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An Efficient Methodology to Calculate Unit Transportation Costs: Case Studies for Trucks and Busses

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Abstract Calculating the unit transportation costs for trucks and buses is very important for companies in logistics and transportation. This helps companies to manage operations efficiently, remain profitable, and set competitive prices. Transportation companies gain insights into each component of their expenses by analyzing costs per ton-kilometer (for trucks) or per passenger-kilometer (for buses), such as fuel, maintenance, and labor. Based on these calculations, the cost for a whole trip can be easily calculated. This enables them to control budgets and optimize resource allocation. This metric also supports efficient route planning, fleet management, and cost-effective scheduling. Additionally, lowering unit costs often aligns with sustainability goals, reducing emissions through practices like load consolidation and fuel-efficient routing. Overall, understanding unit transportation costs fosters financial stability, customer satisfaction, and environmental responsibility. In this paper, we illustrate the different parameters which affect the calculation of unit transportation cost and the step-by-step methodology to calculate the variable, fixed, total and unit transportation costs for both trucks and buses. Two case studies with result analysis and comparisons with the actual costs are also included in this paper.

Keywords Unit transportation costs, Logistics operations, Cost optimization, Sustainable freight transport, Fleet management

1. Introduction and Literature Review

Unit transportation cost for trucks and buses is an important measure when reviewing logistics, freight and public service operations [1,2]. This measure is crucial in order to design, monitor, and put under control all the processes for making efficient operative decisions and containing costs and price policies [3-5]. Transportation is central to the economy and tends to absorb between a quarter to half of the overall logistics costs while warehousing accounts for between 15% to 40% [6]. Because transportation is so large and is such a vital element of the costs of providing logistic services, companies need to be able to anticipate, control and monitor transportation costs if they are to sustain their profits, efficiency and viability in the marketplace [7].

A quantitative measurement of the expenses associated with the transportation of goods or people is obtained from cost per ton-kilometers for trucks and cost per passenger-kilometers for buses [8,9]. These unit costs give a clear picture of the operations or working costs that are flexible and related to fixed as well as other varying factors of transportation [10,11]. The various costs are used in setting competitive prices, preparation of budgets as well as ensuring the survival of the company in a highly competitive industry [12-14]. Cost control therefore ensures that a company can meet anticipated cost responsibilities as well as imbibe cost impacts that arise unexpectedly, ensure that costs are incurred responsibly and that it is possible for a company to post good earnings while delivering quality service [15,16].

In the transportation industry, cost management can be categorized into two broad categories: variable and fixed costs [17,18]. The variable costs vary with the number of miles covered, amount of freight transported and operational factors like fuel consumption and/or frequency of service. Such costs are cost of fuel, cost of maintenance services, driver cost wage which is specific to driver and cost of tolls/permit which are dependent on route choice and vehicle usage. Overhead costs are different from fixed costs in that they do not vary with the amount of goods moved, or with the number of people transported [19,20]. For instance, there are insurance costs, vehicle depreciation charges, costs of leasing the strategic car, and costs of colleagues who do not actually drive the car. Thus, both fixed and variable costs need to be analyzed and controlled to ensure flexible pricing strategies, reasonable profit-making levels, and higher levels of competitiveness among the transportation firms [21].

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This shows why precision in formula and management of the variable costs cannot be overemphasized given the current standard and fuel prices and the push that is being made to make deliveries and transportation cheaper [22,23]. Fuel is among the leading variable costs, making this one of the areas of most importance to trucks operations and consequently the general operations. Most of the prior research are insistent on the idea that the direct transportation costs can be substantially decreased if fuel consumption is reduced through means such as efficient route planning, vehicles' proper maintenance, and use of fuel-efficient vehicles. When it comes to better optimization of the routes, the coming up with modern technologies and gadgets, including GPS systems and real time traffic flow data, can trim down the fuel consumption level by about 15%. In the same way, predictive maintenance systems, which use real-time statistical data and formally modeled algorithms to estimate the time by which a vehicle would need to be serviced, have been shown to optimize fuel consumption and vehicle performance to an extent [24].

