Adjust urban and rural road pricing for fair mobility

Synergistically addressing local and global environmental damages rather than optimizing a specific aspect of the policy conundrum helps to effectively foster climate action in road transport while maintaining public acceptance and socially fair outcomes.

Felix Creutzig, Aneeque Javaid, Nicolas Koch, Brigitte Knopf, Giulio Mattioli and Ottmar Edenhofer

Decarbonizing the transport sector is widely seen as a huge challenge for climate policy making. In some developed countries, emissions from the electricity sector have started to decline, but transport emissions have stalled or even increased. Transport climate policy has so far been treated as technological regulation in terms of fuel efficiency standards, more recently combined with non-binding adoption goals for electric vehicles. While relevant, such measures alone remain inconsistent with the ambition of the Paris agreement, are compromised by both rebound and leakage effects, and are subject to gaming by the automobile industry. As an alternative, fuel taxes have been identified as a key and effective strategy[1], and economists and other academics hence persistently argue in favour of pricing strategies, such as carbon or fuel taxes. Carbon pricing puts a price tag on contributing to dangerous climate change, installs the polluter pays principle and incentivizes the reduction of GHG emissions. Politically, however, this strategy is risky. A fuel price increase was recently tested in France and met a huge backlash, as signified by the 'yellow vest' protests[2]. How then can policy makers effectively address GHG emissions in road transport without eliciting social protests and adversely affecting the socially vulnerable? Here, we argue that a geographically differentiated point of view, respecting both the location-specific environmental costs of road transport, such as congestion and local air pollution, and the opportunities of modal shift, offers a way out of this dilemma (see ref. [3]). Underlying this argument is recent evidence demonstrating that (1) fuel and road pricing have heterogeneous distributional consequences across geography; (2) car transport has higher external costs in dense urban settings, reflecting both congestion and air pollution, compared to rural areas; and (3) fuel and road pricing have a stronger steering effect in urban settings, as public transit and short distances enable a modal shift to alternatives (see sub-section titled 'Easier adjustment for urbanites' below and Fig. 1). Together, these insights strongly point to the need for differentiated pricing of car-related externalities across geographical settings. To further improve social acceptability and fair outcomes, we propose that revenues raised are spent impartially and used to improve the infrastructure of environmental modes, especially in sub- and peri-urban settings.

Table 1 | Differentiating pricing of road transport to address environmental and social costs of car use

	Geographical differentiation	Other differentiation
Carbon price	No	Fuel
Congestion charge	Yes	Time
Pollution charge	Yes	Fuel and vehicle

Vulnerability to fuel price rises

The yellow vest protests in France originated in rural and peri-urban middle-class areas. One significant area of discontentment was the rising fuel taxes that hit car-dependent commuters most, coupled with a perceived disadvantage vis-a-vis urban populations who are wealthier and have better access to services and opportunities. The protests point to a problematic dilemma between effective climate policies and social inclusion, and, more specifically, car-related economic stress, defined as having disproportionately high motoring costs on low incomes[4]. Research from countries including Australia, New Zealand, Canada, France, Germany and the UK shows that vulnerability to fuel price hikes is higher in suburban, peri-urban and rural areas as a result of greater expenditure on fuel (higher exposure) and lack of viable modal alternatives (lower adaptive capacity)[5] (Fig. 1a). In many (but not all) metropolitan areas around the world, this is worsened by the 'suburbanization of disadvantage': low income households, who are more sensitive to fuel price increases, are pushed to outer car-dependent areas by the lack of affordable housing in core cities[6,7]. These observations point to a stark dilemma between effective climate policy and social inclusion emerging from the rural–urban divide. However, geographic differentiation not only harbours the problem, but also the solution.

City driving is most harmful

The effect of GHGs is mostly independent from its location of emission, suggesting the need for universal and equal pricing (Table 1). However, other external costs of car use, such as air pollution, congestion, noise and accidents, strongly depend on location. For example, in urban areas of the United States, people inhale at least 10 times more motor vehicle exhaust fumes than their rural counterparts[8]. This so-called 'intake fraction' increases by yet another factor of 10 in global megacities[8] (Fig. 1b). Congestion is also most problematic in large urban areas, increasing in more densely populated inner cities[9] (Fig. 1b). In 2016, economies such as the USA, the UK and Germany occurred economic losses equivalent to US$500–1,300 per capita due to time spent in urban congestion[10].

