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Avoid-Shift-Improve: The Role of Demand-Side Solutions in the Sustainable Development of Transportation

I. Introduction

Mitigating climate change requires both demand-side and supply-side solutions. Recent research has focused on the supply-side (Creutzig et al., 2018), with an emphasis on reducing fossil-fuel extraction, reforming the agricultural and livestock industries, and general technological innovation. Wiedmann et al. (2020) highlight how overconsumption in affluent societies contributes significantly to greenhouse gas emissions and environmental degradation, an issue that worsens with time as global affluence grows. This demonstrates the importance of demand-side or consumption-based solutions that change the way people consume resources.

A potential framework for approaching demand-side mitigation is the avoid-shift-improve (ASI) model, which has been widely applied as a method for sustainable transportation within cities. It emphasizes avoiding high-emission modes of transportation, shifting users to more-efficient modes, and improving the efficiency of transport infrastructure and services. Transportation is an example of a necessary good or service where consumption tends to be high-emission and low-efficiency. This is due to a reliance on fossil fuels and a tendency for vehicle-dependent lifestyles within and around cities. For example, in North America, many communities are automobile-dependent due to land-use patterns, road design, and the inferior quality of alternative options (Litman, 2002). While communities are locked into these patterns, this reliance on automobiles leads to the overconsumption of energy and of

transportation infrastructure, resulting in a variety of negative externalities. ASI offers a model to transition to more efficient and sustainable modes of transportation.

This paper seeks to understand the origins of ASI, how it offers a demand-side mitigation solution to climate change, and how it can be applied in developing nations. I start by investigating the history of ASI as a response to unsustainable transportation planning. The environmental and social impacts of inefficient transportation are numerous, and ASI offers a suite of policy and planning tools that can reduce the negative impacts. I then analyze the motivations behind ASI's components to reveal how it targets demand for transportation goods and services. Finally, I explore the role of transportation in sustainable development and demonstrate how ASI can be utilized. Improving mobility is an important aspect of development, but it can lead to environmental and social issues that contribute to climate change and inequity. ASI has the potential to allow for the benefits of improved mobility while mitigating its negative consequences. Overall, this process hopes to reveal further insights into the role of demand-side mitigation strategies to climate change.

II. Overview of the Avoid-Shift-Improve Model

A. Background

Starting in the mid-20th century, the dominant method of transport planning in many affluent nations, especially in the United Kingdom and the United States, could be broadly described as *predict and provide* (Krawczyk & Ratcliffe, 2005; Goulden et al., 2014; Zamora, 2014), where expected traffic numbers for a given area were predicted by planners and the road network was then developed (usually increased) accordingly. This method follows the principles of supply and demand, "where congested roads are an indication of too much demand for the

available road supply and therefore supply needs to be increased" (Roby, 2014). As car traffic steadily increased throughout the 20th century, transport planners responded by providing more roads, expanding old ones, and building highways.

While the "predict and provide" approach is still dominating transport planning in the developed world and can be considered "business as usual" (Schiller & Kenworth, 2018), the unsustainability of this method has inspired criticism for several decades. Adams (1981) famously critiqued the model, using contemporary traffic trends to forecast that car usage would increase forever and that, therefore, so would the total mileage of built roads. Incentivizing road transportation has direct and indirect environmental and human consequences. Direct consequences include pollution, greenhouse gas emission, and ecosystem degradation (Demirel et al., 2007, p. 280). Indirect consequences include creating a vehicle-dependent society (path dependency) that restricts individuals into higher-emission lifestyles and reduces the inclusivity of transportation (Ibid., p. 280).

Automobile dependency in cities is linked to a variety of issues. These cities typically have high levels of private transportation energy use and thus produce larger quantities of greenhouse gas emissions and other pollutants (Schiller & Kenworth, 2018, p. 19). They also consistently lose productive land and natural areas to urban sprawl, which leads to the contamination and destruction of important ecosystems (Ibid., p. 20). Since these cities lack density, more money must be spent to extend infrastructure like water pipes, sewage, and roads. In addition, when cities are developed around car usage, public transportation systems are marginalized, become more expensive to maintain, and typically decline in quality (Ibid., p. 21). This exacerbates equity issues since the accessibility of education, work, and basic needs are inherently lower if a personal vehicle is required. In the United States, a history of systemic

racism has caused transportation disadvantage and inequity to be centered in communities with African-American and Hispanic populations (Ibid., p. 34).