Vehicle maintenance is also another great factor affecting operational costs of a fleet. Another factor is the reliability of the vehicle for day–to–day usage [25-27]. This means that regular maintenance and servicing of the vehicle are factors in reducing breakdown time because of faulty car parts. Some of the works of various researchers have given an insight into the relationship between maintenance practices and costs. Previous studies showed that organizations that embark on intentional measures of vehicle maintenance management can cut their cost of vehicle management by up to 20% [28]. Furthermore, well- maintained vehicles have better fuel efficiency, reducing transportation costs in general. Another inclusion of preventive maintenance is the safety, reliability, and increase in duration of services of a given vehicle, therefore, it is cost effective.

Being independent of the level of activity, fixed costs nevertheless take up a rather large part of the total transportation costs. Some fixed costs, for instance, vehicle depreciation, may form a significant proportion of total fixed costs. There are several works that can be mentioned as an attempt to assess the effect of depreciation on costs. Further, in terms of leasing costs, the option is also very useful; more so, when using the total cost of ownership as a measure against leasing that incorporates factors such as usage rates, interest rates, and lease period [29].

Apart from the unit costs, one needs to know the fixed and variable transportation costs parameters to be accurate [30]. Unit costs mean the cost per ton-kilometer for trucks or the cost per passenger-kilometer for buses clearly indicates the performance in terms of transportation cost operations. The unit cost of each of these can be determined and where it appears that fuel has been consumed or routes or management of fleets is not efficient then it will be evident from these analyses that improvements can be made [31]. Precise unit costs also facilitate better decisions regarding pricing policies and cost distribution as well as help create better cost control and management and make activities more environmentally friendly.

The determination of unit transportation costs is equally important in route determination and in the management of fleet [32]. Transportation companies with the ability to estimate the cost per kilometer, per trip or per unit of carriage, have better possibilities to make correct decisions concerning fleet usage. This entails deciding on the right number of vehicles to be used on the field, mechanics of carrying out routine checks, and probably deciding on the most efficient routes to cover depending on the mode of transport among others [33,34]. Moreover, with a focus on unit cost estimates, a firm can identify trends in demand and match this with either the number of vehicles or production capabilities to better satisfy demand without creating undue stress on its assets [35].

This paper aims at exploring the factors that have enhanced interest in minimizing the environmental impact of transportation operations. Since many organizations are making the shift on cost-reduction strategies coupled with environment friendly strategies, cheaper fuel and decreased fuel consumption are now top priorities in many corporations' transportation systems. Much to corporations' amazement, implementing sustainable practices in their business can yield impressive cost savings in the long run as they work towards their objectives. Also, green technology inclusive of electric vehicles, hybrid vehicles and alternative fuels would significantly contribute to lowering carbon footprint in the transportation operations for organizations engaged in long distance operations such as logistics and public transportation respectively.

The current study extends the knowledge on research methodologies applied to estimate unit costs related to transport means, with special emphasis on the comparison of cost estimation methods. Indeed, most of the works begun to investigate some specific cost subcategories, including fuel, maintenance, and many others, and much less attention has been paid to the intricate relationships between different elements of transportation costs and the ways to enhance them. This paper intends to contribute to this discussion by presenting two case studies and practical uses of several cost calculation methods and explaining the benefits and drawbacks of each one. In this way, it provides companies involved in transportation with a full set of tools that would help analyze costs and improve financial and operating performance. Transportation costs must be accurately estimated because they directly affect transport cost structures, pricing and competitive strategies, and the sustainability of transport operations. It is important to identify factors that affect transportation cost such as the amount of fuel used, maintenance cost and cost of depreciation for the transport vehicles to enhance efficiency in transport operations and minimize costs. This study provides information on how cost estimates of transport systems are arrived at including strategies for increasing efficiency in transport now and in the future. Further, the study encompasses a comparison of the results which were arrived at on the basis of calculated

costs and actual cost incurred in the process.

Consequently, the total cost for a trip can easily be determined by multiplying the calculated unit transportation cost for a truck and/or bus by the distance in kilometers travelled.

2. Benefits of Calculating Transportation Unit Cost

The Calculation of unit transportation costs for both trucks and buses is important for several very important reasons in business and operations. This way cost calculation serves as a basis for the price formation, operative management, and planning, which are of paramount importance for health and competitiveness of a financial aspect in transportation industry. Here's why it's important [10,36-41]:

1. Pricing and Profitability

- Set Competitive Rates: Knowing the unit cost helps companies set prices for transporting goods (for trucks) or passengers (for buses) at competitive rates.
- Ensure Profit Margins: Accurate cost calculations allow companies to ensure they are pricing services profitably, covering both fixed and variable costs, and earning a reasonable margin.

