Study of Design and Construction of Transit Facilities in Rural Areas in USA

Sharareh Kermanshachi *, Elnaz Safapour and Apurva Pamidimukkala

Abstract: The United States rural transit facilities have a considerable impact on annual transportation expenditures as there are many of them and they are geographically dispersed. It is challenging to estimate the design and construction costs of the facilities, as the historical and documented cost database is insufficient; therefore, the ultimate aim of this study was to establish a baseline estimate for design and construction costs. Additionally, the key information associated with the different aspects of rural transit facility projects was also provided in this study. Interviews were conducted with professional managers of different departments of transportation (DOTs) who were involved in rural transit projects. A structured survey was then developed and distributed to various DOT representatives, and 26 of them were completed and returned. Two regression models were generated by utilizing the survey data to predict the design and construction costs of rural transit facilities, based on the size of the projects. Furthermore, the results revealed that issues arising from soil conditions and unexpected underground conditions are frequently risk factors for construction of transit facilities. It was also concluded that the popular approach to estimating the cost of the design and construction phases associated with transit facility projects is to use the data from similar projects. These findings support the need for additional literature to provide a baseline estimate for design and construction costs and key information of different important aspects of rural transit facilities.

Keywords: rural transit facility; small transit facility; baseline estimate; design cost; construction cost

1. Background

Many of the rural areas in the United States struggle to retain a sufficient range of facilities ensuring necessary services to the local population. These difficulties are exacerbated in areas experiencing population decline [1,2]. Existing literature provides multiple definitions for rural areas [3–5]. The United States Census defines a rural area based on its population density; accordingly, a rural area is defined as an area with a population of less than 1000 persons per square mile [5]. In 2001, the Federal Highway Administration (FHWA) defined a rural area as an area with a population of less than 5000 and/or the outside area of a metropolitan area with a population of less than 50,000 people [4]. In the present study, the research team adopted the FHWA 2001 definition.

Rural transportation plays a critical role globally in the socio and economic conditions of rural communities [6], as it provides them with access to education, work, and health services [7]. Rural mobility has been recently challenged by an increased demand that is due to an aging population and inadequate resources [8], as transit projects in rural areas commonly receive less attention and fewer resources than projects in urban areas [9] and have to compete with them for funding [10]. To develop rural mobility, governments need to invest in constructing various type of facilities, such as remote roads, transit stops, and park-and-ride lots, and minimize the amount and number of cost overruns, which are related to unreliable and inaccurate cost estimations [11,12].

Tran et al. [3] explained that cost overruns in rural transit facilities commonly occur because the scope of the projects is limited, the funding is constrained, and the locations...
are spread geographically. Accurate and reliable cost estimation is never easy to achieve because of the many uncertainties that are inherent in the construction process. Multiple researchers and practitioners [13–16] espoused that decision-makers and estimators must make correct and reasonable assumptions to minimize the consequences of these uncertainties, based on: (1) thorough information pertaining to the project’s nature, (2) a traditional cost database, and (3) an acceptable estimation method or tool.

Some researchers and practitioners have indicated that there is a dearth of comprehensive information and documented data related to rural transit facility projects [7,10,17,18]. Hallowell et al. [17] indicated that many Department of Transportation (DOT) representatives, city/county managers, and transit officials are silent on construction management practices of rural transportation facility projects, and without their input and the benefit of sufficient data and information in existing literature on the characteristics of rural transit facilities and on viable current cost estimating practices, it is difficult to provide reliable and accurate cost estimates during the early stages of the projects [19].

The growth of rural transportation facilities plays a crucial role in the economic, social, and political health of modern society. The development of rural infrastructures, such as remote roads, bridges, and transit stops, improves the important transportation linkages between rural and urban areas and is necessary for improving the quality of life and maintaining economic stability in rural areas [3,20,21]. Multiple sectors, such as the agricultural sector, depend on transportation, particularly on roads [22,23]. The advantages and benefits of expanding regional transit facilities are recorded in the Regional Transit Coordination Guidebook [24], which espouses that the benefits are important for transit riders, transit travelers, transit providers, transportation systems, and the workforce.

The US DOT established the Rural Transportation Program in 1999 to improve the capacity of rural transit facility projects in the US. This program had several targets: (1) enhance the quality of life in rural areas, (2) increase the safety of the transportation system, (3) decrease material costs of transportation systems, (4) protect the rural natural environment, (5) enhance potential trade, (6) enhance the economic condition of rural areas, and (7) provide national security and border integrity.

In 2012, the Texas Department of Transportation (TXDOT) [25] classified transit facilities into three main categories and eight subcategories, as shown in Figure 1. The three main categories of transit facilities are operations and maintenance, large passenger, and small passenger. These classifications reflect the nature and characteristics of rural transit facilities and are beneficial for further analyses and efficient management [26].

![Figure 1. Categories and Subcategories belonging to Rural Transit Facilities.](image)

The American Public Transportation Association recommended useful practices for implementing a new bus transit facility project and maintenance services in 2010 [27]. The activities associated with the facility services and maintenance were categorized into three classes and levels (Level I, Level II, and Level III), as presented in Figure 2. Their classifica-
tion leads to higher performance, efficient funding allocation, and effective management of rural transit facilities [28–30].

Figure 2. Description of Transit Facility Services and Maintenance.

Rural transit facility projects are commonly small in scope, but numerous and geographically dispersed, so these projects account for a significant portion of funds expended on transportation projects in the U.S. [3]. Accurate cost estimation of these projects leads to considerably fewer transportation cost overruns. [11] stated that transit agencies require reliable cost estimates for the following reasons: (1) reliable estimated costs of transit facilities in the form of simple averages or cost functions during the planning phase [31–33], assist in establishing the funding commitments, and prevent the likelihood and magnitude of cost overruns [12]; (2) cost performance is the key factor in assessing the overall cost-effectiveness of transit facility projects [34]; and (3) accurate cost estimation and prediction help transit agencies appropriately allocate and prioritize resources in situations where the demand for transit outstrips the available funding. For the stated reasons and for purposes of effective management of transit systems in general, agencies seek to continually develop and update planning-level cost models [11].

