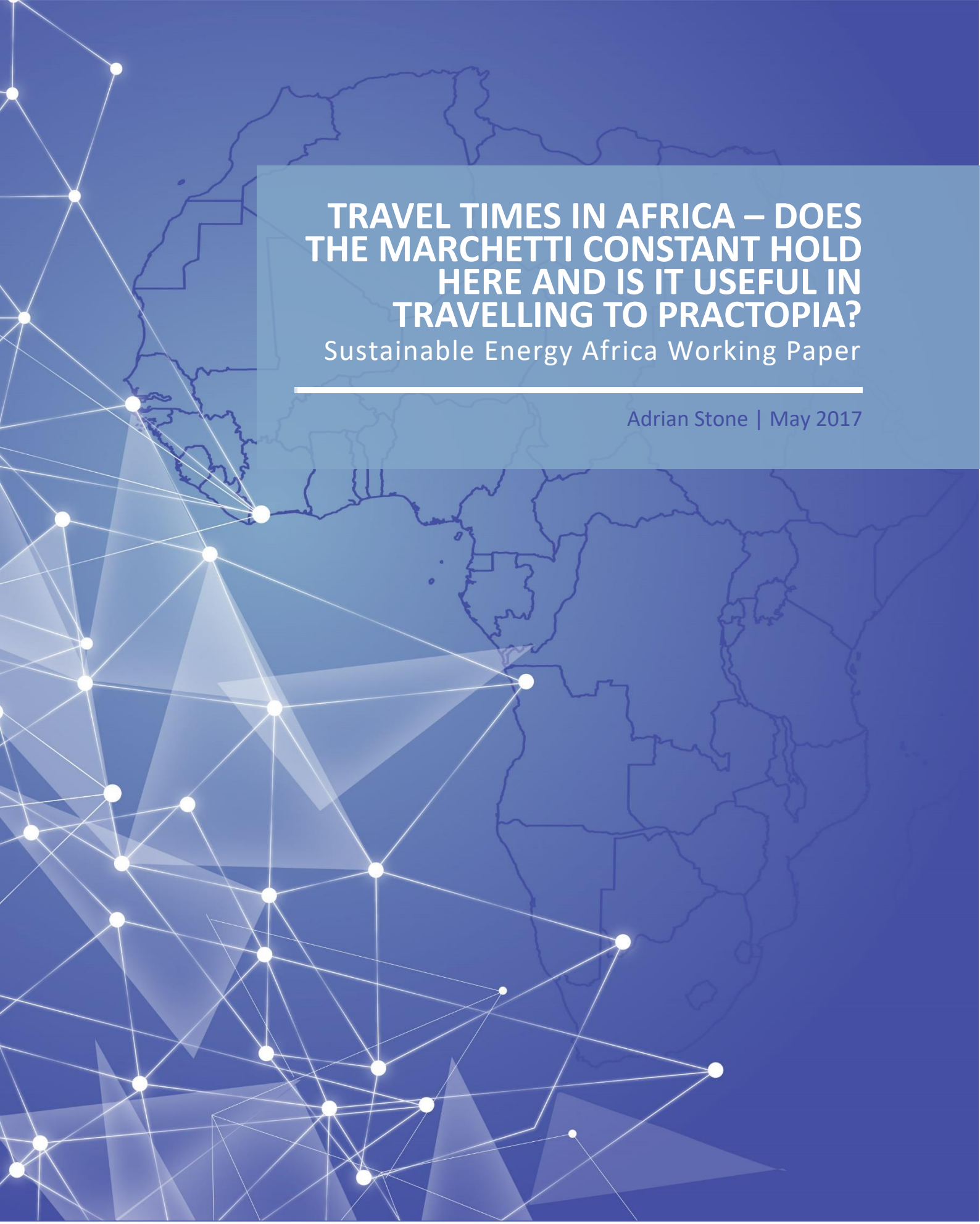

TRAVEL TIMES IN AFRICA – DOES THE MARCHETTI CONSTANT HOLD HERE AND IS IT USEFUL IN TRAVELLING TO PRACTOPIA?

Sustainable Energy Africa Working Paper

Adrian Stone | May 2017

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SAMSET
Supporting Sub-Saharan Africa's Municipalities with Sustainable Energy Transitions

ABSTRACT

Futurism and traffic congestion are considered somewhat frivolously. The discovery of the human tendency to a constant travel time budget called the Marchetti (sometime Zahavi) is reviewed with only marginally less levity. Later surveys in developing countries show however that once walking only trips are discarded that the preference for this constant budget is still evident in distributions of travel time surveys but that tails can be very long dragging the average significantly over the constant of 1.1 hours. The role of paratransit as a developing country solution is discussed and the integration of this mode and its best features into a formalized and modernized version is proposed.

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TRAVEL TIMES IN AFRICA – DOES THE MARCHETTI CONSTANT HOLD HERE AND IS IT USEFUL IN TRAVELLING TO PRACTOPIA?