2. Budgeting and Cost Control

- Identify High-Cost Areas: Breaking down costs per unit (like per ton-kilometer or per passenger-kilometer) allows companies to identify cost-intensive parts of the operation.
- Control Expenses: With precise unit costs, companies can monitor expenses more effectively and find opportunities to reduce costs, such as optimizing fuel consumption or reducing maintenance expenses.

3. Performance Measurement and Efficiency

- Benchmark Performance: Unit cost is a useful metric for measuring efficiency across different routes, vehicles, or time periods, helping companies benchmark their performance.
- Optimize Operations: By analyzing unit costs, companies can optimize route planning, vehicle usage, and even scheduling to achieve the lowest possible cost per unit while maintaining service quality.

4. Decision-Making on Fleet Investments

- Evaluate Fleet Expenses: Calculating unit costs helps determine whether the current fleet is cost-effective or if upgrades are needed.
- Investment Justification: For larger companies, it justifies investments in new vehicles, technologies, or alternative fuels by showing potential cost savings over time.

5. Cost Allocation and Financial Planning

- Allocate Costs Accurately: Unit cost calculations are crucial for dividing transportation costs among different departments, products, or clients in a fair and accurate way.
- Financial Forecasting: Knowing unit costs helps in projecting future transportation expenses, especially if the business is expanding or adding new routes.

6. Competitive Analysis

- Benchmark Against Competitors: Calculating unit costs allows a company to compare its expenses with industry standards or competitors, identifying where it may have a competitive advantage or needs improvement.
- Improve Service Offerings: Companies can analyze costs and, if necessary, add or reduce services, such as more fuel-efficient routes, better amenities on buses, or faster delivery times for trucks.

7. Sustainability and Environmental Impact

- Assess Fuel Efficiency: Tracking unit costs helps in identifying fuel-efficient routes and practices, reducing the overall carbon footprint of operations.
- Lower Emissions: More efficient operations mean lower emissions per unit transported, which can be part of a company's sustainability initiatives and even appeal to environmentally conscious customers.

8. Client Contracts and Negotiations

- Transparent Costing for Clients: For logistics and transportation companies, a clear understanding of unit costs allows for transparent and data-backed pricing, which builds client trust.
- Support Negotiations: Companies can negotiate better terms with customers, especially for high-volume contracts, by knowing their baseline unit costs and using this data to justify pricing.

9. Risk Management and Resilience

- Identify Cost Variabilities: Understanding which costs are variable and which are fixed helps in risk management, especially when fuel prices fluctuate, or economic conditions shift.
- Build Operational Resilience: Knowing unit costs enables a business to remain resilient by adjusting operations (e.g., consolidating loads or adjusting routes) to maintain profitability even during challenging times.

3. Parameters Affecting the Calculation of Unit Transportation Costs

The calculation of unit transportation cost involves multiple parameters that directly influence the cost per unit of transported people and/or goods. These parameters interact with each other and vary based on the specific logistics and operational setup, making the calculation of unit transportation costs complex and dynamic. Here are some key factors:

- Distance and Route: Longer distances generally increase costs due to fuel, labor, and maintenance expenses. Route characteristics, such as road quality, tolls, and geographical challenges (e.g., mountains, rivers), also impact costs.

- Mode of Transportation: Different modes (road, rail, air, or sea) have unique cost structures. For instance, air freight is typically faster but more expensive per unit than sea transport, which is cheaper but slower.
- Fuel Costs: Fluctuations in fuel prices directly affect transportation costs, especially for fuel-dependent modes like trucking and air transport.
- Load and Capacity Utilization: Full truckloads (FTL) or optimized container space lower the unit cost compared to partial loads or less-than-truckload (LTL) shipments. High-capacity utilization reduces the cost per unit by maximizing the cargo carried per trip.
- Type and Value of Goods: High-value, fragile, or perishable items often require special handling, packaging, or refrigeration, increasing unit costs.
- Labor Costs: Wages for drivers, crew, and loading/ unloading staff contribute significantly to transportation costs. Labor costs vary by region and can impact the final unit cost.
- Transportation Infrastructure and Fees: Fees for using ports, warehouses, or airports, and costs related to customs duties or import/export taxes, impact costs, especially for international transport.
- Handling and Packaging Requirements: Special packaging, loading/unloading equipment, or additional handling (for hazardous materials, for instance) increases costs per unit.
- Insurance and Security Costs: Insurance for goods in transit and security measures, especially for high-value shipments, add to the transportation cost.
- Seasonal Variability and Demand Fluctuations: Peak seasons, such as holiday periods, can increase transportation costs due to higher demand for shipping services and labor.
- Regulatory Compliance Costs: Regulations regarding emissions, weight limits, and driver working hours can lead to additional compliance costs, influencing the cost per unit.
- Environmental Impact Fees: Green logistics or carbon footprint reduction fees also contribute to overall transportation costs, especially for companies focusing on sustainability.
- Depreciation and Maintenance of Transport Fleet: The cost of wear and tear, regular maintenance, and the depreciation of transportation assets like trucks, ships, or aircraft are part of the long-term costs, affecting the unit cost over time.

