



Review

The political economy of car dependence: A systems of provision approach

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ABSTRACT

Research on car dependence exposes the difficulty of moving away from a car-dominated, high-carbon transport system, but neglects the political-economic factors underpinning car-dependent societies. Yet these factors are key constraints to attempts to 'decouple' human well-being from energy use and climate change emissions. In this critical review paper, we identify some of the main political-economic factors behind car dependence, drawing together research from several fields. Five key constituent elements of what we call the 'car-dependent transport system' are identified: i) the automotive industry; ii) the provision of car infrastructure; iii) the political economy of urban sprawl; iv) the provision of public transport; v) cultures of car consumption. Using the 'systems of provision' approach within political economy, we locate the part played by each element within the key dynamic processes of the system as a whole. Such processes encompass industrial structure, political-economic relations, the built environment, and cultural feedback loops. We argue that linkages between these processes are crucial to maintaining car dependence and thus create carbon lock-in. In developing our argument we discuss several important characteristics of car-dependent transport systems: the role of integrated socio-technical aspects of provision, the opportunistic use of contradictory economic arguments serving industrial agendas, the creation of an apolitical façade around pro-car decision-making, and the 'capture' of the state within the car-dependent transport system. Through uncovering the constituents, processes and characteristics of car-dependent transport systems, we show that moving past the automobile age will require an overt and historically aware political program of research and action.

1. Introduction

1.1. The problem

The transport sector is heavily implicated in climate change, accounting for 23% of total energy-related CO₂ emissions in 2010 [1]. Since 1970, direct transport-related greenhouse gases (GHG) emissions have risen by 250% worldwide, i.e. "at a faster rate than any other energy end-use sector" ([1]:606). The majority of current emissions, and most of the historical increase, are due to road transport. In developed countries, the second half of the twentieth century has seen dramatic increases in motorization and distances travelled, although both of these may now have plateaued. In developing and emerging economies, motorization and travel distances are now increasing rapidly, albeit from much lower levels [1–4]. All IPCC scenarios for 2020–2050 predict further increases in per capita

passenger travel demand for all world regions ([1]:638). With activity growth likely to continue to outweigh climate mitigation and energy efficiency actions, transport is one of the most intractable sectors for the climate agenda.

At the same time transport, like other forms of energy consumption, delivers energy services which are essential for human well-being and the satisfaction of basic needs [5–13]. World regions are positioned differently with respect to how transport and car use contribute to human well-being. In OECD countries, transport GHG emissions are high and must be radically reduced, but need-satisfaction has come to be dependent on (high levels of) car use [10,14,15]. Car ownership and use can be an essential precondition for social inclusion in developed countries, notably in suburban and peri-urban areas which have been built on the assumption of near-universal car access [16–24]. In developing and emerging countries, motorized transport use and related emissions are still relatively low. However,

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in many circumstances, increases in motorized transport use and related energy consumption may be necessary to achieve decent levels of need-satisfaction [25].

This situation reflects a broader conundrum between mitigating climate change and ensuring human well-being. In this context, a small but growing body of research aims at finding ways of reconciling social and environmental concerns, 'decoupling' human needs satisfaction from energy use [5,8,25–33], although contributions that focus specifically on transport are still relatively rare [10].

The political-economic factors behind the 'coupling' of human needs satisfaction and energy use are likely to be formidable barriers to decoupling efforts, and hence climate change mitigation, yet to date they have drawn only limited attention. In this paper, we identify some of the main political-economic factors underpinning 'car-dependent transport systems', based on a critical literature review which draws together research from several fields. We define a car-dependent transport system as *one in which high levels of car use have become a key satisfier of human needs, largely displacing less carbon-intensive alternatives* [10]. Car-dependent transport systems are an important component of 'carbon lock-in', i.e. "the interlocking technological, institutional and social forces that can create policy inertia towards the mitigation of global climate change" ([34]:817). Recent studies have suggested that the magnitude of the financial and techno-institutional barriers to 'unlocking' is greater for road passenger transport than for most other sectors [35].

By focusing on car dependence (as defined here) we deliberately investigate only some of the factors underpinning the transport-related carbon requirements of well-being, i.e. those linked to energy demand and human behavior. This is illustrated below with reference to the ASIF model, which is a standard decomposition model for transport GHG emissions [1,36,37]:

Transport GHG

$$= \text{Activity} [p \cdot km_{total}] \cdot \sum_{modes} \text{Modal Structure} [p \cdot km_{mode} / p \cdot km_{total}] \cdot \text{Energy Intensity} [MJ / p \cdot km_{mode}] \cdot \text{Fuel Carbon Intensity} [tCO_2eq / MJ] \quad (1)$$

In this paper, we will look at the political-economic factors behind changes in levels of *activity* (total distances travelled) and *modal structure* (the distribution of these distances between different transport modes). The other two, more technological factors – i.e. the *energy intensity* of travel modes, and the *carbon intensity of the fuels* that they use – are beyond the scope of this review, as their investigation would require focusing on rather different processes, actors and policy sectors than those considered here (see e.g. [38–40]). Also, historically changes in activity and modal structure have been the most important drivers of trends towards higher GHG emissions. Grübler [41], reviewing 300 years of technology history, singles out transport as the paradigmatic example of a sector where huge activity growth has negated efficiency improvements – a pattern that is also visible in the latest available figures [42].

Our goal with this review paper is to provide a synthesis of existing research to provide a more comprehensive account of the political-economic underpinnings of car dependence. A car-dependent transport system brings together a complex mix of different kinds of factors, which have been explored under various theoretical and disciplinary approaches. In this paper, we aim to integrate these various accounts into a single coherent and holistic description that gives due consideration to political economy aspects. By investigating the political-economic root causes of car dependence, we aim to learn lessons on how to break free from carbon lock-in in the transport sector.

Overall, the paper makes five contributions. First, it counters the relative lack of political economy and critical perspectives, in mainstream transport research, where transport has largely been seen as a

'technical' and 'apolitical' matter¹ [43–45]. The particular approach within political economy that we draw upon is the 'systems of provision' approach [54–58] as will be discussed in Section 1.2.

Second, and more specifically, the paper extends existing research on car dependence. The main approaches to the study of car dependence focus on different barriers to modal shift – social attitudes, built environment, and social practices [59] – but they all generally neglect the economic and political factors underpinning car-dependent societies.

Third, and conversely, the nascent literature on the political economy of energy systems and climate change (e.g. [60–66]) has not primarily focused on transport to date, perhaps reflecting entrenched disciplinary divisions.

Fourth, we bring together insights from several fields that have so far remained rather disconnected and have not been brought together from a comprehensive critical research perspective. By highlighting the connections between them, we aim to encourage greater cross-fertilization between these fields.

Finally, by highlighting the constituent elements of car-dependent transport systems, this review lays out a theoretical framework which could inform ongoing research into the energy requirements of well-being [5,7,13,25,67].

The paper proceeds in Sections 2–6 to characterize the five constituent elements of car dependence, namely: the automotive industry (Section 2); the provision of car infrastructure (Section 3); the political economy of car-dependent land-use patterns (Section 4); the provision of public transport (Section 5); and cultures of consumption of the automobile (Section 6). Section 7 brings together these different strands of literature into a single account of the political economy of car dependence. It does this by discussing more systematically the interconnections between all the different elements, and how they reinforce each other. It then discusses deeper underlying mechanisms, to suggest a structural account that cuts across single elements.

Our review is inevitably selective. Most notably, the paper does not address directly the political economy of the oil industry even though cars and oil have a symbiotic relationship that can be traced back to early twentieth-century US [68, 69]. It is worth stressing at the outset the significance of this relationship. Road transport currently accounts for 49% of world oil final consumption (up from 31% in 1973) [70] and the share of oil within total road transport energy is 94% (down from 100% in 1973) [71]. In that sense, any political economy of car dependence is necessarily also a political economy of oil (and vice-versa) [72]. However, and by the same token, cars and oil are distinct items that involve distinct, though overlapping, systems of provision. Our aim in focusing on the car-dependent transport system is to establish a political-economic basis upon which future work could expand to inter alia better understand the political economy of oil, building on existing research in that area (e.g. [73–76]).

1.2. Approach

As each of the areas covered in this review is interdisciplinary and diverse, it is important to be able to order and make sense of this diverse material. For this, we draw on 'political economy', which we understand as the tradition of classical political economists and of those diverse 'heterodox' economists who have developed on the basis of classical political economy and in some opposition to mainstream

¹ While this is true for mainstream transport research, there are obviously a lot of critical perspectives on transport from other disciplinary areas, going back to the work of Jane Jacobs [46]. There are more contemporary examples from fields such as history (e.g. [47–49]), urban geography (e.g. [50]), and political science (e.g. [51]). Research within the 'new mobilities paradigm' [52–53] has also developed more critical insights into transport. We will draw on these perspectives in our review.

