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SYSTEM DYNAMICS APPROACH TO IDENTIFY THE FACTORS THAT AFFECT IN DETERMINING FUEL PRICING AND VEHICLE PRICING IN SRI LANKA

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ABSTRACT - Implementing sustainable transportation policies is crucial for countries in worldwide to address environmental concerns and meet global targets. In Sri Lanka, the lack of a clear transportation policy has resulted in the absence of any goals for fuel and vehicle pricing, hindering progress towards a sustainable transportation system. To address this issue, a System Dynamics (SD) approach was used to develop a Causal Loop Diagram (CLD) to visually represent the interdependence and interactions of variables in the transportation system, including socio-economic factors, environmental factors, fuel and vehicle factors, and government policies. The CLD identified five loop behaviours: three balancing and two reinforcing loops. The results showed that SD could be used as a reliable tool to guide policymaking in the transportation sector, including fiscal instruments, consumer information, and regulatory measurements for fuel and vehicle pricing.

Keywords: System dynamics; Causal loop diagram; Fuel pricing; Vehicle pricing

1. INTRODUCTION

Transportation is vital to the growth of any nation, and it is necessary to have sustainable transportation policies in place to ensure long-term development. Fuel and vehicle pricing policies are an integral component of such policies and can profoundly affect the economy, society, and environment. To establish effective policies, it is essential to comprehend the factors influencing the implementation of transportation policies, the various petroleum pricing policies, vehicle pricing, and sustainable transportation. Provision of Euro IV standard fuel to the country, SLVET program implementation in all islands in 2013 and providing tax concessions for importing electric vehicles are some of the practices implemented by GOSL previously [1]. But the concern is how effective they are in achieving the goals.

The government visioned to make all the government vehicles to be either electric or hybrid by 2025 in the 2018 budget. The government had taken some endeavors by providing concession for those vehicles at that time. The efforts were not continued and there is not any positive sign in the vicinity of government vehicles becoming more eco-friendly.

Figure 1 shows the complexity of the context of price determination for fuel and pricing. For example, consider the transport policy of incentives for electric vehicles. Then taxation and related tariff systems should amend in the context of vehicle pricing and need to consider price increments for gasoline and diesel. Therefore, the main objective of this study is to utilize a System Dynamics (SD) approach and Causal Loop Diagram (CLD) to identify and analyze the factors affecting fuel pricing and vehicle pricing in the transportation system of Sri Lanka, with the aim of informing the development of sustainable transportation policies.

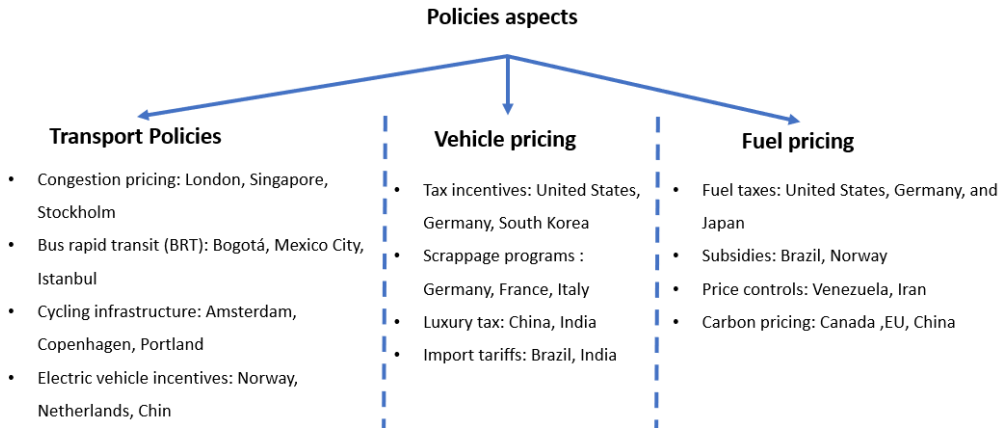

Figure 1. Aspects related to fuel and vehicle pricing.

2. METHODOLOGY

System Dynamics (SD) is a simulation and modelling approach which can be used to understand complex systems. [2]. Further, it allows to design and evaluate policies as simulation helps identify the effects. The SD is used in environmental systems to identify the interactions and evaluate the impacts of policies in climate change, water resources and ecosystem domains. In the context of the economy, SD models would be helpful in understanding the core of the system of the economy for economic policymakers [3]. In a study evaluating fuel and vehicle pricing, the SD method can be used to model the interactions between fuel prices, vehicle demand, and market dynamics. The CLD was developed using data from socio-economic, environmental, fuel, and vehicle factors.