Multiple researchers and practitioners believe that the challenges associated with estimating costs for rural transit facilities include a lack of documented cost data, remote locations, and less competition [3,35,36]. To address those challenges, [3] recommended various resources and methods, such as providing pricing directories and precise cycle time charts for machinery, supplies, and manpower.

Anderson et al. [37] introduced some issues regarding rural and small transit facility projects: the inability to complete rural and small transit facility projects due to lack of funding, and the prevalent use of consultants for estimating the cost of the projects. Virtually all of the DOTs hire consultants for cost estimations of these projects, and then hire additional consultants to review the accuracy of the estimates.

Zheng [38] identified the reasons that it is difficult to accurately estimate the costs of rural transit facility projects: (1) lack of an organized procedure for cost estimating through the planning, programming, and project development phases; (2) possibility of renovation of the rural transit facilities; (3) a wide range of functions in these projects; (4) the wide size of transit facility projects; and (5) unique challenges associated with transit facility projects.
2. Research Gap

Accurate cost estimating is one of the main challenges associated with rural transportation facility projects [39]. Furthermore, the estimation of design and construction costs for transportation facilities in rural areas have rarely been studied. Therefore, the ultimate aim of this study was to provide a baseline estimate for the design and construction costs, based on the size of the rural transit facilities during the early stages of projects. In addition, multiple objectives were formulated to support the literature: (1) analyze the types of design and construction contracts, (2) investigate the cost estimating methods used in the design and construction phases, (3) assess the cost of each construction system, (4) review construction risk factors, and (5) generate statistical models to facilitate the estimation of design and construction costs. This study will provide an important resource for establishing baseline estimates for the design and construction costs of rural projects and will assist DOTs in minimizing cost overruns.

3. Research Framework

In this step, a conceptual framework was provided to illustrate the objective of each step of the research process and to show how the objectives relate to one another. The conceptual research framework, presented in Figure 3, began with a thorough review of transit agencies’ related documents and transportation agencies’ websites, such as the Metropolitan Transportation Commission’s online library. These resources include important details on common types and sizes of rural transit facilities, site factors, and statistical data on the design and building costs. Following a review of the literature, characteristics of rural transportation facilities were described, as well as the scope of the state of practice was identified.

![Conceptual Research Framework](image)

Figure 3. Conceptual Research Framework.

As aspects of rural transit facilities were required that were not addressed in existing literature, multiple interviews were conducted to help the research team develop a structured survey. Telephone interviews are commonly considered an additional source and useful method for procuring information for reviewing and assessing rural transit facilities (NCHRP 20-65 Task 53) [36], and were utilized in this research. An interview protocol was developed, based on the information that the research team obtained through review of the related documents from the transit agencies. It consisted of 13 in-depth questions belonging to the categories of general information, project size, project cost, project duration, historical cost data, risk factors, contingency estimation, and critical items.

A structured survey was then developed to collect comprehensive information and data regarding the various aspects of rural and small transit facilities. As shown in Figure 3, the survey protocol consisted of questions related to the project memorandum, survey instructions, survey declarations, respondent information, characteristics of the project, cost...
estimating, project schedules, project risks, change orders, and others. The research team distributed the survey to more than 1600 personnel working in 52 DOT agencies that were involved in rural small transit projects, and sent them two follow-up emails. They then called the DOTs to ask them to complete the survey, but were told that the DOT agencies did not have any historical or documented data or information pertaining to rural and small transit facility projects.

Next, the research team expanded their efforts by locating private firms nationwide who conducted construction projects in rural communities and sending the survey to them. After sending two follow-up emails, they received a few responses to the effect that they could not share the information and data due to confidentiality mandates.

Finally, the research team contacted the National Rural Transit Assistance Program (National RTAP) regarding the low response rate, and the executive director published an announcement in their newsletter. After all of the mentioned efforts, only 26 completed surveys were collected.

Then, descriptive data analyses were performed for the design and construction phases to describe the basic features of the data in this study. To provide useful information and data for different project parties, such as owners and contractors, different aspects of rural transit facility projects were assessed and analyzed. The contract types were reviewed and the implemented cost estimating methods were assessed and analyzed. Additionally, cost breakdowns corresponding to each construction system of rural transportation facilities were studied. Finally, the regression analysis technique was used to develop a predictive modeling technique for cost estimates. Two regression models were generated to examine the relationship between the design costs/construction costs and project size.

3.1. Interview

The research team made concerted efforts to develop an interview protocol that considered critical questions, for which there were few, if any, literature resources. The protocol consisted of 13 questions, classified into eight categories: general information, project size, project cost, project duration, historical cost data, risk factors, contingency estimation, and critical items. These could be covered in a one-hour interview.

The interview protocol and project memorandum were sent to 13 professional consultants and DOT employees (five DOT employees, six transit managers, and two consultants) who were actively involved in transit management teams, had more than ten years of experience in rural and small urban transit facility projects, and were located in different regions of the United States. The project memorandum presented information pertaining to the background of this study, such as objectives, procedures, and time and date of the interview. The purpose of the interview was explained in the research background, and the characteristics of the rural transit facility projects were explained in the expectations and instructions. The interviewees were expected to review the interview protocol and project memorandum so that they could be prepared for the interview questions. Of the 13 invited to participate, only six were willing to be interviewed: three DOT personnel, two consultants, and one transit manager. Multiple articles and books have suggested that anywhere from 5 to 50 participants as adequate for conducting in-depth interviews [40].