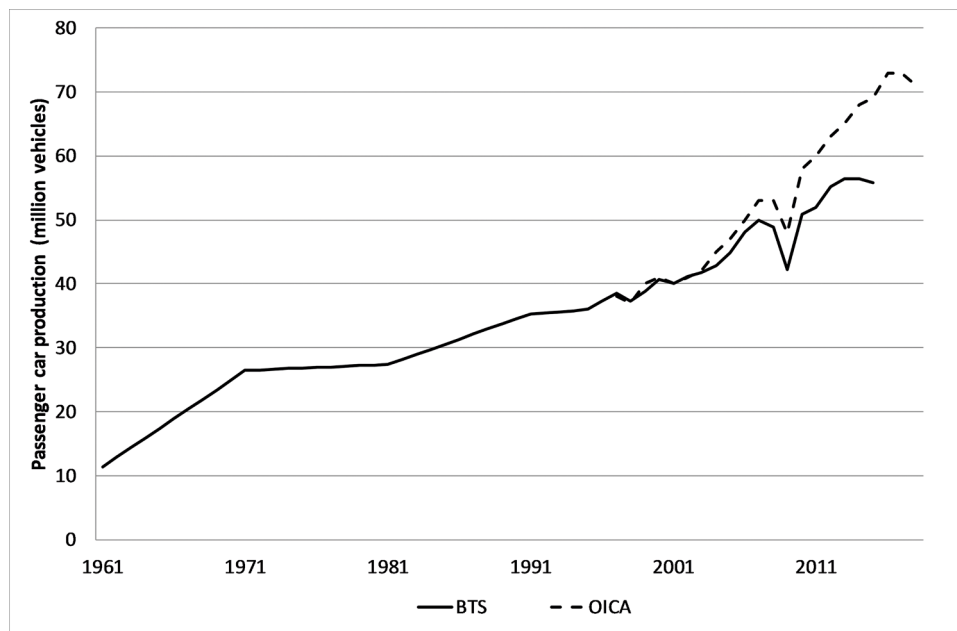


Fig. 1. World passenger car production according to BTS 1961–2015 [84] and OICA 1996–2018 [85]. Note: BTS figures do not include minivans, pickups, and sport utility vehicles.

neoclassical economics. Such a broader and more social science orientated approach to economics acknowledges inseparable links between the economy and political, technological, social, historical and context-specific dimensions [77].

More specifically, we draw from a particular approach to concrete analysis developed within the political economy tradition, called the ‘systems of provision approach’ (SoP) [54–58]. Whilst rooted in the understanding of accumulation developed within the political economy tradition, SoP has been developed to aid concrete research in a way that both recognizes the social, cultural, technical, as well as economic specificities of any one provisioning process, whilst at the same time incorporating understanding of the more general dynamics of capitalism.

Our review is oriented by three key principles of the SoP approach. First, the adoption of a ‘vertical’ analysis framework i.e. the “idea that consumption (needs) to be understood more closely in relation to its attachment to production” ([58]:29) and to be placed “on the broader terrain of provisioning, where it belongs” ([58]:39). This leads us to cover automotive industry research in our review – unlike most contemporary research on car dependence, which tends to focus on the consumption and use of motor vehicles [15,21,59], while neglecting the logics underpinning their supply.

Second, attention for historical developments, as “the prevailing state of affairs rests heavily on past forms of provision and the way in which these have informed the continuing evolution of both material and cultural aspects of provision” ([58]:40).

Third, the inductive selection of the main ‘elements’ of the SoP, with the aim to “shine a spotlight on (those) that are of particular relevance to the issue under consideration” ([58]:34), i.e., in our case, the environmental (un)sustainability of transport.

Overall, the SoP approach allows us to demonstrate how the different elements underpinning the political economy of car dependence are interlinked, allowing a holistic understanding of how car dependence perpetuates itself. This approach overlaps with other perspectives highlighting the interconnectedness of technological, social, and institutional factors in energy systems. These include ‘technology clusters’ [41], ‘techno-institutional complexes’ [34], and ‘socio-technical systems’ [78]. Rather than providing a comprehensive systemic account of automobility as has been attempted using some of these approaches, however, our aim is to highlight the key political economy factors that underpin car-

dependent transport systems. In doing this, we thread a middle ground between two positions in sustainable consumption and production research [79]: the ‘revolutionary’ position – entailing a radical critique of modern capitalist societies, but with an overwhelming focus on deep structures rather than specific energy sectors – and the ‘reconfiguration’ position – focusing on the transformation of specific socio-technical systems and daily life practices, but with a tendency to overlook politics and power. Our approach allows us to identify underlying cross-cutting characteristics of car dependence which we believe will be crucial in developing an overtly political program to move beyond it.

The focus of the review is not on a specific spatial and temporal context. Rather, we draw from examples from different countries and different times, in order to illustrate what the main constituent parts of a car-dependent transport system are, and how such situations can arise historically. Due to the topical range of our review and our research goals, it fits under the “narrative review” categorization of Sovacool et al. [80]. Our goal is the achievement of novel in-depth qualitative perspectives on this topic, consistent with establishing a systemic causal description of the most important generic elements of the political economy of car dependence.

2. The automotive industry

The growth of the global fleet of light-duty vehicles shows no sign of slowing down and has even gathered pace since the turn of the century, passing the 1 billion mark in the 2010s [81,82]. Meanwhile, the global motorization rate has increased linearly from 20 vehicles per 1000 inhabitants in 1950 to approximately 143 in 2015 (own elaboration based on [81–83]). This has been accompanied by almost uninterrupted growth in levels of passenger car production (Fig. 1)

Based on a selective review of the literature, with a notable focus on the environmental implications of vehicle manufacturers’ actions, in the remainder of this section, we identify five key characteristics of the industry and their implications for car dependence.² Fig. 2 summarizes

²Over its long history, the automotive industry has obviously undergone significant change in many respects. In this section, however, we focus on the ‘deep drivers’ that have consistently contributed to increasing levels of car dependence, and have changed only very little over the course of the last century [86–92].

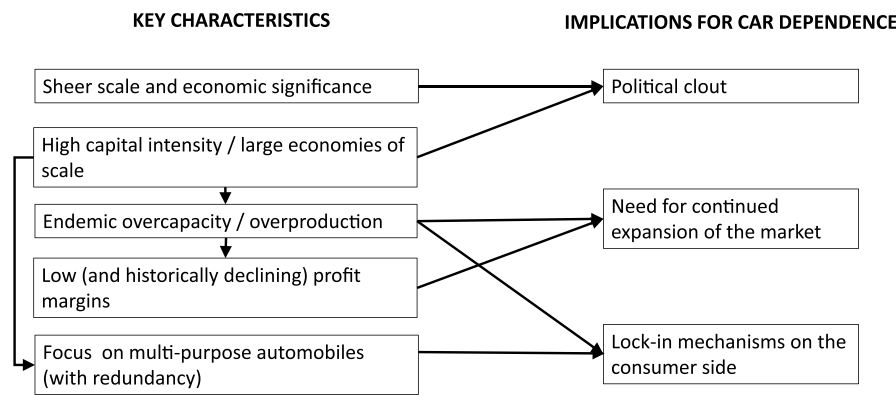


Fig. 2. Key characteristics of the automotive industry and implications for car dependence (own elaboration).

the elements and the relationships highlighted.

2.1. Scale and economic significance

The first key feature of the automotive industry is its sheer scale and economic significance. Since its beginnings at the end of the 19th century, it has grown into one of the main industrial sectors of the global economy. According to industry estimates, in 2005 it accounted for a global turnover of €1.9 trillion, higher than the GDP of most national economies, and for 5% of the world's total manufacturing employment [93]. In the main car-producing world-regions (North America, Europe and East Asia) these figures are even higher [94].

The industry also has strong economic linkages to other sectors, through upstream supply chains to supplier industries (e.g. steel, rubber, and glass), and to downstream spin-off effects, notably oil consumption, which magnify its economic importance [51,69,95]. While external suppliers can account for a large share of vehicles' value [92,96], here we focus mostly on vehicle manufacturers, given their key position in the structure of the industry, both in strategic and economic terms [86].

Mainly as a result of large economies of scale (Section 2.2), the car market is dominated by relatively few large global multi-brand conglomerates, with 67% of global production accounted for by the top ten manufacturers in 2017 (own elaboration based on [85]). Three of the world's top twenty businesses by revenue are car manufacturers [97], providing "the archetypical example of (a) sector dominated by multinational corporations" ([39]:3).

Historically, car manufacturing has played an important role in the economic development of early industrialized countries, introducing productivity-enhancing innovations in technology and labor organization that have then spread to other sectors [51]. Current emerging economies, such as India [98] and Vietnam [99], see the development of an automotive sector as a key step forward in industrialization, because of the high labor productivity and the economic multiplier effects associated with the industry [2,4,87]. The state typically has a leading role in promoting efforts to establish the industry in new countries [51,89,100–103]. This is part of a broader pattern of globalization of 'carbon lock-in', whereby developing economies promote "rapid industrialization through the adoption of ... development strategies that have proven successful in industrial countries" ([104]:1188).

2.2. High capital intensity and large economies of scale

Economies of scale are a critically important element shaping the structure of the automotive industry [86,88,89,92]. Particularly important here is the all-steel body [86,96,105], which resolved several production bottlenecks when it was introduced in the 1920s, thereby allowing mass production. This also, however, required large capital investments in high-volume plants focused on one or few models

[86]:116). It has also led to a consolidation and centralization of the industry during the twentieth century into a small number of companies, with very high barriers to entry for outsiders, and high barriers to exit, due to sunk investments [88,89,91,92,106].

This has important impacts on the industry's political clout. Large factories and large, consolidated companies mean that the car industry, or even specific car plants, can become "too big to fail," leading governments to lend support using public funds, thereby adding political lock-in not just to the industry itself, but also to a specific configuration of production. Luger [38] applies the notion of 'state dependence' to characterize the privileged position of the automotive industry within capitalist states due to governments' dependence on the jobs, growth, and state revenue it provides, arguing that "policymakers often do not have to be pressured to respond to industry requests because economic growth and political stability can hinge on a healthy auto industry" ([38]:184–185). For example, at both national and local levels the state obtains significant revenues from the industry in the form of VAT, taxes on income and profits, both from manufacturers and others (e.g. dealerships, insurance industry). These considerations may inform the decisions of state actors in key policy areas, even in the absence of outright lobbying – as discussed in Sections 3 and 4.