As a child I remember my mother reading a certain book and periodically looking up from it at me apprehensively. Alvin Toffler, a pioneer of future studies, was the author of that book. A fading figure now perhaps, he did much to make looking into the future respectable, unlike say a cigarello smoking Tarot lady or the people who tell you they can earn you 30% on the stock market….guaranteed. Futurism will always have irresistible Wellsian overtones though and who with blood in their veins could resist such stirring gothic passages as the following from his first all-conquering 1970 bestseller Future Shock.

> *"The incipient worldwide movement for control of technology, however, must not be permitted to fall into the hands of irresponsible technophobes, nihilists and Rousseauian romantics. For the power of the technological drive is too great to be stopped by Luddite paroxysms. Worse yet, reckless attempts to halt technology will produce results quite as destructive as reckless attempts to advance it." (Toffler, 1970)*

Well Alvin, I wish that an army of 10 foot high Rousseauian romantics, bewigged perhaps, but definitely with War of the Worlds spindly tripod stilts and laser eyes would, in a fit of Luddite paroxysm, storm my office and clean out my email inbox. For Alvin Toffler in his next 1980 bestseller, The Third Wave, foresaw a wave of information technology bringing a computer to every home but didn't, in my limited reading of the material, foresee that a caste would exist to move work around in circles from inbox to inbox as their only work. He rather proposed that networked computerization would enable families to work at home with flexible hours re-establishing the pre-eminence of family, enhancing democratic practice and banishing loneliness, urban decay, traffic congestion and pollution. He came in for some stick for this in New Scientist Magazine of 23 October 1980 in the best tradition of acerbic British tall poppy scything. Thus spake Donald Gould:

> *But, as in Future Shock, the pictures Toffler sees in his crystal ball are such as might, just conceivably, become reality if the world consisted of middle-class Americans. They have not the smallest relevance to the circumstances facing the poverty-stricken billions of the backward continents, whose very existence he virtually ignores. Toffler doesn't call his visionary Third Wave society Utopia. He calls it "Practopia". I call it myopia* (Gould, 1980)

This article will explore a little bit of how the future has treated one of the 'backward' continents 36 years later as regards a very small aspect of this sweeping human drama: traffic congestion as reflected (or not) by travel times. Travel times are a subject of great interest for transport researchers not just because of the obvious link with economic efficiency and quality of life but also because researchers have observed that they tend to be constant across region, urban form and occupation. Some of the more high-minded literature even posits this as an inherent human characteristic dating from Neolithic times linking the rhythms of the hunter gatherer, the trudging peasant and the lily-handed office worker with a single atavistic thread across the ages (Marchetti, 1994) (Ausubel, Marchetti, & Meyer, 1998). The implication is that people will seek other utilities like cheap land further from work up to a certain level of tolerance on average. This total travel time budget for a day of around 1.1 hour is often referred to as the Marchetti constant or Zahavi constant after the researcher who accumulated some of the pioneering empirical data. Some of this compelling data is presented below covering time, space and income (Schafer & Victor, 2000).