3.2. Survey

After conducting the phone interviews, the research team utilized the results of interviews and developed a survey that was designed to gather historic project-specific cost estimates from the consulting firms, state DOTs, and transit agencies associated with transit facilities: (1) types and sizes of facilities, (2) features of facilities, (3) locations of facilities, (4) actual design costs, (5) actual construction costs, (6) design schedules, (7) construction schedules, (8) unexpected conditions, and (9) cost of construction components. Brief descriptions of the 11 survey sections are presented in Table 1.
Table 1. Brief Description of Survey Sections.

| Category                  | Description                                                                                                                                 |
|---------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------|
| Project Memorandum        | The purpose of this section is to discuss the objectives of the research, email address of the research team, and the timeline for completing the online survey. |
| Survey Instructions       | This section discussed specific types of transit facilities that have been constructed within the past five years.                               |
| Survey Declaration        | The survey declaration was created to ensure that participants had a working knowledge of cost estimate procedures for rural and small urban transit facility projects and consented voluntarily to participate in the survey. |
| Respondent Information    | The purpose of this section is to collect general information regarding the respondents such as full name, agency name, agency type, etc.        |
| General Project Information| The purpose of this section is to collect general information regarding the project such as project location, start of the design and construction, funding source, etc. |
| Characteristics of the project | The purpose of this section is to collect information regarding the project characteristics such as size, main facility systems and elements, etc. |
| Cost Estimating           | The purpose of this section is to collect actual data regarding the cost estimating methods, database, and documentation, etc.               |
| Project Schedule          | The purpose of this section is to collect information regarding the project duration, and delays.                                               |
| Project Risk              | The purpose of this section is to collect information regarding the project risk factors.                                                   |
| Change Orders             | The purpose of this section is to collect information regarding the time, reason, and cost of design and/or construction changes.               |
| Others                    | The purpose of this section is to collect any lesson learned about cost estimating of the project.                                           |

Before distributing the survey, a pilot survey was conducted by sending the questionnaire to four practitioners who were managers of rural transit facility projects and were introduced to the research team by a member of the RTAP. The research team asked the practitioners to complete the survey in order to ensure: (1) the efficacy of the questionnaire; (2) the clarity of the survey instructions; (3) the efficiency of the survey’s format; and (4) the prevention of any errors in the survey. The feedback was used to revise the survey questions.

Next, the research team sent the survey to the personnel of 52 state DOTs and consulting firms who were program managers, transit managers, or consultants of rural transit facilities. The survey was conducted online, and the survey invitations were sent through email. Follow-up survey requests were sent to the same group of people. Despite two follow-up emails, only 26 surveys, belonging to 26 different state DOTs, were returned because of the respondents’ difficulty in accessing actual project data.

4. Data Analysis and Findings

4.1. Preliminary Data Analysis

The information and data retrieved from the 26 collected surveys are shown in the five columns of Table 2: project number, transit facility type, project size based on square feet (sf), baseline budget of design phase, and baseline budget of construction phase.
Table 2. Information about Rural Transit Facility Projects.

| #  | Transit Facility Type                                                                 | Project Size (sf) | Baseline Budget ($) | Design  | Construction |
|----|----------------------------------------------------------------------------------------|-------------------|---------------------|---------|--------------|
| 1  | Shelter bus stop, Sign-only bus stop                                                   | 30 sf             | $1850 $6691         |         |              |
| 2  | Shelter bus stop                                                                       | 100 sf            | $6000 $90,000       |         |              |
| 3  | Administration, Maintenance                                                             | 200 sf            | $12,400 $20,000     |         |              |
| 4  | Administration, Operations, Maintenance, Vehicle Storage, Small Passenger Facility, Shelter bus stop, Un-shelter bus stop, Sign-only bus stop | 2000 sf           | $15,278 $122,500    |         |              |
| 5  | Administration, Shelter bus stop                                                        | 4078 sf           | $127,210 $1,345,760 |         |              |
| 6  | Operations                                                                             | 5000 sf           | $156,000 $468,000   |         |              |
| 7  | Operations                                                                             | 6000 sf           | $130,000 $1,170,000 |         |              |
| 8  | Operations, Vehicle Storage                                                             | 6720 sf           | $277,637 $100,000   |         |              |
| 9  | Operations, Maintenance, Vehicle Storage                                               | 8184 sf           | $43,600 $545,000    |         |              |
| 10 | Operations, Maintenance                                                                 | 8300 sf           | $120,000 $1,200,000 |         |              |
| 11 | Administration, Operations, Maintenance, Vehicle Storage                               | 12,500 sf         | $90,000 $985,000    |         |              |
| 12 | Administration, Vehicle Storage                                                         | 13,529 sf         | $105,000 $1,375,000 |         |              |
| 13 | Administration, Operations, Maintenance, Vehicle Storage                               | 16,500 sf         | $200,000 $4,790,000 |         |              |
| 14 | Administration, Operations, Maintenance, Vehicle Storage                               | 17,000 sf         | $250,000 $2,500,000 |         |              |
| 15 | Large Passenger Facility                                                                | 19,000 sf         | $216,246 $1,889,067 |         |              |
| 16 | Small Passenger Facility                                                                | 28,000 sf         | $446,980 $3,980,000 |         |              |
| 17 | Administration, Operations, Maintenance, Vehicle Storage                               | 29,030 sf         | $482,000 $4,088,000 |         |              |
| 18 | Administration, Operations, Maintenance, Vehicle Storage                               | 30,000 sf         | $129,500 $2,450,000 |         |              |
| 19 | Administration, Operations, Maintenance, Vehicle Storage                               | 32,000 sf         | $350,000 $5,000,000 |         |              |
| 20 | Administration, Operations, Maintenance, Vehicle Storage                               | 33,295 sf         | $450,000 $6,816,772 |         |              |
| 21 | Administration, Operations, Vehicle Storage                                             | 36,967 sf         | $350,000 $3,739,432 |         |              |
| 22 | Administration, Operations, Maintenance, Vehicle Storage                               | 40,000 sf         | $1,586,500 $7,557,392 |     |              |
| 23 | Administration, Operations, Maintenance, Vehicle Storage                               | 45,000 sf         | $70,696 $1,390,762  |         |              |
| 24 | Administration, Operations, Maintenance, Vehicle Storage                               | 70,000 sf         | $1,500,000 $30,000,000 |     |              |
| 25 | Administration, Operations, Maintenance, Vehicle Storage                               | 75,000 sf         | $2,000,000 $30,000,000 |     |              |
| 26 | Operations                                                                             | 75,000 sf         | $95,000 $210,000    |         |              |

