SENSITIVITY ANALYSIS OF TRANSPORTATION PRODUCTION COSTS IN INDONESIA

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Abstract

The transportation production cost (TPC) considerably has strong influence to the national economic condition. This paper focused on the analysis of the transportation production cost sensitivity in relation to the variation of the external affecting factor, which are fuel price, rupiah exchange rate and Bank of Indonesia interest rate. Based on the R^2 values, the TPC components in general have significant correlation, with the fuel prices. However, they do not have high correlation to the fluctuation of interest rate and rupiah exchange rate. The sensitivity analysis shows that a 10% rise on fuel price would cause 6%, 2%, 7%, 2.4%, and 4.9% rise on the TPC of intercity bus, ferry ship, interisland ship, train, and airline, respectively.

Keywords: *sensitivity analysis, transportation production cost, external affecting factor.*

INTRODUCTION

Transportation has a strategic role as a driving force of a nation's economic development. As a part of a system, the transportation sector will always either impose or draw the effect of any policy made by each member of the system, either direct or indirectly. In the transportation sector, inter-modal sensitivity can be observed from the effect of the low-fare air transport action resulting in the decreasing demand of other transportation mode.

Realizing that the sensitivity is inevitable, efforts to examine and manage it need to be done so that the negative effects of the sensitivity can be measured and minimized, and therefore do not interfere with the transportation sector performance. This study describes the sensitivity of the transportation production cost (BPP–Biaya Pokok Produksi), in relation to the variation of several affecting factors. The study also examines the ability to pay (ATP) and the willingness to pay (WTP) for passengers using sea, road, air, and railway transportation and the correlation to transportation production cost.

THE SIGNIFICANT FACTORS

Several external significant factors reviewed in this study are fuel prices, exchange rate of ID Rupiah to US Dollar and the interest rates. The variation of fuel prices (gasoline and diesel fuel) and jet fuel (avtur) from the year 2000 to 2006 is shown in Figure 1.

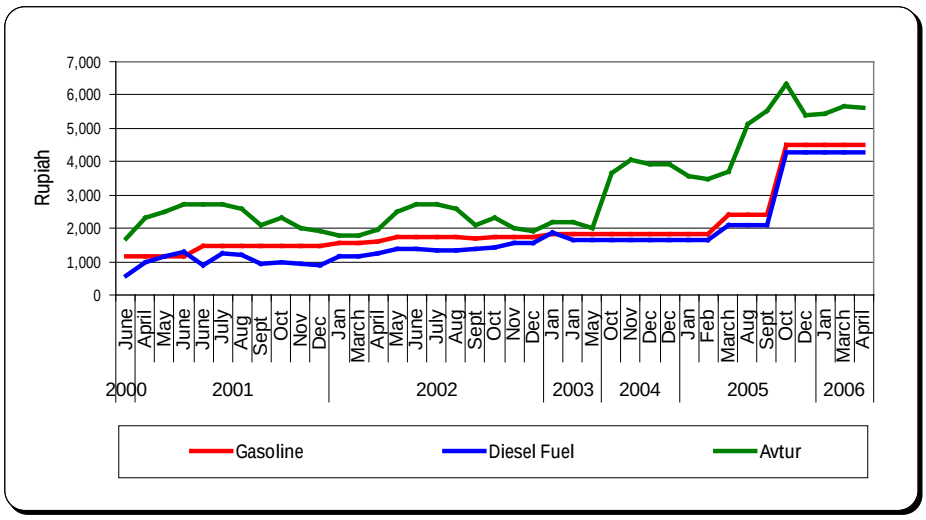

Figure 1 The variation of Fuel Prices During the 2000-2006 Period

The rupiah exchange rate affects cost of transportation modes which use US $ for its operation. Air transport is one of the modes significantly affected since it uses enormous portion of components which use US $ as standard. The fluctuation of ID Rupiah's exchange rate to US $ in the 2001-2006 period is shown in Figure 2.

The interest rate is considered to have significant influence towards components of transportation production cost. The fluctuation of Bank Indonesia's Interest Rate in the January 2001 – December 2006 period is shown in Figure 3.

Figure 2 ID Rupiah's Exchange Rate to US $ in 2001-2006 Period.