Overall, due to its environmental, economic, and social implications, "predict and provide" or "business as usual" transport planning has been criticized for being an ineffective solution to increasing traffic congestion. Krawczyk & Ratcliffe (2005, p. 7-8) identify seven major shortcomings of the predict and provide approach as: "deficiency in dealing with complexity and uncertainty of change;" "limitations of projections as the main methods supporting urban decision-making;" "main focus on spatial form;" "short-term orientation of planning;" "lack of an integrated and holistic approach to the urban system;" "lack of effective community participation and collaboration between stakeholders;" and "neglect of a visionary approach towards future." Goulden et al. (2014) argue that "despite the huge investment in roads under preceding governments [in the UK], congestion was increasingly costly for businesses; vehicle emissions were growing, contributing to climate change and local air pollution; and a mobility gap was widening between those with, and without, cars." With increasing scrutiny around the negative externalities of traffic planning in the 1990s, transport policymakers, planners, and researchers began to push back against the status quo and to develop alternative models to predict and provide, with an increasing emphasis on environmental sustainability.

The avoid-shift-improve (ASI) model was developed in the mid-1990s in Germany, where it was applied as an alternative framework for traffic planning (Creutzig et al., 2018). It has since been applied as a model for sustainable transportation initiatives in developing countries. The general goal of ASI as a traffic planning framework is to "affect individual mobility decisions such that some trips do not take place, others are shortened and that the remaining motorized trips are as sustainable as possible" (Bräuninger et al., 2012, p. 28). Avoid

strategies aim to reduce vehicle activity and trip length through pricing mechanisms, travel reduction policies, and lifestyle changes such as shorter work weeks, increased telecommunication, and ridesharing (Zamora, 2014, p. 145). Shift strategies seek to shift populations away from less efficient modes of transportation to more efficient modes through improving pedestrian and bicycle infrastructure, land-use strategies, parking management, and transit-oriented development (Ibid., p.145-148). Improve strategies focus on improving the efficiency of remaining traffic by regulating roads (for example, creating "low-emissions zones") and greening public and personal transportation (Ibid., P. 148).

ASI falls under a broader umbrella of revisionary transport planning ideologies defined as *demand management*. These concepts were initially developed in the UK and US during the 1990s as a response to the failures of predict and provide and can be simply defined as actions seeking to incentivize travelers to use alternative mobility options (Goulden et al., 2014). ASI's fundamental goals align with demand management and it has been touted as a demand-side mitigation strategy -- one that mitigates the externalities of transport and traffic by reducing demand for polluting transportation and increasing demand for more sustainable alternatives. Others have argued that it even has the potential to be applied as a demand-side mitigation measure outside of transportation. Analyzing ASI through a demand and supply framework reveals that it is a nuanced strategy that utilizes both demand and supply-side forces. In the next section, I explain the differences between demand and supply-side mitigation strategies and explore how ASI fits in.

B. ASI: A Demand or Supply-Side Solution?

Climate change mitigation actions (whether policy or planning) can be broadly broken into demand and supply-side efforts. Within a market for a polluting good or service,

demand-side solutions focus on the choices and behavior of consumers, while supply-side solutions focus on the actions of firms or governments who supply the polluting good or service. Examples of demand-side policies include taxing the consumption of resources or regulating the use of certain technology. Examples of supply-side policies include taxing resource extraction or instituting an emissions cap and trade program on firms. In regards to mitigating fossil fuel use, "supply-side policies regulate exploration and extraction of fossil fuels, whereas demand-side policies regulate the combustion of fossil fuels" (Asheim et al., 2019). In the context of transportation, supply-side policies can be thought of as those that restrict the supply of polluting vehicles or trips, whether through reducing the quantity or through converting them into energy-efficient transport. Demand-side policies are those that incentivize consumers of transportation to reduce their demand for polluting vehicles and trips.

This requires some assumptions to be made about supply and demand. Marxian political economics and environmental sociology typically understand the economy to be supply-dominated (Wiedmann et al., 2020, p. 2). York (2017, p. 7) argues that elite capitalists have the ability to create and manipulate markets and are not bound to respond to pre-existing demand. This raises concerns over how effective demand-side solutions can be, especially within the economic framework of Western capitalism. Wilhite (2016) argues that to address climate change the very imperatives of capitalism must be addressed, but so must the excessive consumption norms and habits that capitalist imperatives have proliferated (Wilhite, 2016). Therefore, while acknowledging that demand-side efforts may have limitations, I argue that they are an important tool in addressing consumption habits and will inevitably be explored by planners and policymakers seeking a more sustainable future.

