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Unlocking Economic Benefits of Clean Transportation

(Background Paper for Pre-Event -1)

Final Draft

This background paper has been prepared by Prof. Peter Droege, Director, Liechtenstein Institute for Strategic Development, Liechtenstein and Mr. Sebastian Davies, Curtin University, for the 12th Regional EST Forum in Asia. The views expressed herein are those of the authors only and do not necessarily reflect the views of the United Nations.

Unlocking Economic Benefits from Clean Transportation

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Preface

From movement friendly street geometries and urban form to light rail, from smart buses to track bound or trackless mass rapid transit, from personal VTOLs to delivery drones – a technology driven transport revolution is in full swing. But are there economic benefits that can be unlocked by 'clean' transportation, and what are they - for people, communities, companies, cities, regions and nations – and what are they?

By 'clean' we really mean 'good': appropriate and sustainable mobility and transport modes, fit to maximise the role of the sector in stabilising the global climate, devoid of harmful emissions, renewable energy based, featuring sustainable resource input along the entire value chain and life cycle – and minimising time, resource and energy costs in travel and trips. 'Good' spatial design and urban geometries afford access through proximity, density and the rich quality of synergy and vitality – while also being affordable to all. Good, clean transportation is a public good indeed. As a basic human right, community or public mobility should be free, or very affordable to use. It then has three dimensions: a) emission free energy or fuel, b) spatial configuration and functional integration of cities, blocks, streets and roads – and c) the design or infrastructural integration of the conveyance systems themselves.

This goes beyond calls for integrated land use planning or the shifting of car movements to rail, or attempts at making transport and propulsion systems more efficient. It involves systems of propulsion and motion that are entirely without fossil or nuclear power input, renewable, non-polluting, quiet, elegantly integrated and accessible. The sustainable transport sector as an economic, systemic phenomenon as a bellwether element in local and national economies, local and national policy, framed by and innovating infrastructure guidelines, green bond and other zero-carbon investment and finance funds, industry incentives – all the way to urban design, energy policy, technology policy and regulation they can all help unlock economic benefit through 'clean' transportation. It is also a fundamental feature in the technological innovation and evolution of cities, societies and economies, with profound ramifications throughout all of its associated value chains.

Efficiency, sufficiency and clean, renewable sources, the three dimensions of sustainable energy and resource use, also are valid for transportation. Sustainable development and its economic performance are by no means a surprising pairing: without sustainability there is no economic benefit, no efficiently functioning economy.

1 Terminal cost avoidance: the ultimate economic benefit

Ending fossil fuel use in transport has both the highest priority and economic benefit, as it means lowering the risk to incur the ultimate, ie highest possible cost - the very termination of economic activity. Nuclear electricity, too, poses massive risks, not only in accident and waste disposition risks but also in terms of inevitably increasing unreliability and failure under vortually all climate change scenarios: increased heat, cooling water source evaporation and diminishing operational management capacities in times of government and corporate financial and operational distress.

Mechanized transport represents close to 30% of final energy demand globally. All major sector modes: passenger transport, road freight, aviation and international shipping -are said to show good energy intensity improvement potential during 2017-2040 (IEA 2019). However, all such mechanized transport is still 95% petroleum dependent, and the massive hydrocarbon flow shows little sign of abating. Global emissions are at 410+ ppm in atmospheric CO2 concentrations and exponentially rising, with a series of feedback mechanisms kicking in: methane levels are at the verge of flaring up. An emergency mechanisms requires application: the rapidly reduction of emissions through maximising the power of proximity design and the rapid acceleration of renewable energy throughout the system.

Many calculations and estimations exist on the economic cost of climate change (Stern 2006, EIU 2015) – implying a corollary benefit will presumably result from actions designed to compensate for emissions. Most, if not all, showed both the simple strength but also the deep flaws in the approach. For example, in 2015 the Economist Intelligence Unit (EIU) stated, somewhat ludicruously:

> *'Warming of 5°C could result in US$7 trn in losses – more than the total market capitalisation of the London Stock Exchange - while 6°C of warming could lead to a present value loss of US$13.8trn of manageable financial assets, roughly 10% of the global total.'* (EIU 2015)

These calculations were grotesquely, even cynically flawed. At these temperatures losses could not be limited to something comparable to the equivalent of the 'London Stock Exchange's capitalisation' but would encompass the entirety of the known global economy. A warming of 2 or 3, let alone 5°C is likely going to be extremely damaging if not fatal for a majority of humanity. It would trigger the ultimate cost – not only when compared to current frameworks. Because of the loss of life - most people would most certainly lost at a 4°C rise (du Pont and Malthausen 2018) - the cost would be infinite. More importantly, it is not plausible that a 5°C rise in such a short period of time of no more than 150 years, could even be controlled at that level. The greatest and most rapid temperature rise in Earth's history, the Paleocene-Eocene Temperature Maximum - PETM - warming spike of 55 million years ago played out over thousands of, perhaps 15,000 years, increasing global average temperatures by 6-8 °C. Today we face a potentially even more dramatic PATM – the Post-Anthropocene Temperature Maximum. The PATM plays out in a mere 50-100 years, a tiny fraction of the time the PETM took, on the burst of a far more powerful greenhous gas boost – so far 6-7 Gigatons of carbon annually, plus 1 GT of methane - as compared to perhaps five times of C today, and 27 times the methane - that triggered the deep-ocean killing PETM. There are too many feedback mechanisms at play not to trigger a runaway heating process leveling perhaps at 10-12 °C after a short spike – or keeping going all the way to 250 °C, as Stephen Hawking posited, boiling and burning off all oceans and forms of life. A 12 degree rise already within the realm of the possible, given that methane concentrations have rised threefold while CO2 'only' rose by 40%.

Eliminating fossil fuels through a combination of total demand reduction, efficiency improvements and simultaneous source and fuel and propulsion system substitution are key to achieving the highest, indeed infinite economic benefit: contributing to the avoidance of human extinction. Nothing can be more productive than eliminating fossil fuels and boosting carbon absorbing natural environments and industrial processes.