TRANSPORTATION PRODUCTION COST

There are several components influencing tariff, besides regulation and market mechanism, Tariff is affected either directly or indirectly by the production cost. When the production cost is high then the tariff must be adjusted to cover the cost and thus generate profit. However, when the tariff is too high the industry needs to take steps to improve company efficiency and reduce costs thus lowering the tariff and make it more affordable.

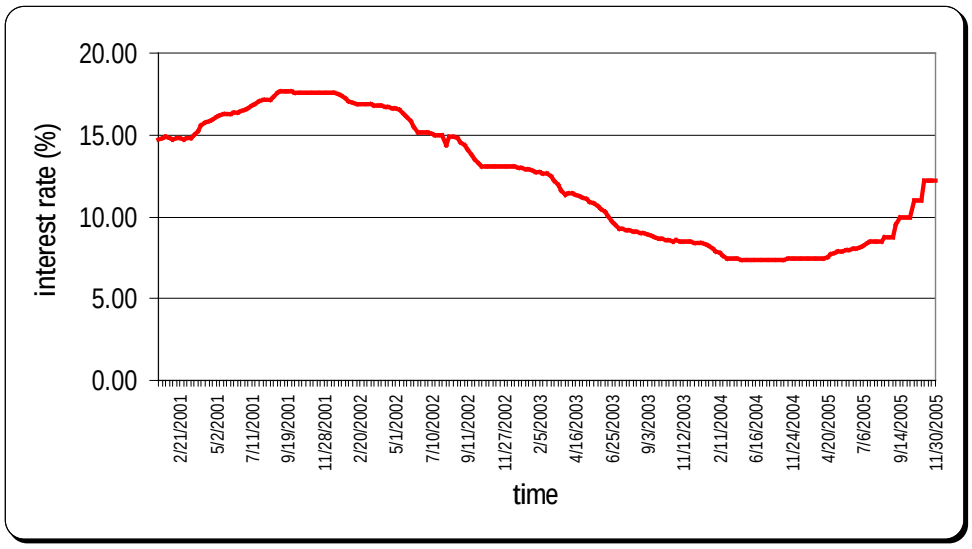

Figure 3 Bank Indonesia's Interest Rate in January 2001 – December 2005 Period

The proportions of the components comprised in the transportation production cost (TPC) are shown in Figure 4 to Figure 8.

