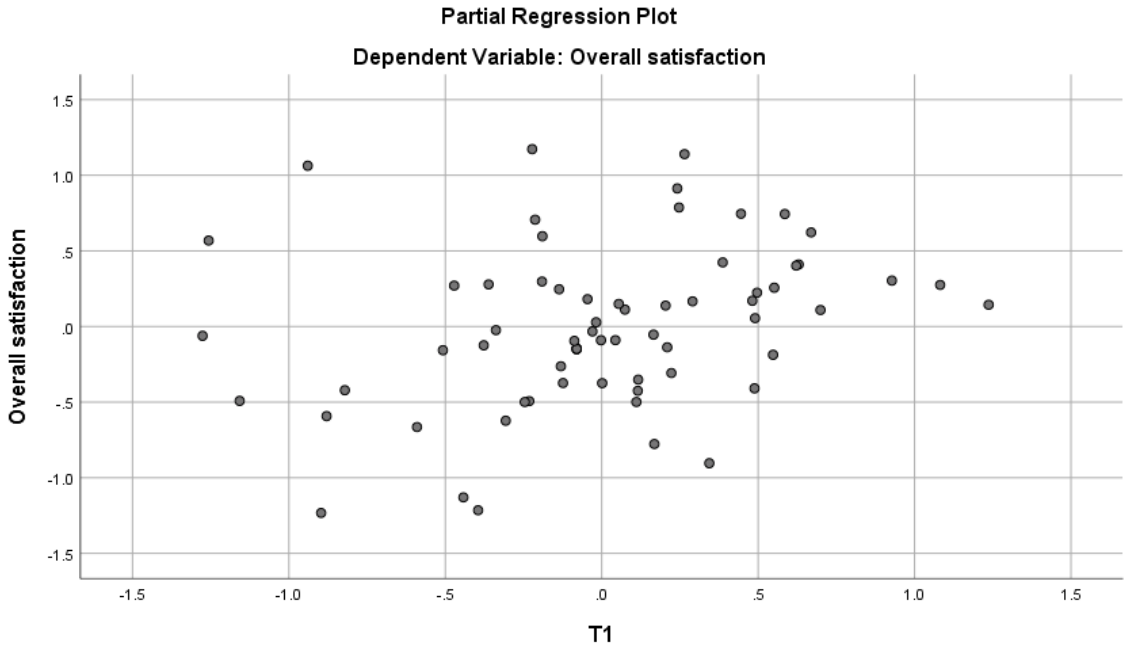
   c. No idea
   d. Agree
   e. Strongly agree
4. The bikes were comfortable
   a. Strongly disagree
   b. Disagree
   c. No idea
   d. Agree
   e. Strongly agree
5. The bicycles allowed a good drivability (light weight, easy to guide, not hard)
   a. Strongly disagree
   b. Disagree
   c. No idea
   d. Agree
   e. Strongly agree
6. The bikes did NOT present fail during use.
   a. Strongly disagree
   b. Disagree
   c. No idea
   d. Agree
   e. Strongly agree
7. The application and/or the system of the stations were in operation at the requested time.
   a. Strongly disagree
   b. Disagree
   c. No idea
   d. Agree
   e. Strongly agree
8. The station system did not fail during use.
   a. Strongly disagree
   b. Disagree
   c. No idea
   d. Agree
   e. Strongly agree
9. The card is easy to use
   a. Strongly disagree
   b. Disagree
   c. No idea
   d. Agree
   e. Strongly agree
10. The card did not fail during use
   a. Strongly disagree
   b. Disagree
   c. No idea
   d. Agree
   e. Strongly agree
11. The station/application system interface was easy to use.
   a. Strongly disagree
   b. Disagree
   c. No idea
   d. Agree
   e. Strongly agree

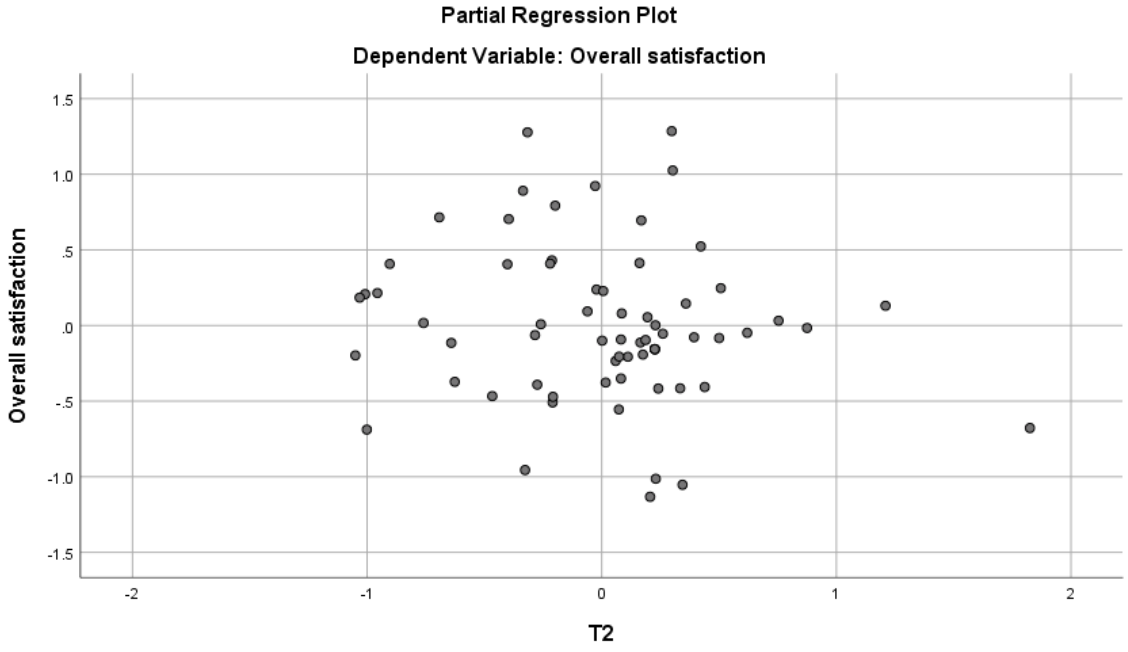
12. The station/application system responded to commands quickly.
    a. Strongly disagree
    b. Disagree
    c. No idea
    d. Agree
    e. Strongly agree
13. It was easy to find the information in the station/application system.
    a. Strongly disagree
    b. Disagree
    c. No idea
    d. Agree
    e. Strongly agree
14. It was easy to unlock the bike using the station / application system.
    a. Strongly disagree
    b. Disagree
    c. No idea
    d. Agree
    e. Strongly agree
15. It was easy to return the bike using the station/application system.
    a. Strongly disagree
    b. Disagree
    c. No idea
    d. Agree
    e. Strongly agree
16. The station/application system reported updated information.
    a. Strongly disagree
    b. Disagree
    c. No idea
    d. Agree
    e. Strongly agree
17. It was easy to pay for the service.
    a. Strongly disagree
    b. Disagree
    c. No idea
    d. Agree
    e. Strongly agree
18. I felt safe entering my bank information in the application.
    a. Strongly disagree
    b. Disagree
    c. No idea
    d. Agree
    e. Strongly agree
19. I felt safe entering my personal data in the application.
    a. Strongly disagree
    b. Disagree
    c. No idea
    d. Agree
    e. Strongly agree
20. I believe the company would not charge me unfair amounts.
    a. Strongly disagree
    b. Disagree

