Environmental benefits of intelligent transport systems implementing

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Abstract. Intelligent Transportation Systems (ITS) have been shown to have positive effects on the economy and on efficiency, but this study aims to show that they also have a positive effect on carbon emissions. This article is based on the premise that implementing these technological steps is a win-win for long-term economic and ecological viability. The first research question asks if there is evidence that ITS systems can be implemented and operated in a way to generate environmental benefits, and the second asks if the policy priorities of national and international stakeholders reflect a propensity for ITS deployment in order to yield those benefits. Both fundamental drivers and a synthesis of the empirical facts are used to provide an answer to the first question. New propensity models to accomplish climatic and environmental objectives are one solution to the second problem. According to the findings, the likelihood that ITS would be included as a high priority policy instrument in future transport policies is significantly influenced by the Vehicle Density and High Technology exports of a country. The study's significance lies in its promotion of ITS as a policy instrument with the potential to improve economic performance and environmental performance. It's useful for transport planners and policy experts on a global, national, and even regional scale. Keywords: intelligent transport, transport policy, environmental impacts, sustainability

1 Introduction

It is impossible to overstate the value of dependable transportation to today's society and economy. In contrast, regular reliance on automobiles is a major contributor to the warming of the planet. Considering that 95% of transportation energy comes from fossil fuels, the prospects of decoupling transport growth from emissions growth appear dim in the absence of significant policy or technological advancements (Liu et al., 2021).

Given the diversity of approaches, it is not unexpected that there has been inadequate agreement on a single strategy for reducing the carbon intensity of transportation (Serrano-Hernandez et al., 2021; Zakharchenko et al., 2019; Ermilova & Ushakov, 2019). Primary routes for reducing carbon emissions include encouraging low-carbon technological innovation and deployment, encouraging modal shift from private car use to less polluting options like walking, cycling, and public transport, advocating for more efficient forms of traffic management and driving behaviour, and implementing strategies to minimize the need

The primary areas of disagreement appear to be related to the differences between behavioural and technical innovation, as well as reform and radical change (Kraus & Proff, 2021). To guarantee substantial savings in emissions from transport, it is possible to argue that a technical reformist strategy would be more politically and socially expedient than one that focuses on preventing private automobile usage through extensive behavioural interventions (Gutiérrez et al., 2022). Experts agree that making the shift to a low-carbon civilization will require changes on both the behavioural and technical, reformist and radical, fronts at the same time. According to the socio-technical framework, all the necessary actors, artefacts, and institutions must be in place at the same time for the transition to the low-carbon option to be a success.

Due to the difficulty of decarbonising the transportation sector and the difficulty of achieving a coherent behaviourally-oriented demand management strategy for private car usage, the focus in the past has been on piecemeal technological innovation for providing more sustainable transport solutions (Hoonsiri et al., 2021).

As a result, intelligent technologies are playing an increasingly critical role in the drive for green innovation, albeit overcoming socio-behavioural obstacles may still be required for broad adoption. Two possible future scenarios are described, both of which include the use of ICT to help lower carbon emissions. The transportation industry benefits from ICT in two ways: first, ICT is integrated into the whole transportation system, connecting the different technologies and services; and second, ICT helps connect the transportation industry to other industries and infrastructure. Intelligent Transport Systems (ITS) refer to all of the information and communication technology (ICT) based tools and services used in the transportation sector.

2 Overview of Intelligent Transport Systems

There are two scenarios in which information and communication technology (ICT) acts as a cross-sector facilitator to promote a low carbon future. Integration into the transportation system itself, or into systems that work in tandem with the transportation sector. These two contexts are not always clearly differentiated from one another. To help make the case for ITS as a long-term solution, we provide a summary of the roles that ICT plays in both contexts, discussing how ICT can represent technical progress or help foster behavioural change. There is a lot written on the effects of pervasive computing, as well as the implications of the spread of ICT, associated information networks and flows, and related information flows (Hamurcu & Eren, 2020; Sultana et al., 2019; Tan & Ismail, 2020).