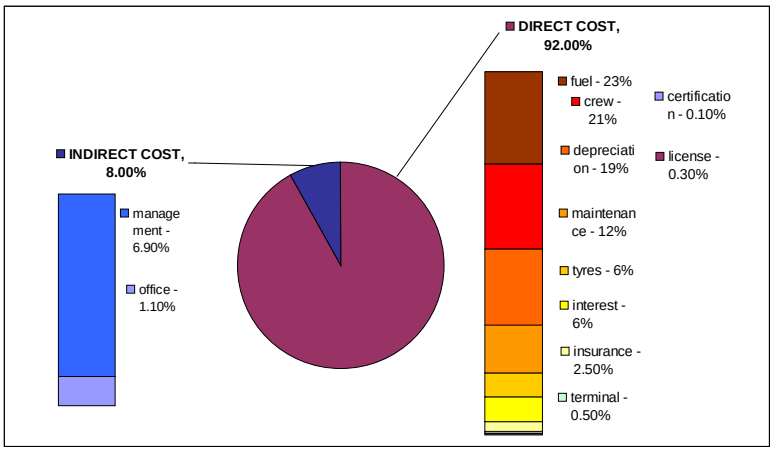

Figure 4 Proportions of TPC Components for Intercity Bus Operation

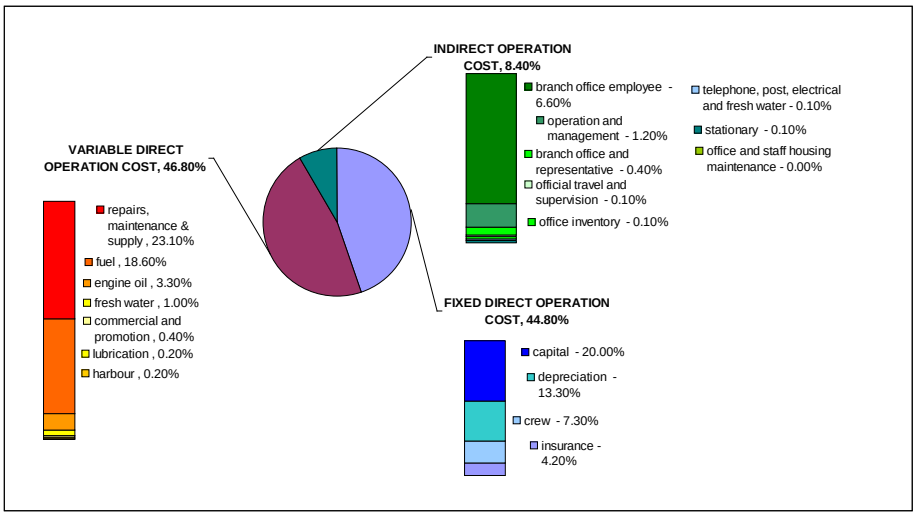

Figure 5 Proportions of TPC Components for Ferry Operation

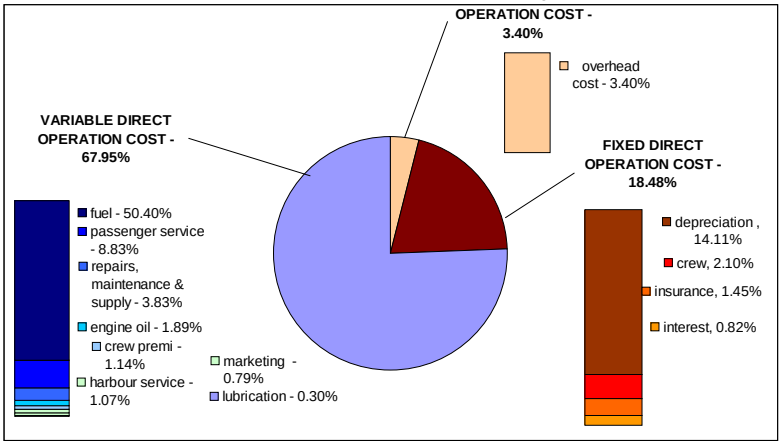

Figure 6 Proportions of TPC Components for Interisland Ship Operation

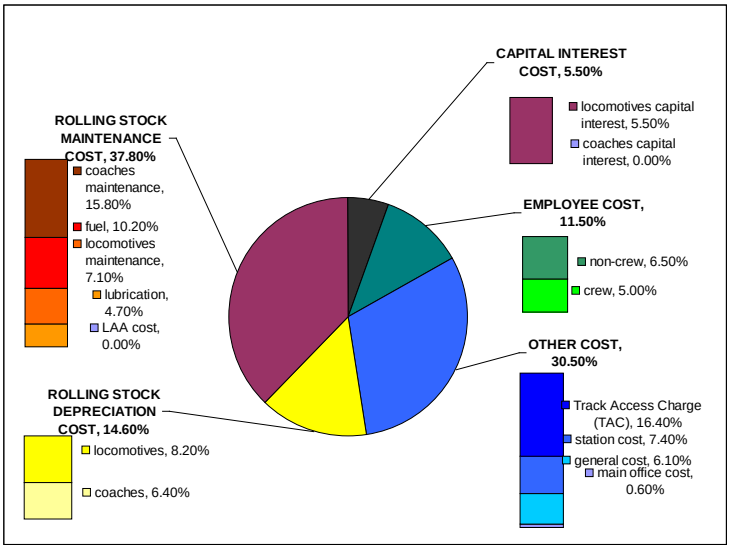

Figure 7 Proportions of TPC Components for Train Operation

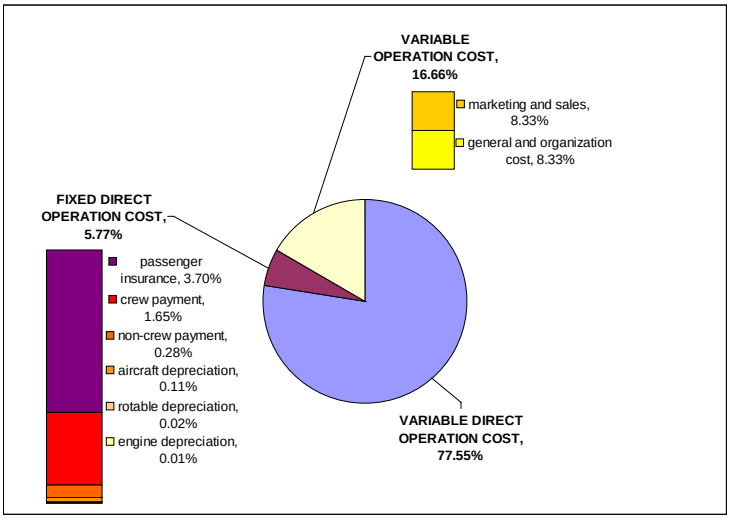

Figure 8 Proportions of TPC Components for Airline Operation

TRANSPORTATION PRODUCTION COST SENSITIVITY

Correlation of TPC Components Variation to Fuel Price

In intercity bus operation, some of the most significant components affecting the TPC are fuel cost (39.1%), depreciation (16.3%), maintenance (11.5%), crew (8.9%), tyre (8.7%), and interest (8.2%). TPC component sensitivity analysis is done by comparing the TPC components value variations to fuel prices. The variation of those TPC components in the 2000 – 2005 periods is shown in Figure 9.

