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Updating Vehicle Operating Cost based on Wholesale Price Index

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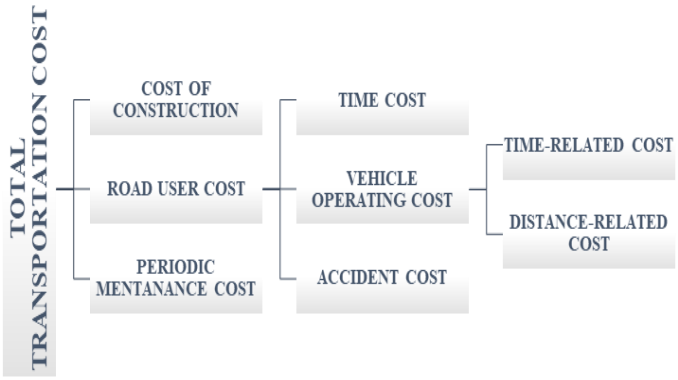
***Abstract*— The road user cost components must be updated to accurately evaluate the costs and benefits of road improvements during economic evaluation. The examination of rules and regulations, the comparison of different designs, the sequencing of projects and programs within a constrained budget, and the justification of highway investments all take road user costs into account. An important factor in the assessment of highway projects is the calculation of road user costs. It is essential to establish a procedure for routinely updating road user cost data to conduct an economic evaluation that analyses the benefits and costs of road projects realistically. The best way to update road user costs is to gather information on each of the cost elements individually. But it would take a long time, and it would be difficult. The Wholesale Price Index has been suggested as a replacement for updating the road user cost components (WPI). Data on road user costs were therefore updated and acquired from pertinent government sources. Based on the data the escalation factor obtained as 1.5 and using VOC equations total vehicle operating cost found for expressway is 253.26 Rs/Km.**

***Keywords*—Vehicle Opertaing Cost; Road User Cot; WPI Index**

I. INTRODUCTION

Any country's economic progress can be significantly boosted by the transportation sector. Careful planning is required for the best use of resources in the road transportation industry due to the rapidly dwindling financial, land, and other resource availability as well as the rising demand for travel. It is crucial to make the best use of the resources at hand to build an effective road network and allow the economy to expand with the least amount of resistance. The cost of transportation is what a country spends for the geographic separation of activities that use natural resources and benefit from specialization, congregation, and individual mobility When analyzing the economics of highways, one must take into account the total transportation costs, which are made up of the initial building costs, ongoing maintenance costs over the course of the road's design life, and the costs incurred by road users (RUC). The designer must select the option that keeps the sum of these three interdependent components to a minimum. The first two elements are simpler to quantify. But because it depends on numerous variables and is difficult to define, the third portion, 1.e. RUC, calls for a lot of research.

According to Figure 1, the two fundamental parts of the total transportation cost are the cost of the roads and the cost of the users of the roads. Road user costs account for a sizable portion of the entire transportation cost, between 80 and 90 percent according to numerous research studies on various aspects of road paving and transportation.



"Fig. 1,Total Transportation Cost"

A. *Road User Cost*

The expenses experienced by drivers of vehicles as well as by the general travelling public can be referred to as "road user costs." RUC consists mostly of three elements: time cost, accident cost, and vehicle operating cost (VOC) . Among them, VOC is a significant component as indicated in Equation 1 and is quite easy to quantify. The amount of each type of resource used (by users throughout the process of using road infrastructure) is multiplied by the unit cost of consumption of the resource to arrive at the RUC.

$$\text{Road User Cost} = \underset{(55\%-70\%)}{\text{Vehicle Operating Cost}} + \underset{(20\%-40\%)}{\text{Time Cost}} + \underset{(5\%-10\%)}{\text{Accident Cost}} \quad \ldots(1)$$