Academics are increasingly interested in studying the impacts of the ICT revolution on transportation, as well as the consequences of ICT-enhanced mobility on urban planning. For (Karjalainen & Juhola, 2021), in particular, this ICT growth should be aimed towards low carbon enterprises, where extensive use of intelligent technologies may enhance the economy and speed up the move toward environmental sustainability. Complementary usage of ICT with the transportation system allows people to make choices that affect the total demand for transport and on alternative models, such as increasing the viability of working from home or promoting a switch in mobility modes (Ghaffar & El Aziz, 2021; Ren et al., 2020; Tang et al., 2020).

There are several ways in which a transportation network's performance may be enhanced by incorporating information and communication technology (ICT), such as via increased efficiency, reduced accidents, enhanced customer service, and reduced environmental effect. This takes occur when a remote digital dialogue takes the role of in-person negotiations over a physical location. So, owing to ICT development, there is less need for individuals to travel
for both personal and professional reasons (Karjalainen & Juhola, 2019).

By avoiding unnecessary trips via digital connection and organizing crucial routes with real-time traffic data, travellers may influence and encourage more sustainable, voluntary behavior at school, the workplace, and at home. Even if there isn't much evidence to support it, companies may be beginning to recognize they need to include six environmental issues into their travel strategy if they want to show they're socially responsible and attract top talent. If the smarter choices agenda is successful in lowering traffic volumes using these methods, then it will dramatically reduce carbon emissions from the transportation sector, as stated in (Stokes & Seto, 2019).

Some progress has been achieved in reducing carbon emissions and private vehicle usage thanks to Smarter Choices, but the program has not made major breakthrough into transport policy. When information and communication technology (ICT) is thoroughly integrated into the transportation network, we get what is known as an Intelligent Transport system (ITS). Electronic tollbooths and variable-message signs are only two examples of ITS infrastructure that might be permanently put in one location (Linton et al., 2014; Mahmoudi et al., 2019; Reyes-Rubiano et al., 2021).

Communication between vehicles (V2V), vehicles and infrastructure (V2I), and infrastructure and vehicles (I2V) is at the heart of today's most advanced intelligent transportation systems (ITS), which in turn improves traffic management, road safety, and efficiency. It is possible to place these devices in moving cars or to carry them on one's person.

Through the use of dynamic and pervasive connectivity, integrated ITS systems aim to detect transport movement, evaluate incoming information, and relay information in real time to users of private or public transport, as well as those responsible for traffic management. Drivers may be given with data to aid in transportation system decision-making, limit their behaviours, serve as alerts, or prompt them to take urgent action (Sugrue & Adriaens, 2022). In addition, with this information in hand, travellers may be able to make more sustainable choices that will ultimately result in fewer carbon emissions in the future. In addition, ITS can indirectly enhance traffic management via data provision. Those drivers don't do things like speed up and rev their engines for no reason or make a lot of sudden stops and starts. It can also refer to the process of keeping a vehicle in peak condition. In theory, well-designed policies and plans could be used to promote, encourage, and even police eco-driving (Cohen, 2009).

The combined effects of ITS's rewards and punishments are to increase the rate at which behaviour is modified. Together, ITS and entry control technologies (such rising bollards) could offer the smart infrastructure required for pricing systems to go forward.

Automatic Number Plate Recognition (ANPR) has the potential to increase surveillance, which in turn might lead to penalties for aggressive and excessive driving, which in turn could help hasten the transition to less carbon-intensive behaviour.

Due to the volitional nature of eco-driving, it may be essential to implement additional measures, such as financial incentives and instructional initiatives. ICT may enable smarter automation in the transportation industry, including adaptive speed adaptation, which would be a further step toward reducing carbon emissions. Using two vehicles to form a mobile nexus that is intelligently coordinated, the Safe Road Trains for the Environment (SARTRE) project is an example of EU FP7-funded research into the future of cooperative ITS (Tao et al., 2019; Thomas et al., 2016).