This requires equipping local communities, regional systems and national economies with distributed renewable energy supplies, networks and infrastructures: building both locally integrated and large-scale solar and wind, solar powered propulsion and locomotion systems, renewable electric and hydrogen buses and trains, and heavily investing in the substitution of the entire fossil and nuclear infrastructure by renewables.

Many economists agree that fossil fuels are stranded assets from an investment point of view – and their production and supply systems a drag on national economies, credit balances and the health of nations. The cost of military systems and risks of spreading conflicts over fossil energy resources have simmered for over 100 years, and frequently exploded in the Middle East, Eastern Europe, Africa and elsewhere, and threaten wreak havoc elsewhere, for example in the South China Sea, with China jockeying with many SEA nations for natural gas fields. Decommissioning nuclear power plants is a critically important measure in the age of accelerating climate change when centralised, water cooled thermal generators in extensive high tension power grids are going to be increasingly difficult to maintain: they have become thermal time bombs - activated by temperature rise over time, as water and human capacity to manage complex systems inevitably evaporate.

2 Healthy benefits: accident and pollution avoidance

The 2030 Agenda for Sustainable Development set a target of halving the number of traffic accident fatalities by 2030 – the World Health Organization estimates that these cost most countries 3% of their gross domestic product (WHO 2018), or 2.4 trillion USD in 2017, when the GWP stood at 80.27 trillion (CIA 2017). There are other economic benefits associated with reducing motor vehicles use as well as switching propulsion energy sources. The steep rise in pedestrian fatalities alone paints a grim picture: more than 40% in the United States in the the years since 2008, highest since 1990, and 16% of all US traffic fatalities in 2018. Blamed are, ironically, increased walking especially at night, predictably paired with insufficient crossings, rising numbers of SUVs and 'unsafe driving' (Rettig 2018).

Air pollution is reported to cost more than $5.11 trillion annually in welfare costs (including health and consumption data) globally, with the most dire damage incurred in the developing world – lost income alone is valued at 225 billion annually (WB 2016). Cities everywhere are affected, not only those in the developing world.

The welfare figure incorporates a number of costs associated with air pollution like health and consumption. Only considering lost income, air pollution costs the global economy $225 billion annually, the report says.

Included in these figures are both indoor and outdoor air pollution. Indoor pollution from home heating or cooking, remained level for decades despite. Outdoor pollution has risen massively with the rise in industrial activity and transportation (WB 2016). As a calculational *quid pro quo* the massive health costs incurred through lack of movement created by Car City are *not included* – obesity, high blood pressure, heart attacks and strokes are only some of the more common health problems. Taking traffic accident and air pollution fatalities and welfare costs – these total annual 7.5 trillion annually.

3 Systemic economic benefits: sustainable transportation innovation as purposeful technology advancement

Lowering mechanized transport energy demand by optimizing the systems and spatial geometries underlying in bold and imaginative ways is essential, but this must be matched by a supreme policy focus onto technological innovation, to remove all non-renewable content from the entire system. Although the electric car by itself presents an enormous efficiency advantage of the ICE powered car self-driving cars, it requires a 100% renewable infrastructure to really extend that gain. Still, it generates all the other problems of cars: congestion, wasteful land use, destroyed urban fabric, cultural decline, pedestrian and other accidental deaths. Uber style application driven innovations and other individual motor vehicle novelties do not by themselves produce any advantage when it comes to purpose, social benefit and sustainability. Similarly, there es yet no indication at all that self-driving or autonomous vehicle make much of a difference.

Transport technology innovation and investment are high impact economic drivers. Throughout history, advanced systems of propulsion and conveyance meant profound civilisational advantage, economic advantage and settlement growth – besides providing a military edge. Innovation is essential to possibly avoid a central feature of much of human urban civilization in the past: the seemingly inexorable collapse of the human settlement networks that made up urbanised empires throughout history (Fletcher 1995). Roman road systems and carriages, Egyptians canal and road networks, Angkor's elaborate water management and irrigation systems, the Mongol Empire's migration routes, Chinese imperial dynasties' road and street networks and urban civilisation – they all had the same fate in a long and glorious rise, und ultimate fall. The challenge today is to find genuinely transformational innovations that can both boost economic benefits and stave off collapse by building resilience. The invested spatial capital postulated by Fletcher as reason for collapse has its analogy in our incumbent energy and transport infrastructure investment. Comprehensive renewal is required to increase our chances at staving off collapse.

The gains go far beyond the land use benefits most commonly described in treatises about economic benefits derived from sustainable transport. Today, electric cars, autonomous driving, vertical takeoff and landing vehicles or VTOLs, proximity enablers such as ITC enabled advanced telepresence systems, T-com, 3D-printing of vehicles, hybrid modes of transport integration and the long rediscovery and resurgence of traditional, integrated, place based and fine-grained street network theories and practices (Duany 2012, Jacobson 1996, Hillier 1995) present countervailing forces. Each one is vying for recognition and application in optimized and purposeful manners and carriesits specific, quanitifable benefits and costs – but there can be little doubt about their economic benefits through mere activity stimulation and flow-on impacts into the wider economy.

The benefits of technological innovation on economic growth and performance are well studied and documented (Zalewski and Sawinska 2009, Sener and Sandogan 2011, Oystrakh 2016, Maslennikov 2017, Bilton et al 2017, Broughel and Thierer 2019). By shifting investment from conventional transport into advanced regenerative transport systems (ARTS) entire value chains are being triggered:

AI
TransTech
Automation
Material science
Finance and Fintech
Urban development
Information technology
all do not exist in isilation but impact a greater world.

Bilton et al (2017) focus on five technological innovations of profound impact in embracing technological innovation: in ‘delivering long-term benefits for the economy: **cloud computing, IOT or the Internet of Things, AI or Artificial Intelligence, robotics and blockchain technology.** All five have a strong role to play in transportation technology innovations and management, ricocheting within and beyond the various technology innovation realms.

Avoiding failure: endow technological progress with purpose

Progress, however, cannot be expected without a shared and positive purpose. The economic benefits of purposeful technological progress: vision, planning, policy and regulation are key to avoiding and/or learning from failures. Emerging technologies are likely to shape the economics of sustainable transport and sustainable cities – but are they likely to improve sustainability itself?