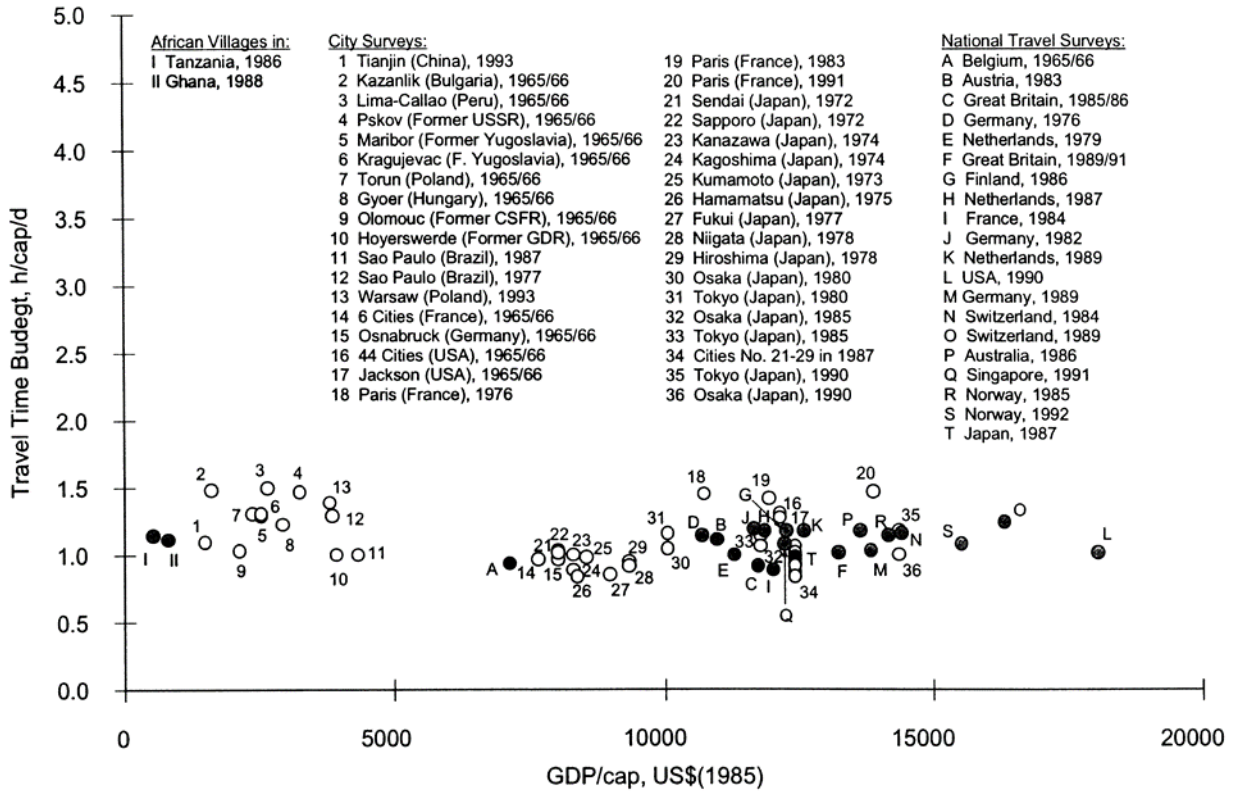

Figure 1: Average per-capita travel time budget from African villages, 44 city and 20 national surveys (Schafer & Victor, 2000)

This assertion of a constant time budget provides a useful constant for models of transport energy use and emissions and also has profound policy implications in the sense that investment in infrastructure to relieve congestion may only yield a system that reverts to a similar time budget but with potentially longer trips (Cervero, 2011). The constant travel time budget hypothesis is not however without controversy. Some researchers have shown that travel times indeed seem to change with factors such as income level, gender and mode but concede that travel time budget may average out to a constant across a whole city population and all its transport modes (Mokhtarian & Chen, 2002). The work supporting this article has come out of a joint Ghanaian, South African, British and Ugandan collaboration, the SAMSET project (Supporting African Municipalities in Sustainable Energy Transitions - http://samsetproject.net/project-overview/)

This topic is of interest to SAMSET for two reasons. Firstly, because transport energy use has dominated the data collected and energy models developed for the 6 secondary cities in Ghana, Uganda and South Africa so far, with that dominance increasing into the future, but secondly because anecdotal evidence from project meetings and stakeholder consultations indicate that travel times in urbanizing Africa may be very long for large numbers of people and not conform to observed trends elsewhere. This article will briefly explain some of the prevailing theory on travel times and explore some of the published data on travel times in Africa comparing how well that conforms to expectations. In doing so we will very briefly explore how African cities have dealt with rapid sprawl and ask whether 'Practopia' is not indeed possible on this rapidly changing continent now that economic prosperity is emerging in many parts of it with average growth in Sub-Saharan Africa generally outstripping average global growth (AFDB, 2014).

There is a general paucity of data in sub-Saharan Africa but national and city level household travel survey data does exist in the public domain although limited in geographic coverage. Household travel surveys undertaken between 1992 and 2003 in 6 Central and West

African cities and one Southern African city namely, Ouagadougou, Bamako, Niamey, Dakar, Conakry, Douala and Cape Town are described in great detail (Diaz Olvera, Plat, & Pochet, 2013), (Behrens, Diaz Olvera, Plat, & Pochet, 2004), (Behrens, 2002). The results showed that in the West and Central African cities travel time budgets conformed to the approximately one hour international norm for all cities except for Douala and Conakry which had travel time budgets of around one and a half hours attributed to heavy congestion. Walking was the dominant mode (57 – 74% of trips) in all the cities except for Ouagadougou where motorcycles had a 39% share of trips close to the walking mode share of 42%. Cars still accounted for around 10% or less of trips in the six cities at the time (Diaz Olvera, Plat, & Pochet, 2013).

Behrens (2002) undertook an activity based survey in Cape Town, South Africa using travel diaries with a particular attention to the walking mode. The sample size was relatively small but brings some insights to the interactions of income and walking trips. In general the low income group undertook more and longer walking trips which translated into longer travel time budgets per household and per person even though time spent on motorized modes was similar as shown below:

Table 1: Travel Times for Walking and Motorised Modes from Cape Town Household Travel Survey (Behrens, 2002)

Income Group (#Households)	Mean Walking Time Households (min/day)	Mean Time Motorised Modes Households (min/day)	Mean Walking Time per Person (min/day)*	Mean Time Motorised Modes per Person (min/day)*	Total Personal Time Budget (min/day)*
Low-income (64)	160	133	53	44	97
Middle-income (75)	84	143	24	40	64
High-income (65)	21	150	7	49	56
Average					72#

** Authors estimates based on household sizes reported by Behrens, 2002*

 # As reported by Behrens, 2002

In contrast, members of low-expenditure households in Dakar who were confirmed pedestrians spent slightly less time on average walking (42 minutes) but users of motorized modes had long weekday time budgets of 110 minutes on average and working men as a sub-group averaged 129 minutes (Behrens, Diaz Olvera, Plat, & Pochet, 2004). The differences may be accounted for by South Africa's city form having developed under apartheid policies such that low income residential areas where confirmed pedestrians might traditionally be found are impractically far from employment opportunities. Both these data sets however indicate a cohort of motorized travelers experiencing long travel times possibly due to both urban sprawl and low public transport speeds.