B. *Vehicle Operating Cost*

VOC models are among the RUC models that are analytically challenging. One of the most important factors in assessing roadway construction is the VOC determination. They are required for the evaluation of highway projects, particularly those involving the upkeep, repair, and improvement of roads. VOC is a crucial factor in the evaluation of different designs, the selection of projects and programs within a finite budget, and the justification of highway investments. When a vehicle is operating on a public road, VOC is produced. As the pavement's surface starts to

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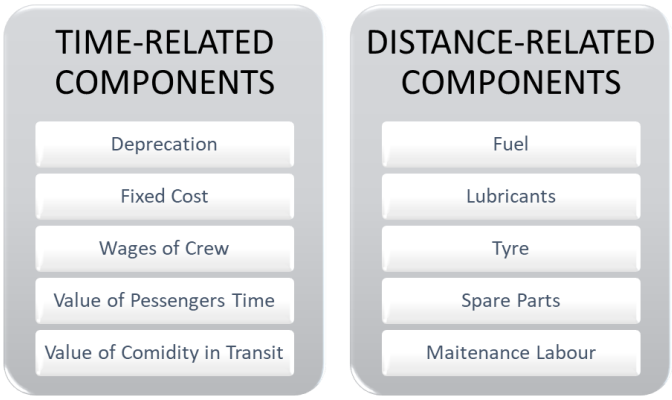
deteriorate, the cost of operating a car rises quickly. If the upkeep of the pavement is ignored, the surface begins to crack, which leads to the development of potholes. The VOC is predicted to rise by roughly 15% at this stage of degradation. If maintenance is neglected further, the pavement will soon begin to crumble, and VOC will rise by 50%. This is about equal to the cost of building a road, as it has been noted that total VOC over the course of a road's life is typically four times the initial construction cost, whereas maintenance costs only account for 1 or 2 percent of the cost of transportation. The operating or operation of the vehicle is associated with variable costs, whereas the fixed costs are stable throughout time and unrelated to the operation of the vehicle. The total of the elements can be used to compute the VOC.



"Fig. 2,Components of VOC"

II. UPDATION OF RUC COMPONENTS

A. *Methodology*

Updates to RUC components are now required, as was already noted, to accurately estimate the costs and benefits of road projects during economic review. The best way to update a model is to gather data on each of the different cost components that are entered into the RUC model. However, the procedure would be quite time-consuming and labor-intensive. As a result, it has been suggested that the RUC components be updated using the Wholesale Price Index and inflation (WPI). Since the updated cost components may be utilized as direct inputs into the existing VOC equations, this method of updating VOC components is easy, rapid, and reliable. To understand the concepts of inflation rate and WPI better, they are explained in the following sections.

B. *Inflation Rate*

The average price level's rate of growth is referred to as the inflation rate in economics. commonly known as the consumer price index. Alternately, the inflation rate refers to the rate at which money's purchasing power is declining. Even when the time being assessed is less than a year, this is commonly stated as an "annualized" value. According to conventional economic theory, inflation is the steady increase in overall prices as compared to a predetermined level of purchasing power. The pricing of goods is said to affect different groups of people according to the various inflation measures in use. The Consumer Price Index (CPI), which gauges changes in nominal consumer prices, and the GDP deflator, which gauges inflation in newly produced goods and services, are the most well-known.

C. *Wholesale price index and escalation factors*

The WPI measures the average change in price over time for a predetermined basket of goods and services. Whether the changes are to be measured in retail, wholesale, or producer pricing can affect how the basket of products and services is put together. For national, local, or sector-specific series, the basket may also change. The price fluctuations at the retail and wholesale levels in India are currently captured by separate series of index numbers. The wholesale pricing index (WPI) is a weekly indicator of economic wholesale price change. It is a known fact that an increase in VOC causes an increase in RUC, implying that changes in WPI affect RUC. For all types of commodities, the Economic Advisory Board, Ministry of Commerce and Industry, GoI maintain and publishes WPI statistics on a weekly, monthly, and annual basis. The base for updating VOC in this study was the Wholesale Price Index for pertinent commodities listed within the six key groups (i.e., Mineral Oils, Tyers, Tubes, Rubber Products, Automotives and Auto Parts). Table 1 provides relative weights and WPI for pertinent commodities. However, recent research has demonstrated that an Escalation Factor (EF) can be created using WPI data.