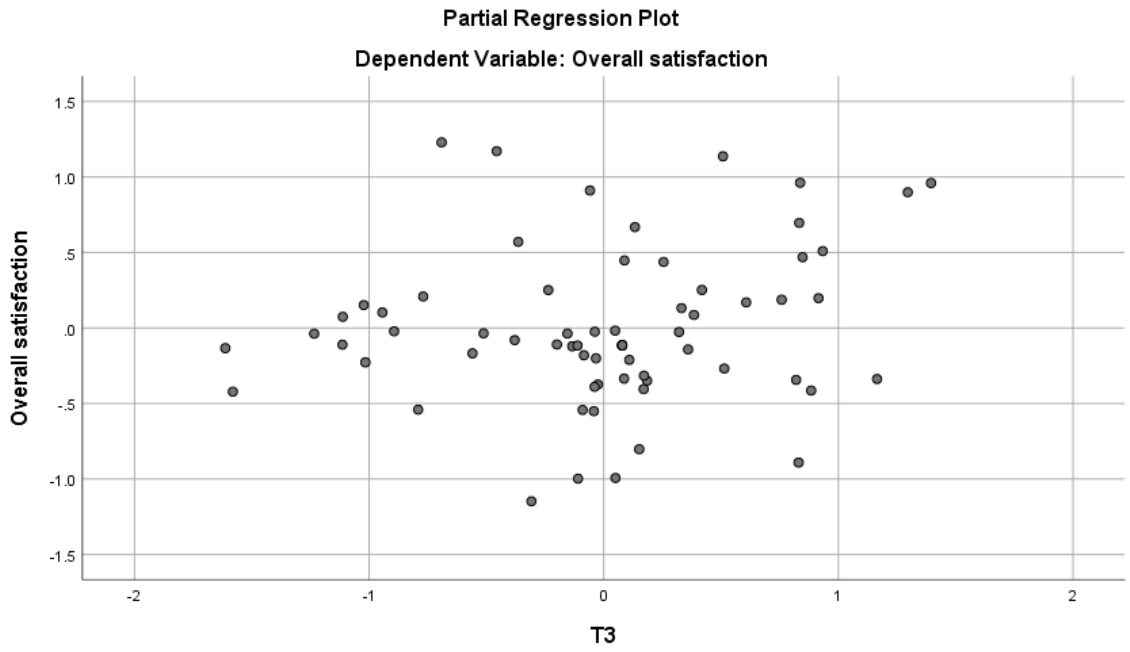
c. No idea
d. Agree
e. Strongly agree

21. Overall, do you consider yourself satisfied with the service provided by the company?
    f. Strongly disagree
    g. Disagree
    h. No idea
    i. Agree
    j. Strongly agree
22. Rate your last experience (1 terrible and 10 excellent)
    a. 1
    b. 2
    c. 3
    d. 4
    e. 5
    f. 6
    g. 7
    h. 8
    i. 9
    j. 10