The ASI model for transportation planning aims to change consumption behaviors - or demand - but does so by targeting both demand and supply-side forces. Avoid strategies target demand by incentivizing individuals to take fewer vehicle-requiring trips usually by increasing the costs. Notably, avoid strategies could also be achieved without increasing costs, but instead by incentivizing lifestyle changes. For example, mandating shorter workweeks or increasing telework can reduce the demand for travel without putting costs on individuals, who may be locked into vehicle-dependent lifestyles. By targeting the behavior of the transportation consumer and not the suppliers of polluting vehicles, they are entirely focused on reducing the demand for polluting trips. Shift strategies aim to shift demand away from inefficient transport, but they do so by moderating the supply of transportation goods and services. For example, a city might seek to shift demand away from cars and towards bicycles by supplying more bicycle infrastructure. The ultimate goal is a decrease in demand for inefficient car trips, but this is achieved by supplying an alternative option, not by reducing demand for travel. Improve strategies are similar in that they do not seek to reduce the overall demand for travel, but rather to ensure that trips that do take place are sustainable. These actions are somewhat removed from the demand and supply model since it is assumed that these trips will take place regardless of how avoid and shift strategies might influence demand. Still, improving public transportation through electrification or "greening" might incentivize some individuals to shift from a polluting vehicle to the public option, resulting in a decline in demand for polluting trips. Overall, this discussion demonstrates that ASI actions can utilize demand or supply-side forces, but that their ultimate goal is to affect individual decisions about transportation, and thus ASI can be considered a demand-side mitigation approach.

III. Transportation, ASI, and Development

A. Background

While the ASI model initially emerged as a reaction to unsustainable transport planning within developed nations, especially the UK and Germany, it has since been applied as a framework for addressing sustainable transportation in developing countries. The transportation sector contributes significantly to global emissions each year and is associated with a variety of other issues including air and noise pollution, accidents, and environmental degradation. While developing countries have historically emitted much less than developed countries, emissions tend to increase with development. This is the result of carbon-intensive activities helping to alleviate poverty, the position of the developing world in the global economy (Williams et al., 2009), and that resource consumption and its associated externalities increase with affluence (Wiedmann et al., 2020). Transportation trends in developing countries follow this pattern. Bräuninger et al. (2012, p. 15-17) show that car ownership and urbanization tend to increase with income and with stages of development more broadly. Further, many developing countries have growing populations, leading to increased vehicle ownership, strain on transport infrastructure, and intensive usage of energy (Sperling & Salon, 2002). Therefore, developing nations are faced with a dilemma over how to improve mobility opportunities and infrastructure while considering their impact on environmental sustainability.

Before sustainable transportation can be implemented in developing nations, a lack of access to transportation must first be addressed. As nations develop, it is crucial that they provide new infrastructure to improve lives. For individuals, “enhanced mobility” in the form of better infrastructure and more inclusive transportation opportunities allow easier access to clean water,

necessary goods and services, healthcare, work opportunities, education, and more (Sperling & Salon, 2002). For a developing economy, transportation offers the opportunity to expand economic activity, as well as its beneficiaries. This suggests that in regions of very low development, enhanced mobility should be the primary objective. There is no need to reduce transportation demand where there is already a deficiency.

Some scholars of development suggest that developing countries have the potential to "leapfrog" the environmentally damaging stages of development, and this idea has been applied in transportation studies (Sperling & Salon, 2002). In these cases, as demand for transportation increases, low-emission options would be readily available so that shifting demand would not be necessary. Whether the earlier development of transportation infrastructure can be achieved while avoiding emissions-intensive activities likely depends on funding from developed nations. If sustainable transportation options are affordable and available in low-development areas, they are more likely to be incorporated as development continues. Regardless if "leapfrogging" is possible, considering ASI even in earlier stages of development could help to avoid path dependency and the creation of lifestyles dependent on inefficient vehicles.

The United Nations acknowledges that inclusive access to transportation is essential for developing economies, and has considered ASI an optimal model for guiding the development of transport infrastructure and services (United Nations, 2013). Rapid growth in motorization and transport activity has allowed for rapid economic growth and reduction of poverty in developing countries but has also resulted in increased air pollution, reduced road safety, traffic congestion, and emissions that contribute to climate change (Ibid., p. 4-7). The social, environmental, and economic costs of these issues are high, making sustainable transportation an essential component of sustainable development.