Because the structure of the industry makes it ill-suited to cope with rapid fluctuations in demand, (Section 2.3), its political clout becomes particularly apparent during economic crises, such as the 2008 financial crisis and its aftermath. During recessions, car sales plummet, as the purchase of new cars is one of the first expenses that households cut [107]. This motivates government attempts to rescue the car industry through emergency financing, loans, sales incentives, or excise duty cuts ([89]:165, [95,98]).

These measures are typically not politically controversial, partly because jobs in the car industry are an important bargaining chip. To ensure state support, car companies can threaten to relocate production or invest abroad [38,88]. Car production is concentrated into a few large plants, with entire regional production systems specialized in car manufacturing [90,101,108–110]. Therefore, the social impacts of automotive plant closure or relocation have greater political relevance and media visibility than for industries whose employment is more geographically dispersed. This strengthens the bargaining hand of pro-car interests in all areas where measures can be presented as having a negative impact on employment in the automotive industry. For similar reasons, trade unions are likely to side with the car industry in conflicts over government support, or transport policy [38,40,88].

2.3. Overcapacity and overproduction, with declining profitability, and focus on multipurpose vehicles

Large economies of scale and capital intensity in the car industry mean that high levels of production are required to recover incurred costs, with break-even points "at about 85 percent capacity utilization"

(of plants) ([89]:146). So, while the dominant technological regime of car production allows large economies of scale, it also *requires* high volumes of production and sales relative to capacity, while the size and cost of new car plants make it difficult to adjust output to demand [92]. This forces manufacturers to 'push through' as many vehicles as possible, almost regardless of demand, resulting in price reductions in both new and used vehicles [82,86,88–90,92]. Overproduction has created profitability problems for the industry and encouraged a "fire and forget" attitude towards car sales ([89]:106) which exhibits "indifference in systems resources optimization" ([111]:326). Automotive companies have therefore ignored a potentially profitable, and ultimately more sustainable business model in which car companies would become 'mobility service providers,' capturing downstream revenue rather than relying on overproduction [86,88,111–113].

The production system described above became locked-in in the particular conditions of the early stages of motorization [114], "where demand for any form of low-cost motorization meant that consumers were willing to accept standardized products" ([90]:231). Later on, however, saturated car markets in developed countries forced producers to increasingly compete through product differentiation, with a proliferation of models, body styles and variants ([89]:25–26; [106]:20–21), which have become means of class and (sub)cultural distinction for consumers. This came at considerable cost to the industry, which had to re-design its production facilities, re-orient its relationship with its workers, and re-structure itself to give more resources to design and marketing rather than production [115]. It also further exacerbated the industry's profitability problems, as lower volumes per variant made it even harder to break even [86]. Therefore, it has been estimated that typical profit margins were 20–30% in the 1920s, 10% in the 1960s, and lower than 5% in the 2000s ([86]:101–111; [89]:126).

Orsato and Wells [88] argue that to mitigate these profitability problems, car manufacturers focused on "general-purpose designs that approximate to several user needs" ([88]:997) as a risk-reduction strategy, which allows a single type of vehicle to appeal to as wide a market share as possible. In practice this means that the vast majority of passenger cars are five-seat vehicles with maximum speeds of over 160 km/h and a fuel range of approximately 400 km ([88]:997; [90]). Many of the differences used to market them as separate vehicles for differentiated customer groups are therefore limited to the superficial level of models, variants and trim choices, while diversity has actually been reduced at the more important but less visible level of vehicle platforms and architectures, as a result of strategies such as platform consolidation, common vehicle architectures and modular assembly [88,89].

In a nutshell, the industry has sought to combine economies of scale (via underlying platforms) with brand and model differentiation that sustain the (illusion of) product variety, while the basic pattern of the multipurpose, five-passenger vehicle continues to dominate. A more fundamental challenge to this configuration would require a profound shakeup in the structure of the car industry — something that car companies therefore have every incentive to avoid. From a consumer perspective though, this means that cars have in-built redundancy or "excess" ([16]:17–18). This in turn leads to the car system as a whole having a great deal of unused capacity, making it more inefficient from a financial, spatial, energy, and carbon perspective.

Another important strategy adopted by car manufacturers to maintain profitability is to expand aggressively into new markets, such as emerging and developing countries. The rapid growth of car transport systems therein accounts for much of car companies' present-day profits [89,106,116]. In short, the industry has been adept at achieving growth through spatial expansion alongside the deepening of car dependence in those economies that were early adopters of mass car ownership and use. This shows that there is a spatial-temporal aspect of the continued prevalence of car dependence.

Overall, the automotive industry provides an excellent sectoral

illustration of the self-expanding, spiraling dynamic of value under capitalism, and of the global ecological challenges that emerge as a by-product [117]. The research reviewed in this section is also consistent with Unruh's [34] view that increasing returns to scale are a key driver of 'carbon lock-in': early technological choices which made the industry highly capital-intensive led to a process in which product technology, production technology and business structure mutually reinforced each other and resulted in a high degree of isomorphism and lock-in [86–91]. This lock-in forces the industry to fight tooth and nail against threats to its established business models, and it therefore lobbies to water down regulations on issues such as safety and the environment [16,38,109,118–126]. This suggests that it is the automobile industry as a whole that should be seen as unsustainable, rather than specific products or technologies as is often claimed [89,92,113].

2.4. Lock-in mechanisms on the consumer side

The characteristics of the automotive industry described in the previous sections can be linked to two important lock-in mechanisms on the consumer side. First, the industry's tendency towards overproduction means that new and used vehicles depreciate rapidly, so that their owners are unlikely to trade them in even if they no longer need them. This sunk investment could explain the 'hysteresis effect' in car ownership, whereby households are more likely to acquire a car in response to a change in life situation than they are to dispose of it when there is an equivalent change in the opposite direction [127,128]. More broadly, transport behavior research has demonstrated that "travellers commit themselves to particular behaviors through the ownership of cars (as) they trade a large one-off payment for low (...) marginal cost at the point of use" ([129]:259). This means that the cost of public transport trips (at least when paid on a pay-as-you-go basis) tends to compare unfavorably with the perceived marginal cost of an additional car trip.

Second, the multipurpose nature and surplus capacity of cars has wider implications for how people relate to them, and can potentially explain why, once acquired, they tend to dominate individual travel practices. We discuss this point in more detail in Section 6, along with other aspects of cultures of consumption.

3. The provision of car infrastructure

Mass production of vehicles tends to be accommodated through the publicly-funded provision of supportive systems and institutions, including paved roads, parking, and the enforcement of driving laws [51]. These elements, which we collectively refer to as 'car infrastructure' constitute the public-sector aspects of car-dependent transport systems. The institutionalization of mass car use within these infrastructures is a key element of the political economy of car dependence.

In this section, we first highlight the societal distribution of the costs associated with car infrastructure (Section 3.1), and then focus more specifically on road infrastructure, discussing both how cars achieve domination over existing road space (Section 3.2.1), and how road networks are expanded to accommodate traffic growth (Section 3.2.2).

3.1. The socialization of the costs of car infrastructure

The involvement of the state in the regulation and delivery of transport systems pre-dates the development of the automobile [130], and has persisted since then to create a 'mixed private-public' system in which individuals pay for the vehicles themselves, while various public bodies pay for the infrastructures, institutions, and systems that enable their use ([131]:26–27).

There are disputes over the nature of these financial flows, and particularly over whether user fees and other dedicated taxes are commensurate to the cost of providing car infrastructure [132–134]. Sustainable transport advocates often argue that car travel benefits

from “hidden subsidies”, as costs are shifted to other sectors or externalized, resulting in an underpricing of driving compared to alternatives. Free parking and minimum parking requirements are a good example of this, as they arguably constitute a “hidden tax on [building] development to subsidize cars” ([135]:16). Differences in the level of these hidden subsidies might help explain the differences in driving per capita between the United States versus other OECD countries, although car travel tends to be ‘underpriced’ in most OECD countries ([136]:37).

These hidden subsidies, however, are often so prevalent that they can seem normal and fair ([136]:46). Parking pricing and supply restrictions, for example, are often resisted on the grounds that they harm local development [137]. The lack of charges for the use of most roads has long been criticized as inefficient by mainstream economists, who have proposed various forms of “Pigouvian taxes,” [138] or road pricing, as a solution. These, however, have low public and political acceptance, and their introduction has been limited to a few large urban areas [139–143]. Overall, subsidies to car travel, whose costs are spread among the government and private individuals, are often more politically defensible than support for public transport, which tends to be largely publicly funded [136].

Thus, there is a normalized set of political and policy institutions that spread the costs of driving either among the public at large or among the motoring public (meaning that low users subsidize high users). Either way, this is, according to Freund and Martin, “one expression of how society subsidizes a system of individualized consumption that is highly energy and resource-intensive and is not viable on a global or a long-term scale” ([16]:1).

3.2. The provision of road infrastructure

Roads are the most important ‘infrastructural counterpart’ to cars. The use-value of cars is dependent on the existence of a paved road network that allows fast and safe travel to destinations of interest. Historically, this is achieved by appropriating existing road space for car use, as well as through the provision of additional road space.