C. Tables for multi regression assumptions



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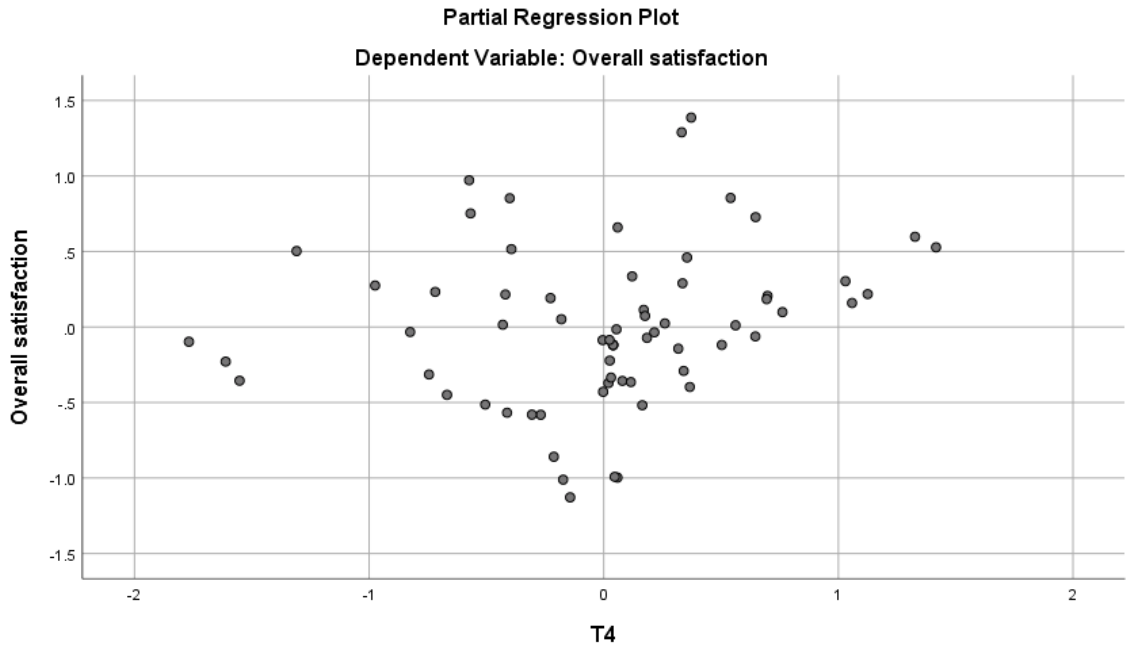
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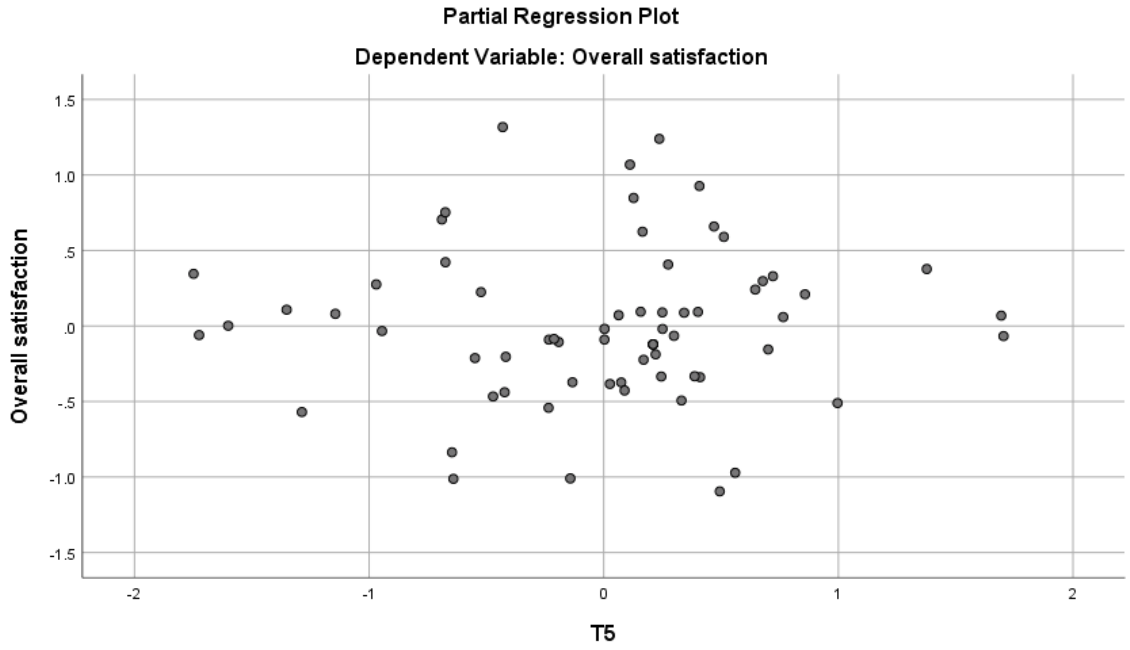
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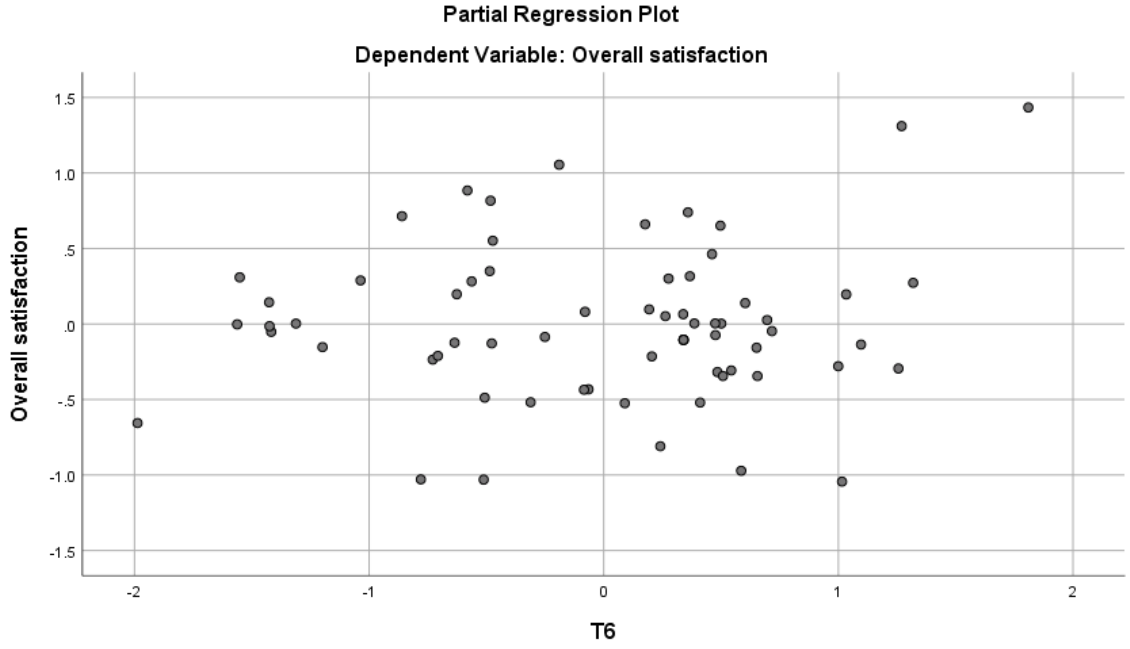