$$EF_{B-S} = \frac{\sum \frac{WPI_S}{WPI_B} \times \text{Commodity Weight}}{\sum \text{Commodity Weight}}$$

Where,

EFB-S = Escalation Factor from base year to stated year

WPIS = WPI for stated year say, May 2023

WPIB = WPI for base year (the base year is taken as March 2019)

A close examination of the WPI index tables found in the Economic Advisory Board demonstrates that using the WPI value to derive the escalation factor, which can then be applied to the estimation of VOC for any given year in the horizon year, is prudent for quick estimation of VOC for a given year. The escalation factor has been determined from the data to be 1.5. This escalation factor can be used to calculate the VOC for May 2023 as follows:

$$VOC_{May,2023} = VOC_{March,2019} * EF_{B-S} \quad \text{..... Eq (3)}$$

D. *Escalation Factor for Fuels*

Due to changes in the price of crude oil together with the government's tax policy, the price of fossil fuels, i.e., gasoline and diesel, a significant part in VOC, has experienced significant price volatility over the past 20 years when compared to other commodities. Considering this, it is suggested to compare the WPI of fuels in the base years of 2009 and 2019 and to develop an EF independently.

It should be emphasised, nevertheless, that future VOC can always be estimated by extrapolating the trend to forecast future WPI using the present data and assuming that WPI will follow the historical trend. In case of significant changes in the

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rate of inflation brought on by an accelerated pace of economic growth or other circumstances, the evolving future escalation factors might not be proper.

Table 1 Indexes of wholesale prices and relative weights for pertinent commodities

COMMODITY NAME	COMMODITY WEIGHT	WPIS 2019	WPIB 2023 (Up to May)	RATIO=WPIB (2023)/WPIS (2019)	Ratio*Commodity Weight
MINERAL OILS					
LPG	0.64481	82.1	125.28	1.526	0.984
Petrol	1.60470	85.4	158.48	1.856	2.978
Kerosene	0.18685	167.0	345.18	2.067	0.386
ATF	0.31991	97.0	163.68	1.687	0.540
HSD	3.09548	94.4	176.58	1.871	5.790
Naphtha	0.86678	81.6	131.9	1.616	1.401
Bitumen	0.22677	82.5	130.48	1.582	0.359
Furnace Oil	0.66576	84.9	113.26	1.334	0.888
Lube Oils	0.29199	131.2	184.92	1.409	0.412
Petroleum Coke	0.04663	138.2	258.58	1.871	0.087
Manufacture of rubber tyres and tubes					
Motor Car Tyre	0.20706	99.2	112.72	1.136	0.235
Tractor Tyre	0.03327	93.4	104.46	1.118	0.037
2/3-wheeler Tyre	0.04030	104.0	121.72	1.170	0.047
Medium & heavy commercial vehicle tyre	0.12918	97.5	114.76	1.177	0.152
Solid Rubber Tyres/Wheels	0.00473	96.2	107.26	1.115	0.005
Rubberized dipped fabric	0.00203	100.0	129.34	1.293	0.003
Motor Car Tube	0.01126	94.6	98.08	1.037	0.012
Rubber cloth/sheet	0.01224	138.6	151.88	1.096	0.013
2/3-wheeler rubber tube	0.01601	123.3	135.26	1.097	0.018
Medium & heavy commercial vehicle tube	0.12918	92.1	109.88	1.193	0.154
Cycle/Cycle rickshaw tyre	0.02371	113.4	116.64	1.029	0.024
Manufacture of motor vehicles					
Light, medium & heavy commercial vehicles	0.69584	114.1	117.04	1.026	0.714
Minibus/bus	0.79295	118.3	142.54	1.205	0.955
Passenger vehicles	0.86336	111.4	117.84	1.058	0.913
Chassis of different vehicle types	0.15893	114.7	136.02	1.186	0.188
Body (for commercial motor vehicles)	0.08918	110.3	128.68	1.167	0.104
Manufacture of parts and accessories for motor vehicles					
Engine	0.83798	111.7	123.92	1.109	0.930
Wheels/Wheels & parts	0.14275	106.4	128.5	1.208	0.172
Shock absorbers	0.10028	104.0	108.2	1.040	0.104
Shafts of all kinds	0.07112	119.2	134.32	1.127	0.080
Axles of motor vehicles	0.12553	114.2	145.5	1.274	0.160
Radiators & coolers	0.06161	116.8	150.6	1.289	0.079
Piston ring/Piston and Compressor	0.05103	132.8	148.68	1.120	0.057
Crankshaft	0.02807	96.9	112.44	1.160	0.033
Silencer and Damper	0.07898	107.8	125.92	1.168	0.092
Brake pad/brake liner/brake block/Brake rubber, others	0.10145	119.3	135.4	1.135	0.115
Head lamp	0.03681	130.9	152.7	1.167	0.043
Gear box and parts	0.31546	105.8	120.18	1.136	0.358
Steering gear control system	0.08627	108.6	130.74	1.204	0.104