As indicated in Table 2, the project sizes ranged between 30 sf and 75,000 sf, with 16 of the 26 projects (61.5%) exceeding 10,000 sf. Eleven (11) of the 26 projects (42%) were facility
types for administration, operations, maintenance, and vehicle storage. The baseline design budgets ranged between $1850 and $2,000,000, with 18 of the 26 (69.5%) projects having design costs that equaled or were greater than $100,000. The baseline construction costs of the projects ranged from approximately $6500 to $30,000,000, with 17 of the 26 (65.5%) having construction costs equal to or greater than $1,000,000.

4.2. Descriptive Data Analysis

The results corresponding to the descriptive data analyses for the cost and schedule of design and construction phases are shown in Table 3. The mean value of the actual design cost was $387,544, ranging between $2365 and $2,000,000. The value of standard deviation for the actual design cost was $580,439, indicating a large variation of projects’ actual design cost, because the value of the standard deviation indicates how closely or widely each actual cost value spreads around the cost mean value.

| Different Categories | Minimum   | Maximum   | Mean      | Standard Deviation |
|----------------------|-----------|-----------|-----------|--------------------|
| Design Phase         | Baseline  | $1850     | $2,000,000| $356,570           |
|                      | Actual    | $2365     | $2,000,000| $387,544           |
| Construction Phase   | Baseline  | $6691     | $30,000,000| $4,851,832         |
|                      | Actual    | $7531     | $40,000,000| $5,278,808         |

Table 3 indicates that the mean value of actual construction cost was $5,278,808, and ranged between $7531 and $40,000,000. The value of the standard deviation for actual construction cost was $10,011,426, which indicates the large variation in projects’ actual construction cost.

The actual schedule of the design phase ranged from 2 months to 82 months; the mean value and standard deviation of the actual schedule for the design phase were 20 months and 23 months, respectively. These values illustrate that the projects’ actual design phase schedule covers a wide range. Actual construction schedules ranged between 4 months and 53 months, with the mean value and standard deviation being 11 months, indicating a large data variation.

4.2.1. Cost Difference (Overruns/Underruns)

The results of the descriptive data analyses, conducted to determine the absolute difference between design and construction baseline budgets and actual costs of the transit facility projects, are presented in Table 4. This table indicates that the design cost difference ranged between $0 and $103,678, and the mean value and standard deviation of design cost difference were $11,506 and $24,861, respectively. The value of the standard deviation showed large variations in the design cost overruns and/or underruns.

| Phase       | Minimum | Maximum  | Mean    | Standard Deviation |
|-------------|---------|----------|---------|--------------------|
| Design      | $0      | $103,678 | $11,506 | $24,861            |
| Construction| $0      | $10,000,000 | $598,576 | $1,946,754         |

As presented in Table 4, the construction cost difference ranged from $0 to $10,000,000. The mean value and standard deviation of the construction cost difference were $598,576...
and $1,946,754, respectively, which showed the wide variations in the projects’ construction cost difference.

The large variations in the cost overruns and/or underruns of both the design and construction phases indicate that the DOT agencies should focus on accurate cost estimation for rural transit facility projects in order to minimize cost overruns/underruns and improve the projects’ success.

4.2.2. Contract Type

This step investigated the contract type associated with the 26 collected surveys. As presented in Figure 4, the contract types of the design phase for rural transit facilities were lump sum, unit price, and cost plus fee. This figure shows that 66% of the contract types were lump sum for the design phase. The contract types for the construction phase were lump sum, unit price, and cost plus fee; most of them (73%) were lump sum. Obviously, lump sum is the dominant contract type in both the design and construction phases of rural transit facility projects. In a lump sum contract, the contractor agrees to complete the project for a fixed price. This contract type has less risk for the contractor when the scope of the project is well-defined [41,42].

Figure 4. Design and Construction Contract Types.

Nineteen percent (19%) of the contracts were cost plus fee for the design phase, and 12% were cost plus fee for the construction phase. Cost plus fee is a type of contract in which a client pays the actual cost of the delivered service, plus a fixed fee or a percentage of actual cost. In this contract type, the owner is at risk if cost overruns occur [43].

4.2.3. Cost Estimating Methods

The utilized design and construction cost estimating techniques were studied and the results are presented in Table 5. This table indicates that roughly 48% of the design and 55% of the construction cost estimating methods were utilization of similar projects. In this cost estimating method, the actual costs of previous similar projects are utilized for estimating the cost of the present project. Accordingly, one or multiple similar projects might be used as a reference. In other words, historical data of similar projects is the foundation and basis of estimating the cost of a project [44]. This method of estimation is not commonly considered accurate, because there is no provision for uncertainties and unknowns [45].