3.2.1. The appropriation of road space for car use

Historically, roads were used by a variety of transport modes including walking, horse-drawn vehicles, trams and bicycles. Increasing motorization, however, led to conflicts over road space between motorists and these pre-existing road users, typically entangled with debates around safety, congestion and modernity [144, 145]. A critical element of any car system is the resolution of these conflicts, through regulation and reconstruction of roads to give priority to motorists. Norton's [146] account of the history of the American street is a good illustration of how this occurs. Initially, the introduction of cars onto American streets led to a rash of casualties from collisions, and subsequent calls for stricter regulation of motorists. Motorists and car companies, however, gained enough influence over policy and public discourse to re-frame the problem, so that the solution was to remove pedestrians and other road users from the path of motor vehicles. The outcome of this conflict was thus a ‘social reconstruction’ of city streets as “chiefly motor thoroughfares, open to others only under carefully defined restrictions” ([146]:333).

A parallel process of ‘physical reconstruction’ of city streets further entrenched the domination of the car over road space. The decades-long development of ‘pedestrian infrastructure’ (such as zebra crossings, street crossing signals, and pedestrian subways) had the double goal of “making roads safe for pedestrians” while “keeping them out of the way” of motor vehicles and thus allowing faster traffic flow [147]. Often, the second goal appears to have prevailed, as these measures were sometimes developed *ad hoc* and in the absence of evidence of their impact on pedestrian safety – and there is in fact evidence to suggest that systems like pedestrian railings can have a negative impact on pedestrian safety [148]. Over time, such elements of street design and traffic

regulation have become entrenched and spread globally [149,150]. This complex of infrastructure and regulation can result in a situation where walking, while ‘protected’ from traffic, is slowed down and made inconvenient [151].

Effectively, the twin processes of social and physical reconstruction transform roads from a commons, accessible to everyone, to a space reserved to car users, making a car a critically important need satisfier while also limiting the ability of other transport modes to satisfy people's needs.

Historically modes alternative to the car, regardless of their popularity, were similarly marginalized to make room for them. Tram networks offered a ubiquitous and accessible form of travel [152] but were often removed and replaced with motor buses, partly on the grounds that they were to blame for congestion [153,154]. Cyclists were marginalized based on similar arguments which positioned them as dangerous and obstructive to motor traffic [155, 156]. Many countries in the Global South are today moving in a similar direction of excluding non-motorized transport, such as cycles and rickshaws, from their roads [4,157–159]. In both developed and developing countries, these processes have been justified, not on the grounds that cars outnumber alternative modes (typically they claim road space well before this happens), but claiming that cars are inherently modern, progressive, and inevitable (see Section 5).

The assumption that cars should have priority access to road space has persisted into the present day and continues to make the use of alternative modes more difficult [147,154,160]. In this context, promoting the use of alternative modes of transport requires taking space back from cars [23,161] – a process which can encounter public and political opposition [110], because of the common (but usually erroneous) assumption that these projects will increase congestion [162]. Efforts to sustain the dominance of the car over road space are also clearly visible in recent controversies over whether electric kick scooters should be allowed to ride on the road, and whether the introduction of autonomous vehicles should require further limitations being placed on pedestrians and other transport modes.

3.2.2. The provision of additional road space

Beyond encroaching on existing road space, growing motorization is intertwined with the provision of additional road space. Road building typically requires large, expensive, state-funded projects [103,51], and thus considerable political justification and legitimization. We argue that five typical ‘strategies of legitimization’ [163,164] can be identified (Table 1). The first of these includes two apparently contradictory appeals to *economic growth*. First, the necessity for road building can be presented as *arising from* economic growth, as more economic activity means more car ownership and use, in turn leading to additional road space requirements. This translates to a neoclassical view of demand-driven welfare and utility expansion. The second variant sees road building as being *required for* economic growth, despite the weak empirical evidence on this relationship [165–168]. In economic terms, this is a Keynesian argument of infrastructure and public investment stimulus.

Over time, the emphasis can shift between the ‘roads to accommodate growth’ and ‘roads to kick-start growth’ variants, depending on the economic climate [169–171]. These arguments are extremely effective, as they justify road building under any circumstances, and invoke economic growth, which is routinely considered a political imperative.³ As Reardon and Marsden [167] argue, linking economic growth, growing travel demand and road-building also tends to result

³ It should be noted that although economic growth is still routinely held up as the ultimate metric of progress, its high-level critics have severely undermined this claim, by exposing the links between growth, inequality and environmental damage, as well as lack of connection to well-being and social benefits [172–175].

Table 1
Main strategies of legitimization for road building.

Strategy	Variant	Summary	Application & purpose
1a - Appeal to economic growth	Neoclassical	'road building is necessary to accommodate economic growth'	Used in times of economic growth
1b - Appeal to economic growth	Keynesian	'road building is required to stimulate economic growth'	Used in times of economic crisis
2 - Appeal to popular consumerism	–	'car infrastructure is required by consumer preferences'	Appeals to the political right
3 - Road building as a means to regional development and social inclusion	–	'car infrastructure is required for region X to grow and 'catch up' with the rest of the country', or to facilitate social inclusion	Appeals to the political left
4 - Road building as a solution to the problems caused by increasing motorization	–	'the answer to current transport problems is road building'	Fuels self-reinforcing cycle of road building, traffic growth and congestion, through induced demand
5 - Appeal to technical expertise	–	'road building is sanctioned to be in the public interest'	Removes road building from public/political debate

in the 'discursive depoliticization' of transport policy.

The second strategy appeals to '*popular consumerism*', which sees growing consumption by the public as inherently positive and worthy of encouragement [176]. This argument assumes that increasing car use reflects 'consumer preferences' and thus *deserves* to be provided for with additional dedicated infrastructure. This fits well with perceived electoral benefits of providing "a consumer-minded public with the public investment to meet their private needs" ([176]:99). This framing of automobility as an expression of healthy individualism can be particularly useful to justify public investment in road building in individualistic political cultures, such as American conservatism, which are traditionally averse to public interventionism [177].

A third justification is based on the idea that roads assist with *regional development* and the reduction of spatial economic inequalities, by facilitating economic growth in the regions in which they are built. The post-war British Labor Party, depression-era American governments, developing-world governments, and the EU have all used road-building in an alleged attempt to address spatial economic inequalities [78,176,178,179].

The combination of this more left-wing justification with the more right-wing appeal to popular consumerism is particularly powerful, as it means that road-building can be justified from across the political spectrum, and is thus easy to present as an obvious policy choice that has "transcended party differences, and instead (serves) the general national interest" ([176]:99). Road building and maintenance can thus come to be seen as a matter of basic political common sense, and a neutral indication of policymakers' competence [144]. This means that many of the justifications for road building discussed here, despite being firmly in the repertoires of the 'road lobby' (as discussed below), often do not even need to be voiced.

A fourth strategy of legitimization presents road building as *the main solution to the problems generated by increasing motorization* [176]. Here it is argued that new (and 'better') roads will reduce congestion (by providing the necessary space for handling traffic 'flows') and improve safety (through the segregation of different types of traffic, e.g. long-distance and local). Again, there is an element of circularity here, as greater road provision can result in increased traffic, through the mechanism of 'induced demand' [180–187]. The resulting feedback loop – whereby more roads create more traffic, which in turn leads to calls for further road building – has been identified as a key driver of the self-reinforcing dynamic of car dependence [23,53,188,189]. This ultimately results in the exacerbation of the congestion and safety problems that road building was supposed to solve.

A final legitimization strategy is based on *technical expertise*: road network expansions are officially sanctioned to be in the general public interests (on a scheme-by-scheme basis) by experts applying appraisal methods that are considered to be objective and scientific [49]. Traditional transport planning approaches [3,16,23,149,153,190,191] and mainstream economics methods of appraisal such as Cost-Benefit Analysis often have a bias towards road building, for example when they

disregard or underestimate induced demand, or privilege motorists' travel time savings over environmental impacts and accessibility for all road users [9,185,192–199]. In practice, though, these approaches and methods are often used to confer legitimacy to transport decision-making (on grounds of scientificity and neutrality), even when the decisions are taken mostly on other grounds [43,44,176,200]. This has become increasingly entrenched as the process of motorization has gained momentum, resulting in the establishment of relevant knowledge communities.

While various strategies are used to legitimize road building, certain economic interests stand to benefit from these developments either directly (from road building per se) or indirectly (from greater levels of car ownership and use). These economic actors, often referred to collectively as the 'road lobby', can lend a powerful voice behind the arguments discussed above. It has been suggested that countries that undertook particularly large road building programs, such as Germany and the US, owe this to the power of the local road lobby ([169]:169–170; [72]).

The road lobby can be defined as a "network of vested interests" bringing together the automotive, oil, road haulage, road construction, concrete, steel, insurance, and other industries, as well as motoring clubs [119]. It can act through formal advocacy groups, representing the alliance between different businesses and trade associations, and can influence policy by directly lobbying policymakers (which is often easy due to the fact that transport is typically not a major national election issue), or by shaping public opinion through media campaigns and the mobilization of political support [72,119,176]. While these are all important channels of influence, it must be kept in mind that governments' inclination towards road building might also result from the objective situation of 'state dependence' [38] towards the car industry (and other related industries), as discussed in Section 2.2.