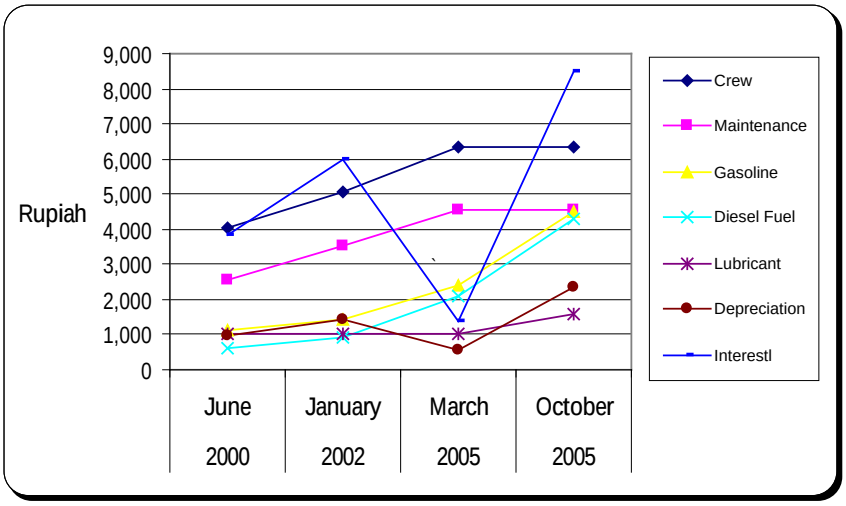

Figure 9 Variation of Cost Components for Intercity Bus Operation (2000-2005)

In ferry ship operation, some of the most significant components affecting the TPC are maintenance cost (23.1%), capital interest (20.0%), and ship depreciation (13.3%). The cost components reviewed were the ship prices, wages, tariff and maintenance cost to fuel price fluctuation. The information regarding the correlation of the above components is shown in Figure 10.

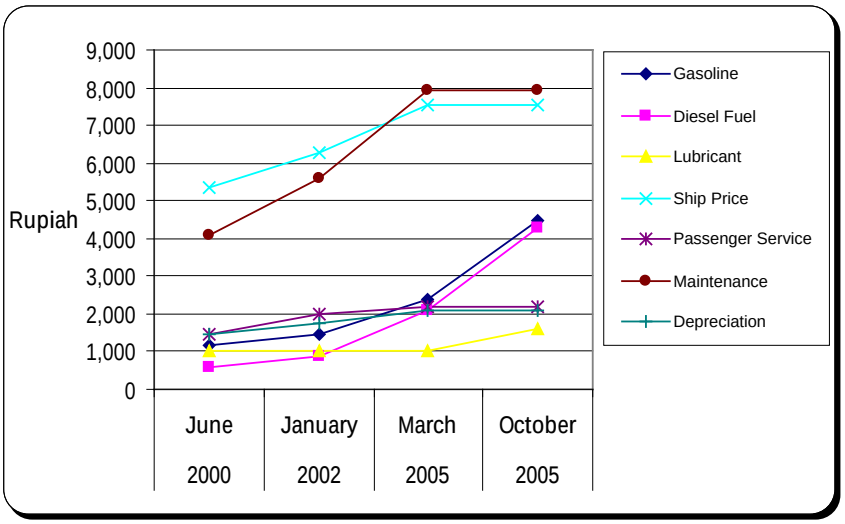

Figure 10 Variation of Cost Components for Ferry Operation (2000-2005)

Significant components of the rise of transportation production cost for interisland ship operation are fuel cost (50.4%), ship depreciation (14.11%), passenger service (8.83%) and repairs, maintenance and supply cost (3.82%). Therefore, the cost components reviewed for evaluation after the fuel prices rise are passenger service cost and RMS cost. The information on this matter is shown in Figure 11.