TNCs: a story of dashed blind hope in progress

The fact that technological progress without policy and regulatory guidance cannot be expected to yield improvements can be demonstrated by the rise in ITC augmented personal transport services. The rise of Uber and its global, regional and local derivates, transport network companies (TNCs) has brought much excitement about the abililty of engaging 'last mile' services in support of public transit. The reality and lessons learned in the fastest growing global market, that of the United States, paints a sobering picture. TNCs focus on central city business only, and on their own customers, who seek to avoid parking fees and other conveniences over the desire to reach public transport systems. Moreover, Uber and Lyft have more than doubled individual car traffic in the United States and concentrated it in inner cities – just where pedestrian density tends to be highest (Schaller, 2018).

This illustrates the principle postulated by Droege (2006) that throughout modern history, each technological advance in transport and communications has tended to remove a level of spatial constraint – from horsedrawn suburban tram networks to motor vehicles to ubiquitously networked transport services to autonomous vehicles. The only aspect that can prevent this evolution from descending into chaos is purposeful intelligence, policy and judicious self-restraint.

In the first half of the 2010s a program funded by the European Community looked intensively into evidence for economic advantages in transport sustainability, EVIDENCE. Appendix 2 assembled some summary characterisations of the beneficial aspects of same (Shergold and Pankhurst 2016).

4 Economic benefit through spatial optimisation: Traditional-Space Emulating Development (T-SED)

Traditional-Space Emulating Development (T-SED) is marked by projects of adapting preservation, but also new development marked by exceptional integration, connectivity, public transport connectedness, urbanity and well-structured multi-functionality. Often these projects are also characterised by a high performance in local appropriate bioclimatic design. In transport terms it is well linked and supremely organised internally.

Good T-SED based design - also known as good urban design - has had the highest ROI, land values, net leasing yield, profit margins of any property investment. The seminal Australian Design Dividend Project (Droege et al 1999) showed that those projects that took advantage of and contributed to their urban settings are far more resilient to down turns and have a higher upside in boom times, when compared to wider indexed property behaviour.

From a climate viewpoint all of this is of limited use without sufficiency, efficiency and fuel substution. While views differ on this: the rebound effect is likely to neutralise efficiency gains quickly, and sufficiency by some is take up by the opulence of others (Greening et al 2000).

City form as movement facilitator

It is a fundamental fact - but not widely understood - that the very basic function of all cities and buildings is to facilitate movement. Spaces, settlements, urban regions have always been optimised to bring people together, assemble brains, move information through brains – and to convey people, their services, goods and waste. Cities are made to facitilitate movement – their very fabric engenders or hinders transport. Cities do not just require or feature transport: cities *are* transport, 'Space is the machine', as the Bartlett School's Bill Hillier cites one of his students exclaiming in a moment of epiphany about the understanding the role of architecture and urban form as being a 'machine' to live and work in, in the terms of Le Corbusier.

Hillier demonstrated the key link between urban form and movement, with the very geometry of the urban network the primary driver of actual movement patterns (Hillier and Hanson 1984, Hillier 1996 and 1997). Hillier describes this relationship as the principle of natural movement guided by spatial psychology and visual cognition, and this principle shapes the urban fabric and its uses according to the predominant pedestrian and vehicular modes and their spatial perception and orientation psychology. Grid integration and connectivity are supreme values and performance dimensions of highly used streets. Along these the highest value businesses and real estate can be expected to locate. The configuration of the urban grid does not necessarily differ between pedestrian and slow-moving automobile driver logic in itself, although as automobile traffic takes becomes prevalent usefulness to pedestrians changes by virtue of the disruptiveness and coarseness of street connections of the latter, favouring car driven choices.

The seminal findings of Hillier illustrate the economic efficiency and optimisation that can be achieved by aligning urban geometry with land use. He also found a high correlation between integration value of spatial transport vectors, land use, land values and crime rates, as measured in burglaries and street assaults. This logical system has been structured and packaged into the Space Syntax method of spatial analysis and design. The observations support the fundamental geometric framework of place based complexity, where functional and land use integration, vertical zoning – pedestrian oriented retail and ground floor uses, with residential and office uses above - the age old shop-top or shophouse configuration – provides the seed for application in new development.

At a more simplified level the physicist Cesare Marchetti observed that the time most people budget to commute a day is one hour (Marchetti, 1994), stretching increasingly across space throughout history as transportation technology became increasingly mechanised and fast. This figure is misleadingly referred to as *Marchetti's Constant* since Marchetti attributed it to transportation engineer Yakov Zahavi; and Lewis Mumford to Betrand Russell (Mumford 1934). This observation resonates with a well-known dimensional principle of the Greek *polis* of the Bronze Age, built around the idea, that physical form provides an civilising framework for democracy – perhaps its very cradle.

Depending on economic circumstance, fewer people have fixed budgets of this kind in the car suffused hybrid city, as experienced by the denizens of suburban conurbations, or peri-urban slum dwellers who spend many hours a day commuting every day. Time also stretches and contracts: these behavioural patterns also depend on how commuters perceive the nature of their chosen transport mode: taking public transport can be falsely experienced as slower than driving. Frequent drivers tend to think of sitting in a car queue as productive 'travel'. They consistently underestimate how long they travel by car or wait in traffic – and overestimate comparable travel time by public transport (Fuji et al. 2001). *Time* does not equal *time* – *perceived* time matters.

Still – cities exploded with faster travel choices, leading commuters into ever longer commutes, in slums and city regions of suburbanised countries, like the United States, alike.

The Marchetti Constant does not suggest that cities tend to be 'one hour wide' but that, given choice, *people tend to organise their lives and daily travel patterns around a one-hour commuting maximum* – naturally this could be within a much larger city, conurbation or metroregion. The 'Theory of Urban Fabrics' seems to be based on the former reading, the one-hour-city assumption. It postulates three fundamental forms of urban fabric, based on the changing spatial extent allowed at higher ground travel speeds: the so-called walking, transit and automobile city (Newman and Kenworthy, 1999). Pedestrian geared development - the 'Walking' City - indeed existed for thousands of years. This is a compact and dense urban fabric, and where it can be found in a single urban setting, usually supportes a population of between 30'000 – such as the Greek *polis* of the Bronze Age - and 100,000 people, although some notable exceptions to this rule exist.