A key goal of the road lobby is to ensure that road expenditures are insulated from competition with other spending priorities, as well as from political scrutiny and the consequences of alternation of different parties in power [38,119,176]. This can happen when governments, for a range of reasons, earmark funds or adopt investment appraisal and decision-making procedures that are biased towards road building. In these conditions, outright lobbying may even no longer be necessary, as road building gains momentum and becomes entrenched into the workings of government.

Despite the formidable material and symbolic forces mobilized in its support, road building eventually encounters three related kinds of constraints [153,176]: (i) *financial* constraints, as it comes into conflict with other areas of public expenditure; (ii) *physical* constraints, due to the need to reclaim land from other uses, which is particularly problematic in urban areas; (iii) constraints related to *public and political acceptability*. These can arise from opposition to the substitution of previous land uses, severance and 'visual intrusion', as well as from concerns for environmental and safety impacts.

Eventually, the push to road and motorway development becomes a

victim of its own success, creating forms of resistance and counter-action, although this will obviously vary across contexts. This kind of opposition spawned a major movement in the form e.g. of North American “freeway revolts,” and British anti-motorway protests, that occurred from the 1970s through the 1990s [51,201–203]. On the other hand, it is possible that at some point existing roads require a schedule of maintenance that is large enough to ‘keep busy’ at least some of the vested interests behind road building,⁴ including perhaps also the automotive industry (as the ‘natural’ replacement of huge car fleets in developed countries still accounts for a large share of their production).

4. The political economy of car-dependent land use patterns

A large body of research in urban planning and transport studies investigates the relationship between land use patterns and travel behavior, showing that factors like low population and building density, low street connectivity, and monofunctional land use result in greater levels of car use [205]. In this context, car ownership plays a key mediating role, i.e. car-dependent land use patterns tend to result in greater vehicle ownership, which in turn induces greater car mileage [206].

Historically, increases in motorization in the 20th century have gone hand-in-hand with significant changes in land-use patterns, creating car-dependent low-density settlement patterns, referred to as ‘urban sprawl’ [207], which in turn have resulted in greater need for vehicle ownership and use. While this broad trend has been more pronounced in ‘new-world’ English-speaking countries such as the United States, Canada, and Australia, it is common to most developed countries [207–212]. More recently it has extended to emerging economies [4,213], although it is unlikely that they will ever reach the same extremes [3].

Much existing research presents sprawl as the unintentional outcome of market and policy ‘distortions’, and of deficient spatial planning (e.g. [23,214]), rather than considering its political-economic drivers. There are exceptions to this, however. Gonzalez [72,121,215,216] adopts an eco-Marxist perspective to explain the rise of urban sprawl in the US, portraying it as the result of a Federal Housing Administration bias, starting in the 1930s, towards the financing of spacious single-family suburban houses rather than city cores. This arguably started as a stimulus policy during the Great Depression, as low-density suburban development boosted demand for automobiles, consumer durables, and energy consumption, thereby absorbing overproduction from some of the biggest American industries at the time, crucially including the oil industry. It thus fitted with the needs of producer groups and real-estate interests involved with the Federal Housing Administration. Thus, from an eco-Marxist perspective, the increased consumer demand and environmental inefficiency associated with car-dependent land-use patterns is a feature, not a bug. In the second half of the 20th century, a range of economic interests “came to rely on the sprawled urban form to create and expand markets for their products” ([121]:345) and US suburbanization played a key role for global economic growth, as well as in pushing up global oil demand [72].

Logemann [217] comes to a similar conclusion, arguing that the tax credits and government loans used in the US to encourage suburbanization can be construed as a form of ‘hidden welfare state’ [218] typical of the American economic model, which uses indirect public spending to encourage private consumption (e.g. home-ownership, car ownership), rather than providing goods and services publicly. This model of state intervention tends to mask “the extent to which government spending ... actually (contributes) to private consumer affluences” ([217]:37). In the case of suburbanization, it also obscures the extent to which sprawl is encouraged by the state, rather than simply being the aggregate outcome of the ‘preferences’ of rational, self-

interested individuals. Similar ‘hidden subsidies’ to car-dependent suburban development have also been documented in Australia [3,219], France [220] and Germany [210,221–223].

Another important feature of Anglo-American suburbanization is how it tends to create political support for car dependence. Walks [224] reviews research documenting the divergence in political preferences between right-leaning suburban areas and left-leaning central cities since the 1950–1970s. He argues that, while part of this trend is explained by a ‘self-selection’ processes (whereby e.g. conservative voters selectively moved to suburban areas that better reflected their tastes), there is also an important ‘conversion effect,’ due to the alignment of suburban lifestyles with privatized consumption, which results in suburbanites’ support for private market solutions ([224]:204). In short, Walks argues that “automobility and the experience of driving help reproduce an ethos of individualism, self-reliance and competition” ([224]:204). This can be seen in local political debates in e.g. London [50], Toronto [110] and San Francisco [225], where suburban car-dependent areas have supported of policies that reduce subsidies to public transport, maintain the ‘hidden welfare state’ supporting sprawl and automobility, and preserve the car’s domination of street space. Conversely, for instance, the German middle classes comparatively greater willingness to support public spending for urban public goods (including public transport) is partly explained by their relative concentration in metropolitan cores, where they directly benefitted from the provision of such goods ([217]:180). Thus, according to Walks’ ‘conversion hypothesis’ [224], urban sprawl is the means through which “automobility generates political demands for policies and programs that promote and enhance the system at the expense of competitors” ([224]:199). This highlights a political feedback loop within the self-reinforcing dynamic of car-dependent transport systems.

Most of the literature reviewed in this section focuses on the Anglo-American world, as these are the countries where sprawl first emerged and are still the most extreme in this respect. While hidden subsidies aimed at stimulating private consumption may well be a common driver of urban sprawl across countries, scholars of suburbanization caution against generalizing features of the Anglo-American suburban model to other world regions and have shown the diversity of e.g. continental European suburbs [226] and ‘postcolonial suburbs’ in African cities [227]. It is, therefore, possible that the political economy drivers of car-dependent land-use patterns will vary accordingly - something that only empirical research can shed light on.

5. The provision of public transport

Growth in car ownership and use is typically accompanied by the declining use of alternative transport modes. While walking and cycling are the lowest carbon modes, their usefulness has historically been diminished by changes in road space allocation (Section 3) and by the expansion of activity spaces resulting from urban de-densification (Section 4). Motorized public transport can, at least in principle, compete with the car on distances beyond walking and cycling range, while emitting less carbon, due to higher vehicle occupancy rates.⁵

Given the relationship between the built environment and car dependence (Section 4), it is often assumed that public transport provision is not ‘viable’ below certain levels of density ([153]:29–32). While there is some truth to this argument, it tends to obscure the important political economy dimension of public transport provision which, in turn,

⁴ For example, Wiedenhofer et al. [204] found that approximately half of the resource requirements for residential buildings and transport networks in the EU25 could be explained through maintenance of existing stocks.

⁵ The scope of our discussion in this section is limited to ‘traditional’ public transport, e.g. we do not consider services such as car sharing. This is for two reasons: first, while they have drawn much research attention, their penetration remains very limited and concentrated in large urban areas which are already less car dependent [228]. Second, the benefits of car sharing in terms of reduced private car ownership, use, and related emissions are the subject of ongoing debate (see, e.g. [229–231]).

can explain why city-regions with similar density levels can vary considerably in terms of public transport performance.

While it is straightforward to provide convenient public transport where the urban fabric pre-dates the motor era, the spatial diffusion of residences and activities puts traditional ‘radial’ public transport networks at a disadvantage [232,233]. Competitive public transport services can still be provided, but require an increased coordination effort through a ‘network planning approach’, characterized by the following elements [153,232,234–240]: ‘supply-based’ service provision and extensive coverage; integration of different modes within a broader hierarchical network; high frequency or timed-transfer ‘pulse’ time-tables; integrated fares and ticketing.

These elements enable the reaping of economies of scope and ‘network effects’, whereby the appeal, patronage and revenue of a public transport link are magnified by the existence of other links in the network [153]. In lower-density areas, due to the dispersion of origins and destinations, the natural monopoly nature of public transport and the magnitude of network effects are even stronger.

While public transport systems designed according to the network approach are associated with higher use [233,234], in practice they can coexist with high (and unsustainable) levels of car use. They do however provide levels of service potentially allowing the satisfaction of basic needs with lower energy and environmental impact, which is helpful from a resilience and low-carbon transition perspective while making it easier to build consensus for car restraint measures ([153]:142;[241]).

Not all models of public transport provision are equally suited to network planning though. Public transport systems are sometimes presented as on a spectrum between central planning and free-market provision [232,242]. However, ‘free market’ forms are in fact planned, created and maintained (for example via regulatory bodies) by the state [56,243] so that in practice public transport systems all have a mix of state and private involvement (Table 2). Mees [153] argues that public oversight of strategic and tactical functions, and jurisdiction over the whole functional region are necessary (though not sufficient) conditions for adequate planning of an integrated network of services, while private companies can be involved at the operational level – a position that is supported within the literature [232,233,238,239,244]. According to this perspective, deregulated (and to some extent franchising) systems will struggle to provide public transport that is competitive with car travel, notably in lower-density areas.

The main reason for this is that providing high standards on the entire public transport network requires cross-subsidies between different modes, routes and operations, and hence the pooling of revenues, and there is no incentive for operators to do so in a competitive market ([153]:152–153). Also, deregulated competition results in ‘fragmentation effects’ such as poor interconnections between services and lack of inter-ticketing, which can be seen as forms of market failure [244].