In large cities, other costs can often equal or supersede the social costs of CO_2 emissions. The example of Beijing demonstrates that local environmental and congestion costs can be equal to the social costs of CO_2 emissions[11]. While often

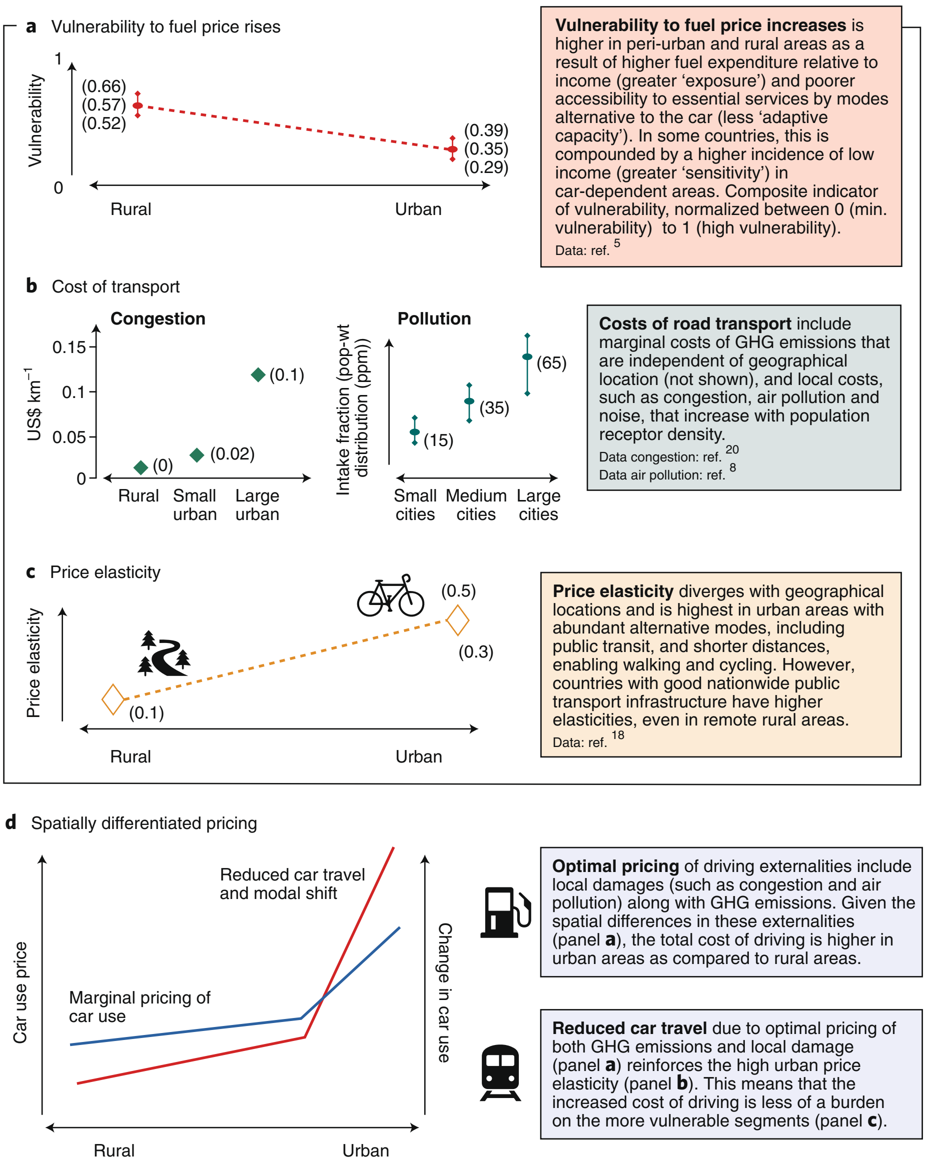

Fig. 1 | Comparison of road transport challenges in rural and urban areas. a–d, Rural areas have higher vulnerability to fuel price hikes (**a**), but road transport has higher marginal costs in urban areas (**b**). Urbanites can also more easily shift from car transport to public transit or cycling (**c**). Together, this implies higher marginal charges on road transport in cities, achieving more notable effects (**d**) and thus improving the relative burden in more vulnerable rural areas. pop-wt, population-weighted.

carbon prices of only US$20 tCO_2^{-1} are implemented, the social costs of carbon are around $US420 (range: 180–800) tCO_2^{-1} (ref. [12]), which is similar to both congestion and air pollution costs, while costs of urban accidents and noise are slightly below these climate change costs[11]. In other cities like Barcelona, the health-related costs of noise pollution from road transport, including motorcycles, can also be similar to the costs of climate change[13]. The external costs of noise are 30× higher in high-density cities compared to low-density settlements[14].