The goal of the platoon is to reduce wind resistance, gas consumption, and greenhouse gas emissions. One crucial aspect of evaluating the overall benefits of ITS systems is being aware of the potential downsides and unexpected consequences of using them. The rebound effect might lead to greater travel as a result of the increasing efficiency of motor vehicles. Users of transportation systems may compensate for, or even increase, their consumption in
tandem with any efficiency benefits brought about by technology solutions. It's also possible that certain ITS may lead to increased reliance on personal autos. This means that the whole breadth of ITS's potential implications must be considered in transport policy formation.

2.1 Benefits and Sustainability Forecast

Table 1. Measures to develop Intelligent Transportation systems (experience of UK).

<table>
<thead>
<tr>
<th>ICT Measures</th>
<th>Emission Savings</th>
<th>DfT Assessment</th>
<th>NPV</th>
</tr>
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<tbody>
<tr>
<td>Extended smarter choices programme</td>
<td>0.8</td>
<td>-75</td>
<td>1.468</td>
</tr>
<tr>
<td>ECO driving lessons for existing car license holders</td>
<td>0.4</td>
<td>-45</td>
<td>152</td>
</tr>
<tr>
<td>Speed Reduction</td>
<td>1.3</td>
<td>307</td>
<td>-5.002</td>
</tr>
<tr>
<td>Total Abatement Potential</td>
<td>2.5</td>
<td></td>
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</tbody>
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However, local scheme level investment choices or comparing an ITS option to more traditional scheme alternatives may not benefit from such aggregate data. Researchers have created composite sustainability indices for ITS projects to help in policy evaluation and goal accomplishment. Other research has shown that ITS systems are useful when integrated into a monitoring and modelling approach for assessing the environmental impacts of transportation. Supporting and supporting low carbon transportation projects; encouraging actions that increase knowledge and education; negotiating international climate change treaties; providing ITS at a level that completely satisfies the needs of various stakeholders.

Understanding the political climate gives this quantitative framework, allowing researchers to examine the propensity for prioritizing ITS. Here, the United Kingdom is used as an example of a country where it may be challenging to develop the transport and cross-sectoral policies needed to support ITS efforts. These are likely to vary on a worldwide scale based on factors such as economic development, transportation infrastructure, and regional and national political structures. Regardless, knowing why and how technologies have been prioritized in earlier policy decisions provides the foundational information necessary to predict the future predisposition to emphasize technology solutions. From the perspective of ecological objectives, we separate mitigation from adaptation here.

United Kingdom legislation mandates that the government take action to mitigate and adapt to climate change. The policy aims to strengthen the transport system's resilience via long-term risk management, the adoption of adaptive measures (such as updated road specifications), and readiness for unexpected disruptive occurrences. If the strategy is put into action, the United Kingdom's transportation infrastructure will be better prepared to deal with the expected effects of climate change, such as spikes and drops in demand for various modes of transportation.

2.2 City Stakeholders

Some research shows that urban road traffic may be impacted by climate change in two ways: by increasing the frequency and severity of congestion and by increasing the frequency of accidents but not necessarily their severity. The growing capacity of cities to launch sustainable transitions and their increasingly central role in climate change governance has been the subject of several studies. Since the late 1990s, the United Kingdom has been following a national trend of devolving power and accountability, and transportation planning authority has been one of the areas that have been delegated to local governments.

However, the level of transport policy difference between the devolved administrations has not increased much as a consequence of more devolution. Comprehensive Spending Review funding in October 2010 enhanced decentralized transport planning; 65]. It is
uncertain what role ITS will play in this, but it might open up opportunities for innovative regional and local sustainability solutions.

The establishment of the Traffic Management Act and accompanying recommendations in 2004 is another indication of decentralization since they lay a strong emphasis on the potential utility of ITS in addressing local traffic concerns and enhancing network efficiency. But as revealed by a survey of local Traffic Managers, not enough funding has been allotted to the widespread deployment of intelligent technology.

### 2.3 Policy Challenges

The United Kingdom already had a hodgepodge of carbon reduction policies in place, demonstrating the government's seriousness about its low-carbon transportation targets. The massive restructuring of the regional tier of administration and the ensuing reductions in funding are expected to further complicate transportation policy at the municipal and regional levels. However, policy disarray has long been a major issue at the federal level. To reduce reliance on new road development, the government opened the door to the possibility of an integrated transport policy in 1997 (Hassan et al., 2018).