The transit facility projects, comprised of four Categories (administration, operation, maintenance, and vehicle storage), are referred to as Combination I. The percentage associated with the cost breakdown of each construction system is indicated in Figure 5.
Table 5. Results of Cost Estimating Methods.

| Cost Estimating Methods | P * (%) | Cost Estimating Methods | P * (%) |
|-------------------------|---------|-------------------------|---------|
| Design Phase            |         | Construction Phase      |         |
| Similar projects        | 48%     | Similar projects        | 55%     |
| Hours to design         | 30%     | Historical bid data     | 20%     |
| Historical percentage   | 9%      | Contractor’s estimates  | 10%     |
|                         | of construction cost |                       |         |
| Architect’s estimates   | 5%      | Architect’s estimates   | 5%      |
| Contractor’s estimates  | 4%      | Consultant’s estimates  | 5%      |
| Historical bid data     | 4%      |                         |         |

*P refers to percentage.

For the design phase, 30% of the projects used hours to design for cost estimating. Other methods employed for design cost estimating were historical percentage of construction cost (9%), architect’s estimate (5%), and contractor’s estimate (4%). For the construction phase, the cost estimating techniques used were historical bid data (20%), contractor’s estimate (10%), combination of similar projects and historical data (5%), architect’s estimates (5%), and consultant’s estimates (5%).

Figure 5. Cost Breakdown Percentage for Each Construction System of Combination I.

The transit facility projects that include two or three types of facilities are referred to as Combination II. The cost breakdown for each construction system of Combination II is illustrated in Figure 6. The percentages of substructure and special construction and demolition of Combination II facilities were similar to those of Combination I facilities. The primary reasons for the mentioned differences are as follows:

- A higher percentage of cost breakdown was recorded for building site work, because of the necessity for more mechanical and electrical utilities at the site.
- Combination I facilities had a higher percentage of cost of interior, equipment, and furnishings than those of Combination II, because a higher number of walls, floors, and ceiling finishes, interior doors, partitions, and furnishings were required.
- Combination II facilities had a higher shell and service cost percentage than Combination I facilities, owing to the fact that their function, maintenance, and vehicle storage typically require additional heating, airflow, conditioning systems, pipework, and electrical constructions to provide effective and reliable assistance.
The transit facility projects that include two or three types of facilities are referred to as Combination II. The cost breakdown for each construction system of Combination II is illustrated in Figure 6. The percentages of substructure and special construction and demolition of Combination II facilities were similar to those of Combination I facilities. The primary reasons for the mentioned differences are as follows:

- A higher percentage of cost breakdown was recorded for building site work, because of the necessity for more mechanical and electrical utilities at the site.
- Combination I facilities had a higher percentage of cost of interior, equipment, and furnishings than those of Combination II, because a higher number of walls, floors, and ceiling finishes, interior doors, partitions, and furnishings were required.
- Combination II facilities had a higher shell and service cost percentage than Combination I facilities, owing to the fact that their function, maintenance, and vehicle storage typically require additional heating, airflow, conditioning systems, pipework, and electrical constructions to provide effective and reliable assistance.

4.2.4. Construction Risk Analysis

In this step, the frequency of observed construction risk factors was investigated. As shown in Table 6, soil conditions (23%) and unexpected underground conditions (17%) were the highest construction risk factors. Buried debris, contaminated soil, and unexpected utilities can increase costs and cause schedule delays of transit facility projects. The cost of risks must be added to the baseline budget of the mentioned projects.

| Risk Factors                              | Percentage (%) |
|-------------------------------------------|----------------|
| Soil condition                            | 23             |
| Unexpected underground conditions          | 17             |
| Environmental issues                      | 8              |
| Increased slope                           | 8              |
| High project complexity                    | 8              |
| Lack of bidding competition                | 6              |
| Higher transportation expenses             | 6              |
| Omissions and errors in design            | 6              |
| Unexpected weather conditions              | 3              |
| Bidding time                              | 3              |
| Complaint from neighborhood                | 3              |
| Lack of funding                           | 2              |
| Buy America compliance                    | 2              |
| Material                                  | 2              |

4.2.5. Contingency Estimating

The results demonstrated that 75% of studied rural transit facility projects used a percentage of construction cost for estimating the contingency value. The percentage of contingency ranged from 4% to 15%. The median contingency was roughly 10%.

4.2.6. Estimation of Design and Construction Cost

A regression statistical technique was generated to predict the design and construction costs based on the project size (sf) of the rural transit facilities. Although this study was exploratory, the authors attempted to develop a reliable and valid model for both design and construction costs. The adopted criteria were as follows:

- The sample size was limited to data and information of 26 rural transit projects. The research team was aware that the small number might negatively affect the models’ predictability; however, there were not enough solid criteria associated with the
required number of data to develop a regression model. Some researchers and authors, such as Roscoe [46], followed a rule of thumb, and assumed that 10 samples were required for each dependent variable. The rule of thumb is also commonly used for exploratory studies [47].

- The coefficient of determination was considered for the developed models to evaluate how accurately the regression models could predict the design and construction costs for rural transit facilities. If there was a strong relation between the independent variable and the dependent variable(s), the coefficient of determination became 1. On the contrary, if there was no relation between the independent variable and the dependent variable(s), the coefficient of determination became 0. The authors made an effort to develop regression models for design and construction costs with a coefficient of determination closer to 1.

A straight-line regression model was generated for the design cost with 90% confidence level, as shown in Table 7. In this table, design cost and project size (sf) were presented by Z and X, respectively. The result of the straight-line regression model was obtained as \( Z = 31.64 \times X \) (\( X > 0 \)). This equation clearly shows that the design cost of a rural transit facility is approximately 32 times its size, based on square feet. The result of p-value was obtained as \( 0.0001 < \alpha = 0.1 \). Additionally, the R-square was recorded as \( R^2 = \frac{SS_{model}}{SS_{total}} = 0.91 \). The result of R-square shows that the straight-line regression model is a good fit for the normalized design cost data.