In the Global North, public transport has alternated between public and private ownership since the 19th century. While there has been a trend towards deregulation and private sector involvement since the 1980s, development has been highly variegated and uneven across countries and regions ([153]:70–71;[232,245]).

No country has gone further in this respect than Great Britain, where local bus transport (outside of London) was deregulated and privatized in the 1980s, in the belief that competition between a multitude of small operators would improve provision [169,246,247]. Yet the consolidation that quickly followed deregulation rapidly led to the market being dominated by few large operators, which effectively act as monopolists in many local areas. There are now strong barriers to market entry, as the ‘big players’ benefit from the economies of scale inherent to local public transport [245]. While they do not cross-subsidize routes that are socially necessary (but unprofitable), they use cross-subsidies to prevent the entry of new competitors [247]. Since the 1980s, and despite the shrinking size of the bus market, firms like Stagecoach have achieved impressive growth through the acquisition of competitors, company restructuring, asset

Table 2
Models of public transport provision (adapted from [153]:72–73).

Model	3 levels of activities in public transport provision			Examples
	STRATEGIC level (setting of objectives)	TACTICAL level (translation of objectives into service strategies)	OPERATIONAL level (translation of tactical planning into day-to-day operations)	
1 Government or municipal department	Performed ‘in-house’ in public agency	Performed ‘in-house’ in public agency	Performed ‘in-house’ in public agency	Much of Europe before the 1980s
2 Public corporation	Shared between ‘public agency’ (‘private’ company in which the state or municipality owns the shares) and political arm of government	Public agency	Public agency	Paris
3 Public transport federation or ‘Verkehrsverbund’	Federation	Federation	Various companies (public and private)	Many city-regions in German-speaking countries (see [233]), Madrid
4 Public agency with sub-contracted, tendered services	Public agency	Public agency	Competitively tendered based on cost and quality	London
5 Concession system or franchising	Government	Competitively tendered to private firms	Competitively tendered to private firms	British railways; Melbourne’s railways and trams
6 Private operation with deregulation	Competing private firms	Competing private firms	Competing private firms	English local buses outside of London; many developing countries

divestment and, increasingly, ventures abroad [247], all the while benefiting from substantial public subsidy [153].

Overall, bus deregulation in Great Britain has been linked to large fare increases and a strong decline in passenger numbers ([169]:90–95; [248,249]);, with associated impacts in terms of fragmentation of services [153,244], increased car dependence and transport-related social exclusion [246,250,251]. Attempts to re-regulate the market have been fiercely opposed by the private operators, as their profits in a deregulated environment are much higher than e.g. in a tendering system [246,247,252]. This suggests that privatization and deregulation, once enacted, are to some extent locked-in by the fact that ‘incumbents’ lobby against reforms that would threaten the status quo.

While instructive, the British case remains quite unique in the Global North, where “private players generally continue to operate under the coordination of regional transit agencies and have a role in service delivery rather than in configuring the network” ([232]:224). However, similar deregulation reforms have been implemented at the local level in other countries. In the late 1980s, for example, Auckland (New Zealand) deregulated bus services on the British model, resulting in broadly similar dysfunction, which led to partial re-regulation in 2009 [153,253–255].

In contrast, it has been argued that the model of *Verkehrsverbünde* (VVs), common in German-speaking countries, is ideal to achieve multimodal network planning in contexts where several public and private actors are involved in public transport provision [153,233,256,257]. VVs are regional associations that coordinate public transport provision over a city-region, integrating operators and local governments in ‘cooperative planning’. Originally developed to counter the deleterious effects of uncoordinated competition in 1960s Hamburg, this model has since been adopted in several European city-regions, with positive effects in terms of increased public transport use and reduced car dependence [233,256].

At the heart of the VV model is the idea of ‘cooperative competition’, in which “businesses emphasize cooperation with their competitors as a means to greater success” ([256]:45), as network effects benefit all participants in terms of greater patronage and revenue. VVs generally require higher public subsidies than deregulated systems, although the differences are not dramatic [233,258,259]. In Germany, VVs are often cross-subsidized using the revenue of more profitable municipal utilities such as electricity [256,258]. Cross-subsidies between different routes and operations are essential to VVs, as revenues are distributed through a single coordinating institution, in a way that is “at odds with the principle of market initiative” ([260]:36).

In the Global South, public transport provision is generally closer to the ‘free market’ end of the spectrum ([153]:75), whereby “a large number of providers compete in a deregulated market, operating individual vehicles, lines, or on-demand transportation services ... with no necessary consideration for broader network context” ([232]:224) and high levels of ‘informal’ provision [261]. This is often the result of the historical transition from state-led development to ‘roll-back’ neoliberalism (through structural adjustment policies), with the associated shift from monopolistic state-owned public transport to privatization [262]. The resulting public transport systems are characterized by abundant supply, but also poor integration, as well as safety and congestion problems, and this in a period of increasing private motorization. While there is a consensus around the need for integrated, hierarchical public transport networks in developing cities, these are hard to implement due to state weakness and resistance from current operators [4,262,263]. As incomes rise and urban densities decrease, the poorly integrated systems of Global South cities may find it difficult to compete with rising car ownership.

6. Cultures of consumption: the ‘car culture’

The cultural institutions that have coalesced around the private car, giving it iconic status across the globe, are fundamental to the car-dependent transport system, and tightly interwoven with all other elements

of the system [51]. These institutions exert a profound influence on people's choices and behaviors, for example in many cases encouraging them to choose to travel by car even if there are other options available, and indeed even if these options might be superior in terms of price, convenience, or societal and environmental impact. This means, inter alia, that many motorists continue to drive cars despite living in cities with functioning public transit systems, walkable streets, or networks of cycle lanes. It also creates another set of political obstacles that obstruct efforts to provide alternatives to car use, which tend to get stronger the more dominant car use is in a given location. It is, therefore, necessary to consider carefully these institutions of ‘car culture’, in order to achieve an integrated understanding of the car-dependent transport system.

The word “culture” is notoriously ill-defined [264]. For the purposes of this discussion, we understand culture as having two components. Firstly, it encompasses the things people *do*: Patterns in individual behavior that recur as a matter of habit, practice, routine, or tradition. While these patterns of everyday life have a relationship with material factors, such as car infrastructure and the capital structure of the automotive industry, they also have their own inertia. The second aspect of culture encompasses the things that people *say, write, and believe* about their own activities and the wider social context of those activities. This includes powerful discourses of gender, nationality, or the good life, which people aspire to live up to in their everyday lives, and also shape how people engage with wider social structures, through either political or commercial decisions. This section discusses each of these components of car cultures in turn.

The cultural underpinnings of car dependence go beyond just car travel and are connected to the very idea of travel as an intrinsically desirable practice. Prior to modern travel infrastructures such as railways and highways, most people did not travel very much at all. The development of railways, however, created a clear economic incentive to encourage people to travel more. This led the nascent railway industry to develop new practices of tourism, as it encouraged people to travel more, to access railway-run resorts [265,266]. The development of the automobile further increased this tendency, leading to the development of new forms of tourism, such as bus and car touring [267,268]. These developments connected with cultural trends in many wealthy countries during the 1920s and 1930s, which prized self-reliance, adventure, and domestic travel as an act of patriotism. As such, the narratives and behaviors that currently entrench the centrality of the car in everyday life initially emerged in opposition to everyday life, as the early car enjoyed a public reputation as an adventure machine. Travelling to new places by car became not only a reason for people to own cars and to drive them more often but also a justification for building new roads and tourist amenities in places of natural beauty, leading to the car-centric development of many areas, which had been more sparsely populated to that point. The practice of “auto camping” was a prominent outcome of these developments in the United States, and it led not just to new patterns of travel, but also to an entirely new form of travel infrastructure in the form of motels [269]. Torrie's [270] numerical analysis of the history of Canadian automobility finds that Canadians radically increased the total distance they travelled during the 1920s and 1930s: cars did not just enable existing mobility needs to be satisfied in a new way; they created entirely new travel patterns which were not necessary before. Today, driving—even if there is no particular destination in mind—remains a common way for people to “escape” from their everyday lives [271]. Cars are a critical part of the frictionless mobility that has come to be an important part of social privilege [272], integrated into people's lives in diverse ways [273].

There is also a distinct temporal aspect of car dependence in everyday life. Shove [274,275] shows how the temporal flexibility inherent to private car use contributes to a fragmentation of the socio-temporal order, i.e. a decline in collective modes of socio-temporal coordination, with a corresponding rise in personalized scheduling practices. In this context, the car as a ‘convenience’ device enables temporal co-ordination, while also contributing to further loosening of

collective schedules, which in turn increases the reliance on cars for co-ordination, in a self-reinforcing process. The end result is an entrenchment of the need for cars to juggle the complex temporal ordering of 'modern life' – as illustrated by the perceived car dependence of commuters with flexible working schedules [276].

Jarvis [277–279] observes that cars can play an important role in the time-scapes of everyday life, as people, under increased pressure from the demands of work, home, and caring for children, will often “buy time” through the use of private vehicles. These kinds of constraints, combined with the sorts of amenities that many people expect to have available in their lives (such as good schools, or houses with backyards) can force people to live in places that they might not otherwise choose, and which are not accessible without driving.

Once a vehicle is purchased, furthermore, it suddenly opens up a whole range of possible uses, including long-distance travel, the transport of bulky objects, and the adoption of new car-dependent leisure practices [59,280,281]. This helps explain why car ownership is a strong predictor of car use (e.g. [129,206,282]). Acquiring a car has a very strong transformative effect on individuals' travel behaviors and thought patterns, making motorists reluctant to switch to alternative modes of transport once a car has been acquired. This is closely connected to the multipurpose nature and surplus capacity of cars, as discussed in Section 2.