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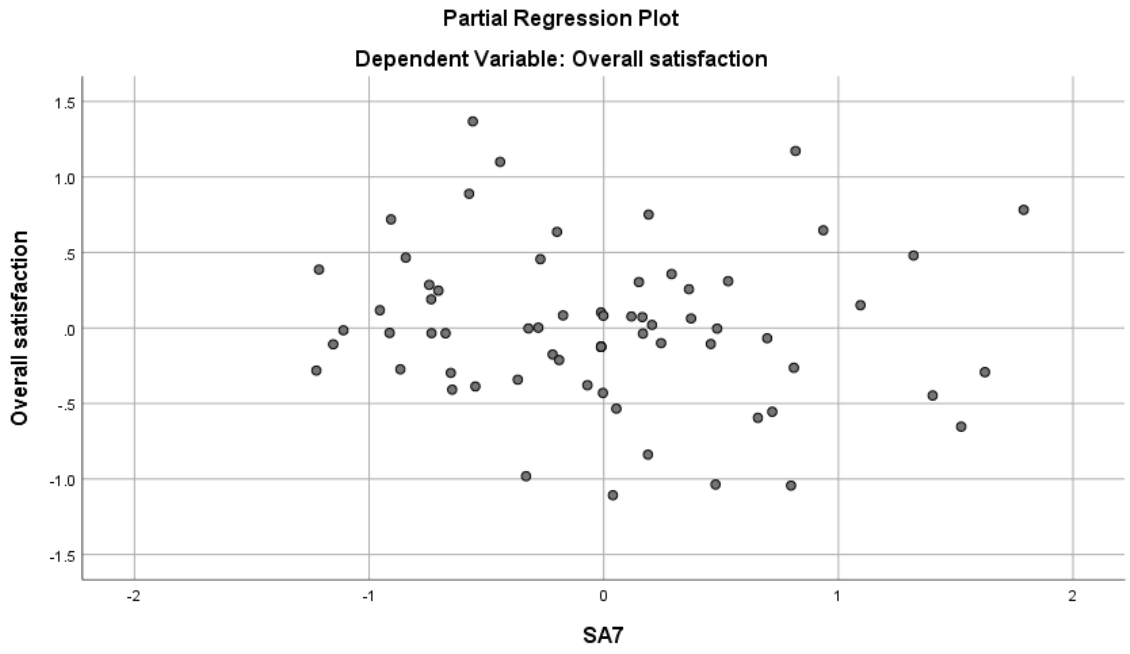
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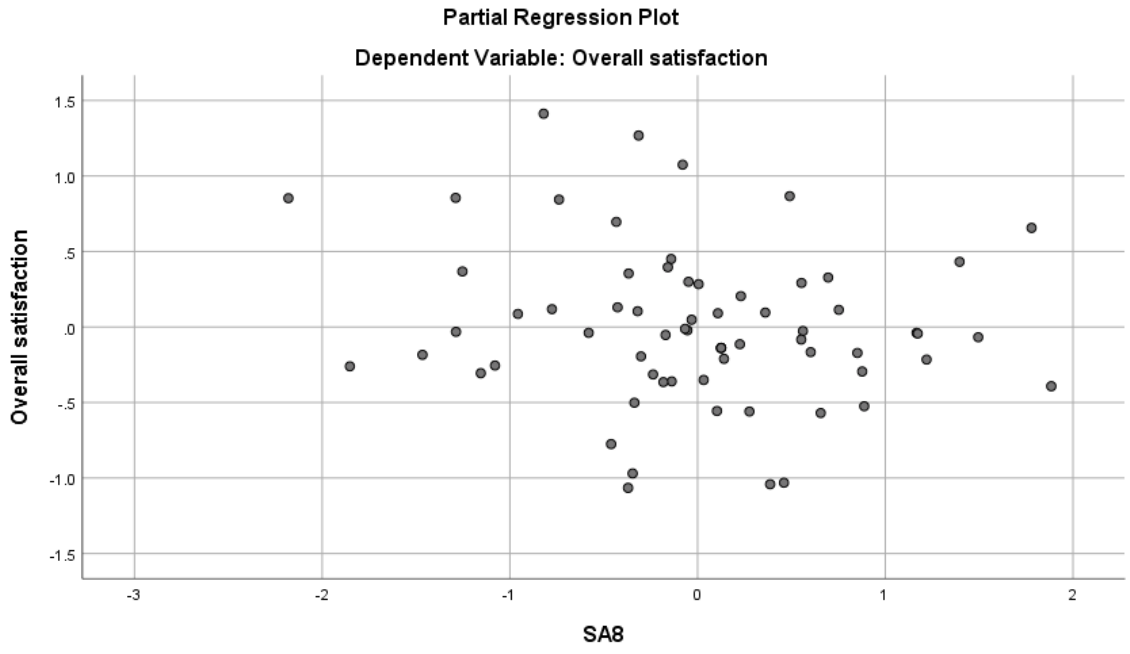
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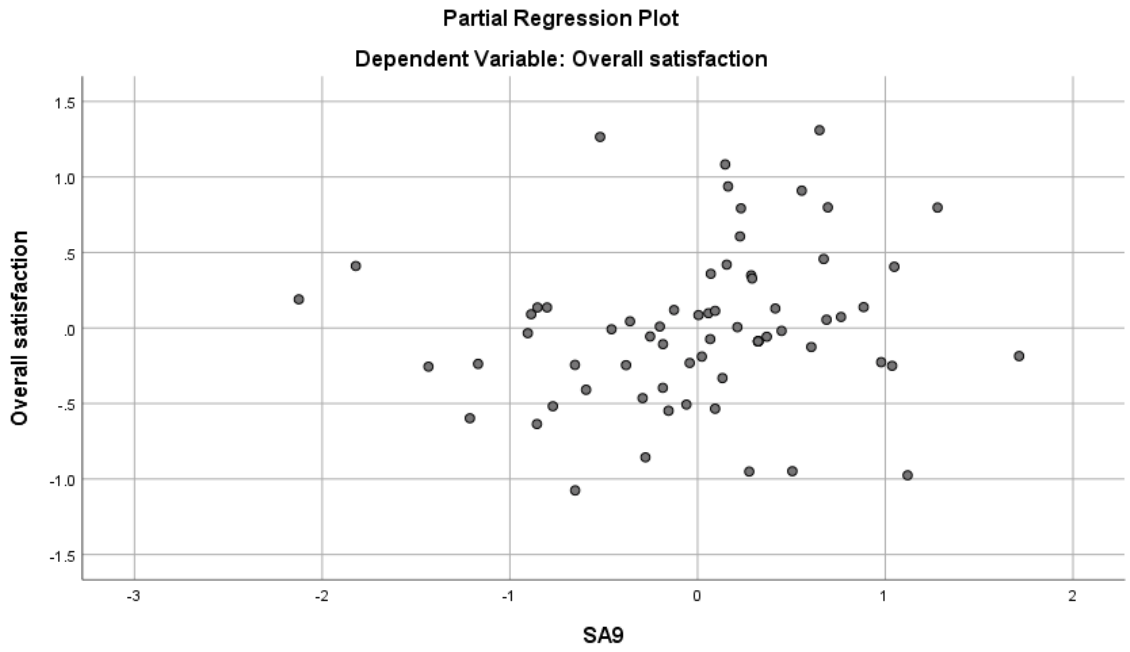