Table 7. Result of Straight-Line Regression for Prediction of Design Cost.

| Analysis of Variance |
|----------------------|
| Source | DF | Sum of Squares | Mean Square | F Ratio | Sig. |
|---------|----|----------------|-------------|---------|------|
| Model   | 1  | 1.6421 \times 10^{13} | 1.642 \times 10^{13} | 132.9848 | 0.000 |
| Error   | 13 | 1.6053 \times 10^{12} | 1.235 \times 10^{11} |         |      |
| C. Total| 14 | 1.8027 \times 10^{13} |             |         |      |

Parameter Estimates

| Term                  | Estimate | Std. Error | t Ratio |
|-----------------------|----------|------------|---------|
| Project Size (sf)     | 31.63567 | 2.743308   | 11.53   |

The results of a generated straight-line regression model for prediction of construction cost are presented in Table 8. Similar to the design cost, the construction cost and project size (sf) are Y and X, respectively. The straight-line regression model was obtained as \( Y = 172.70 \times X \) (\( X > 0 \)) with 90% confidence level. The equation clearly shows that the construction cost of rural transit facilities is roughly 173 times their size, based on square feet. Additionally, the p-value is recorded as \( <0.0001 < \alpha = 0.1 \). The R-square was attained as \( R^2 = \frac{SS_{model}}{SS_{total}} = 0.94 \). The R-square suggests that the straight-line regression model fits for the standardized construction cost of rural transit infrastructure reasonably well.

Table 8. Result of Straight-Line Regression for Prediction of Construction Cost.

| Analysis of Variance |
|----------------------|
| Source | DF | Sum of Squares | Mean Square | F Ratio | Sig. |
|---------|----|----------------|-------------|---------|------|
| Model   | 1  | 1.3637 \times 10^{14} | 1.364 \times 10^{14} | 175.0717 | 0.000 |
| Error   | 11 | 8.5685 \times 10^{12} | 7.79 \times 10^{11} |         |      |
| C. Total| 12 | 1.4494 \times 10^{14} |             |         |      |

Parameter Estimates

| Term                  | Estimate | Std. Error | t Ratio |
|-----------------------|----------|------------|---------|
| Project Size (sf)     | 172.6989 | 13.05214   | 13.23   |
5. Discussion

The key components of rural transit facilities, design and construction cost estimating methods, construction risk factors, and design and construction contract types were identified in this study. The nature of rural transportation projects is very different from that of large transportation projects, which makes it more difficult to establish a clear and detailed overall scope and accurately estimate the cost of the project during its early stages [11,12]. As these are different types of facilities than the ones that we have in urban areas, the models that are developed for the urban areas might not be accurately applicable for these types of projects in rural areas.

Therefore, two regression models were generated to predict the design and construction costs. The regression model was adopted to develop design and construction costs of rural transit facilities inspired by [47–49]. A straight-line regression model was generated for design cost and construction cost and is presented in Tables 7 and 8. The developed equations help to estimate the actual cost and overrun in construction and design of transit facilities in rural areas. This enhances the proper planning, which helps in allocating sufficient contingency so the projects will not face any funding issues or will not be suspended.

6. Conclusions

As there is insufficient information and data associated with rural transit facilities, the ultimate aim of this study was to provide a baseline estimates for both design and construction costs of rural transit projects. In addition, this study identified the key components of rural transit facilities, identified design and construction cost estimating methods, determined construction risk factors, assessed the cost of each construction system, and identified design and construction contract types associated with rural transit facilities.

Two regression models were developed to predict the design and construction costs. It was concluded that size is a significant predictor in determining the conceptual design and construction costs of rural transit facilities. Moreover, the results demonstrated that the “similar projects’ cost technique” was the most frequently used method in which the actual cost of previous similar projects are utilized for estimating the cost of the present project. The lump sum contract was employed most often for both the design and construction phases. In this contract type, the contractor agrees to complete the project for a fixed price. The data collected from interviews were used to identify risk factors, and their frequencies were determined using an online survey. The most frequently encountered construction risk factors were soil conditions and unexpected underground conditions. To manage project risks, contingency is projected as a percentage of construction cost. The contingency percentage ranges provided by interview respondents and survey results served as a guide for establishing the default contingency range for the cost estimating prototype tool. Lastly, a straight-line regression model was generated to estimate both the design and construction costs based on the project size of the rural transit facilities. The findings of this study provide a beneficial baseline estimate for the design and construction costs in the early stages of the rural transit facility projects, and will assist DOTs in accurately analyzing bidders’ proposed cost estimates, enabling them to select the one that most effectively minimizes the potential for cost overruns.

Although this research was exploratory in nature and somewhat limited by the relatively small number of interviews and completed surveys, the authors made every effort to provide valid and reliable outcomes. It is, however, recommended that future studies query a larger number of DOT representatives to obtain more comprehensive results. The models were not generated as a replacement for estimates of design and construction costs associated with rural transit facilities, which require detailed construction cost techniques. In addition, this study relied on information pertaining to U.S. rural transit facility projects and lacks cross-professional, cross-organizational, and cross-national studies from rural transit facility projects worldwide.
Author Contributions: Conceptualization, S.K.; methodology, S.K.; software, S.K.; writing—original draft preparation, S.K. and E.S.; writing—review and editing, E.S. and A.P.; supervision, S.K.; project administration, S.K., E.S. and A.P. All authors have read and agreed to the published version of the manuscript.

Funding: The National Cooperative Research Highway Program (NCHRP) (project 20-65)/Task 53 of the Transportation Research Board sponsored this research project.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: All data generated or analyzed during this study are included in this published article.