4. Step by Step Methodology

To calculate the unit transportation cost in a step-by-step process, follow the following methodology. This structured approach allows for a comprehensive calculation of unit transportation costs, adaptable to various modes and types of goods [42-45].

Step 1: Define Scope and Gather Data

- Determine the parameters affecting transportation costs, including mode of transport, distance, fuel prices, and load capacity.
- Collect data of fixed and variable costs associated with the chosen transportation method, such as fuel expenses, labor costs, maintenance, tolls, etc...

Step 2: Calculate Total Ton-Kilometers or Total Passenger -Kilometers

To calculate the total ton-kilometers done by a truck, multiply the truck load by the total traveled kilometers by the truck through a certain period, this period could be a year, a month or so. The same procedure to calculate total passenger -kilometers for a bus, multiply the number of seats in the bus by the total travelled kilometers done by the bus through the studied time window.

- Formula for Total ton-km for a truck:

$$Total\ ton.kilometers\ (per\ year) = Truck\ load\ (ton) * Total\ travelled\ kilometers\ (per\ year) \quad (1)$$

- Formula for Total passengers-km for a bus:

$$Total\ passenger.kilometers\ (per\ year) = Bus\ seats * Total\ travelled\ kilometers\ (per\ year) \quad (2)$$

Step 3: Identify Fixed Transportation Costs

Fixed costs are expenses that don't vary with the distance or volume of goods transported. This cost includes:

- Fleet purchase or lease costs (depreciated over time)
- Insurance premiums
- Permit and licensing fees
- Administrative and overhead costs (e.g., office expenses, general staff wages)
- Formula for Fixed Costs Per Unit:

$$Fixed\ Cost\ Per\ Unit = \frac{Total\ Fixed\ Costs}{Total\ Units\ Transported} \quad (3)$$

- Formula for Fixed Costs Per Ton-km:

$$Fixed\ Cost\ Per\ Ton - Km = \frac{Total\ Fixed\ Costs}{Total\ Ton-Km} \quad (4)$$

- Formula for Fixed Costs Per Passenger-Km:

$$Fixed\ Cost\ Per\ Passenger - Km = \frac{Total\ Fixed\ Costs}{Total\ Passenger\ -Km} \quad (5)$$

Step 4: Calculate Variable Costs

Variable costs change based on the distance traveled, fuel usage, and volume. Key components are:

- Fuel Costs: Multiply fuel consumption per unit distance by fuel price and total distance.
- Labor Costs: Total wages for drivers/crew per trip, adjusted for travel time.
- Maintenance Costs: Per-mile maintenance cost times distance.
- Tolls and Fees: This includes road tolls, port fees, or airport charges based on route (if exist).
- Formula for Total Variable Costs Per Unit:

$$Variable\ Cost\ Per\ Unit = \frac{Total\ Variable\ Costs}{Total\ Units\ Transported} \quad (6)$$

- Formula for Total Variable Costs Per Ton-Km:

$$Variable\ Cost\ Per\ Ton-Km = \frac{Total\ Variable\ \ Costs}{Total\ \ Ton-Km} \quad (7)$$

- Formula for Total Variable Costs Per Passenger-Km:

$$Variable\ Cost\ Per\ Passenger-Km = \frac{Total\ Variable\ \ Costs}{Total\ \ Passen\ ger-Km} \quad (8)$$

Step 5: Calculate Handling and Packaging Costs

Some goods require specific handling or packaging to ensure safe transport, particularly for high-value or perishable goods. Include:

- Packaging materials and labor
- Special handling equipment or refrigeration costs (if applicable)
- Formula for Handling and Packaging Costs Per Unit:

$$Handling\ Cost\ Per\ Unit = \frac{Total\ \ Handling\ \ and\ \ Packaging\ \ Costs}{Total\ \ Units\ \ Transported} \quad (9)$$

- Formula for Handling and Packaging Costs Per Ton-Km:

$$Handling\ Cost\ Per\ Ton-Km = \frac{Total\ \ Handling\ \ and\ \ Packaging\ \ Costs}{Total\ \ Ton-Km} \quad (10)$$

- **Note: NO** Formula for Handling and Packaging Costs Per Passenger-Km.