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Cylinder liners	0.08823	110.7	111.92	1.011	0.089
Chain	0.02190	111.1	141.18	1.271	0.028
Release valve	0.00101	120.8	131.54	1.089	0.001
Filter element	0.05030	97.5	106.24	1.090	0.055
Seat for motor vehicles	0.15245	139.7	159.26	1.140	0.174
Ignition device	0.01704	158.8	174	1.096	0.019
Manufacture of motorcycles					
Motorcycles	1.16610	112.9	143.76	1.273	1.485
Scooters	0.12322	102.6	122.04	1.189	0.147
Auto rickshaw/Tempo/Matador/Three wheelers	0.01273	136.3	160.76	1.179	0.015
Manufacture of bicycles and invalid carriages					
Bicycles of all types	0.11700	129.2	138.06	1.069	0.125
SUM	**14.94623**			**SUM**	**21.86553783**

III. DATA FOR VOC UPDATION

Table 2 Inputs for VOC calculation

SL No	Components	Data
1	**Roughness (RG)**	2150 m/km
2	**Rise (RS)**	1m/km
3	**Fall (FL)**	1m/km
4	**Width of Carriageway W & W_D**	11.25 m
5	**Power to Weight Ratio PWR $_{HCV}$**	0.005 kw/kg
6	**Power to Weight Ratio PWR $_{MCW}$**	0.008 kw/kg

SL No	Cost of New Vehicles (2019 March Price)	Price with Taxes (Rs)
1	**Cars**	
(a)	**Small Cars**	489972
(ii)	**Big Cars**	999892
2	**Buses**	2948400
3	**Light Commercial Vehicles**	805000
4	**Heavy Commercial Vehicles**	1683550
5	**Multi-Axle Heavy Commercial Vehicles**	2533475

SL No	Costs of Petroleum Products (2019 March Price)	Price with Taxes
1	**Petrol**	79.92 Rs/ Lit
2	**Diesel**	72.61 Rs/Lit
3	**Engine Oil**	384.39 Rs/Lit
4	**Other Oil**	338.78 Rs/Lit
5	**Grease**	390.9 Rs/Kg

SL No	Costs of New Tyres (2019 March Price)	Price with Taxes (Rs)
1	**Two Wheelers**	1668
2	**Cars**	4456
3	**Buses**	17500
4	**LCV_s**	8900
5	**HCV_s & MCV_s**	20000