The transit based city emerged with the railways and tramways of the 19th century, and spread the city in radial corridors from the old walking core. 'Transit City' suburban infrastructure extensions allowed the old 'Walking City' core to be extended and proliferated into the region, but, where they are well designed, concentrated in dense, mixed use development around railway stations and tramway corridors – smaller 'walkable city centres' in themselves.

The automobile or car based city developed in the mid-20th century, and substantially expanded the scale of cities, fundamentally changing their form from tightly woven, organically grown grids to larger, lower density and larger blocks fed by roadway hierarchies over vast territories. This 'Automobile City' is generally marked by separated land uses. (Wright, 1932; Herman, 2012). Modern cities are seen to be a hybrid of these primary modes of movement and associated urban fabrics. The form of the three urban fabrics – density, spatial extent, land use mix and ecconomic dimensions – have been discussed at length (Newman and Kenworthy, 2015), there are several differences in the economics of these three forms.

To this we can add a fourth and fifth 'fabric' or type: the Hybrid and the Virtual City Fabrics – a rising bane of city planners everywhere. The advent of modern telecommunications and information technology created virtual community networks and fleeting, stringy realms that have spatial chracter but also littered the globe with wholly incongruous and incoherent waste scapes, ranging from data centers in far-flung suburban realms to low-wage manufacturing facilities springing up in southeast Asian rice fields, creating traffic jams and time-space discontinuous pressures far from the traditional 'walking', 'transit' and 'car' cities, in homogeneous heterogeneous spaces of an increasingly chaotic planet, alien to itself.

Hybrid City is the most common form: the distinctions of the three are highly artificial, since none of them can be found in pure isolation. Walking City - or traditional, pre-industrial – space patterns are most concentrated, with a high share for walking, high levels of consumer services and high land values. Automobile City is the most spatially extensive, with a higher proportion of land-intensive uses, such as hypermarkets, warehouses and car yards. Such land-intensive uses naturally require inexpensive land, and land values are lowest in the dispersed Automobile City. Walking and transit use are lowest in automobile city fabric, as it lacks the dense, mixed-use agglomerations that are most suitable for successful transit services. The low density and spatial extensiveness of the Automobile City results in high infrastructure costs (Trubka, Newman and Bilsborough 2010, Transportation Research Board 2000).

In a nutshell, the economic dimension here lies in the scarcity of land and the opportunity to save infrastructure costs through concentrated development. One source of the space savings of walking and transit urban fabrics is the space savings of different transport modes. The automobile requires large areas of road and parking space, compared with reduced road space required for walking and cycling, or the road and parking space required for transit.

The savings in land and infrastructure costs also enable a more compact urban form and larger labour markets, resulting in productivity gains due to agglomeration economies. Larger labour markets and higher density have been observed to increase labour productivity in cities around the world (Trubka, 2011; SGS Economics and Planning, 2012; Melo and Graham, 2009; Combes et al, 2008). Indirect transport emissions for electrically-powered transport will also reduce further as the electricity supply is decarbonised with a switch to renewable power.

Changing economics of sustainable transport

After decades of car-oriented growth, cities around the world have begun returning to investment in transit infrastructure (Newman and Kenworthy, 2015). This “Second Rail Revolution” has been seen in both developed and developing cities. This phenomenon shows up in increased transit patronage, increased investment in transit infrastructure and a plateau and then fall in vehicle kilometres travelled (Glazebrook and Newman, 2018). The latter is despite a long term trend of a falling real cost to purchase a car and rising incomes and rising rates of car ownership (Newman and Kenworthy, 2015). There is also evidence of young people acquiring their first driver’s license at a later age (Delbosc and Currie, 2013), although there are many possible causes of this phenomenon.

Private cars require a large amount of space compared with other modes, or conversely, the *capacity* of roads and private vehicles is relatively small. A high capacity metro lines can potentially carry twenty times the number of travellers as a single expressway lane. The spatial inefficiency of private vehicles inevitably limits average speed in the long run, as road upgrades are quickly filled with new traffic, as predicted by the concept of Triple Convergence, as outlined by Downs (1992), and in other theoretical and empirical studies.

This can be observed empirically, with data from the Global Cities Database showing that average speeds on rail were almost as fast as traffic speeds in the North America, at 95%; 28% faster in European cities; and 8% faster in Australian cities. In developed Asian cities, rail speeds were 13% faster where high quality railways and high urban density make car-dominated transport systems infeasible. Time is money.

4 Transport systems integration: proximity still is king

To skilfully, sublimely and elegantly connect transport into transport-integrated land use and spatial systems is an art, and key to the performance of cities. Their economic systems are optimised or deteriorated, weakened, depending on the priority place on the design of these dynamic and static systems.

LUI is seen to yield high economic benefits, rippling throughout the economy in the wider impacts such as those described by Wang et al (Wang, Zhong and Hunt. 2019) studying integrated land use transport models.

LUI is seen as the secret to achieving, or providing the civilising framework for successful centrality. Saskia Sassen (1997) described the countervailing trends of information technology: centrality and dispersion, spatial concentration and distribution, or sprawl. Droege described the opportunities in hybrid settings: integration also occurs in the virtual dimension of the computer augmented space-time continuum.While the limits of automobile-based transport were reached a profound economic shift was observed, with some aspects of 'the knowledge economy' becoming increasingly urban, and therefore urbane. Some knowledge industries thrive on face-to-face contact and walkability – others on low cost, far-flung ex-urban sites (data centers). These are part of the countervailing trends intrinsic to information technologies, which can reinforce concentration but also drive spatial segregation and social isolation (Droege 1997).The return of physical proximity seems manifest. This type of contact is best facilitated by place-based integrated urban development of mixed use, usually based on traditional urban environments, structured around well connected, integrated urban networks – urban geometries. The so-called knowledge economy, not dependent on city fabric destroying, mono-cultural industrial space, and appreciative of synergy and serendipity in encounters, have driven a return to the inner cities after decades of neglect (Gleiser, 2012; Florida, 2002). The result may be another delimiting factor in car use (Puentes and Tomer, 2009) and a reinvigoration of sustainable transport and sustainable cities.