Considering geographical differences in these other externalities, the EU handbook of external costs in transport assesses that the marginal costs of congestion in metropolitan and urban areas used at capacity can supersede climate change costs (if evaluated at US$420 tCO_2^{-1}) by a factor of 6 to 7, whereas such values in remote rural areas amount to zero[15]. However, the capacity usage factor for congestion can vary significantly between different kinds of urban roads. Similarly, air pollution costs are about twice as high in urban areas than in rural areas, although their absolute scale varies with emission class, fuel used and size of vehicle[15]. On average, full costs of road transport can be 3 to 5 times higher in urban areas compared to rural areas if we conservatively assume social costs of carbon of US$420 tCO_2^{-1} (ref. [15]). Importantly, fuel taxes based only on social cost of carbon are not able to effectively tackle these other externalities of car use[16]. Given this, we propose that rather than relying solely on carbon pricing for transport-related emission reduction, policymakers should consider directly tackling this bundle of externality costs, which, by their nature, are differentiated based on geographical areas (Table 1). So, if all social costs of car driving — not just climate change — were properly addressed, the price of driving would be higher in urban areas and would comprise not only fuel taxes but also other road and pollution charges that depend on time and location as well as fuel and vehicle characteristics.

Easier adjustment for urbanites

An important variable for price-based instruments is the reaction of car drivers to fuel prices. As a technical measure, price elasticity measures the reduction in demand to increases in fuel prices. Traditionally presented as aggregate demand change, recent insights demonstrate that social impact and responses to fuel pricing differ with respect to geographical aspects. Novel studies using disaggregated micro-level data, either from surveys or odometer readings, highlight that drivers' responses to price changes vary significantly depending on how much they drive, whether they live in an urban or rural area and whether they have adequate access to public transport[4,17]. Specifically, fuel price elasticity has been estimated to range between 0.10 and 0.30 in the USA and in the upper bound of this range and up to 0.45 in Europe[18]. A key reason is that public transit serves as an alternative to car driving in many parts of Europe, but less so in the USA. To illustrate the significance of geographical position relative to fuel price elasticity in the USA and in Europe, consider that the fuel price elasticity in rural areas of the USA without public transit is estimated at 0.13 (ref. [18]). In stark contrast, a central estimate for Denmark — with ample opportunity for public transit, including long distances — is about 0.30, with higher fuel price elasticities both for inner cities and very long commutes that can be shifted to public transit[18] (Fig. 1c). Without adequate public transit, rural households with long commutes would not be able to substitute away from driving when fuel prices rise, which contributes to their socio-economic

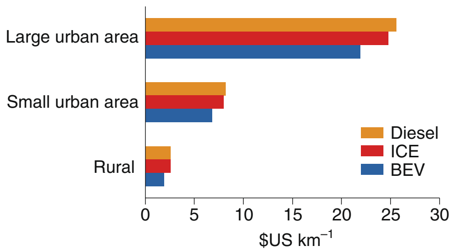

Fig. 2 | Comparison of average marginal external costs of passenger cars during rush hour. Battery electric vehicles (BEV) have lower externalities than gasoline (internal combustion engine (ICE)) and diesel cars but still need to shoulder about 80% of the externalities, notably congestion. Data present estimates for Norway[20] and include costs of CO_2, local pollutants, noise, congestion, accidents and road wear.

vulnerability. In many countries, access to public transport is less universal than in Denmark, and rural households lack options for avoiding large tax burdens. In inner cities, where walking and cycling constitute other alternatives and where car trips are more discretionary, the price elasticity may be above 0.8, as shown by the London congestion charging experience[19]. Overall, the empirical evidence suggests that the demand response is higher in urban areas with public transit infrastructures. As higher local environmental costs imply higher prices for car use in cities, this means that, under a geographically differentiated pricing framework, the avoided car use and modal shift to other modes is an order of magnitude higher in cities compared to the countryside (Fig. 1d).

The rising market penetration of battery electric cars raises the question as to whether geographically differentiated road pricing is very different with zero-emission vehicles on the road. Norwegian data suggest that electric vehicles would be charged differently, but that the overall relationships would remain stable[20]. In inner cities, drivers of battery electric vehicles would have to pay about 80% of that paid by drivers of gasoline or diesel car (Fig. 2).