Acknowledgments: The authors would like to express appreciation to the sponsor, as well as to the practitioners and professionals who devoted their time and energy to support us in conducting this research. Additionally, the authors also acknowledge the contributions of other NCHRP 20-65/Task 53 research team members for providing significant inputs to complete this study.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Thiede, B.C.; Brown, D.L.; Sanders, S.R.; Glasgow, N.; Kulesar, L. A Demographic Deficit? Local Population Aging and Access to Services in Rural America, 1990–2010. Rural Sociol. 2016, 82, 44–74. [CrossRef] [PubMed]
2. Queiroz, C.; Gautam, S. Road Infrastructure and Economic Development: Some Diagnostic Indicators; World Bank Publications: Washington, DC, USA, 1992; Volume 921.
3. Tran, D.Q.; Hallowell, M.R.; Molenaar, K.R. Construction management challenges and best practices for rural transit projects. J. Manag. Eng. 2015, 31, 04014072. [CrossRef]
4. Federal Highway Administration. Planning for Transportation in Rural Areas. Available online: https://www.fhwa.dot.gov/planning/publications/rural_areas_planning/ruralguide.pdf (accessed on 15 May 2019).
5. Womach, J. Agriculture: A Glossary of Terms; Programs, and Laws; Report; Library of Congress: Washington, DC, USA, 2005; p. 279.
6. McAndrews, C.; Beyer, K.; Guse, C.E.; Layde, P. How do the definitions of urban and rural matter for transportation safety? Re-interpreting transportation fatalities as an outcome of regional development processes. Accid. Anal. Prev. 2016, 97, 231–241. [CrossRef] [PubMed]
7. Godavarthy, R.P.; Mattson, J.; Ndembé, E. Cost–Benefit Analysis of Rural and Small Urban Transit in the United States. Transp. Res. Rec. J. Transp. Res. Board 2015, 2533, 141–148. [CrossRef]
8. Chen, C.; Achtari, G.; Majkut, K.; Sheu, J.-B. Balancing equity and cost in rural transportation management with multi-objective utility analysis and data envelopment analysis: A case of Quinte West. Transp. Res. Part A Policy Pract. 2017, 95, 148–165. [CrossRef]
9. Jiang, X.; Yang, Z.; Tao, T.; Hu, T. Service Design of Rural Transit Routes in China. In Proceedings of the CICTP 2015, Beijing, China, 24–27 July 2015; pp. 1407–1418. [CrossRef]
10. Closs, S. Small Town Transit-Oriented Development in Eastern Ontario and Sweden. Master’s Thesis, York University, Toronto, ON, Canada, 2019.
11. Murillo-Hoyos, J.; Volovski, M.; Labi, S. Rolling stock purchase cost for rail and road public transportation: Random-parameter modelling and marginal effect analysis. Transp. A Transp. Sci. 2016, 12, 436–457. [CrossRef]
12. Sinha, K.C.; Labi, S. Transportation Decision Making: Principles of Project Evaluation and Programming; John Wiley & Sons: Hoboken, NJ, USA, 2007.
13. Chou, J.-S.; O’Connor, J.T. Internet-based preliminary highway construction cost estimating database. Autom. Constr. 2007, 17, 65–74. [CrossRef]
14. Chou, J.-S.; Chen, H.-M.; Hou, C.-C.; Lin, C.-W. Visualized EVM system for assessing project performance. Autom. Constr. 2010, 19, 596–607. [CrossRef]
15. Kim, K.N.; Choi, J.-H. Breaking the vicious cycle of flood disasters: Goals of project management in post-disaster rebuild projects. Int. J. Proj. Manag. 2013, 31, 147–160. [CrossRef]
16. Rui, Z.; Li, C.; Peng, F.; Ling, K.; Chen, G.; Zhou, X.; Chang, H. Development of industry performance metrics for offshore oil and gas project. J. Nat. Gas Sci. Eng. 2017, 39, 44–53. [CrossRef]
17. Hallowell, M.; Tran, D.; Molenaar, K. Guidebook for Construction Management Practices for Rural Projects; Transportation Research Board: Washington, DC, USA, 2012.
18. Majkut, K. Rural Transportation Issues and Strategies. Knowledge Synthesis for Monieson Centre, Queen’s School of Business 2011. Available online: https://smith.queensu.ca/centres/monieson/index.php (accessed on 10 October 2021).
19. Lokshin, M.; Yemtsov, R. Has rural infrastructure rehabilitation in Georgia helped the poor? World Bank Econ. Rev. 2005, 19, 311–333. [CrossRef]
20. Kermanshachi, S.; Beaty, C.; Anderson, S.D. Improving early phase cost estimation and risk assessment: A department of transportation case study. In Proceedings of the Transportation Research Board 95th Annual Meeting, Washington, DC, USA, 10–14 January 2016.

21. Kermanshachi, S.; Safapour, E. Identification and quantification of project complexity from perspective of primary stakeholders in US construction projects. J. Civ. Eng. Manag. 2019, 25, 380–398. [CrossRef]

22. Fox, W.F.; Porca, S. Investing in rural infrastructure. Int. Reg. Sci. Rev. 2001, 24, 103–133. [CrossRef]

23. Kermanshachi, S.; Safapour, E.; Anderson, S.; Goodrum, P.; Taylor, T.; Sadatsafavi, H. Development of multi-level scoping process framework for transportation infrastructure projects using IDEF modeling technique. In Proceedings of the Transportation Research Board 98th Annual Conference, Washington, DC, USA, 13–17 January 2019.

24. Lewis, C.A.; Higgins, L.; Perkins, J.; Zhan, F.B.; Chen, X. Regional Transit Coordination Guidebook; Texas Transportation Institute: Bryan, TX, USA, 2009.

25. Texas Department of Transportation. The Texas Rural Transportation Plan. Transportation Planning and Programming Division; Texas Department of Transportation (TXDOT): Austin, TX, USA, 2012.