Large-scale infrastructure projects often have a price tag that is too high to be covered by a decentralized budget, highlighting the need for centralized, top-down decision making. Since many traditional projects are expected to last for decades, the devolved agency need only cover the cost of upkeep. Given the wide range of initial and continuing expenses associated with ITS systems, distributed decision making and tailored methods are often required (Baker Al Barghuthi & Togher, 2020). In conclusion, a complicated and highly fragmented regulatory framework serves as a backdrop to the growth of intelligent technologies as an important policy option in the UK to create a low carbon transport system. It's possible that countries in other parts of the globe have similar challenges, albeit those with a more flexible political system may have an easier time of it than those with a more divided one.

### 3 Methodology

The research was based on the results of an online survey administered between July and August 2022 to a wide range of interested parties, including national and international policymakers, consultancies, industry, transport providers, academics, and others. The technique of sampling was developed with the intention of include only those stakeholders who had prior experience with ITS. Many other organizations were represented at this event, including the European Cities and Regions Networking for Innovative Transport Solutions (POLIS), the International Benefits, Evaluation, and Costs Network for Intelligent Transport Systems (IBEC), and national ITS groups. There were 75 total responses.

In order to achieve the full potential of ITS, it is essential that ITS systems be given a high priority in national and regional projects and be prioritized by a broad variety of stakeholders, from national and regional policy and decision-makers to local transport authorities. It could be argued that if ITS's potential environmental and economic benefits are not recognized, the benefits of ITS and alternative schemes will not be fully considered, the roll out of ITS will be slower and more piecemeal, and financial and investment decisions on large schemes will be made on a less rigorous basis.
Table 2. Data on the research sources.

<table>
<thead>
<tr>
<th>Perceived ITS priority in existing strategies</th>
<th>Transnational Government/coordinator</th>
<th>National Governmental/coordinator</th>
<th>Regional/local governmental</th>
<th>Transport supplier/Consultancy/Consultancy</th>
<th>Academic/research</th>
<th>Overall Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improve Local Environment</td>
<td>2.54</td>
<td>3.36</td>
<td>3.12</td>
<td>1.33</td>
<td>2.12</td>
<td>3.01</td>
</tr>
<tr>
<td>Minimize Climate Impacts</td>
<td>2.63</td>
<td>2.69</td>
<td>3.29</td>
<td>2.36</td>
<td>2.36</td>
<td>2.84</td>
</tr>
<tr>
<td>Economic Growth</td>
<td>2.36</td>
<td>3.61</td>
<td>3.39</td>
<td>2.93</td>
<td>2.96</td>
<td>3.26</td>
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4 Discussion of Findings

The study reveals the need of spreading the word about ITS' many benefits and the significance of communicating sector-spanning synergies (in terms of advantages and solutions) to achieve this goal. Given that technological advancements may have far-reaching effects on road safety and the economy, ITS looks to have high cross-sectoral effectiveness. However, the most significant findings are the probability models for future ITS prioritizing based on primary international data. While propensity models have been used extensively for analyzing individual choices and market share, this is the first time they have been used to the context of strategic transport policy. Vehicle density, high technology exports, and carbon dioxide levels are all acknowledged as key considerations in the future prioritizing of ITS due to their potential to deliver environmental and economic advantages.

5 Conclusion

Research into the dataset's strategic aims has shown wide discrepancies across countries and among the numerous players operating in the transportation sector. However, there is more agreement in the prospective future than there is at the present. Finally, it's quite unlikely that a fully established ITS system will prove to be an effective method for successful climate change mitigation and adaptation in the transportation sector. While progress in technology is essential, it is not likely to act as a silver bullet in the search for a sustainable transportation system. A policy mix that encourages behavioural change via taxes, carbon pricing, and regulation, as well as a more sustainable approach to spatial planning, vehicle, and infrastructure design, are all required.

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