Cell phone call detail records (CDRs) present a unique opportunity to examine aspects of the travel behaviour of populations including travel times. As a coherent observation is dependent on a single users proximity to cell phone towers and their call patterns relative to their commuting behaviour, an analysis of CDRs generally best resolves commuting patterns for users with fixed home and work locations and regular commute times (Kung, Greco, Sobolevsky, & Ratti, 2014). Nonetheless, the quantity of data compensates for this to some degree and insights around travel characteristics like work commuting time can be gained. Kung, Greco, Sobolevsky, & Ratti,

2014 contrasted analyses of CDR data at country level for Ivory Coast, Portugal", Saudi Arabia, at city level for Boston and GPS data for Milan. The resulting filtered distributions of commuting time for Ivory Coast, Portugal and Boston are shown below in Figure 2.

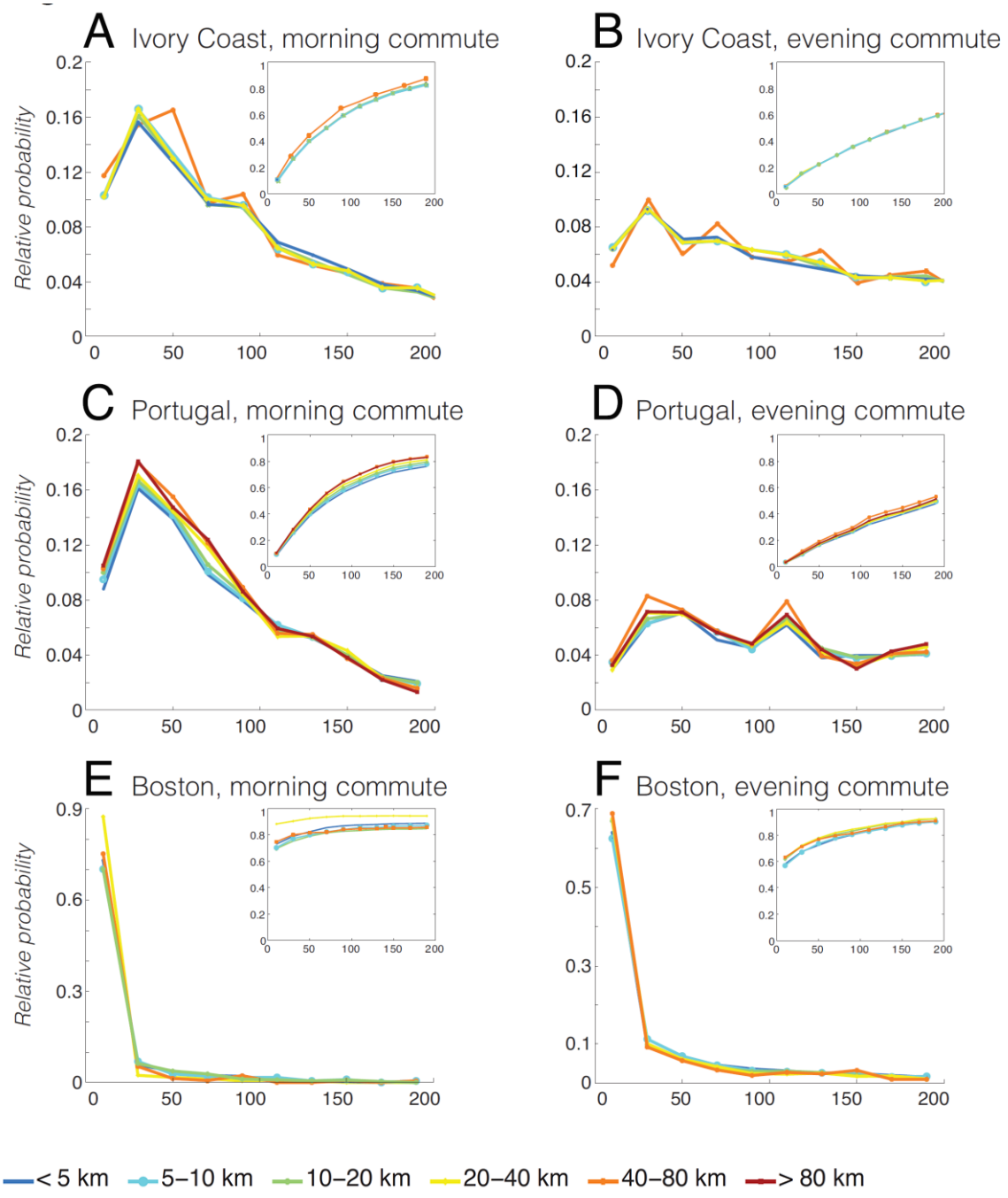

Figure 2: Distributions of Commuting Time for Various trip distances derived from mobile phone data for 2 countries and the city of Boston (Kung, Greco, Sobolevsky, & Ratti, 2014)