26. Jin, Z.; Kang, S.; Jung, Y.; Koo, C.-G.; Choi, S.-H. Issues and Needs for Standard Classifications for Facility Management in Smart Manufacturing. In Proceedings of the International Symposium on Automation and Robotics in Construction, Berlin, Germany, 20–25 July 2018; pp. 1–8. [CrossRef]

27. American Public Transportation Association (APTA). Architectural and Engineering Design for a Transit Operating and Maintenance Facility; Rep. No. APTA BTS-BMF-RP-001-11; American Public Transportation Association: Washington, DC, USA, 2010.

28. Abd Wahab, S.R.H.; Chohan, A.H.; Che-Ania, A.I.; Tawil, N.M.; Omar, H. The Classification of Facilities to Determine the Management Fund Allocation at Non-Low Cost of High-Rise Residential Building. Rev. Fac. Ing. U.C.V. 2016, 31, 9–18. [CrossRef]

29. Kermanshachi, S.; Rouhanizadeh, B. Sensitivity analysis of construction schedule performance due to increased change orders and decreased labor productivity. In Proceedings of the 7th CSCE International Construction Specialty Conference (ICSC), Laval, QC, Canada, 12–15 June 2019; pp. 12–15. [CrossRef]

30. Kermanshachi, S.; Safapour, E.; Anderson, S.D.; Goodrum, P.; Taylor, T.R. Establishment of effective project scoping process for highway and bridge construction projects. Pract. Period. Struct. Des. Constr. 2020, 25, 06020001. [CrossRef]

31. Jacobs, F.H. The Five-tiered Approach to Evaluation: Context and Implementation. In Evaluating Family Programs; Aldine DeGruyter: New York, NY, USA, 1988; pp. 37–68. [CrossRef]

32. Rossi, P.H.; Lipsey, M.W.; Freeman, H.E. Evaluation: A Systematic Approach; Sage Publications: Southend Oaks, CA, USA, 1993.

33. Rouhanizadeh, B.; Kermanshachi, S.; Ramaji, I.J.; Shakarian, S. Development of an Automated Tool for Cost Estimation of Transportation Projects. In Proceedings of the ASCE International Conference on Transportation and Development, Virtual Conference. 8–10 June 2021; pp. 178–190.

34. Karlaftis, M.G. Ownership and competition in European transit: Assessing efficiency. Transportmetrica 2010, 6, 143–160. [CrossRef]

35. Kermanshachi, S.; Zheng, Y.; Anderson, S.D.; Cliff, S.; Molenaar, K.R. Cost Estimating Tool for Early Estimates for Rural and Small Urban Transit Facilities. In Proceedings of the 95th Annual Meeting of Transportation Research Board (TRB), Washington, DC, USA, 10–14 January 2016.

36. Kermanshachi, S.; Safapour, E.; Anderson, S.D.; Molenaar, K.; Schexnayder, C. Development of the Cost Baseline for Achieving Excellence in Rural Transit Facilities. In Proceedings of the Transportation Research Board 98th Annual Conference, Washington, DC, USA, 4–7 November 2018.

37. Anderson, S.; Quiroga, C.; Overman, J.; Choi, K.; Sahu, J.; Kermanshachi, S.; Goodrum, P.; Taylor, T.; Li, Y. Effective Project Scoping Practices to Improve on-Time and on-Budget Delivery of Highway Projects; Transportation Research Board: Washington, DC, USA, 2016; ISBN 9780309375108. [CrossRef]

38. Zheng, Y. Cost Estimating Database and Prototype Tool to Support Design and Construction of Rural and Small Urban Transit Facilities. Master’s Thesis, Texas A & M University, College Station, TX, USA, 2014.

39. Ferguson, E.M.; Duthie, J.; Unnikrishnan, A.; Waller, S.T. Incorporating equity into the transit frequency-setting problem. Transp. Res. Part A Policy Pract. 2012, 46, 190–199. [CrossRef]

40. Dworkin, S.L. Sample Size Policy for Qualitative Studies Using In-Depth Interviews. Arch. Sex. Behav. 2012, 41, 1319–1320. [CrossRef]

41. Kaplanogu, S.; Arditi, D. Pre-project peer reviews in GMP/lump sum contracts. Eng. Constr. Arch. Manag. 2009, 16, 175–185. [CrossRef]

42. Kermanshachi, S.; Safapour, E.; Anderson, S.; Goodrum, P.; Taylor, T.; Sadatsafavi, H. Exploring current scoping practices used in the development of transportation infrastructure projects. In Proceedings of the CSCE 12th International Transportation Specialty Conference. Fredericton, NB, Canada, 13–16 June 2018.

43. Bogus, S.M.; Shane, J.S.; Molenaar, K.R. Contract payment provisions and project performance: An analysis of municipal water and wastewater facilities. Public Work. Manag. Policy 2010, 15, 20–31. [CrossRef]

44. Bley, A.F.S. Improved Conceptual Estimating Performance Using a Knowledge-Based Approach; The University of Texas at Austin: Austin, TX, USA, 1990.

45. Phoabunjong, K. Parametric Cost Estimating Model for Conceptual Cost Estimating of Building Construction Projects; The University of Texas at Austin: Austin, TX, USA, 2002.
46. Roscoe, J.T. *Fundamental Research Statistics for the Behavioral Sciences [by] John T. Roscoe*; Holt, Rinehart and Winston: New York, NY, USA, 1975.

47. Le-Hoai, L.; Dai Lee, Y. Time-cost relationships of building construction project in Korea. *Facilities* 2009, 27, 549–559. [CrossRef]

48. Choudhury, I.; Rajan, S.S. Time-cost relationship for residential construction in Texas. *CIB Rep.* 2003, 284, 73.

49. Forcada, N.; Gangolells, M.; Casals, M.; Macarulla, M. Factors affecting rework costs in construction. *J. Constr. Eng. Manag.* 2017, 143, 04017032. [CrossRef]