3. RESULTS AND DISCUSSION

3.1. Causal Loop Diagram

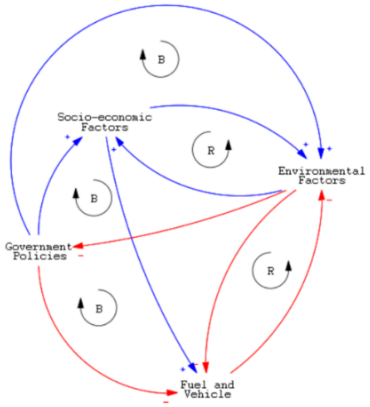

Figure 2. CLD for Sub models

Initially, the context is concise into four sub-models, including relevant variables. The selected subsects are Socio-Economic conditions, Environmental conditions, Fuel and Vehicle Factors and Government policy[2]. Socio-Economic conditions include GDP, GDP per capita, population growth rates, import taxes and duties, exchange rates, employment rates, income distribution, education levels, and urbanization rates. The Environmental conditions include Environmental regulations, carbon emissions, air pollution, and climate change. The Fuel and Vehicle factor consisted of variables like Crude oil prices, refining and distribution costs, government subsidies, demand for fuel, local manufacturing and assembly costs, cost of raw materials, availability of supply, competition in the market, and overall consumer demand for vehicles. Finally, the

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Government Policies include the Stability of government, government regulations and taxes, and energy policies.

As per Figure 2, the system has five loop behaviours with the considered boundary. In this diagram, three balancing loops and two reinforcing loops can be identified. The loop that connects government policies, fuel and vehicle factors and environmental conditions is a balancing loop (government policies $\xrightarrow{-}$ fuel and vehicle factors $\xrightarrow{-}$ environmental conditions $\xrightarrow{-}$ government policies). If we start from government policy factors, when government increases the import tariffs and taxes on fuel and vehicles, the demand for fuel and vehicles will be reduced. When there is an increase in fuel and vehicle consumption, it adversely affects the environmental factors. When the environmental factors are badly affected government, need to revise their policy decisions. The loop that connects government policies, socio-economic conditions and environmental factors is a balancing loop (government policies $\xrightarrow{+}$ socio-economic conditions $\xrightarrow{+}$ environmental conditions $\xrightarrow{-}$ government factors). When there is a better increment in socio-economic conditions, it leads to an increase in sustainability concerns reducing the adverse environmental conditions. An increase in destructive impacts on the environment leads to changes in governmental policies. Therefore, the effect is balanced within the loop. The rest three loops are associated with two factors. There is a balancing loop between government policies and environmental factors (government policies $\xrightarrow{+}$ environmental conditions $\xrightarrow{-}$ government policies). When government policies have been implemented aligning with sustainability, it leads to the betterment of environmental factors. On the other hand, when an adverse impact happens to the environment, there might be stress to revamp policy implementations. There is a reinforcing loop between socio-economic factors and environmental factors (socio-economic conditions $\xrightarrow{+}$ environmental conditions $\xrightarrow{+}$ socio-economic conditions). When there is an improvement in environment well-being, it improves socio-economic conditions. Conversely, better socio-economic conditions will lead to more sustainable activities that serve environmental factors. There is another reinforcing loop connecting environmental factors and fuel and vehicle factors (environmental conditions $\xrightarrow{-}$ fuel and vehicle factors $\xrightarrow{-}$ environmental conditions). An increase in fuel and vehicle consumption adversely impacts environmental well-being and increments in environmental regulation might adversely affect demand for fuel and vehicles.

4. CONCLUSION

In general, the SD approach can be utilized to guide policy establishment regarding fiscal instruments, consumer information, and regulatory measurements for fuel and vehicle pricing[4]. In the context of Sri Lanka, it must pay attention to the socio-economic and environmental factors in developing government policies to cater to the fuel and vehicle factors. The critical factor is that requires to make sure effective transport policy implementation needs a comprehensive analysis and considerable time. This can also be expanded to produce reliable, practical, and well-tested analytic tools to address policy challenges related to transportation and address the impact of sectoral transportation policies on a global scale and on a long-term horizon. It requires some additional steps to develop this as more analytical tools will be necessary for use as a policy tool as the SD models will only show the complexity and the impact.

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