The ‘economics of parking’ help to limit automobile-based growth as well. Car parking is generally required on private land as a condition of receiving development approval, as well as ample public space dedicated to parking. The unstated objective is generally that parking be supplied to such an extent that parking be provided free to the motorist and supply still being sufficient at peaks in demand. In practice, this often results in a legal requirement for commercial developments to have a larger area devoted to car parking than to lettable floor area, regardless of cost or demand (Shoup, 2011).

Despite the substantial cost to the economy of such policies, this model still reaches its limits even at its intended objectives. The under-pricing of parking often results in lengthy search periods looking for a free or cheap bay (ibid.). There is a substantial value attached to this time, which could be put to more productive purposes, and it undermines the speed and convenience of the private car. These policies also affect economic development. In the United States alone the cost of foregone development was estimated in 2012 at between US$127 billion and $274 billion per year (ibid. page 591).

Reforming parking frees up more space for development and walking, which allows movement of large volumes of people (Newman and Kenworthy, 1988). A pedestrian requires only 0.7 m^2 per person to travel, whereas a car requires 40 m^2 per vehicle on an urban street and 47 m^2 per person on an expressway (Montgomery, 2013). Average vehicle occupancies are typically little over one person per vehicle, so driving requires that each person take up in the order of fifty times the space as if that person were on foot.

Increasing car use has long been viewed as an inevitable consequence of rising levels of wealth, and average wealth levels are incorporated as an independent variable into traffic prediction models. However, recent evidence has emerged of car use peaking in many cities, while wealth continues to rise. Car use is thought to be peaking in Germany, Australia, France , the United Kingdom, United States and Japan.

Trubka (2011) investigated agglomeration economies in the two largest Australian cities, modelling labour productivity. This study confirmed significant productivity benefits to density and proximity in knowledge-based industries.

5 Securing economic benefit through capacity building on transport finance techniques

Theoretically, cities in both developed and less developed countries can implement sustainable transport and develop sustainable cities. Promising mechanisms to facilitate this would include the following.

Challenging but rewarding: funding and financing through private land development

Over the past thirty years, substantial research has been done on the link between transit and land values. It has been well established that quality transit, particularly railways, boosts land values and accelerates development (Salon and Shewmake, 2011; McIntosh, Trubka and Newman, 2014; Cervero, 1994). This finding, observed in cities around the world, naturally raised the idea of tapping into this increase in land values to help fund the infrastructure itself.

However, this implies that the increase in land value can actually be tapped into. Before embarking on this complex, costly and risky path it is important to ensure that all institutional, political, regulatory and professional financial and negotiation skills and conditions are available and secured in place for many years to come in order to sustain a potentially arduous path to success. It is also important to be prepared for the fact that 'the public purse gains last' – that any profits will be sequestered swiftly along the development value chain. Given this caveat, it is profitable to consider the potential benefits outlined here. This notion of value capture has been pursued in the public policy realm, borne of academic publications (see, for example, Federal Transit Administration, 2018; Transport for London, 2017; Department of Prime Minister and Cabinet (Australia), 2016).

To date, the thinking has mostly centred on new levies and charges for property owners or developers. Since the devolution frenzy of the 1980s interest has focused on the role of the private sector in defining and procuring projects (Newman et al. 2017b; Davies-Slate and Newman, 2018; Newman et al. 2018a; Davies-Slate et al. 2019), either in partnership with the government, or with government acting as land provider, enabling regulator and interested approval authority, as a more or less direct participant in the project. This approach has been used successfully during the early rail history, and more recently in the transit-integrated metropolises of East Asia, such as the major cities in Japan, Hong Kong and Singapore (Cervero, 1998; Davies-Slate and Newman, 2018; Levinson, 2008).

Partnerships are said to create innovation, community support, financial security and agency enablement of land assembly and permits.However, they can also result in semi-public or privatised environments. City Deals have been promoted for the purpose of aligning the different tiers of government, the private sector and communities.

A problem with deals and partnerships can be that they require very sophisticated planning cultures, and that overwhelming evidence shows that communities become gentrified and cities are usually left to cover the tab, while the business community insists on guaranteeing its ample profit margin, taking little or no risk.

The 'ten principles for successful Public/Private Partnerships' (PPPs) espoused by the Urban Land Institute shows the level of maturity and certainty required – besides an uncanny ability to understand abstract instructions such as these, and the easy sophistication in converting them into well-resourced and prioritised practice:

'Prepare Properly for Public/Private Partnerships'
'Create a Shared Vision'
'Understand Your Partners and Key Players'
'Be Clear on the Risks and Rewards for All Parties'
'Establish a Clear and Rational Decision-Making Process'
'Make Sure All Parties Do Their Homework'
'Secure Consistent and Coordinated Leadership'
'Communicate Early and Often'
'Negotiate a Fair Deal Structure'
'Build Trust as a Core Value'

(Corrigan et. al. 2005)

Many cities - in any economic or cultural state of development - are not in a position to negotiate good and lasting outcomes for themselves and their communities, and can be pressured to relinquish control and make concessions as the private partner ramps up pressure.

Successful cities have learned that it requires political strength, vision, perseverence, skill, resources, organisational maturity, mechanisms of quality control - and pervasive integrity by all partners – rare occurrences indeed.

There is a role for the private sector in sustainable transport and cities, easing land assembly, expediting permits and engaging locals and communities from the outset – but it requires delicate handling and experienced management. Cities and regional entities are to acquire these in-house financial and management skills along the institutional frameworks before initiating development partnerships. There are synergies – but interests are also fundamentally different.

Appendix 1

Technological Innovation and Economic Growth

'… Most economists agree that technological innovation is a key driver of economic growth and human well-being. Negative cultural attitudes about technology and its disruptive effects could threaten reaping these benefits. Policy responses that reflect such attitudes (and discourage innovation) risk triggering economic stagnation, decreased economic dynamism, and lower living standards….'