Step 6: Add Insurance and Security Costs

If applicable, calculate the per-unit cost of insurance and any additional security measures for high-value goods.

- Formula for Insurance and Security Costs Per Unit:

$$Insurance\ Cost\ Per\ Unit = \frac{Total\ \ Insurance\ \ Costs}{Total\ \ Units\ \ Transported} \quad (11)$$

- Formula for Insurance and Security Costs Per Ton-Km:

$$Insurance\ Cost\ Per\ Ton-Km = \frac{Total\ \ Insurance\ \ Costs}{Total\ \ Ton-Km} \quad (12)$$

- Formula for Insurance and Security Costs Per Passenger-Km (if applicable):

$$Insurance\ Cost\ Per\ Passenger-Km = \frac{Total\ \ Insurance\ \ Costs}{Total\ \ Passenger\ \ -Km} \quad (13)$$

Step 7: Determine Environmental and Regulatory Compliance Costs

For companies focusing on sustainability, calculate:

- Environmental fees (such as carbon offsets or emissions fees)
- Compliance costs (costs associated with meeting transport regulations)
- Formula for Compliance Costs Per Unit:

$$Compliance\ Cost\ Per\ Unit = \frac{Total\ \ Compliance\ \ Costs}{Total\ \ Units\ \ Transported} \quad (14)$$

- Formula for Compliance Costs Per Ton-Km:

$$Compliance\ Cost\ Per\ Ton-Km = \frac{Total\ \ Compliance\ \ Costs}{Total\ \ Ton-Km} \quad (15)$$

- Formula for Compliance Costs Per Passenger-Km (if applicable):

$$Compliance\ Cost\ Per\ Passenger-Km = \frac{Total\ \ Compliance\ \ Costs}{Total\ \ Passenger\ \ -Km} \quad (16)$$

Step 8: Compute Total Transportation Cost

Add up all fixed, variable, handling, insurance, and compliance costs.

- Formula for Total Transportation Cost:

$$Total\ Transportation\ Cost = Total\ Fixed\ Costs + Total\ Variable\ Costs + Total\ Handling\ Costs + Total\ Insurance\ Costs + Total\ Compliance\ Costs \quad (17)$$

Step 9: Calculate Unit Transportation Cost

Finally, divide the total transportation cost by the total units transported as in equation (18), or by the total ton-kilometers for trucks as in equation (19), or by the total passenger-kilometers for busses as in equation (20), to determine the unit transportation cost.

- Formulas to Calculate Unit Transportation Cost:

$$Unit\ Transportation\ Cost = \frac{Total\ \ Transportation\ \ \ Cost}{Total\ \ Units\ \ Transported} \quad (18)$$

$$Unit\ Transportation\ Cost = \frac{Total\ \ Transportation\ \ \ Cost}{Total\ \ Ton-Kilometers} \quad (19)$$

$$Unit\ Transportation\ Cost = \frac{Total\ \ Transportation\ \ \ Cost}{Total\ \ Passenger\ .Kilometers\ *Occupaion\ \ rate} \quad (20)$$

Step 10: Validate and Adjust

- Compare with historical costs to check for significant deviations and ensure accuracy.
- Adjust calculations based on changing factors like fuel prices or seasonal demand fluctuations.

5. Case Study 1: Calculating the Unit Transportation Cost of Trucks

A freight transportation company owns a fleet of trucks with different loads. Let us consider one of their trucks to calculate the unit transportation cost based on data of this truck. Table (1) below illustrates all the given data of the studied truck where all prices are in Kuwaiti Dinar (K.D.).

Table (1). The collected data of the studied truck where all prices are in Kuwaiti Dinar (K.D.)