ASI inevitably works differently in developed and developing nations. Bräuninger et al. (2012, p. 32) argue that while individual transport has to be reduced in developed countries, its growth has to be curbed in developing countries. This suggests avoid-strategies are more effective in poorer countries where road transportation is still in development, while richer countries tend to have an existing reliance on-road transportation and thus depend on shift strategies to change behaviors (Ibid., p. 8). A UN status report on the role of sustainable transport identifies improving infrastructure as the developed world's primary focus, considering their mature vehicle fleets and established infrastructure (United Nations, 2013, p. 9). For the developing world, the report notes that the need for new transport infrastructure and services coupled with rapidly increasing urbanization makes avoid and shift strategies most important (Ibid., p. 9). The UN report argues that, overall, "ASI has universal applicability and is equally relevant for the developed and the developing world" (Ibid., p. 9). In the next section, I explore two examples of ASI's implementation in developing contexts.

B. ASI Development Projects in Practice

Many projects have been funded to improve the sustainability of transportation in developing nations. The German Agency for International Cooperation (GIZ) is involved in several and utilizes ASI as a central component of its work. Projects in Brazil and Costa Rica, both developing nations with upper-middle-income economies, reveal how ASI is used as a framework for sustainable policy and planning.

In Brazil, the GIZ instituted a project between 2016 and 2018 to address rapidly growing transportation emissions resulting from urbanization and population growth. The objective of this project was specifically to implement the ASI framework within the decision-making processes

of Brazil's Ministry of Cities and within the local institutions of pilot cities ("Energy efficiency in urban mobility," 2018). The actual efforts of the project went into providing technical guidelines for the relevant institutions to shape future policy and planning. This includes guidelines for integrating efficiency criteria into mobility strategies and for bus management, which is projected to increase public transport ridership by 30 percent. These developments will help cities meet Brazil's National Urban Mobility Plan, which prioritizes public and zero-emission transport and requires cities to develop individual urban mobility plans. For future development, three general strategies were identified: "prevent further increases in traffic volumes and reduce existing demand" (i.e., avoid); "shift demand to more efficient modes of transport and improve the service network;" and "improve vehicle and fuel efficiency" (Ibid.).

In general, the Brazil project demonstrates how the ASI model is applied in a developing context. Avoid strategies target future travel demand to curb increases in traffic, which requires careful planning of cities and sufficient public transit infrastructure. Shift strategies target existing and inevitable traffic and seek to incentivize travelers to use more efficient modes of transport. Improve strategies aim to improve the supply of existing and future infrastructure as well as to improve the efficiency of transportation. Notably, the ability of a government - whether national or local - to implement ASI seems to rely on improvements in technical capacity, infrastructure, and technology. Improved technical capacity allows for smarter planning and more efficient management of transport systems. Improved infrastructure and technology are crucial for providing alternative forms of transport and for improving existing ones. For cities that lack funding, this may present a barrier to the success of ASI.

In Costa Rica, transportation is a major contributor to emissions despite that much of the country's energy comes from renewable sources. This makes improving the sustainability of

transportation an important objective. GIZ completed a project between 2017 and 2021 with the national government and the city of San Jose to improve the sustainability of their transportation sector ("Vermeiden, verlagern, verbessern," 2021). A key development was the formulation of a law to promote electromobility. Executive Decree 41092 includes a host of regulations that incentivize Costa Ricans to shift from polluting vehicles to cleaner electric alternatives. These include tax breaks that limit or remove taxes on the sale, ownership, and import of electric vehicles. Electric vehicle owners are also exempt from paying parking meters and have access to special parking spaces. The GIZ project also helped develop a plan to implement charging infrastructure for electric vehicles. Laws were drafted to improve the rights of cyclists, promote pedestrian-friendly design, renew and optimize freight vehicle fleets, and electrify public transportation. Finally, the project carried out an information campaign to promote cycling and educate the public on efforts to decarbonize transport (*Vermeiden, verlagern, verbessern*, 2021).