THE EFFECTS OF INNOVATION

- *Technological innovation brings benefits. It increases productivity and brings citizens new and better goods and services that improve their overall standard of living.*
- *The benefits of innovation are sometimes slow to materialize. They often fall broadly across the entire population. Those who stand to benefit most—the poor and future generations—have little or no political influence.*
- *Innovation causes short-term disruptions. These disruptions may be unsettling, as some old business mod- els fail and some individuals lose their jobs.*
- *Incumbent interests may resist change. Those affected are often well-organized and powerful. They may try to derail opportunities for innovation and entrepreneurship that could lead to more growth and pros- perity over the long haul.*
- *Policymakers act within notoriously short time horizons. They are also likely to hear disproportionately from constituencies and interests that are harmed by new technologies. This may lead to (1) resistance to change among policymakers and (2) policy interventions that stifle entrepreneurship and protect incum- bents from new competitors.*

  THE NEED FOR SOUND PUBLIC POLICY
  Public policy plays an important role in fostering innovation by establishing the "rules of the game." These include the rule of law, property rights, patent protections, contracts, free trade policies, freedom to travel, various incentives to invest, and light-touch regulations and regulatory regimes. When it comes to new technologies, the policy default should be permissionless innovation rather than restrictive regulations.

  Permissionless innovation is the idea that experimentation should generally be permitted by default, even when innovation might lead to some short-term disruption of established business models. In the long run, the perpetual search for new and better ways of doing things drives human learning and, ultimately, prosperity for all.'

(Broughel and Thierer 2019)

Appendix 2

The evidence of EVIDENCE

Evidence of the Proven Economic Benefits of Sustainable Transport Initiatives to Facilitate Effective Integration in Urban Mobility Plans (EVIDENCE) - Results

- The review of evidence clearly demonstrate that sustainable urban mobility interventions and investments are as effective as "traditional" infrastructure projects, which are typically adding new road capacity in or around cities.
- The evidence presented in this study reveals that shifting patterns of spending and project selection away from new high-capacity roads or intercity high-speed rail links has the potential to reduce congestion and pollution and create highly attractive living environments that are increasingly factored into global decisions about inward investment, corporate relocation and the attraction and retention of highly qualified staff.
- The Cost-Benefit-Analysis (CBA) methodology is widely criticised in the transport literature for the way it skews decisions in the direction of projects such as additional road capacity, when a wider analysis of costs and benefits would produce a more balanced approach across all modes. It is clear that if we include values for the health benefits and reduce the importance of time savings in calculations, we would get very different results. It is likely that such an approach would result in more funding for traffic reduction and decarbonised road transport.
- Clear messages emerged from the evidence review about practical steps that should be taken to ensure sustainable urban mobility interventions are deployed successfully and their economic, social and environmental benefits are maximised. These factors have been categorised under the themes of 'Deployment', and 'Acceptance' (see 'The Economic Benefits of Sustainable Urban Mobility Measures - Independent Review of Evidence: Report'.
- EVIDENCE has published key evidence sources available to support the view that investing in sustainable transport measures produces outcomes that are economically successful (see www.EVIDENCE-project.eu). The website registered over 12,500 visitors and 60,000 page views, 677 backlinks and more than 19,000 document downloads. Around 600 individuals followed the project on Twitter and LinkedIn.
- EVIDENCE has produced a large body of evidence to support an enhanced role for sustainable urban mobility in EU cities which has been summarised in a series of documents that should be part of the essential reading list of policy makers and practitioners.

Lessons learned

- Whilst the EVIDENCE project has highlighted the economic benefits that cities can achieve, the evidence base would greatly benefit from changes and improvements in evaluation and appraisal: The evidence base should be widened from the current relatively narrow set of criteria considered in Cost-Benefit-Analyses and include factors such as direct and indirect effects of travel choices on health; effects of attractive environments for work and shopping; economic costs of congestion and pollution.
- Existing forms of economic evaluation (such as CBA) should be extended to avoid missing the central economic benefits of sustainable urban mobility interventions, or worse, using assumptions which seriously bias or underestimate the potential benefits.
- Whilst it was necessary for practical purposes to consider measures individually, the report also seeks to communicate the importance of those interrelationships and how the 'whole can be greater than the sum of the parts' if such a package of measures is carefully selected and delivered in full.
- Strong awareness of SUMPs and mobility management measures and schemes was identified, much of which came through involvement in EU projects, conferences, seminars, and training programmes.
- In some countries there is a need to increase the number of educational programs on sustainable mobility. Training should be multi-disciplinary and the interaction between educational institutions and practitioners should be further encouraged.

(Shergold and Pankhurst 2016)

Citations *used in the writing of this paper and other useful references*

Bilton, J., et al. 2017. The impact of technology on long-term potential economic growth. JP Morgan. http://www.jpmorganassetmanagement.de/dms/JPM50455%20LTCMA%202018%20-%20TECHNOLOGY.pdf

Bintliff, J. 1999. The Origins and Nature of the Greek City-State and its Significance for World Settlement History. Actes de la table ronde internationale organisée par le Centre Jean Bérard et l'Ecole française de Rome Naples, 27-29 octobre 1994. Publications de l'École Française de Rome. Année 1999. 252. pp. 43-56.

Broughel, J. and Thierer, A. 2019. Technological Innovation and Economic Growth, A Brief Report on the Evidence. Mercatus Research. Entrepreneurship Research Papers, March 4, 2019. Accessed on 20.09.2019 from https://www.mercatus.org/system/files/broughel-technological-innovation-mercatus-research-v1.pdf. Citation from https://www.mercatus.org/publications/entrepreneurship/technological-innovation-and-economic-growth , gleaned on 22 09 2019

Cervero, R. (1994) Rail Transit and Joint Development: Land Market Impacts in Washington, D.C. and Atlanta. Journal of the American Planning Association. 60:1, 83-94.

Cervero, R. (1998) The Transit Metropolis - A Global Inquiry. Washington DC: Island Press.

Cervero, R., Kang, C. (2011) Bus rapid transit impacts on land uses and land values in Seoul, Korea. Transportation Policy 18 (1), 102–116. doi:10.1016/j.tranpol.2010.06.005.

CIA Central Intelligence Agency. 2017. World Factbook. Washington D.C.

Clark, G. and Clark, G. (2014) Nations and the wealth of cities: A new phase in public policy. Centre for London.