Company Name	Hidden for privacy	Price of Liter of Diesel (K.D.)	0.115
Truck Type	Mercedes	Engine Oil Consumption (Liters)	120
Truck Model – Starting Service Date	2023	Price of Oil Liter (K.D.)	2
Truck Load (ton)	40	Annual Consumed Tires	10
Purchase Price (K.D.)	35000	Price of one Tire (K.D.)	300
Expected Lifetime in Years	10	Annual Consumed Batteries	3
Scrap Value	4000	Price of one Battery (K.D.)	200
Average Annual Kilometers Done by Truck	120000	Average Annual Maintenance and Repair Costs Including Spare Parts and Labors	12000
Insurance Cost per year (K.D.)	50	Salaries of The Driver and The Worker on This Truck per year	11000
Registration Cost per year (K.D.)	12	Number of Stopping Days for This Truck Per Year	50
Annual Fuel Consumption (Liters)	40000	Taxes	None
Annual Administrative Cost Per Truck	1000	Average Overhaul Cost Per Year (K.D.). Overhaul is done every 5 years	3000
Average Other Oil Cost per Year in K.D.	230		

Based on the collected data for this truck, here are the calculated costs:

Table (2). Calculation of the fixed cost of the truck

Item	Value
Depreciation cost = (Purchase price – Scrape value) / Lifetime (in years)	(35000-4000)/10 = 3100 K.D.
Registration cost	12
Insurance cost	50
Administrative cost	1000
Average annual overhaul cost	3000
Total Fixed Cost Per Year	**7162 K.D.**

Table (3). Calculation of the variable cost of the truck

Item	Value
Fuel consumption cost = Annual fuel consumption per liter * Price of liter of Diesel	40000 * 0.115 = 4600 K.D.
Engine oil cost = Annual engine oil consumption per liter * Price of liter of oil	120 * 2 = 240 K.D.
Other oil costs	230 K.D.
Tire consumption cost = Annual consumed tires * Price of one tire	10 * 300 = 3000 K.D.
Batteries consumption cost = Annual consumed batteries * Price of one battery	3 * 200 = 600 K.D.
Average Annual Maintenance and Repair Costs Including Spare Parts and Labors	12000 K.D.
Salaries for driver and worker	11000
Total Variable Cost Per Year	**31670**

Table (4). Calculation of the total transportation cost of the truck

Total Fixed Cost Per Year	7162
Total Variable Cost Per Year	31670
Total Transportation Cost Per Year	**38832 K.D.**

Total Ton-Kilometer Done Per Year

Use equation (1) to calculate the total to-kilometers done by the truck.

$$Total\ ton-kilometer\ (per\ year) = 40 * 120000 = 4800000\ ton-km.$$

Unit Transportation Costs of The Truck

Use equation (19) to calculate the unit transportation cost per ton-kilometer.

$$Unit\ Transportation\ Cost = \frac{38832}{4800000} = 0.00809\ K.D./ton-km$$

i.e. Unit transportation cost = 8.09 Fills / ton-km.

Result Analysis and Comparison

1. The calculated unit transportation cost just covers the expense of the company and the truck fixed and variable cost. The company may add another amount of money to cover their profits.
2. Both the collected and the calculated amounts may differ from one company to the other and from one country to the other according to the usage of the vehicle. But the methodology still fine for all companies in any country.
3. The calculated price is good for domestic shipping. But for international shipping the price may change to be doubled or even more due to many other factors and regulations.
4. When comparing the calculated unit cost with the actual one that is charged by the company, we found that their rate is about 25% to 40% more. This is logical to cover the stopping days, non-productive kilometers when the truck moves with no loads and to cover any sudden failure plus the company profits.
5. The time consumed for loading and unloading the vehicle may be considered. That is why short trips are more expensive than longer trips.

6. Case Study 2: Calculating the Unit Cost for Buses

A passenger transport company owns their own fleet of buses. Some of these busses are working inside Kuwait. Others are working between Kuwait and Makkah at Saudi Arabia. Let us study one of these buses and calculate the transportation unit cost based on the collected data of this bus. Table (5) below illustrates all the collected data of the studied bus where all costs are in Kuwaiti Dinar (K.D.).

Table (5). The collected data of the studied bus where all costs are in Kuwaiti Dinar (K.D.)