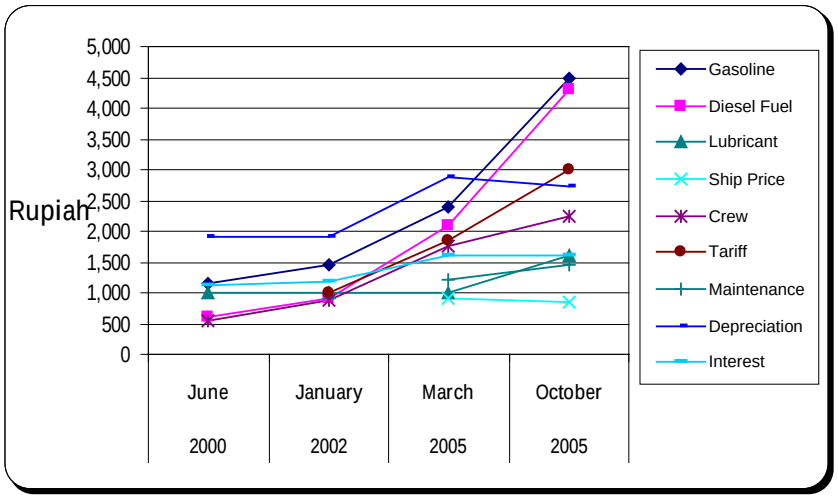

Figure 11 Variation of Cost Components for Interisland Ship Operation (2000-2005)

Components of cost that have large effect on the transportation production cost for train operation are the yearly track access charge (TAC) cost (15-16%), rolling stock maintenance cost (15-17%), fuel cost (10-12%), and coach depreciation cost (6-22%). Cost components being reviewed for evaluation due to the rise of fuel prices are coach maintenance cost and fuel cost. This is shown in Figure 12.

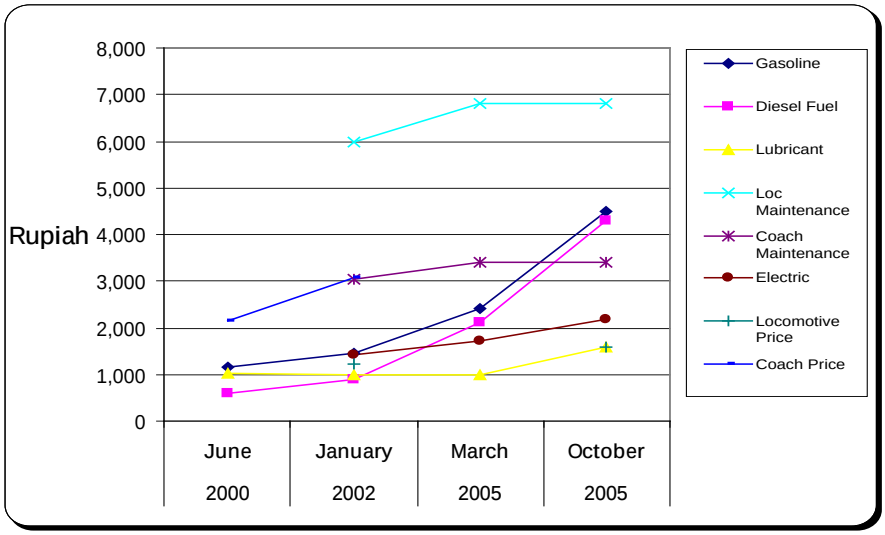

Figure 12 Variation of Cost Components for Train Operation (2000-2005)

Components of cost that have large effect on the transportation production cost for airline operation are fuel cost (49.95%), maintenance cost (36.54%), passenger insurance cost (4.44%), and ground handling cost (2.71%) Cost components being reviewed for evaluation due to the rise of fuel prices are maintenance cost, fuel cost, and ground handling cost. This is shown in Figure 13.