Combes, P., Duraton, G., Gobillon, L. and Roux, S. (2008) Estimating Agglomeration Economies With History, Geology, and Worker Effects. halshs-00347451. https://halshs.archives-ouvertes.fr/halshs-00347451

Corrigan, M.B., Jack Hambene, William Hudnut III, Rachelle L. Levitt, John Stainback, Richard Ward and Nicole Witenstein. 2005. Ten principles for successful public-private partnerships. Urban Land Institute. http://uli.org/wp-content/uploads/2005/01/TP_Partnerships.pdf

Davies-Slate, S. and Newman, P. (2018) Partnerships for Private Transit Investment – The History and Practice of Private Transit Infrastructure with a Case Study in Perth, Australia. Urban Science, 2(3), 84-104, doi:10.3390/urbansci2030084.

Davies-Slate, S., Conley, D., Hargroves, C., Newman, P. and Mouritz, M. (2019) Transit Activated Corridors: Reinventing an Entrepreneurial Approach to the Design, Financing and Delivery of Corridor Transit and TODs. Transportation Research Part A: Policy and Practice (submitted manuscript).

Delbosc, A. and Currie, G. (2013) Causes of Youth Licensing Decline: A Synthesis of Evidence. Transport Reviews, 33:3, 271-290, DOI: 10.1080/01441647.2013.801929

Department of the Prime Minister and Cabinet (Australia) (2016). Smart Cities Plan. https://cities.dpmc.gov.au/smart-cities-plan.

Downs, A. (1992) Stuck in Traffic: Coping with Peak-Hour Traffic Congestion. Brookings Institute.

Droege, P. 1997. Intelligent Environments – spatial aspects of the information revolution. Elsevier

Droege, P. 1999. The Design Dividend. Property Council of Australia.

Droege, P. 2006. The Renewable City – comprehensive guide to an urban revolution. Wiley

EIU – Economist Intelligence Unit. 2015. The Cost of Inaction: recognizing the value at risk from climate change. Citation from page 2. Accessed on 22 September 2019 on https://eiuperspectives.economist.com/sites/default/files/The%20cost%20of%20inaction_0.pdf

Federal Transit Administration (United States) (2018) "Value Capture". https://www.transit.dot.gov/valuecapture. Accessed 3 July 2019.

Fletcher, R. 1995. The Limits of Settlement Growth – a theoretical outline. Cambridge University Press.

Florida, R. (2002). The Rise of the Creative Class: and how it's transforming work, leisure, community and everyday life. Basic Books, New York.

Fuji, S., Tommy Gärling and Ryuichi Kitamura. 2001. Changes in drivers' peceptions and use of public transport during a freeway closure. Effects of Temporary Structural Change on Cooperation in a Real-Life Social Dilemma. Environment and Behavior. Vol. 33 No. 6. November 2001. 796-808.

Glazebrook, G. and Newman, P. (2018) The Future City, Urban Planning, Volume 3, Issue 2, Pages 1–20 DOI: 10.17645/up- .v3i2.1247.

Glaeser, E. (2012) Urban public finance (No. w18244). National Bureau of Economic Research.

Greening, L.A., David L. Greene and Carmen Difiglio. 2000. Energy efficiency and consumption — the rebound effect — a survey. Energy Policy Volume 28, Issues 6–7, June 2000, Pages 389-401

International Energy Agency. 2019. Energy Efficiency: Transport. Paris. Retrieved on 24 August 2019 from https://www.iea.org/topics/energyefficiency/transport/.

Herman, A. 2012. Freedom's Forge: How American Business Produced Victory in World War II. Random House, New York.

Hiller, B. and Hanson, J. 1984. The Social Logic of Space. Cambridge University Press.

Hillier, B. 1996. Space is the Machine. Cambridge University Press.

Hiller, B. 1997. Cities as Movement Economies. In Intelligent Environments: Spatial Aspects of the Information Revolution, Droege, P (ed.), pages 295-344. Elsevier, Oxford.

HM Government. 2011. Unlocking growth in cities. Retrieved on 24 August 2019 from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/7523/CO_Unlocking_20GrowthCities_acc.pdf. Accessed 3 July 2019.

Greater Auckland. 2014. Proximity and Integration (The Metropolitan Revolution). https://www.greaterauckland.org.nz/2014/05/23/the-metropolitan-revolution-proximity-and-integration/. Accessed 6 August 2019.

Levinson, D. 2008. Density and dispersion: The co-development of land use and rail in London. J. Econ. Geogr., 8, 55–77.

Marchetti, C. 1994. Anthropological invariants in travel behaviour. Technical Forecasting and Social Change 47(1) p. 75-78.

Maslennikov, M. 2017. **The Technological Innovations and Their Impact on the Economy**. Economy of region. Centre for Economic Security, Institute of Economics of Ural Branch of Russian Academy of Sciences, vol. 1(4), pages 1221-1235. https://ideas.repec.org/a/ura/ecregj/v1y2017i4p1221-1235.html

Du Pont, Y. R. and Meinshausen, M. 2018. Warming Assessment of the bottom-up Paris Agreement emissions pledges. Nature Communications 9, Article Number 4810.

Stern, N. 2006. Stern Review on the Economics of Climate Change. Government of the United Kindom.

McDonald, J. and McKillen, D. 2007. Urban Economics and Real Estate Theory and Policy, 2nd ed. John Wiley and Sons, Hoboken, NJ.

McIntosh, J.; Trubka, R.; Newman, P. 2014. Can Value Capture Work in a Car Dependent City? Willingness to Pay for Transit Access in Perth, Western Australia. Transp. Res. Part A, 67, 320–339.

Melo, P. and Graham, D. 2009. Agglomeration Economies and Labour Productivity: Evidence from Longitudinal Worker Data for GB's Travel-to-Work Areas. Spatial Economics Research Centre Discussion Paper 31.

Millard-Ball, A. and Schipper, L. 2010. Are we reaching peak travel? Trends in passenger transport in eight industrialized countries. Transport Reviews 31 (3), p. 1-22.

Montgomery, C. 2013. Happy City: Transforming Our Lives Through Urban Design. New York Farrar, Straus and Giroux.