The distributions for Milan and Saudi Arabia (not shown above) exhibited low peak commute times less than 20 minutes and were significantly more attenuated than Ivory Coast and Portugal although not to the degree of Boston. The data suggests that while commuting times and their distribution varied between places, within one location commuting times were remarkably independent of distance. Milan, which was a car only sample, was an exception and quite scattered suggesting possibly that this consistency only

arises when data is averaged across all modes. The Ivory Coast data which showed a marked similarity to the Portuguese data but with slightly longer tails, showed that the largest cohort for both morning and evening commutes had travel times of around 30 minutes indicating a preference for time budgets close to the Marchetti constant. The cumulative probability distributions however suggest very long median commuting times of around 1 hour in the evening and around 2.5 hours in the evening. The implication seems to be that inclination favours the Marchetti constant but that considerable numbers of people are condemned to long commutes and that this can occur in Europe as well as Africa.

Two detailed National Household Travel Surveys have been conducted for South Africa in 2003 and 2013 (Stats SA, 2013) to provide a basis for research, planning and policy development in the Department of Transport. The survey covers mainly land transport but includes public and private transport and motorized and non-motorised modes including a number of questions relating to travel times and satisfaction levels of modes as regards travel time. The distribution of surveyed travel times for commuting to work only is shown below in Figure 3 and in common with the Ivory Coast measurements has a peak around 30 minutes suggesting the largest cohort has a travel time budget of around the magic 1.1 hours. A long tail however pulls the average travel time to work of the sample to 47 minutes implying an average daily work commuting travel time budget of over 1.5 hours for the sample.

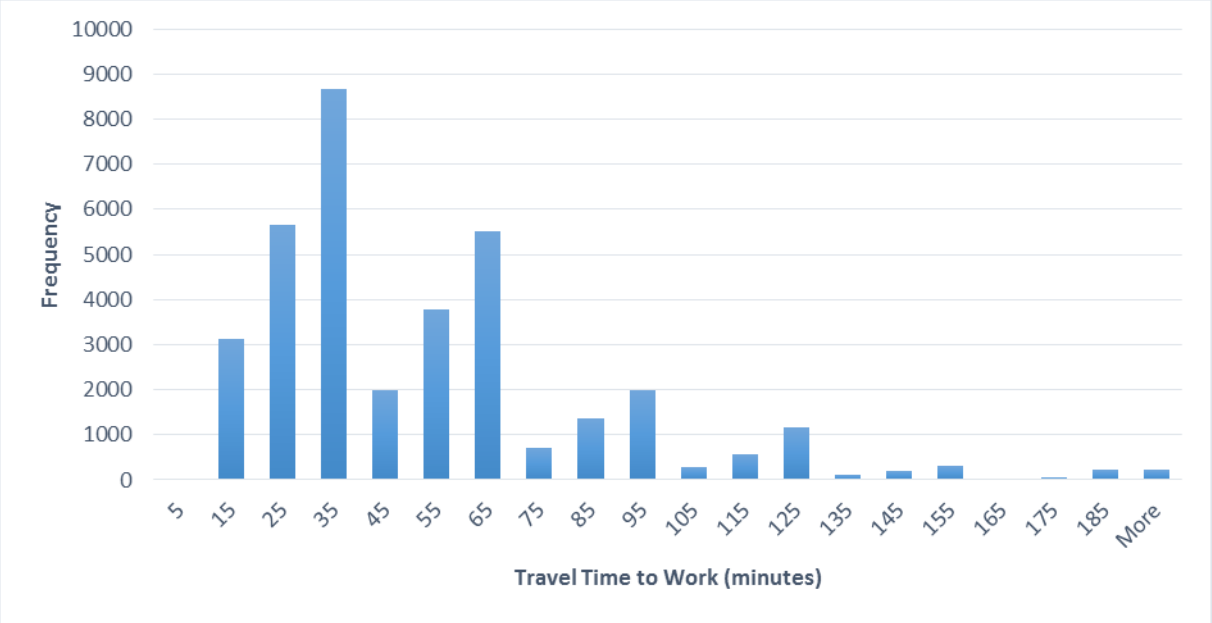

Figure 3: Travel Times to Work from the South African National Household Travel Survey [Unweighted - processed by author from published survey data] (Stats SA, 2013)

A disaggregation by mode however presents a more disturbing picture. The shorter time trips are dominated by the passenger car and walking modes with mean travel times of 38 and 34 minutes respectively while public transport mode mean travel times are much longer with 50 minutes for minibus taxis and 74 minutes for both train and bus (Stats SA, 2014). Weighting these by their mode share and assuming that non-work related trips will also be necessary at times implies a daily time budget in excess of 2 hours on average for dedicated formal and informal public transport users in South Africa.