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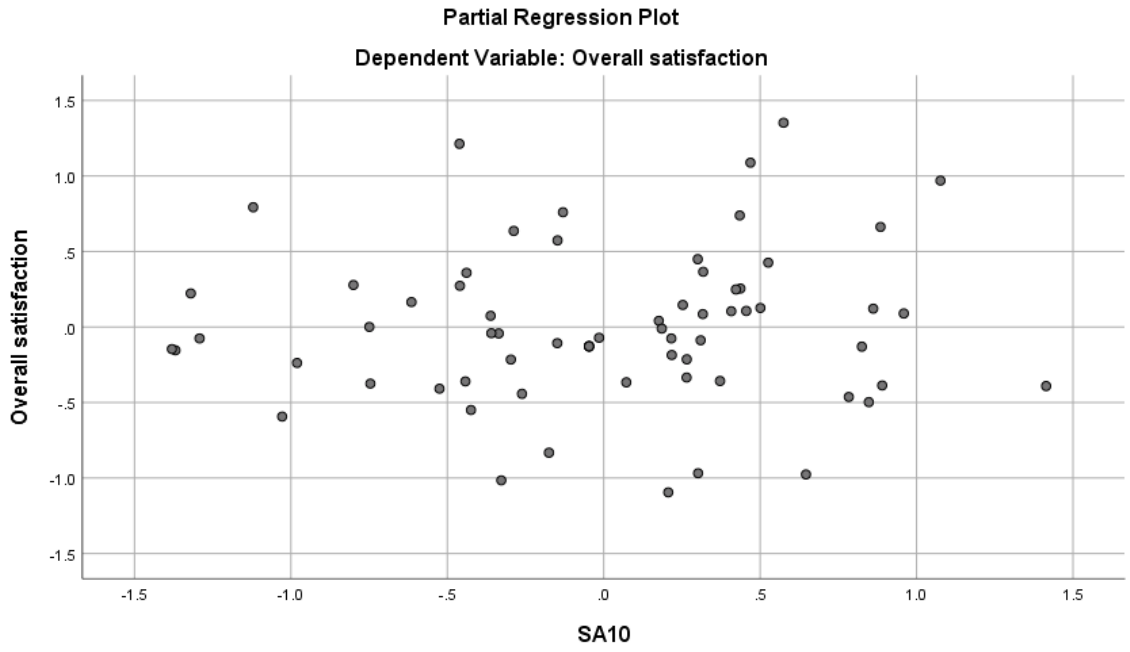
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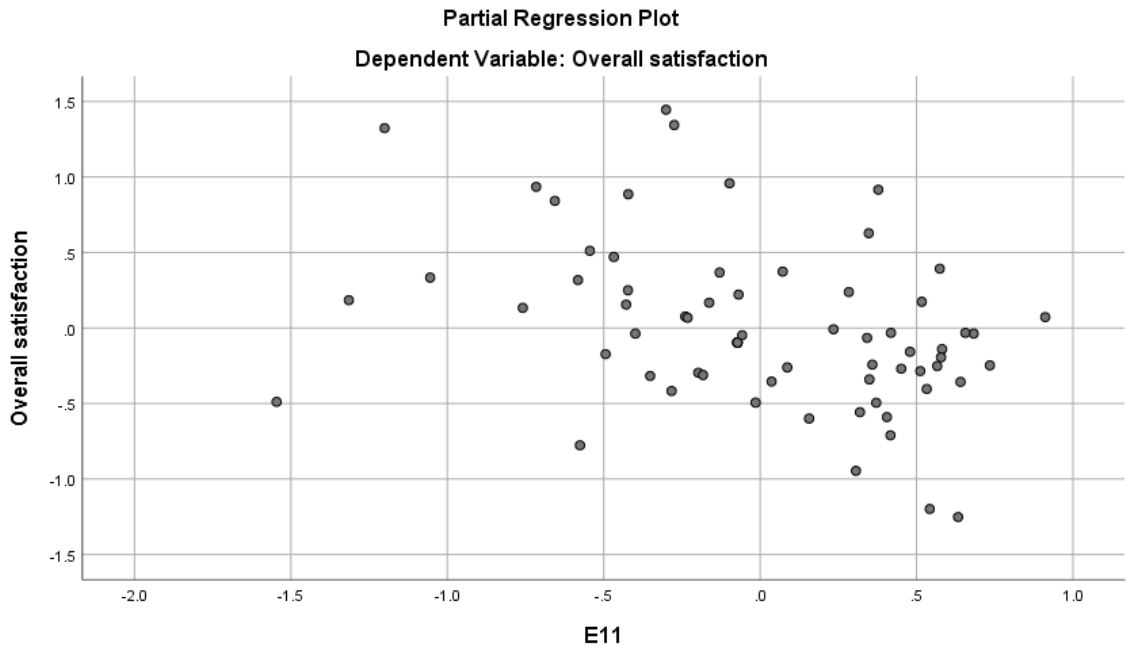
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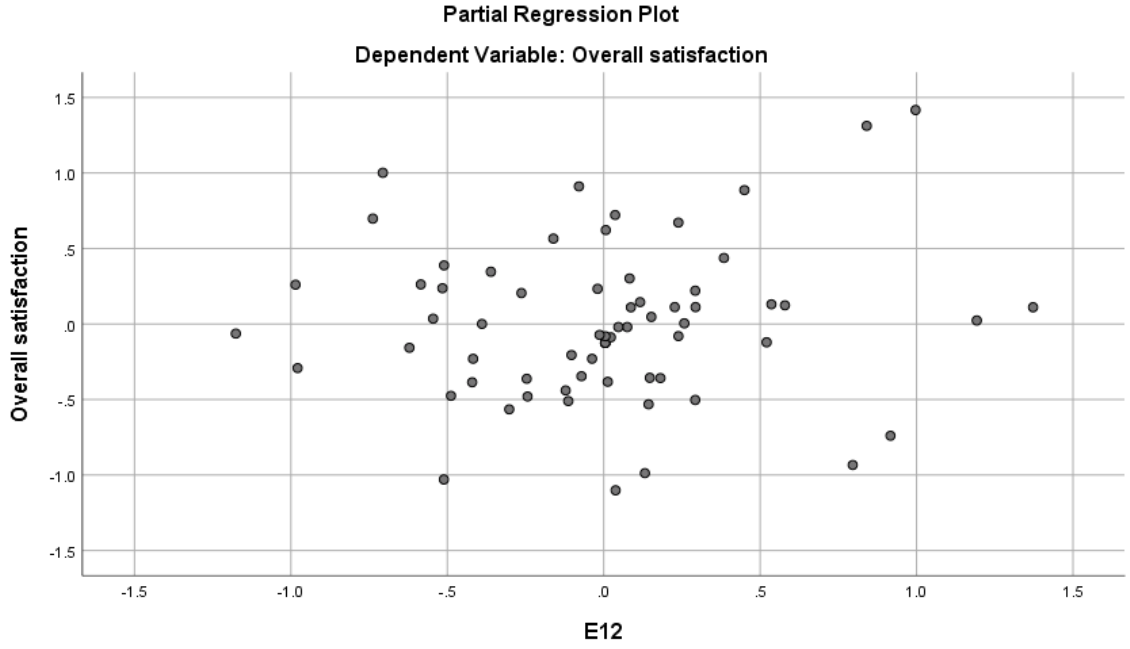