Car dependence is thus propped up by a “coercive flexibility”: the automobile affords great flexibility of movement and temporal co-ordination, but it also *requires* it, causing motorists to reshape their lives, their obligations, and their expectations around it [53]. This points to an ‘elective affinity’ and a recursive relationship between social modernization and car use growth [283].

The role of the car in people's everyday lives can also reach beyond mobility, as narrowly defined. Wells and Xenias [284] argue that, in an initial phase, cars were valued as a rapid means of transport, but also as cultural signifiers of ‘freedom’, independent travel and class distinction (as discussed below). However, motorization growth and associated effects (e.g. congestion) tend to erode these functional and symbolic qualities. As a result, the cultural role of the car shifts towards that of a personal space providing protection from a hostile outside environment (in terms of crime, weather, road-traffic safety, encounters with strangers and, paradoxically, air pollution) and ‘cocooning’ (through e.g. insulation and in-car entertainment systems). Many car users are reluctant to switch to alternatives because they enjoy the private space of the car and its affordances, while they feel anxious and vulnerable in public space [15,276,285–294]. The role of cars as a guarantor of safety has its own positive feedback mechanism attached to it, as increasing numbers of cars on the road create more pressure for people to drive cars themselves to protect themselves or their children from traffic danger [295].

These perceptions are actively encouraged by industrial strategies promoting safety and cocooning technologies as selling points, and have two important implications: (i) they provide an alternative source of use-value for cars in saturated and congested contexts; (ii) they give cars an edge over alternative modes (e.g. public transport), which are perceived to compare negatively on these attributes [284].

In addition to this practical functionality that cars have for the everyday lives of their users, they also have important symbolic and discursive functionalities, not only for individual drivers but also for society as a whole. On the most basic level, car use influences how motorists think about transport, inducing a psychological bias towards more car travel, and an aversion to alternatives. Studies of how drivers think and talk about, and behave towards their cars, and how they consider alternative modes of transport, reveal an additional form of lock-in in the entrenched attitudes and patterns of thought that predispose them to prefer car travel over alternatives. This can affect motorists' mental maps of urban environments [296]; their unconscious habits [129,297–299]; and the embeddedness of the car in everyday practices [21,59,274,276,300,301]. Focus group studies consistently show the *discursive* bias that motorists exhibit towards car use [291,302–304]. When talking about driving, motorists focus on

perceived benefits, such as convenience and comfort, portraying these as immediate, undeniable, and conferring a massive advantage over alternatives. Downsides such as congestion, limited parking, and environmental damage, meanwhile, are seen as distant, theoretical, and ultimately negotiable.

These latent predispositions towards car use are also propped up by a more conscious emotional affinity for driving [291,294], sometimes based on incidental elements of car travel, such as weather, road surface and the unique sonic environment provided by the vehicle [271,285,305]. This provides a powerful emotional and psychological attachment to driving, which alternative transport struggles to compete with. When consciously acknowledged, these emotional affinities can be projected outwards, causing car use to become associated with various aspects of individual or collective identity. Cars, for example, have been domesticated as ways of expressing individuality and escape from monotony among some working-class Scandinavian communities; while among Aboriginal Australians, they are symbols of group leadership. While the specific symbolic meaning of the automobile varies by culture, cars are routinely identified as masculine; and as indicators of class and status [273]. This can create a strong inducement in favor of car ownership even for people who neither want nor particularly need a car, as to not own one results in a loss of social status.

These affinities for car travel are complemented by macro-level cultural ‘repertoires’ or ‘ideographs’ [306,307]. The power of these kinds of macro-discourses about technologies, or “techno-tales” [266,308] is well-demonstrated and is not unique to the car [265], but the history of the automobile shows that they played a particularly important role in the move towards automobility. As road transport became more prevalent, popular techno-tales began positioning it as superior to pre-existing alternatives, such as railways and tramways. Streetcar companies in the United States, for example, had a widespread reputation as abusive monopolists. This meant that buses had a unique appeal as a political weapon to progressive politicians in the 1920s and 1930s [309], with a similar phenomenon affecting the intercity railways [144,310]. These oppositional techno-tales gave road transport an early edge and began to associate it with freedom, independence from monopoly, and progressivism while positioning both cars and car-centric infrastructure as a progressive, modern technology [51,177,267,268,311]. These discourses, combined with ideas of national pride and national affirmation and public concerns about the role of road infrastructure in national defense, played a key role in supporting the construction of early motorways [144,176,177,268,312–315].

While these justifications were particularly important in the historical establishment of the road transport system and the political norms that facilitate its continuation, they became less important in later phases, when motorization reached saturation and cars and motorways came to be seen as a kind of mundane necessity for which there is no alternative [144]. Utopian techno-tales gave way to more stable public discourses. A new, defensive variety of pro-car discourses emerged, portraying road transport as the only credible system or as an expression of freedom, and portraying its opponents as either clueless hippies or tyrannical authoritarians [51,68,144].

Deep notions of class can also become entangled with cars; an association deliberately cultivated not just in marketing materials, but in the design of the cars themselves [115]. Cars are also associated with prominent ideas about gender, a factor that contributed to the desires of men to own cars [316], but also encouraged car dependence among women, as driving became a symbol of women's increasing independence during the early twentieth century [317,318]. Class distinction is a particularly notorious example of a cultural trend that supported motorization. Gartman's [115] historical survey of different cultural logics of automobility describes varying roles that cars have benefited from cultures of class distinction. In the modern era of proliferating postmodern subcultures, different patterns of cars (pickup trucks vs. convertibles vs. SUVs) can be an expression of a subcultural identity. This, however, has an unintended consequence for the car industry, as the multiplication of different makes and models tends to

erode economies of scale and profit margins for the car industry (as discussed in Section 2). This illustrates how the cultural dynamics of consumption are a key element to explain the trajectory of automotive production.

The personal habits and cultural narratives underpinning car culture are both connected to the wider structures of car dependence discussed in this paper. The habits and practices of everyday life, for example, are shaped by infrastructural investments, while the political power wielded by car companies can be used to shape the symbolic value of cars in ways that benefit them. Car culture, however, has an inertia of its own: Even if car companies stopped advertising cars and lobbying for car-centric infrastructure, people would still retain the preferences and lifestyles that encourage and in some cases necessitate car use. These cultural aspects of car dependence, furthermore feedback into the other aspects of car dependence. The high cultural status of driving, for example, establishes motorists as an important political bloc, with predictable impacts on car infrastructure and public transit provision. Thus, car culture is not a mere ephemeral or emergent quality of car dependence: it is one of the key driving forces that continues to entrench it.

7. Synthesis: interconnections and underlying characteristics of car-dependent transport systems

In this section, we review the causal interconnections between the five elements of car-dependent transport systems (Section 7.1). These have been briefly discussed in the preceding sections, but are treated here more systematically. Our review also brings to light four “underlying characteristics” that cut across the five elements. These are discussed in Section 7.2, as they provide further insights into the workings of car-dependent transport systems, and have implications for further research, as well as for political action for environmentally sustainable transport systems.

7.1. Causal interconnections

The interconnections of different aspects of car-dependent transport systems are shown in Table 3, emerging from the five literatures reviewed in this paper, and their relationships to each other. Each cell shows causation in one direction, with the titles of the columns showing the cause, and the titles of the rows showing the effect. For example, while the automotive industry influences car infrastructure (through lobbying, for example), said infrastructure also helps to prop up the industry by creating space for the intended use of its primary product. Another example is how car-dependent land-use patterns develop in synergy with the provision of new car infrastructure, while at the same time requiring an increased co-ordination effort in the provision of public transport. Further relations between the five elements of car-dependent transport systems are illustrated in Table 3. Overall, this exercise shows an elaborate structure by which different aspects of the political economy of car dependence create a single, locked-in and self-reinforcing system that is very difficult to disrupt, while also showing some of the historical co-evolutionary dynamics that helped put it in place. Such dynamics are important in revealing that the system is never static, and might change in the future (as we discuss in Section 7.3).

One limitation of our analysis is that our approach is almost entirely retrospective, using historical and sociological evidence to highlight the core elements and tendencies of car-dependent transport systems. These are formidable obstacles to attempts to develop more sustainable transport systems in the urgent time-frame required by climate change. As such, we have deliberately given little consideration to prospective research on sustainable transport solutions and visions. A more prospective political-economic analysis of potential sustainable mobility futures would be a good way to expand on the research presented here. While there is an emerging literature on the governance of innovations such as ‘smart mobility’ [319,320], and ‘Mobility as a Service’ [321], to date this has not adopted an explicit political economy perspective.

7.2. Underlying characteristics

We identify four underlying characteristics which appear throughout our study, and provide deeper knowledge of the creation and maintenance of car dependence: (1) the role of integrated socio-technical aspects of provision; (2) the opportunistic use of contradictory economic arguments serving industrial agendas; (3) the creation of an apolitical façade around pro-car decision-making, and (4) the capture of the state and other entities by the complex of car-dependent transport systems.

7.2.1. The role of integrated socio-technical aspects of provision

Studying the interconnections between social and technical aspects of reality is crucial in understanding the dynamics and constraints of the automotive industry. The all-steel body car production requires immense economic capital, requiring large production levels to recover costs. As a result, the automotive industry cannot deal with downturns. The production of all-purpose vehicles, a result of the capital intensity and rigidity of car production, in turn, induces the adoption of car-dependent practices that become embedded in ‘car culture’.