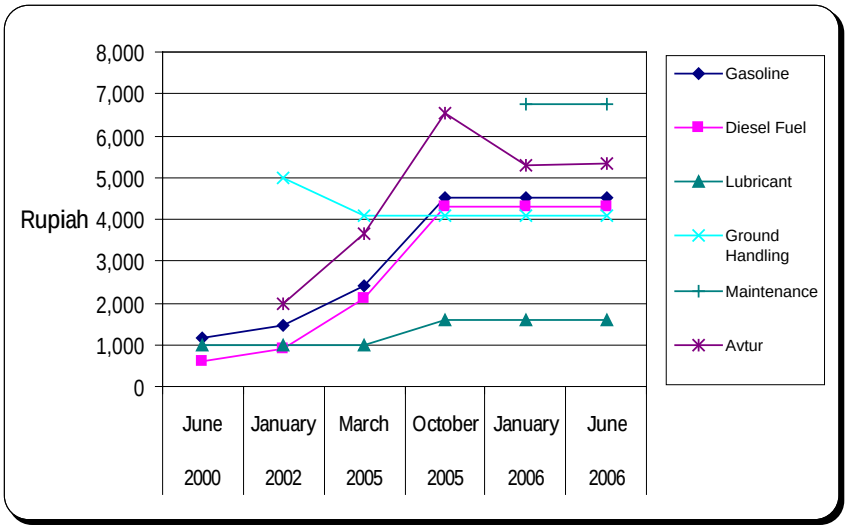

Figure 13 Cost Components Variation of Air Transport

Regression Equations

From the regression analysis, the resulting equations, R^2 and t-stats for cost components having significant proportions to TPC for all modes are presented in Table 1. The table shows that based on the R^2 values, the TPC components in general have significant correlation, with the fuel prices. But, they do not have high correlation to the fluctuation of interest rate and rupiah exchange rate.

One of the interesting things to note are the TPC components for ferry ship and interisland ship operation. In these modes, the interest rate does have good correlation but, the sign of some coefficients are not as expected. DM fluctuation has a significant correlation to the TPC components for ferry ship and interisland ship operation. This is mainly because components that have respectively large proportion in the TPC such as ship depreciation, capital interest and ship prices were purchased in DM. Therefore the fluctuation of Rupiah-DM exchange rate has significant effect to TPC.

Next, the t-stat values show the level of influence of each attribute to the mode-selection model equation. Each attribute's t-stat value is compared to the critical t-stat value. With a confidence level of 95% (therefore using critical t-stat value of $t_{0.025}$ at ±4,303 for the degree of freedom of two, while for confidence level of 90% then the critical t is $t_{0.05}$ at ±2,920. With taking a confidence level of 90% for the intercity bus mode there are two components having absolute value of less than 2,920 which are depreciation cost and capital interest cost. This shows that theoretically the two components have low level of correlation to the selected model. In the correlation equation for ferry crossings, there are two TPC components having absolute value lower than 2,920, which are depreciation cost and fuel cost. Meanwhile to the Rupiah-DM exchange rates there is one component which is fuel cost.

For interisland ship operation, there is one component having absolute value lower than 2,920 which is fuel cost. For train operation, there is also one component which is maintenance cost. Whereas for air transport, the reviewed component is fuel cost and having absolute value greater than 2,920.