A feature of some African countries are peri-urban settlements where quite dense agglomerations of dwellings form over time with limited supporting commercial infrastructure and little in the way of economic opportunities. These communities can be supported by inhabitants commuting long distances to proximate urban centres or by money sent home from relatives in those centres. In certain

cases the basis of agglomeration can be that tenure is allocated by tribal authorities at low cost. A recent energy use survey related to the SAMSET project (University of Limpopo & Sustainable Energy Africa, 2016) polled travel times for the peri-urban settlement of Makweng 66 km south of Polokwane and 56 km South East of Mokopane and indicated an average work trip daily travel time budget of around 90 minutes with nearly 15% of the sample indicating work travel times of over 2 hours daily. The 28% of the sample who indicated travel times of less than 1 hour was similar to the 23% rate of car ownership of households in the sample. 92% of respondents indicated they use minibus taxis and 58% large commuter buses. This survey investigated a very broad range of energy services and is not conclusive in any way regarding travel times but indicates that some investigation of travel behavior in peri-urban areas is warranted.

We have seen from somewhat limited African data that indeed observations of the average travel time budget can be quite constant across regions at a very aggregate level even in congested African cities with high levels of informality but that large numbers of commuters can be experiencing very long travel times within modes and in the low income group. The low income group inevitably has long walking times well in excess of preference and this may be compounded by longer motorization trips as well if shanty towns sprawl far from places of employment. In African cities a number of people tolerate travel time budgets well above world norms but on a very aggregate level older observations accord broadly with the Marchetti constant. One mobile phone data based study supports a preference for a travel time budget of around an hour but doesn't support a constant average time budget across regions. Rather the travel time budget distribution appears remarkably independent of distance within regions and only if walking and public mode trips are included. The African country in this study, the Ivory Coast, had the longest tails to the distribution of commuting times of the regions surveyed but was comparable to Portugal. Outliers of 1.5 hours average travel budget were identified already in older surveys, for instance Peru (see observation 3 in Figure 1), but still seen as being within a tolerance band. It appears this may be problematic in the sense that the average is brought down by large cohorts with low travel money budget that crowd into very dense settlements reasonably proximate to employment opportunities enabled by informality and then undertake walking only or short motorized trips. These shorter trips may offset a long tail of very long motorized public mode trips from peripheral settlements that may combine with long walking trips to yield a relatively low population average. There may be a sheer co-incidence at play in developing cities where large numbers of people walk exclusively and are thus limited in their time budget by physical exhaustion and bring down the average to a value close to the Marchetti constant when combined in a calculation with the motorized cohort who have travel time budgets far in excess of the constant. The long observed consistencies in travel time budgets between regions may therefore conceal much in developing African countries and elsewhere including:

- The dense squalor and low travel budget that may underpin 'short' trips that are actually long walking trips or include long walking trips that can be onerous and not preferential especially for older workers.
- A full set of observations of daily travel or commuting time for a region seems to have a log-normal distribution that may have long tails that affect a significant cohort but are hidden by averaging.
- Most problematically, the constraints on economic activity and opportunities that may be occurring when a region's travel times drift to the upper end of observed norms such that travel times may not be increasing further because workers are declining to or cannot afford to travel in a practical manner.
- There appear to be far fewer travel time observations of poorer quality for the very large population of the developing world.
- The dysfunction of public transport because active workers are able to circumvent constraints through enduring poor living conditions in dense informal settlements and using sometimes unsafe informal public transport .

There is some emerging controversy as to whether sub-Saharan Africa is in fact urbanizing at a net rate that is as dramatic as some published statistics suggest although even the low growth estimates suggest overall urbanization at present of around 1% every 10 years (Potts, 2012). What is clear is that there is urban growth at some level across the region and that there are large centres of historically rapid growth like Lagos and Johannesburg but also secondary cities and peri-urban settlements. Generally speaking, these urbanized environments may exhibit large constituent areas with high levels of informality served by poor public transport (Diaz Olvera, Plat, Pochet, & Maïdadi, 2012). So while transport is likely an economic and growth constraint, communities have adapted to preserve the very valuable commodity of time to some degree. How have they done this? Certainly, one reason, as seen in the Ivory Coast data, is high densities facilitating a high walking modal share and another is high occupancy of all motorized modes. Two other much maligned reasons would likely be the minibus taxi and emerging in many parts of Africa, the motorcycle. The emergence of motorcycles in Africa to some degree mirrors that in historically urbanizing Asia with motorcycles accounting for around 50% of the vehicle population in Nigeria (Stone, 2012) and growth in Kenya outstripping that of cars by a large margin (KNBS, 2015) as shown below in Figure 4. In common with other developing regions, many motorcycles are used as taxis with severe accident risk for passenger and rider but high efficiency compared to cars and incomparable ability to negotiate congestion (Diaz Olvera, Plat, Pochet, & Maïdadi, 2012).