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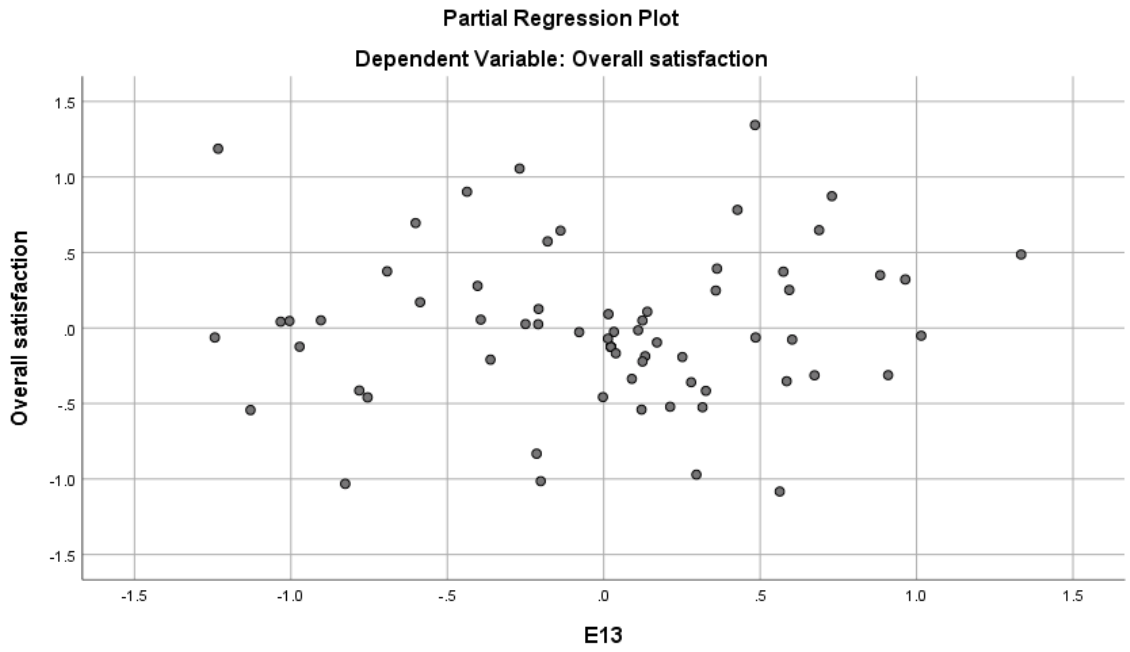
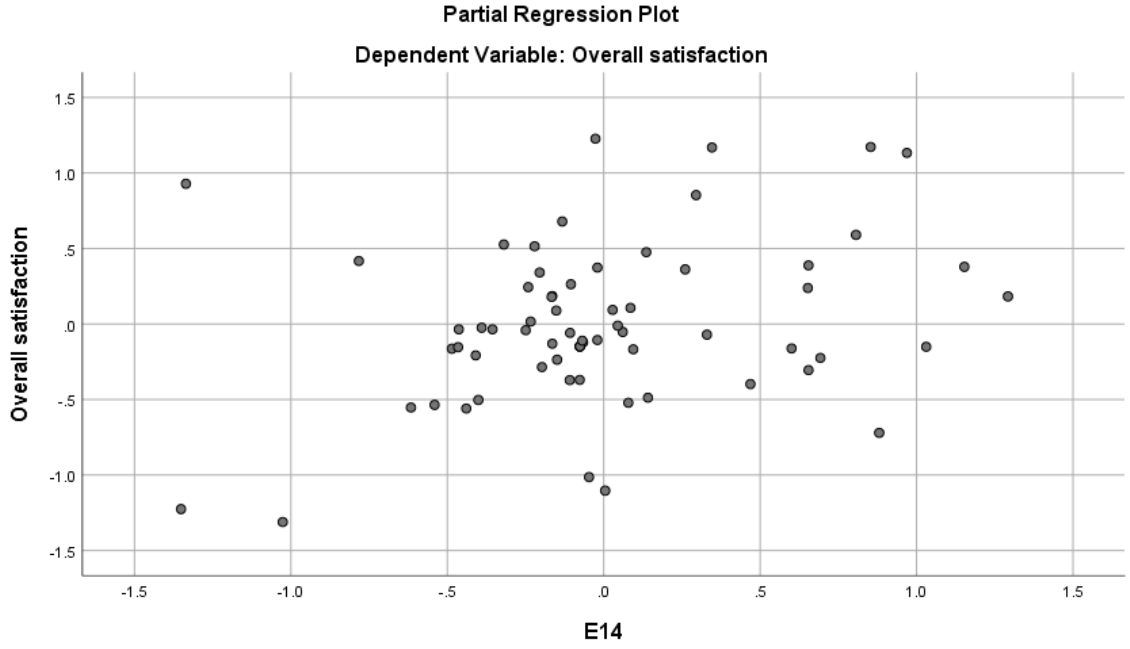
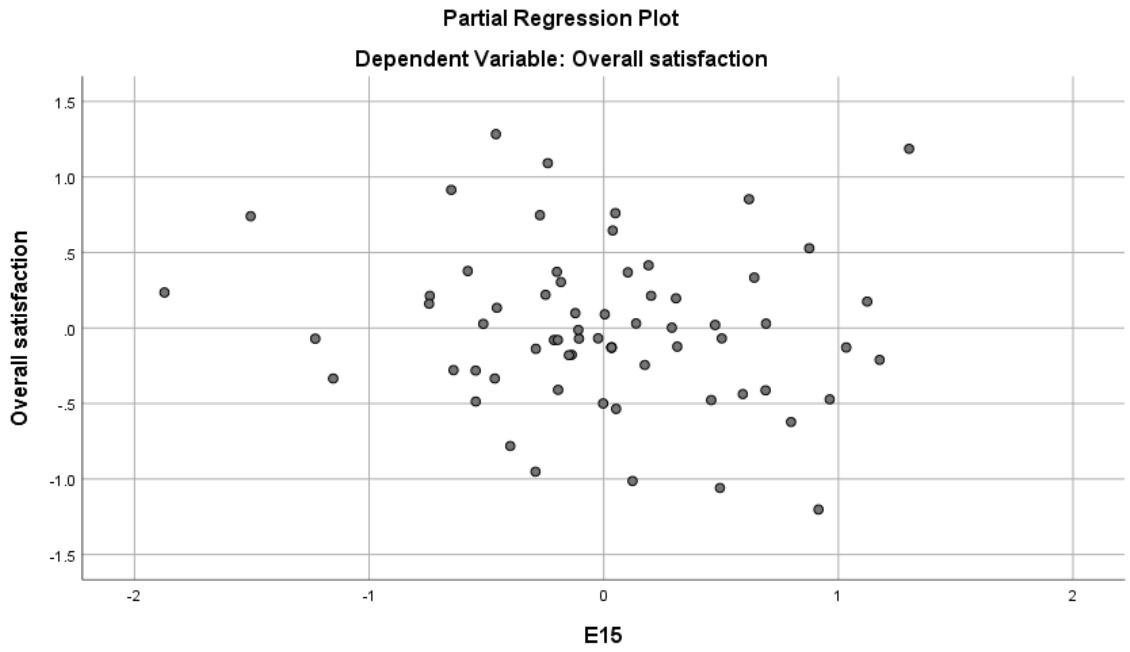
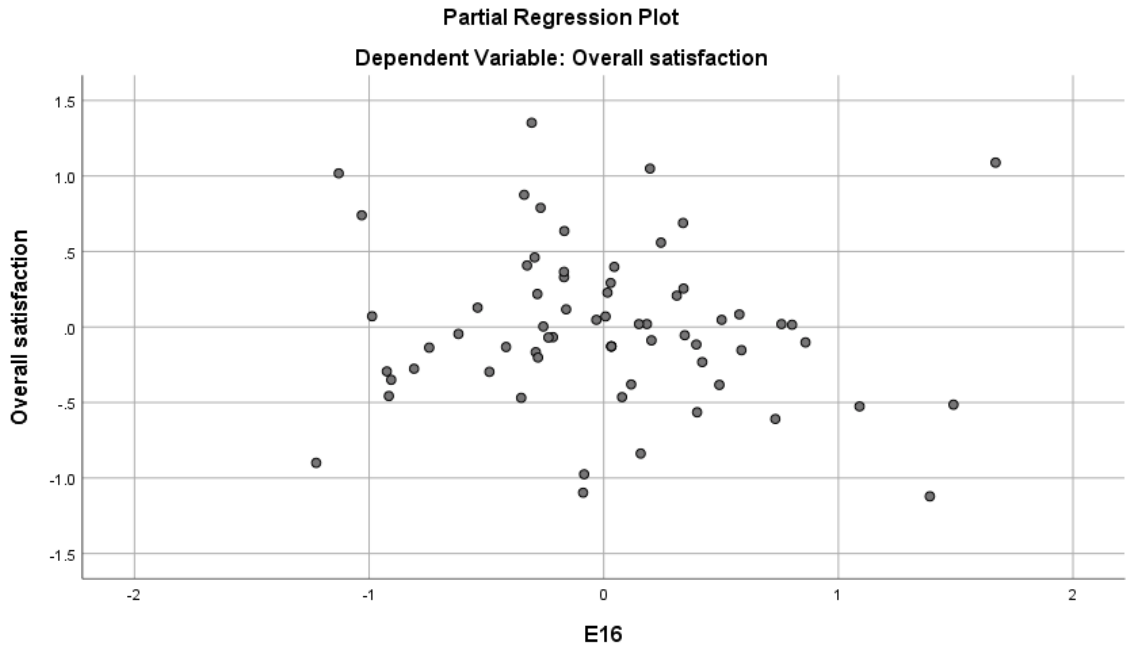
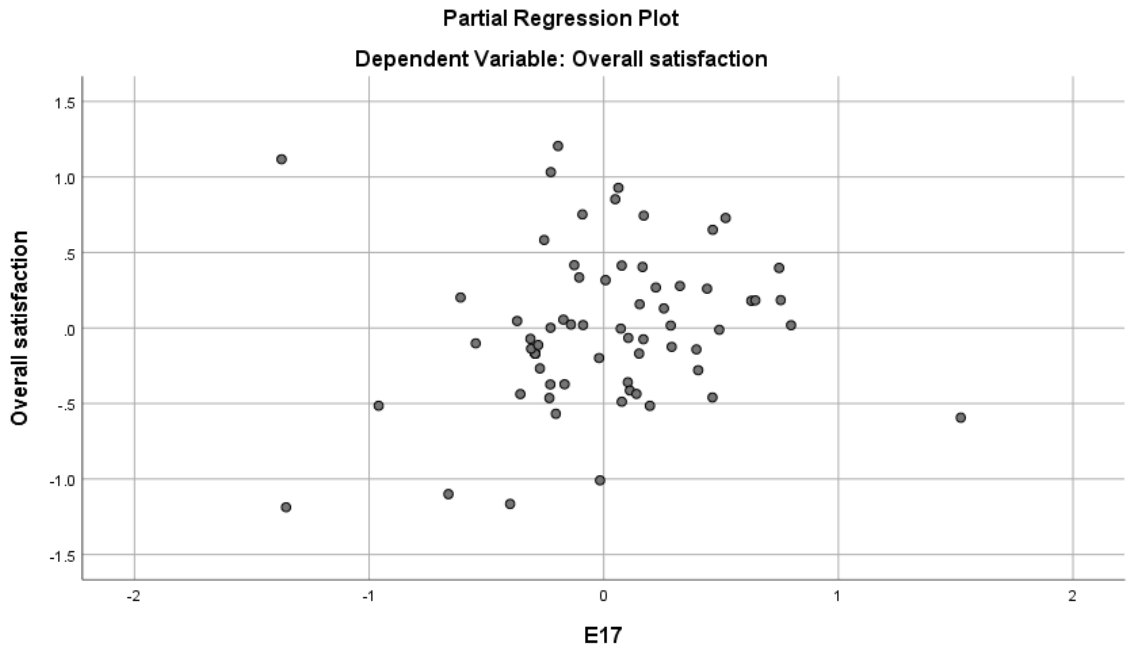
-.5
.0
.5
1.0
1.5
E12