Table 1 Summary of TPC Components Changes due to External Factors

No.	Mode	External Factor	Internal Cost Component	Formula	R^2	T stat X	T. stat intercept	Fitness *)
1	AKAP bus	Fuel prices	Vehicle depreciation	3213.7444x + 7005411.588	0.484	1.370	1.218	+
			Capital interest	962.658x + 3024621.624	0.286	0.894	1.145	+
			Crew cost	10883.869x + 35342541.472	0.870	3.654	4.837	+
			Fuel cost	1704739.604x - 254776567.464	0.984	11.135	-0.678	+
			Maintenance cost	1659.137x + 59358649.902	0.843	3.272	47.722	+
		BI Interest Rate	Vehicle depreciation	338012.298x+9062335.708	0.037	0.278	0.562	+
			Capital interest	266304.688x + 1545798.891	0.152	0.599	0.262	+
			Crew cost	-3556199.384x + 101975244.231	0.646	-1.910	4.130	-
			Fuel cost	-415997841.724x + 8392136756.08	0.408	-1.173	1.785	-
			Maintenance cost	-168584.413x + 64775202.659	0.061	-0.359	10.400	-
		US$ Exchange rate	Vehicle depreciation	8160.666x - 64924548.107	0.352	1.042	-0.863	+
			Capital interest	3935.096x - 32819568.604	0.538	1.525	-1.324	+
			Crew cost	-16906.254x + 219002972.473	0.236	-0.787	1.061	-
			Fuel cost	-987218.955x + 12581488365.106	0.037	-0.278	0.369	-
			Maintenance cost	1381.124x + 49387706.801	0.066	0.375	0.369	+
2	Ferry crossing	Fuel prices	Ship depreciation	25085.486x + 176421971.626	0.549	1.562	4.048	+
			Capital interest	13801.091x + 104502408.148	0.679	2.058	5.743	+
			Fuel cost	809062x + 600000000	0.969	7.908	2.171	+
			Biaya RMS	279028.738x + 275116747.914	0.838	3.216	1.169	+
		BI Interest Rate	Ship depreciation	-10877598.574x + 374063919.900	0.885	-3.927	10.184	-
			Capital interest	-5005950.332x + 200818024.585	0.766	-2.556	7.734	-
			Fuel cost	19057516.535x + 41800345.299	0.083	0.425	0.070	+
			RMS cost	-85801134.031x + 2026840893.694	0.679	-2.057	3.664	-
		DM Exchange rate	Ship depreciation	69191.098x - 58390826.446	0.858	3.478	-0.683	+
			Capital interest	35673.487x - 14501768.279	0.932	5.220	-0.494	+
			Fuel cost	-340527.770x + 1732548404.342	0.633	-1.857	2.199	+
			RMS cost	616165.804x + 1683821454.831	0.839	3.228	-2.053	+

Table 1 Summary of TPC Components Changes due to External Factors (continued)

No.	Mode	External Factor	Internal Cost Component	Formula	$\overline{R^2}$	T stat X	T. stat intercept	Fitness *)
3	Interisland ship	Fuel prices	Ship depreciation	1566809.185x+14793595321.318	0.632	1.853	6.449	+
			Fuel cost	21231896.496x-0.00000762939	1.000	5.7E+16	-7.498	+
			Passenger service cost	755859.969x+11309645003.981	0.590	1.697	5.757	+
		BI Interest Rate	Ship depreciation	-506114767.72x+24938628825.39	0.565	-1.612	6.449	-
			Fuel cost	-3883841187.69x+99721408452.8	0.287	-0.897	1.736	-
			Passenger service cost	-231492591.924x+16043032152.624	0.474	-1.344	5.757	-
		DM Exchange rate	Ship depreciation	4350095.486x+6198366.877	1.000	2303.323	0.764	+
			Fuel cost	37264780.706x-108126571524.78	0.632	1.855	-1.253	+
			Passenger service cost	2159700.799x+3915825452.664	0.989	13.642	5.757	+
4	Railway train	Fuel prices	Coach depreciation cost	28201.706x+196933334.204	0.883	3.883	9.996	+
			Coach maintenance cost	6562.600x+208410396.802	0.547	1.100	11.409	+
			Fuel cost	634456.038x-3854341.578	0.982	10.308	-0.023	+
		BI Interest Rate	Coach depreciation cost	-6368376.777x+344743008.038	0.386	-1.121	4.576	-
			Coach maintenance cost	-2515110.943x+256891166.485	0.881	-2.715	21.783	-
			Fuel cost	-100478298.291x+2778299551.06	0.211	-0.731	1.525	-
		US$ Exchange rate	Coach depreciation cost	-26551.581x+518595152.119	0.109	-0.494	1.004	-
			Coach maintenance cost	-12474.849x+345083412.991	0.338	-0.715	2.080	-
			Fuel cost	-95878.336x+2422643750.388	0.003	-0.079	0.208	-
5	Air transport	Jet fuel prices	Fuel cost	3600x+1.86264514923096E-09	1.000	5.4E+17	65.434	+
		BI Interest Rate	Fuel cost	-1919835.206x+2778299551.057	0.790	-1.092	3.755	-
		US$ Exchange rate	Fuel cost	-10370.386x+109908244.572	0.374	-1.092	1.205	-

Note: *) + as expected; - against the expectation

Sensitivity Analysis of TPC due to Changes of External Factors

The TPC sensitivity analysis is carried out by using two scenarios in order to provide a better representation. In the 1st scenario, the sensitivity analysis is carried out by inputting the values of the TPC components (within 4 milestones of change as resulted by the survey) into the TPC calculation formula. Next, a regression analysis is conducted to determine the correlation of the 4 (four) TPC values due to fuel prices changes, Bank Indonesia's interest rate and the foreign currency exchange rate.