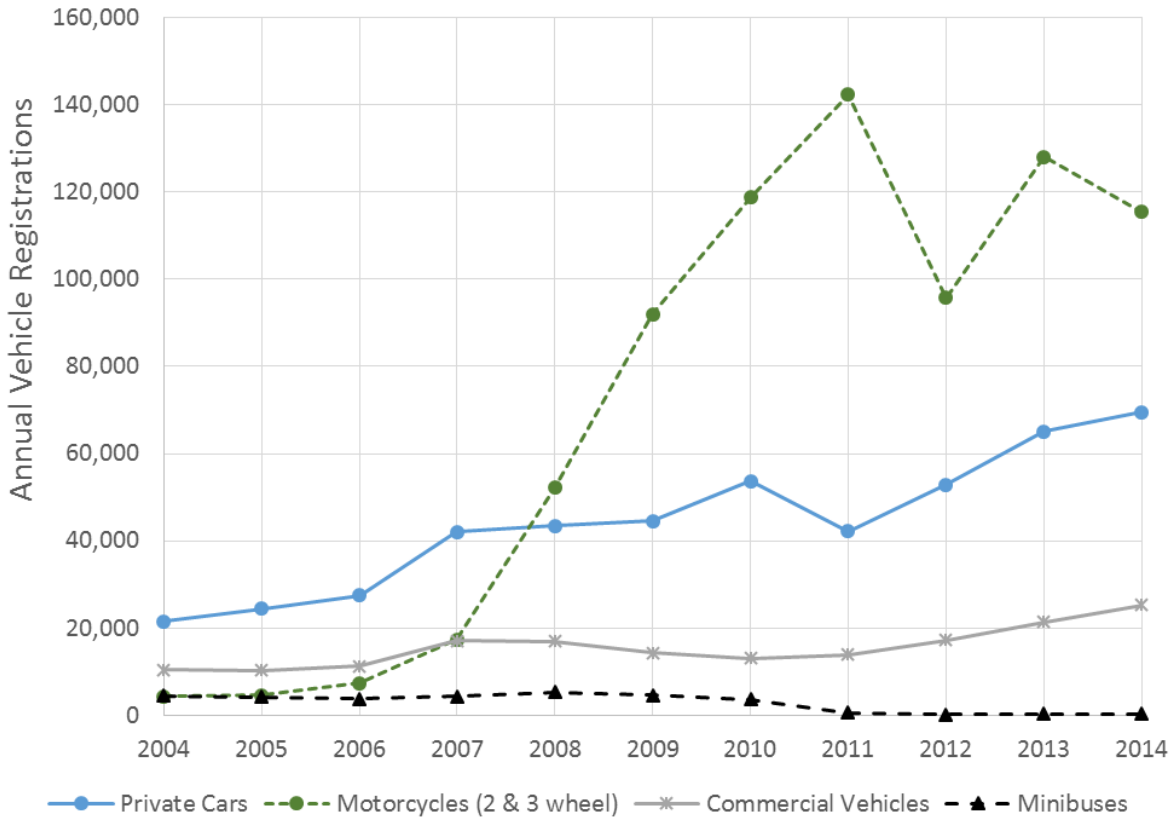

Figure 4: Trend in Annual Vehicle Registrations for Kenya 2004-2014 (KNBS, 2015)

Aside from safety, the qualified positives of the informal transport innovations in Africa and other parts of the developing world are usefully captured in the following extract:

"Illegality and clandestine activity may be seen as intrinsic characteristics of the activity of transport micro-businesses in low-income settings. However, such businesses are often registered with the appropriate authorities and may also comply with some or all of the necessary administrative formalities. More generally, the concept of "informal transport" or "paratransit" is inadequate to express the diversity of organizational forms and production practices exhibited by the myriad of microbusiness which constitute this sector……..In almost all major cities transport supply still relies on paratransit which on its own lacks the political legitimacy, the organizational foundation, and the financial capacity to produce the necessary returns to scale. However, paratransit is genuinely able to innovate and propose a supply of transport to meet demand which, although increasing, is dispersed and barely solvent." (Diaz Olvera, Plat, Pochet, & Maïdadi, 2012)

There have been a number of innovations in city transport to enhance sustainability and speed which are discussed here: link. This article explores the idea of the theory of the *diffusion of innovation* with regard to transit innovations whereby uptake of new innovations proceeds incrementally until a tipping point is reached and then accelerates exponentially as shown in the figure below. The minibus as an African response to transport challenges in the context of fast growing informality has been annotated into the figure only slightly mischievously given that this is a graph of measures with 'green credibility'. Objectively, however the very high occupancies attained by minibuses in many Africa cities (IAPT, 2010) due to their informality or semi-regulation set a very high bar in energy efficiency terms. Indeed, the light motorcycle first in urbanizing Asia and lately in Africa could equally be added to such a graph were it not for the very serious safety concerns with this mode particularly when practiced informally (Diaz Olvera, Plat, Pochet, & Maïdadi, 2012).