IV. UPDATION VOC VALUES

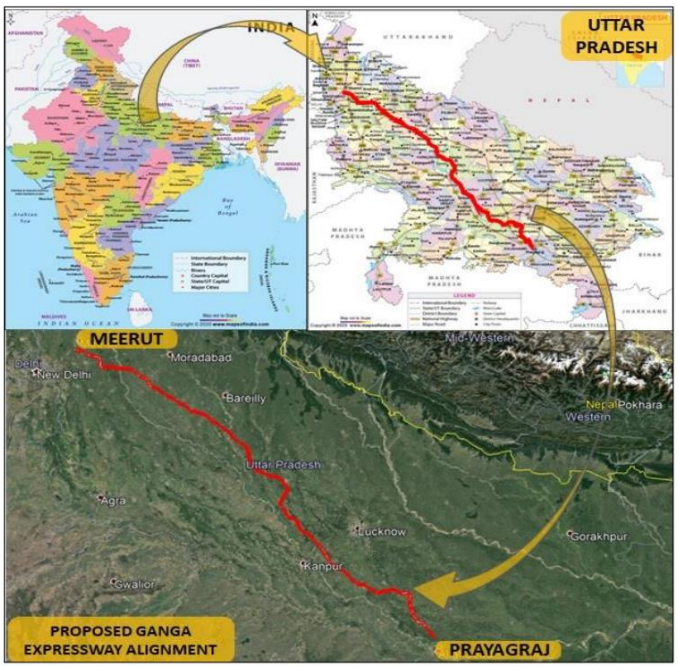
Based on the approach mentioned in the previous section, the RUC equations from the Modified Road User Cost study (Velmurugan et al., 2009) have been updated. The updated RUC tables for various vehicle categories, including cars, two-wheelers, buses, LCVs, HCVs, and multi-axle commercial vehicles (MAV), are shown in Tables 3 and 4. The updated VOC inputs used in the RUC tables are updated to April 2019 price levels based on Eq. (3).

A. Study Area

The Prayagraj Bypass on NH-19 is located close to the village of Judapur Dando (Dist. Prayagraj) (CH 601+847). The proposed Ganga Expressway begins at km 16+000 of the Meerut-Bulandshahar (NH-334) near the village of Bijoli (Dist. Meerut) (CH 7+900).

The planned expressway alignment would be 593.947 kilometres long.

The following project index map is displayed:



"Fig. 3,Study Area Location"

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Table 3 Outputs of VOC calculation for March 2019

SL No	VOC Components	VOC Expressway Outputs (2019)					
		Small Cars	Big Cars	Buses	LCVs	HCVs	MCVs
1	**Speed (V)** (km/h)	93.87	97.68	73.35	70.5	73.54	73.08
2	**Fuel Consumption FC_{CS}** (lit/1000km)	67.69	69.53	93.81	183.79	234.73	424.41
	FC_{CB} (lit/1000km)	76.07	77.85				
3	**Spare Parts Cost (SP)** (paisa/km)	5.51	6.74	168.25	38.5	234.5	353.09
4	**Maintenance Labour (LC)** (paisa/km)	9.91	12.12	198.21	33.02	185.53	279.36
5	**Tyre Life (TL)** (km)	63368.71	63368.71	45970.03	62343.1	68685.75	66276.21
6	**Engine Oil (EOL)** (lit/1000km)	2.06	2.06	0.58	0.87	1.11	1.89
7	**Other Oil (OL)** (lit/10000km)	2.09	2.09	1.38	2.26	5.67	5.67
8	**Grease (G)** (kg/10000km)	1.13	3.21	9.14	0.96	2.4	2.4
9	**Utilisation (UPD)** (km/day)	630.12	658.14	921.5	182.75	366.01	508.27
10	**Fixed Cost (FXC)** (Rs/1000km)	0.63	0.6	1.53	4.53	2.87	2.91
11	**Depreciation Cost (DC)** (Rs/km)	0.12	0.11	0.38	0.94	0.7	0.83
12	**Passenger Time Cost (PT)** (Rs/km)	7.68	7.38	30.8	-	-	-
13	**Crew Cost (CW)** (Rs/km)	-	-	4.09	4.92	4.09	3.54
14	**Commodity Holding Cost (CHC)** (Rs/km)	-	-	-	0.81	2.96	3.35