Mumford, L. 1934. Technics and Civilization. Harcourt, Brace and Company.

Newman, P., and Kenworthy, J. 1988. Parking and City Centre Vitality – An International Assessment. Technical papers presented at the 1st Australian Parking Convention held in Perth, Western Australia, 23-27 October, 1988.

Newman, P., and Kenworthy, J. 2015. The end of automobile dependence: Moving beyond car-based planning. Washington, DC.: Island Press.

Newman, P., Davies-Slate, S., and Jones, E. 2017. The Entrepreneur Rail Model: Funding urban rail through majority private investment in urban regeneration. Research in Transportation Economics. DOI: http://dx.doi.org/10.1016/j.retrec.2017.04.005

Newman, P., Kosonen, L. and Kenworthy, J. 2016. Theory of urban fabrics: Planning the walking, transit/public transport and automobile/motor car cities for reduced car dependency. Town Planning Review. 87 (4): pp. 429-458.

Newman, P., Mouritz, M., Davies-Slate, S., Jones, E., Hargroves, K., Sharma, R. and Adams, D. (2018). Delivering Integrated Transit, Land Development and Finance – a Guide and Manual: with Application to Trackless Trams. Sustainable Built Environment National Research Centre (SBEnrc), Australia.

Newton et al., 2012. P. Newton, P. Newman, S. Glackin, R. Trubka Greening the Greyfields: Unlocking the development potential of middle suburbs in australian cities, proceedings of the world academy of science. Engineering and Technology, 71 (2012), pp. 138-157.

Oystrakh, M. 2016. The Effect of Technological Innovations on Economic Activity. PhD thesis in Economics. University of Waterloo, Ontario, Canada. https://pdfs.semanticscholar.org/0c08/5ec033539267ee1f61323577abc29d268280.pdf

Shergold, I. and Parkhurst, G. 2016. The Economic Benefits of Sustainable Urban Mobility Measures: Independent Review of Evidence: Report. European Commission. https://ec.europa.eu/energy/intelligent/projects/en/projects/evidence. https://ec.europa.eu/energy/intelligent/projects/sites/iee-projects/files/projects/documents/evidence_main-report_final_2016.pdf

Puentes, R. and Tomer, A. 2009. The Road Less Travelled: An Analysis of Vehicle Miles Traveled Trends in the U.S. Metropolitan Infrastructure Initiatives Series, Brookings Institution, Washington, DC.

Rettig, R. 2018. Traffic Fatalities By State – 2018 preliminary data. Governors Highways Safety Association. https://www.ghsa.org/sites/default/files/2019-02/FINAL_Pedestrians19.pdf

Rosen, R. and Ineke Sluiter. 2006. City, Countryside, and the Spatial Organization of Value in Classical Antiquity. Brill.

Salon, D., and Shewmake, S. 2011. Opportunities for Value Capture to Fund Public Transport: A Comprehensive Review of the Literature with a Focus on East Asia. SSRN Electronic Journal. DOI: 10.2139/ssrn.1753302.

Schade, B. and Rothengatter, W. 2004. The Economic Impact of Environmentally Sustainable Transport in Germany. EJTIR, **4**, no. 1 (2004), pp. 147-172

Schaller, B. 2018. The New Automobility: Lyft, Uber and the Future of American Cities. Schaller Consulting. Accessed on 1 April on http://www.schallerconsult.com/rideservices/automobility.pdf

Sener, S. and Sandogan, E. 2011. The effects of science-technology-innovation on competitiveness and economic growth. Elsevier. Procedia - Social and Behavioral Sciences. Volume 24, 2011, Pages 815-828. Accessed on 20.09.209 from https://www.sciencedirect.com/science/article/pii/S1877042811016557

SGS Economics and Planning. 2012. Productivity and Agglomeration Benefits in Australian Capital Cities. Final Report to COAG Reform Council. Available at https://www.sgsep.com.au/assets/productivity-and-agglomeration-benefits-COAG-report-final.pdf.

Sharma, R. and Newman, P. 2017. Urban Rail and Sustainable Development Key Lessons from Hong Kong, New York, London and India for Emerging Cities. Transportation Research Procedia, 26, 92-105.

Sharma, R., and Newman, P. 2018a. Can land value capture make PPP's competitive in fares? A Mumbai Case Study. Transport Policy, Transport Policy 64 (2018) 123–131. https://doi.org/10.1016/j.tranpol.2018.02.002.

Shoup, D. (2011) The High Cost of Free Parking. Chicago: Planners Press.

Transport for London. 2017. Land Value Capture: Annexes. https://www.london.gov.uk/sites/default/files/land_value_capture_report_annexes_transport_for_london.pdf. Accessed 3 July 2019.

Transportation Research Board. 2002. Costs of Sprawl—2000. Transit Cooperative Research Program Report 74. Available at http://onlinepubs.trb.org/onlinepubs/tcrp/tcrp_rpt_74-a.pdf.

Trubka, R. (2011) Agglomeration economies in Australian cities: productivity benefits of increasing urban density and accessibility. Ph.D. thesis, Curtin University.

Trubka, R., Newman, P. and Bilsborough, D. (2010) Costs of Urban Sprawl (1) Infrastructure and Transport. Environ Des Guid, (83):1–6.

Wang, W., Zhong, M. and Hunt., J.D. 2019. Analysis of the Wider Economic Impact of a Transport Infrastructure Project Using an Integrated Land Use Transport Model. Sustainability 2019, 11, 364; doi:10.3390/su11020364

WB World Bank. 2016. The Cost of Air Pollution : Strengthening the Economic Case for Action. https://openknowledge.worldbank.org/handle/10986/25013

WHO World Health Organizaion. 2018. Global Status Report on Road Safety.WHO Management of Noncommunicable Diseases, Disability, Violence and Injury Prevention (NVI), Geneva.

Wright, F. (1932) The Disappearing City. Stratford Press Inc., New York.

Zalewski, R. and Skawinska, E. 2009. Impact of technological innovations on economic growth of nations. Systemics, Cybernetics and Informatics. Volume 7 – Number 6 2009. International Institute on Informatics and Systemics.