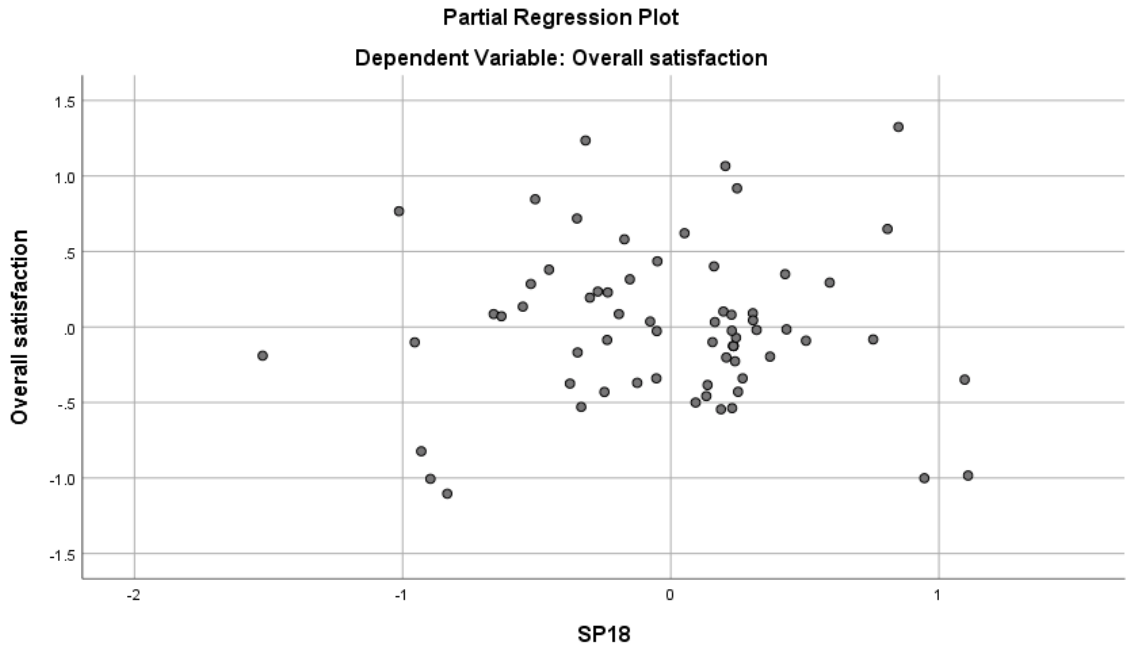

Partial Regression Plot
Dependent Variable: Overall satisfaction
Overall satisfaction
1.5
1.0
.5
.0
-.5
-1.0
-1.5
-1.5
-1.0
-.5
.0
.5
1.0
1.5
E13