Company Name	Hidden for privacy	Price of Liter of Diesel (K.D.)	0.115
Bus Type	Mercedes Benz	Oil Consumption (Liters)	160
Bus Model – Starting Service Date	2022	Price of Oil Liter (K.D.)	2
Number of seats	50	Annual Consumed Tires	8
Purchase Price (K.D.)	70000	Price of one Tire (K.D.)	450
Expected Lifetime in Years	10	Annual Consumed Batteries	2
Scrap Value	5500	Price of one Battery (K.D.)	200
Average Annual Kilometers Done by Bus	150000	Average Annual Maintenance and Repair Costs Including Spare Parts and Labors	7000
Insurance Cost per year (K.D.)	50	Salaries of 2-Drivers per year	12000
Registration Cost per year (K.D.)	12	Number of Stopping Days For This Bus Per Year	50
Annual Fuel Consumption (Liters)	35000	Taxes	None
Annual Administrative Cost Per Truck	900	Average Overhaul Cost Per Year (K.D.). Overhaul is done every 5 years	2700
Average Other Oil Cost per Year in K.D.	250	Occupation Rate	80%

Based on the collected data for this truck, here are the calculated costs:

Table (6). Calculation of the fixed transportation cost of the bus

Item	**Value**
Depreciation cost = (Purchase price – Scrape value) / Lifetime (in years)	(70000-5500)/10 = 6450 K.D.
Registration cost	12
Insurance cost	50
Administrative cost	900
Average annual overhaul cost	2700
Total Fixed Cost Per Year	**10112 K.D.**

Table (7). Calculation of the variable transportation cost of the bus

Item	Value
Fuel consumption cost = Annual fuel consumption per liter * Price of liter of Diesel	35000 * 0.115 = 4025 K.D.
Engine oil cost = Annual engine oil consumption per liter * Price of liter of oil	160 * 2 = 320 K.D.
Other oil costs	250 K.D.
Tire consumption cost = Annual consumed tires * Price of one tire	8 * 450 = 3600 K.D.
Batteries consumption cost = Annual consumed batteries * Price of one battery	2 * 200 = 400 K.D.
Average Annual Maintenance and Repair Costs Including Spare Parts and Labors	7000 K.D.
Salaries for 2-drivers per year	12000
Total Variable Cost Per Year	**27595 K.D.**

Table (8). Calculation of the total transportation cost of the bus

Total Fixed Cost Per Year	10112
Total Variable Cost Per Year	27595
Total Transportation Cost Per Year	**37707 K.D.**

Total Passenger-Kilometer Served Per Year

Use equation (2) to calculate the total passenger-kilometers.

$$\text{Total passenger} - \text{kilometers (per year)} = 50 * 150000 = 7500000 \text{ passenger} - \text{km}$$

Unit Transportation Costs of The Bus

Use equation (20) to calculate the unit transportation cost per passenger-kilometer.

$$\text{Unit transportation cost} = \frac{37707}{7500000 * 0.8} = 0.0062845\ K.D/Passenger - Km$$

Transportation Cost Per Ride (Example):

For a ride of 50 kilometers, the unit transportation cost = 0.0062845 * 50 = 0.314 K.D/Passenger.

Result Analysis and Comparison:

1. The calculated unit transportation cost just covers the expense of the company and the bus fixed and variable cost. The company may add another amount of money for their profits.
2. Both the collected and the calculated amounts may differ from a company to the other and from a country to the other, according to the usage of the vehicle.
3. The calculated price is good for domestic shipping. But for international shipping the price may change to be doubled or even more due to many other factors.
4. When comparing the calculated unit cost per trip with the actual one that is charged by the company, we found that the calculated costs are close to the actual costs of the company.
5. The calculated costs cover the occupational rates when there are only 80% of the bus seats are occupied.
6. The time consumed at the beginning and the last bus station may be considered. That is why more ticket prices appear for some routes.
7. These calculations cover domestic bus trips. International trips need another study.

7. Conclusions

Transportation costs must be accurately estimated because they directly affect transport cost structures, pricing and competitive strategies, and the sustainability of transport operations. Two case studies are introduced in this paper to calculate the unit transportation cost for both trucks and buses. Both fixed, variable, total and unit transportation costs are calculated for both case studies. The calculated unit cost for the bus is 0.0062 K.D./passenger-km. It is close to that cost that is applied by the company right now. The calculated unit cost for the truck is 0.00809 K.D./ton-kilometer. It is a little less than the cost that is applied by the company. This difference may cover the stopping days and the company profit. The whole transportation cost for a trip can now be easily calculated by multiplying the unit transportation cost by the travelled distance in kilometers. The introduced solution algorithm is an effective way to calculate the vehicle unit transportation cost. This methodology can be applied to any transportation company in the world.

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