Costa Rica is a unique example in that, while a developing country, much of its energy is produced from renewable sources. This is ultimately what has determined a strong focus on shift and improve strategies, with little evidence of avoid strategies. The electromobility law and promotion of cycling are shift-based strategies in that they incentivize people to replace polluting vehicles with sustainable alternatives. This is achieved by reducing the costs and barriers of using electric vehicles, with no actual attempt to reduce the overall demand for transportation. The optimization of freight vehicles, electrification of public transportation, and investment in pedestrian and cycling infrastructure represent improve strategies. These actions ensure that trips that do take place are low-emission, again without reducing overall demand for transportation. Costa Rica's ability to rely on these strategies is dependent on its supply of renewable energy, which allows it to shift transportation consumption to sustainable alternatives without explicitly

attempting to reduce demand for travel. This shows that the implementation of ASI in developing countries is linked closely with energy production and access.

This analysis indicates that the implementation of ASI is dependent on the ability of a developing nation to optimize its transportation resources. To inspire sustainable development of transportation, city planners or policymakers need to be trained to apply the ASI framework. In addition, investment is needed in transportation infrastructure to make it more accessible and more energy-efficient. Additionally, since many transportation modes require energy, the sustainability of transportation is closely linked to energy production. These findings suggest that, while demand-side solutions can be effective in changing individual behavior, they rely heavily upon adequate supply-side solutions. Removing fossil fuel subsidies or increasing taxes on fossil fuel extraction while subsidizing renewable energies are necessary policies so that a clean energy base exists for transportation. This is why some scholars of climate change mitigation argue that focusing on the point of fossil fuel combustion is a limited approach and that fossil fuel extraction and energy supply need to be limited through supply-side policies (Lazarus & van Asselt, 2018; York & Bell, 2019).

IV. Conclusions

Analyzing the history and practice of ASI reveals the potential role of demand-side mitigation practices in transportation. A standard “predict and provide” approach to transport planning is considered unsustainable as it fails to consider the social and environmental impacts of increasing motorization. Yet demand for transportation is increasing around the world, and improved mobility is considered an important element for improving outcomes in developing

nations. Therefore, it is crucial that policy-makers and planners implement strategies that improve access to transportation while limiting its negative externalities.

The ASI model mitigates the externalities of transportation by influencing individual mobility decisions. It utilizes policies or strategic planning to reduce and avoid the demand for transportation, shift demand from polluting vehicles to low or zero-emission vehicles, and improve the efficiency of transportation infrastructure and services. These are demand-side mitigation strategies because, while they might involve moderating the supply of certain public goods like transportation infrastructure, they target the demand of transportation consumers and not the suppliers of polluting vehicles or infrastructure.

ASI has been endorsed as a model for transportation within sustainable development. For developed countries and those in later stages of development that are experiencing rapid urbanization, ASI is a helpful framework for transitioning to cleaner and sustainable mobility. Analysis of existing implementations indicates that ASI is most likely to be used where existing energy and transportation infrastructure can be improved and built upon, and where established institutional practices -- such as city planning -- can be modified. Therefore, due to the wide range of benefits that transportation provides, *least* developed countries should prioritize improving inclusive access to mobility. It is still important that policy-makers, planners, or project leaders in these areas consider the long-term implications of transportation development in order to avoid path dependency. Yet the benefits of providing transportation will likely far outweigh the costs.

One advantage of utilizing demand-side strategies in transportation is that the effect of policy and planning actions on individual behavior can be measured. Within the fields of behavioral and experimental economics, randomized control trials and quasi-experimental

methods are often used to estimate the effect of how a treatment incentivizes changes in behavior. Within transportation, policy and planning changes can be considered treatments, and their effect on individual mobility decisions can be measured. Data could be collected on emissions, public transit usage, and transportation energy usage. By statistically analyzing the effects of specific planning and policy decisions, effective demand-side mitigation strategies can be identified.

The unsustainable consumption of resources is a relevant issue outside of the transportation sector, especially in affluent nations. Wiedmann et al. (2020, p. 1) provide evidence that the "consumption of affluent households worldwide is by far the strongest determinant and the strongest accelerator of increases of global environmental and social impacts." This is largely due to a pattern where higher incomes are linked with higher levels of resource consumption, and that consumption growth has increased at such a rate that its negative impacts have outrun the benefits of improved technology (Ibid., p. 2). In their paper, Wiedmann et al. suggest that the ASI model be applied to reduce consumption in affluent societies (p. 3-4). In addition, Creutizig et al. (2018) suggest that ASI be used as a research framework for analyzing how specific technologies and services impact sustainable outcomes by examining how they incentivize avoidance, shifting behaviors, and improving efficiency. Further research should explore how ASI can be applied outside of transportation in order to reduce the unsustainable consumption of resources.

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