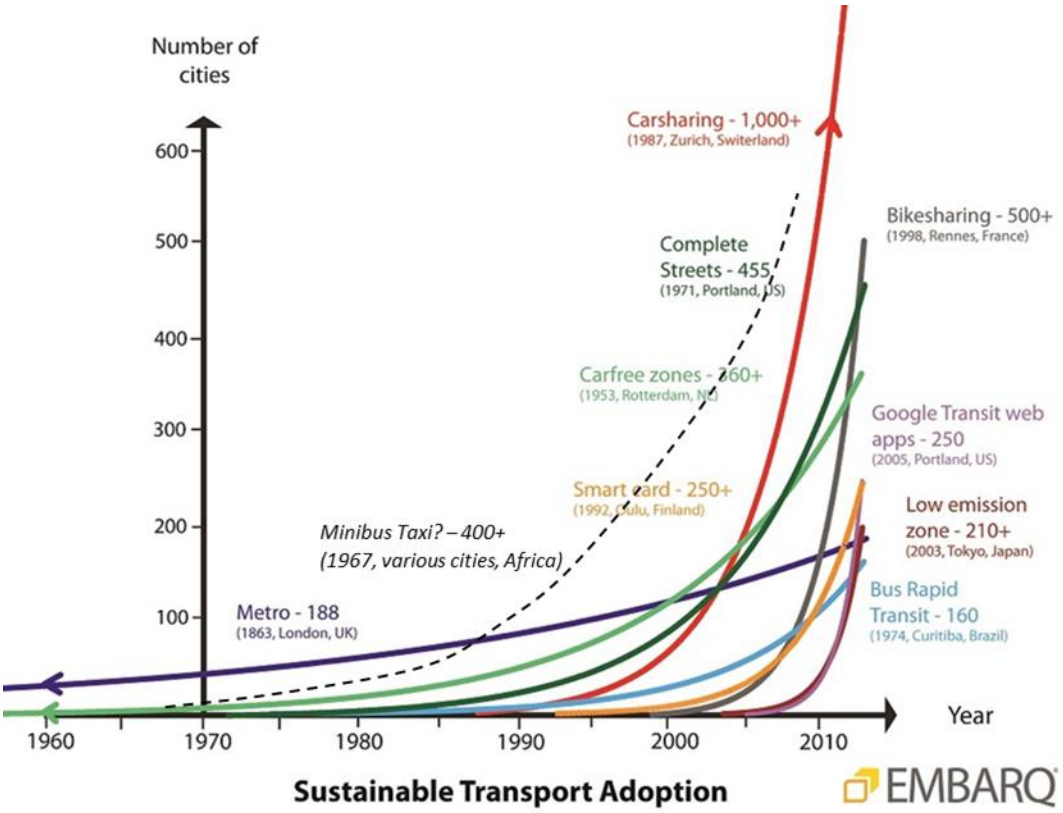

Figure 5: Sustainable Transport Adoption Curves. Graph by EMBARQ (Hidalgo & Zeng, 2013). Illustrative annotations in dotted line by the author

Minibuses themselves have safety concerns due to overcrowding, speeding and poor vehicle maintenance which has detracted greatly from their pivotal role in making African cities possible. Furthermore, it is not known if indeed the apparent conformance of time budgets in Africa to norms, albeit at the upper end does not so much reflect adaptation to circumstances as much as a hard constraint on economic activity. One of sub-Saharan Africa's greatest problems has been high dependency ratios with high numbers of dependents for each worker. Transport constraints are known to be an inhibiting factor for job-seekers and are without doubt a similar constraint for the economy in general.

Many countries in Africa have fast growing incomes and the continent has seen a mobile phone access revolution which has provided access to that crucial enabler of a possible 'Practopia', the internet. Some of the measures in Figure 5 are thus attainable by sub-Saharan African municipalities and others like BRT are certainly being considered and implemented. The SAMSET project has started by developing an understanding of the basic energy picture in 6 municipalities, showing the key role of transport. The next step will be to extend this to more municipalities to enrich this picture but also to develop a better understanding of the transport challenge and the interventions available to municipalities and whether technology leapfrogging with technologies such as online and mobile apps can assist. The harder yards undoubtedly involve spatial planning and extensive infrastructure development to improve the speed of all modes and maybe the faithful old minibus will still be there with humming electric hub motors and sensors under its seats monitoring its occupancy which is sent with its position to online commuter apps from the driver's mobile phone. Let's hope the music is still pumping and 'Practopia' retains an African flavor.

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This document is an output from a project co-funded by UK aid from the UK Department for International Development (DFID), the Engineering & Physical Science Research Council (EPSRC) and the Department for Energy & Climate Change (DECC), for the benefit of developing countries. The views expressed are not necessarily those of DFID, EPSRC or DECC, or any institution partner of the project.

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