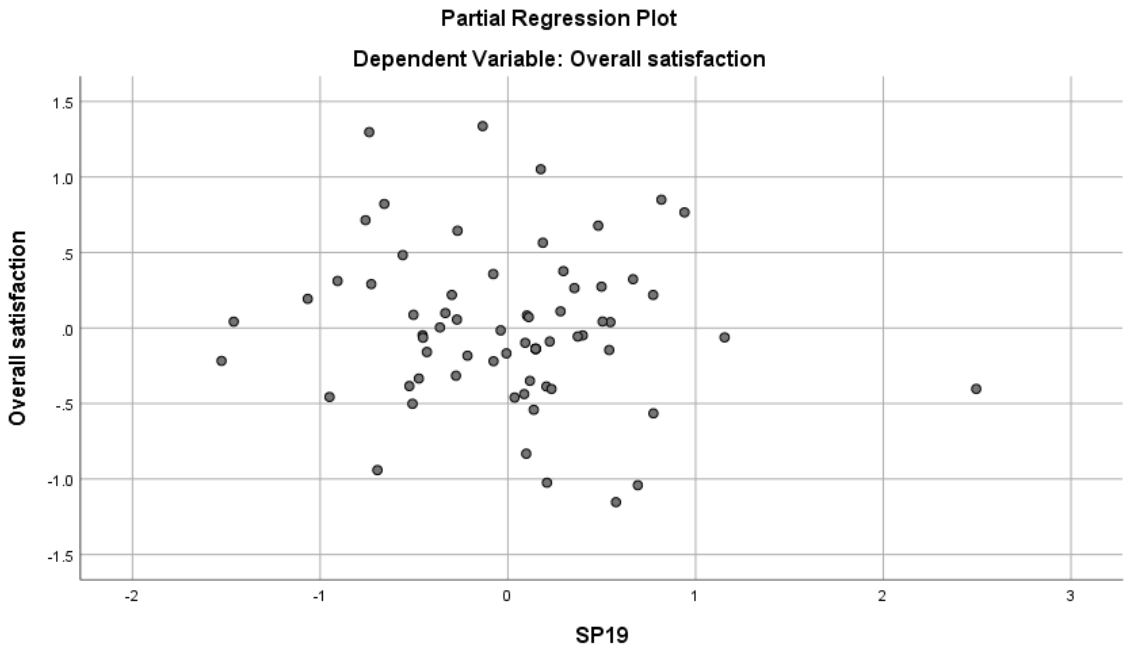

Partial Regression Plot
Dependent Variable: Overall satisfaction
Overall satisfaction
1.5
1.0
.5
.0
-.5
-1.0
-1.5
-1.5
-1.0
-.5
.0
.5
1.0
1.5
E14

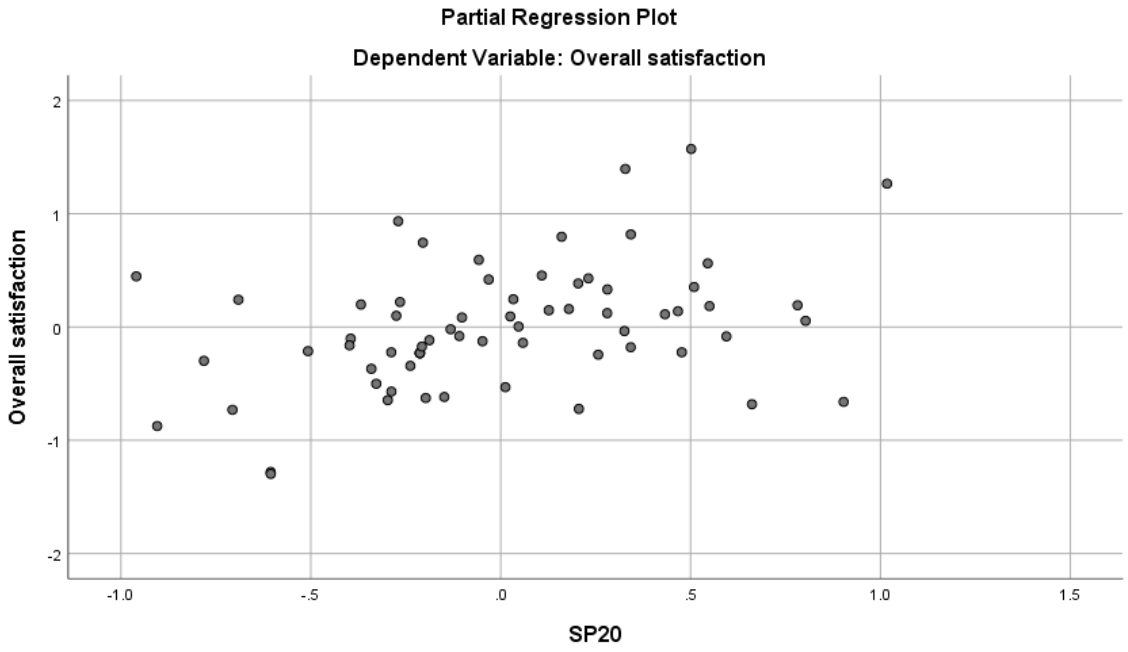

Partial Regression Plot
Dependent Variable: Overall satisfaction
Overall satisfaction
1.5
1.0
.5
.0
-.5
-1.0
-1.5
-2
-1
0
1
2
E15

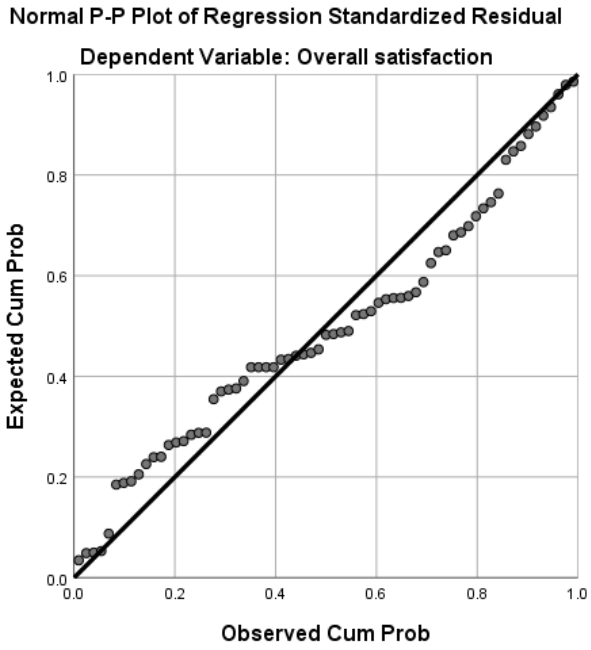

Partial Regression Plot
Dependent Variable: Overall satisfaction
Overall satisfaction
1.5
1.0
.5
.0
-.5
-1.0
-1.5
-2
-1
0
1
2
E16


Partial Regression Plot
Dependent Variable: Overall satisfaction
Overall satisfaction
1.5
1.0
.5
.0
-.5
-1.0
-1.5
-2
-1
0
1
2
E17


Partial Regression Plot
Dependent Variable: Overall satisfaction
Overall satisfaction
1.5
1.0
.5
.0
-.5
-1.0
-1.5
-2
-1
0
1
SP18


Partial Regression Plot
Dependent Variable: Overall satisfaction
Overall satisfaction
1.5
1.0
.5
.0
-.5
-1.0
-1.5
-2
-1
0
1
2
3
SP19


Partial Regression Plot
Dependent Variable: Overall satisfaction
Overall satisfaction
2
1
0
-1
-2
-1.0
-.5
.0
.5
1.0
1.5
SP20


Normal P-P Plot of Regression Standardized Residual
Dependent Variable: Overall satisfaction
Expected Cum Prob
Observed Cum Prob
0.0
0.2
0.4
0.6
0.8
1.0