In the 2nd scenario, the calculated correlation of the TPC components related to the external factors of fuel prices changes, Bank Indonesia's interest rate and the US $ exchange rate will be used to acquire the TPC components value (aside from the 4 milestones). In this scenario there is a TPC value change that strongly correlates to the external factors' changes (with $R^2 = 1$). However, the weakness of the acquired equations lies on the varying correlations among the TPC components due to changes in external factors.

CONCLUSIONS

Tariff of intercity bus and train based on communication minister regulation is within the value of the ATP and the WTP for each survey location. Meanwhile, the air transportation tariff is higher than the value of the ATP and the WTP for distance range of 601-750 km, 751-900 km, and 1051-1400 km. Unfortunately, the data in unit of Rp/pax-km is not available for ferry transport and interisland ship.

Some conclusions of this study are presented as follows:

1. Intercity Bus; in scenario one the only external factor having significant influence on the TPC value is fuel prices, result shows $R^2 = 0.9$. Meanwhile other external factors such as Bank Indonesia's interest rate and US$ exchange rate does not have strong correlation to TPC values. This is proven by the low value of R^2 (less than 0.2). The 2nd scenario shows that there is a strong correlation between the rise of diesel fuel prices to the mode's TPC a 10% rise on diesel fuel price would cause a 6% rise on the TPC of intercity bus.
2. Ferry Ship; scenario one shows that the only external factor having significant influence on the TPC value is fuel prices, result shows $R^2 = 0.9$. Meanwhile other external factors such as Bank Indonesia's interest rate does not have strong correlation to TPC values, this is proven by the low value of R^2 (less than 0.2). On the other hand the fluctuation of DM's exchange rate to Rupiah does have a strong correlation but still not too significant to the TPC since the R^2 is only 0.5. The 2nd scenario shows that there is a strong correlation between the rise of fuel prices to the mode's TPC a 10% rise on diesel fuel price would cause a 2% rise on the TPC of ferry crossings.
3. Interisland ship; scenario one shows that the only external factor having significant influence on the TPC value is fuel prices, with a value of $R^2 = 0.9$ and Rupiah-DM exchange rate having a value of $R^2 = 0.69$. Meanwhile the Bank Indonesia's interest rate does not influence the TPC values too strongly, this is shown by the value of $R^2 = 0.3$ and in addition shows a negative correlation. The 2nd scenario shows that there is a strong correlation between the rise of fuel prices to the mode's TPC a 10% rise on diesel fuel price would cause a 7% rise on the TPC.

4. Train; scenario one shows that the only external factor having significant influence on the TPC value is fuel prices, with a value of R^2 = 0.78. Meanwhile other external factors such as Bank Indonesia's interest rate and US$ exchange rate does not have strong correlation to TPC values, this is proven by the low value of R^2 (less than 0.1). The 2nd scenario shows that there is a strong correlation between the rise of fuel prices to the mode's TPC a 10% rise on diesel fuel price would cause a 2.4% rise on the TPC.
5. Airline; scenario one shows that the only external factor having highly significant influence on the TPC value is fuel prices. Meanwhile other external factors such as Bank Indonesia's interest rate, although having a high value of R^2, the result shows a negative correlation and therefore does not fulfill the fitness expectations thus the factor is not taken into account. The US$ exchange rate only has low level of influence to the TPC values (having R^2 less than 0.4). The 2nd scenario shows that there is a strong correlation between jet fuel prices to the mode's TPC a 10% rise on diesel fuel price would cause a 4.9% rise on the TPC.

Though sensitivity analysis of the TPC due to changes on external factors of the 2nd scenario shows a high value of R^2, there are inadequacy in the equation since the TPC components have varying correlations (from average to satisfactory) to the changes of external factors.

ACKNOLEDGEMENTS

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