The appropriation of road space by cars also benefits from being considered from an integrated socio-technical perspective: the physical reconstruction of city streets for car use is not socially neutral but prevents other uses. Spaces physically designed for cars reinforce car culture, not as a neutral preference, but through spatial coercion. Road building is presented as a simple physical solution to the problem, often quantified through the socio-economic lens of lost time and revenue, of car congestion. This view omits both the physical production of cars and the economic (private) interests and (public) costs of the construction sector. As these sectors mature together, they benefit economically from the physical turnover of the large stock of aging roads and cars, representing a classic case of socio-technical lock-in.

7.2.2. The opportunistic use of contradictory economic arguments serving industrial agendas

Integrated socio-technical constraints lay bare the opportunistic use of economic arguments by various industrial sectors: these arguments are not based on macro-economic benefits, as they claim, but on the macro-economy complying with their own economic imperatives. The first and most important instance we uncovered is in the automotive industry, which presents its mission as aligned with growth and development (more cars are necessary in times of economic expansion), but cannot cope with lower consumer demand during economic downturns, and hence demands public rescue packages and subsidies, moving with agility between supply-side and Keynesian economic arguments to keep itself in business. Similar arguments are made by the road building industry, with the additional twist that the construction and road building industry makes strong overt claims that supporting it during recessions can kick-start growth.

Opportunistic use of economic arguments can also be seen in the socialized costs of car infrastructure (parking, roads) for private car use: although car drivers often view themselves as rugged individualists paying entirely for their own car use, they are being publicly subsidized at levels possibly similar to public transport users, but through more obscure mechanisms.

Opportunistic doublethink of a non-economic variety exists as well in the justification of car-centred pedestrian infrastructure, which is argued for on the basis of making public space “safe” for pedestrians (by keeping them off the roads) – but really makes the space “safe” for cars to drive unimpeded and unchallenged, protecting car supremacy. This can result in a vicious cycle, where roads become more unsafe for pedestrians, require additional “safety” infrastructure, with ever-larger dominance of cars over public space. A similar vicious cycle can be seen in the argument for the expansion of motorways and roadways to reduce congestion, which results in more traffic and more congestion through the phenomenon of induced demand.

Table 3
Reinforcing interconnections between the elements of car-dependent transport systems.

	1 Automotive Industry (cause)	2 Car Infrastructure (cause)	3 Land Use Patterns (cause)	4 (Undermining of) Public Transport (cause)	5 Car Culture (cause)
1 Automotive industry (effect)	-	Car infrastructure enables the sale of more cars, by providing space to accommodate them. The status of roads goes from shared public spaces to motorized flow spaces, literally driving other modes out, and enhancing the value of car ownership.	The need for cars to navigate urban sprawl creates an incentive for consumers to purchase more of them, thereby stabilizing demand for automobiles. Suburban, car-dependent constituencies further strengthen the car industry's lobbying efforts.	Historically, the legacy of monopolistic public transport companies has strengthened the political hand of the car industry. Currently, deteriorating public transport forces more people to buy cars.	Car culture produces a continuous demand for vehicles that upholds the car industry. It also influences the cultural dynamics of the industry itself, locking in certain approaches and business models.
2 Car Infrastructure (effect)	The automotive industry plays a key role in lobbying coalitions which pressure the government to invest public resources, and co-opt public space, to make room for cars.	-	The expansion of the suburbs demands high-capacity roads and highways to serve them, while also making it more challenging to travel by foot, bike, or public transport.	Public transport becomes dependent on car-dependent road infrastructure, bolstering the car industry's lobbying efforts.	Car infrastructure has durable cultural associations with progress, modernity, ruralism, and competent governance, which improve its political viability.
3 Land Use Patterns (effect)	The car industry, working with other aligned industries, such as suburban real-estate developers, actively promotes urban sprawl. Historically, car companies promoted visions of an efficient, modern cityscapes and suburban areas.	The expansion of car infrastructure encourages suburban and single-purpose development, which becomes more viable and more desirable due to mass automobility.	-	Lack of public transport options leads to locational indifference of sprawl, with no reason to prioritize land use around public transport axes.	Suburban land use has a potent set of cultural imaginaries (for example, white picket fences in the USA), which encourage more people to move to the suburbs and own cars.
4 (Undermining of) Public Transport (effect)	The car industry deliberately attempts to undermine public transport and is strengthened in its attempts to do so by the fact that the public costs it imposes are more hidden than those of public transport. During economic crises, public transport gets cut while the car industry gets bailed out. Meanwhile, the surplus capacity that the car industry builds into cars gives it a critical advantage over public transport in terms of range, marginal cost, and cargo capacity.	Infrastructure designed primarily for cars crowds out public transport road-based options such as buses and pulls financial resources away from other alternatives, such as railways or tramways.	Lower population densities make it more challenging to effectively organize public transport networks, leading to more car dependence and settlements outside public transport networks, in a vicious cycle.	-	Public transport is portrayed as unattractive, burdensome, and for the poor, young, or infirm.
5 Car Culture (effect)	The car industry actively supports the development of car culture, both deliberately, through advertising and marketing, and tacitly, through the built-in redundancy in the vehicles they sell, and the effects this has on people's daily practices.	Car infrastructure creates practices, habits and cultural trends (e.g. it is normalized as a symbol in children's toys).	Land use patterns, both for residential and work developments, normalize car transport, ensuring that alternatives are portrayed as marginal.	Poor public transport networks encourage more people to adopt car-centric lifestyles.	-

7.2.3. An apolitical façade around pro-car decision-making

Car dependence benefits from the creation of an apolitical context of decision-making, where pro-car decisions are perceived as synonymous with economic growth, modernity and development, and thus gain support from multiple factions. To this end, the concentrated jobs in capital-intensive automobile manufacturing are often used as a bargaining chip to support the automobile industry regardless of other economic and political priorities.

The subsidies for car-related infrastructure are often similarly presented as apolitical and thus perceived as normal and fair. Indeed, the arguments for road-building are oriented to appeal to the political right (growth, individualism) and left (reducing spatial inequality, promoting social inclusion), often based on expert appraisal methods that are presented as scientific and objective, but in fact, often have inherent pro-car biases. These sit well with broader techno-tale, cultural narratives positioning car transport as superior to other modes. Road-building then comes to be seen as a neutral indicator of a policymaker's competence.

Low-density single-family-home land-use planning also comes to be seen as an apolitical norm, with advantageous financial arrangements compared to alternatives and creates a political constituency wedded to car dependence regardless of other positions.

7.2.4. The capture of the state by car-dependent transport systems

The final cross-cutting characteristic of car-dependent transport systems is the capture of the state and other institutions, like labor unions. This aspect is obviously linked to apolitical perceptions of cars and roads as aligned with growth, progress and industrial strength, as outlined above, but goes further. An initial step in this capture could be seen in the battle over public space, which the car lobby won, resulting in the marginalization of pedestrians and other transport modes in road spaces. Individual battles may be won through lobbying of industry-related groups, but their outcomes then become entrenched and institutionalized in specific decision-making processes (regulations), ministries and budgetary items. The road lobby has been spectacularly successful in this regard throughout the industrialized world. Beyond outright lobbying, the scale and economic significance of the automotive industry underpins the phenomenon of 'state dependence', whereby an almost unspoken alignment of interests between state, industry and labor actors emerges.

Presently visible instances of state- and labor-union capture can be seen in the unquestioning delivery of support for automotive industries during economic downturns. These are periodic and overt – however everyday indirect subsidies of car-dependent transport systems through support for car infrastructure are entrenched in all industrialized countries. Investments in car infrastructure become understood as a core role of the state, whose main function is to facilitate (or even induce) private expenditure and consumption (i.e. on cars). The US government support of single-family homes constitutes another example of this phenomenon. In this way, suburban sprawl can be seen as the effect of state capture by the car-dependent transport system, rather than an outcome of citizen preferences (as it is often presented).

7.3. Conclusions and moving forward

Exploring the elements of what we have called car-dependent transport systems, and understanding their interconnections, exposes a deeply self-reinforcing system, apparently immune from economic and political pendulum swings, able to bend the forces that sway the rest of the society to its purpose. In some ways, it is a comprehensive (and rather depressing) political economy anatomy of carbon lock-in. Can we learn any lessons here in breaking free from these interlinked elements of lock-in? We believe the answer is affirmative.

First, by uncovering the elements of car-dependent transport systems and their interlinkages, we can understand better the aligned forces with a stake in maintaining car dependence and be prepared for their responses. Policies for moving away from car dependence will be

wise to address the five interconnected elements together. Second, we believe our contribution will make it easier for alternative transport mode advocates to express their visions: not just as technocratic alternatives involving alternative technologies and healthier lifestyles, but as comprehensive worldviews that challenge an undesirable status-quo. By understanding the chameleon-like ability of pro-car arguments to fit within all economic and political discourses, they become easier to counter.

Third, our analysis of public transport provision suggests that alternatives to car-dependent transport systems will have to be civic-minded, strategically coordinated for the public good, involving the overt redistribution of resources from profitable routes and areas to unprofitable ones through cross-subsidies. Such alternatives cannot benefit from a purported technocratic or apolitical presentation: instead, they should be argued for on the firm grounds of public co-ordination and delivery of public goods for all, while continually exposing the hidden workings of car-dependent transport systems.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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