Revenue redistribution

The adequate redistribution of revenues across social groups and geographical areas is central to overall policy design. In economic textbooks, the application of Pigouvian taxes to correct for so-called externalities, such as global warming or congestion, is justified by itself, independent of considerations regarding how to spend revenues. However, just and fair revenue recycling is central for the social acceptability. In fact, taxes are not perceived in terms of their Pigouvian benefits, but are mostly seen as a measure to obtain revenue[21]. Hence, transparent revenue spending is a major factor to increase acceptability and salience of a policy instrument. There are two avenues for adequate revenue spending: (1) lump-sum redistribution and (2) investment into alternative transport infrastructures. First, a carbon fee can be presented as 'fee and dividend', with lump-sum redistribution as a salient mobility stipend for everyone[22]. This connects the Pigouvian tax to a beneficial and visible outcome. Importantly, the impartiality of the lump-sum redistribution aligns with social trust in governments[23] and thus also shield the policy instruments from future rollback. Simulations for Germany indicate that rural populations would disproportionally profit from lump-sum redistribution of carbon pricing[24], and results from France show that revenue recycling focused on low-income households would be progressive and address the financial burden of vulnerable households[25]. Hence, such a redistribution scheme would guarantee social inclusion across geography while maintaining incentives for low-carbon mobility. Second, geographically differentiated charges might best be re-invested into local infrastructures. Investments into mass rapid transit, bus lanes and cycling infrastructure decrease the overall costs of fuel pricing and road charges for car drivers by reducing car dependency. Expanded and more frequent public transit and safe cycling lanes induce a further modal shift and reductions in congestion, thereby cutting down time costs for both public transit users and car drivers. For example, calibrated to the external costs of Beijing (congestion, air pollution, climate change, noise and accidents), the difference between hardly any public transit and high-quality public transit translates into overall reduction of car drivers' net costs induced by a city toll by 45%[11]. The financing of better and cleaner public transit is a salient goal of direct interest to considerable parts of the electorate. For example, the recent decision to implement congestion charges in Manhattan, New York, was motivated and gained acceptability by making clear that revenues are necessary to maintain and improve public transit. Similarly, revenues from London's congestion charge are also earmarked and re-invested into London's transport infrastructure, and funds are especially concentrated on the improvement of transit access of suburbs to the inner city. Improving the access to environmental modes at the interface between peri-urban and urban areas is indeed doubly beneficial, as it addresses car dependence of outer areas and reduces their vulnerability to fuel price increases while improving air quality and lessening congestion in the inner city. Either earmarking revenues for expanding public transit or distributing climate and mobility dividends have the capability to shift the focus of pricing instruments to salient outcomes. These suggestions could thereby increase social acceptability in general, but would particularly benefit people in rural areas. At the same time, both measures are also progressive and support inclusive mobility.

Towards implementation

There are several appropriate ways of how to implement comprehensive, geographically differentiated pricing that reflect the costs of road transport. Key design considerations include social acceptability and the state of low-carbon transport infrastructure. Technically, road pricing and air pollution pricing could be implemented by GPS tracking of individual vehicles, where tracking devices are gauged according to fuel used and pollution standards, and where pricing is differentiated according to these characteristics as well as space and time. As such systems are undergoing the process of planning to implementation, proxy instruments prohibiting on-street parking in cities or charging the true costs of parking can serve as intermediary and effective improvements. For GPS tracking, privacy could be secured by block-chain technologies or by trusted transmission protocols that transfer only the monetary charge, but neither location nor route. While revenues from pricing GHG emissions (for example, through fuel taxes) could be redistributed as mobility dividend to all households, revenues from congestion charges and air pollution charges should be invested into locally alternative transport infrastructure at the suburban interface. This differentiated revenue recycling scheme would both communicate impartial and fair policy-making (via the mobility dividend) and would enable commuters to switch transport modes (via public transit investments). Acceptability could be further enhanced by changing the framing from 'paying charges' to 'saving money'. The Israeli 'Going Green' program is a showcase of how this could work[26]: all drivers are allocated an annual credit, but sums are detracted for car usage in congestion. Car drivers who do not use up their credit by driving during rush hour will obtain the remaining credit in cash by end of the year. Annual vehicle taxes could finance this scheme. In this way, there is now a positive incentive to avoid congestion, and the mindset is shifting towards finding opportunities to save cash.

A new pricing system may also induce a transformation that transcends individual marginal user behaviour. Most importantly, changing transport cost patterns will be reflected in land costs, with urban locations and those with access to bicycle infrastructure and railway station(s) further increasing in value. Such repercussions hence require dedicated considerations of housing and real estate policies. Our argument is important in demonstrating that the so far neglected geographical dimension of road pricing can help to overcome the trade-offs between climate change mitigation and social hardship and vulnerability. A differentiated pricing scheme would not only be more efficient because it better targets local externalities, but it would also effectively shield vulnerable groups and, in doing so, lessen the likelihood of political opposition to price reforms. Simultaneously addressing climate change and local environmental pollution of road transport as well as explicitly making revenue spending part of the policy avoids distributional barriers of fuel pricing and instead fosters inclusive and sustainable mobility. ❐

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Additional information

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