Table 4 Outputs of VOC calculation for May 2023

SL No	VOC Components	VOC Costs of Expressway					
		Small Cars	Big Cars	Buses	LCVs	HCVs	MCVs
1	**Fuel Cost** **FC_{CS}** (Rs/1000km)	5409.78	5556.84	6811.54	13344.99	17043.75	30816.41
	FC_{CB} (Rs/1000km)	5523.44	5652.69				
2	**Spare Parts Cost (SPC)** (Rs/1000km)	0.06	0.07	1.68	0.39	2.35	3.53
3	**Maintenance Labour Cost (LC)** (Rs/1000km)	0.10	0.12	1.98	0.33	1.86	2.79
4	**Tyre Cost (TC)** (Rs/1000km)	70.32	70.32	380.68	142.76	291.18	301.77
5	**Engine Oil Cost (EOLC)** (Rs/1000km)	791.84	791.84	222.95	334.42	426.67	726.50
6	**Other Oil Cost (OLC)** (Rs/10000km)	70.81	70.81	46.75	76.56	192.09	192.09
7	**Grease Cost (GC)** (kg/1000km)	44.17	125.48	357.28	37.53	93.82	93.82
8	**Fixed Cost (FXC)** (Rs/1000km)	0.63	0.60	1.53	4.53	2.87	2.91
9	**Depreciation Cost (DC)** (Rs/1000km)	120.00	110.00	380.00	940.00	700.00	830.00
10	**Passenger Time Cost (PTC)** (Rs/1000km)	7680.00	7380.00	30800.00	0.00	0.00	0.00
11	**Crew Cost (CC)** (Rs/1000km)	0.00	0.00	4090.00	4920.00	4090.00	3540.00
12	**Commodity Holding Cost (CHC)** (Rs/1000km)	0.00	0.00	0.00	810.00	2960.00	3350.00
Total VOC Cost Rs/1000Km (March 2019)		**19711.15**	**19758.76**	**43094.40**	**20611.51**	**25804.57**	**39859.81**
Escalation factor (Pupation of WPI Index From 2019-2023(May)		**1.5**					
Total VOC Cost Rs/1000Km (May 2023)		**29566.73**	**29638.14**	**64641.60**	**30917.26**	**38706.86**	**59789.72**
Total VOC Cost Rs/Km (May 2023)		**29.57**	**29.64**	**64.64**	**30.92**	**38.71**	**59.79**

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Total VOC Cost Rs/Km (May 2023)	**253.26**

V. CONCLUSIONS

According to the characteristics of the route and the vehicle, the study demonstrates mechanistic links for the prediction of vehicle operating expenses (VOC). Information on VOC is needed to perform a cost-benefit analysis of road investments and upkeep. VOCs have a significant role in road planning models. The 2019 Updated Road User Cost research is used to update the VOC calculations. The tables VOC inputs have been updated to reflect prices as of May 2023.

The calculation for the escalation factor in various equations is 1.5. Tables 3 and 4, respectively, give the updated VOC values tables for various vehicle categories, including two-wheelers, cars, buses, LCVs, and HCVs. A dynamic system for the updating of RUC based on WPI has been developed in this study, and it can help to accurately depict the altered conditions for economic appraisal of road projects. This was achieved by updating the RUC models using the suggested process of evolving EF based on WPI. The improved software created in this study is envisioned as being a priceless tool for the Highway Engineers to use in comparing options for the road development programs. The highway engineers, managers, and planners will benefit from using this VOC Updation approach while planning new roads and taking maintenance and construction costs into account.

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