

**Expectations in Networks:
Market Shaping Devices of the Driverless Car**

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Abstract

The paper focuses on the role of expectations in shaping technological futures and their impact on how future markets are perceived. The paper foregrounds the way expectations of what new technologies might become, travel and connect actors to form powerful industrial networks that shape imagined markets. Through an analysis of professional reports, media coverage and academic publications presenting and describing expectations of the driverless car, we show how representations of expectations are used to speculate future value. Text and numbers are gathered together to create narratives that enable comparison of alternative worlds: 'now' and 'the future'. Findings show that multiple narratives co-exist. While some get privileged in the media and popular press others are ignored. Some expectations sustain and become part of other actors' narratives, making them powerful. This has a stabilizing effect on how future markets are perceived. Stabilized expectations of future markets have a performative effect and act to shape what actors focus on when developing and adopting new technologies, and when co-ordinating and configuring their individual and collective action to make them to actors in that imagined market. Our findings also generate insights into how actors with different roles shape expectations through the expertise that they bring to the imagined market. This mixture of individual and collective action helps actors make use of expectations in committing to certain kinds of concrete market-making action.

Introduction

What makes new industrial purchasing and marketing networks emerge? Why are new connections formed and new markets made? The IMP group have what is now nearly 40 years of history addressing these questions, exploring the ideas behind industrial networks (Ford and Håkansson, 2006), the connections between a single, dyadic business-to-business relationship and the emergence of an unfolding network (Cova, Prévot and Spencer, 2010) and importantly the power of these networks to create and shape markets (Geiger, Kjellberg and Spencer 2012). Yet we know little about the role that expectations play in how such networks act and unfold. We know that when we expect something to happen, we change our actions in accordance with those expectations. Yet we know nothing of the sociology of expectation in the shaping of industrial networks and markets. By exploring the expectations around new technologies that have no market, we show how such expectations provoke the production of further expectations. We ask, how do expectations produce and shape imagined markets? This paper explores how expectations are generated, circulated and represented amongst different actors and as such, how expectations act as market shaping devices (Callon and Muniesa, 2005).

Frank Geels (2005) describes the rise of the contemporary car culture in the early 20th century as the confluence of interconnected trends that mutually supported and reinforced each other. Ford's model T and the rise of mass production brought standardisation, economies of scale in manufacturing, and affordable, easier to operate cars to a large middle class market (Womack et al, 1990). Powerful coalitions of interests, involving road lobbies (e.g. automobile associations), professional associations (e.g. highways engineers), policy makers, farmers and the middle classes seeking to expand into suburban areas, drove the adoption of cars as an individualised, flexible form of transport.

At the same time, new regulations were adopted to design traffic flows around the needs of cars and away from pedestrian safety. Speed restrictions were relaxed and with it came road accidents, some fatal with most victims being pedestrians and children playing in the street. It took significant efforts to educate drivers and pedestrians and instil a new traffic flow discipline, with cars ruling the streets and pedestrians confined to sidewalks (Geels, 2005).

In many respects, the socio-technical landscape that accommodated and nurtured the modern car culture is still very much with us today. Cars have evolved into more sophisticated and complex artefacts that are better able to withstand crashes and cause less damage to pedestrians. Traffic rules have evolved and are more thoroughly enforced. But, increasing numbers of cars are causing

significant damage in terms of pollution, CO₂ emissions and congestion rendering the life of modern commuters increasingly frustrating and expensive. Predictions of the demise of the current car system have signalled a number of converging threats, including climate change, depletion of global oil reserves, and rising urban concentration (Dennis and Urry, 2008; Geels et al, 2012). It is not difficult nowadays to find signs of change in the current car system. As Dennis and Urry (2008) point out, the current period resembles the early 1900s when multiple alternatives competed and coexisted without anybody being able to discern what lied ahead.

The purpose of this paper is to examine a contemporary development that is heralded by many as potentially revolutionary, the self-driving or driverless car. For the purposes of this paper, we defined a driverless car an autonomous vehicle that, through a complex assemblage of hardware and software does not require human intervention to navigate the existing road infrastructure. It is arguable whether this development is the most relevant to address many of the challenges that face the current car system, namely the need to move away from internal combustion engines. But, it is important to say that this is a development that does not in principle, conflict with other technological options that are currently being pursued, namely battery or hydrogen powered vehicles. Our focus is the role of expectations in shaping technological futures and their impact on how future markets are perceived. Expectations are mentioned in the context of technological development and associated with the roles different actors play in these processes (Mom, 2004; Geels, 2005). Our starting point is Rosenberg's (1976: 523) prescient observation that expectations of future change affect the behaviour of economic agents. In addition, expectations are neither fixed nor external to processes of change. They tend to co-evolve with those processes and thus help steer those processes in particular directions. In short, expectations are performative – they have effects, and they play a role in enacting the very scenarios they describe.

The structure of the paper is as follows: the first section provides a selective review of the literature on expectations with a focus on the sociology of science and technology. The second section explains the methodology employed to conduct our empirical study which is described in the third section. The fourth section analyses and discusses the empirical results pulling together a number of relevant lessons for our understanding of the role of expectations in technical and market development. In the final section we offer some concluding comments and implications.

Uncertain Futures and Expectations

We start with our survey of the expectations literature with a brief discussion on how the social sciences have addressed the broader theme of uncertainty. Selin (2008) contends that the social

sciences have shied away from confronting uncertainty and the lack of knowledge by focusing on evidence and proof. But, positivist, evidence-based social science is poorly equipped to deal with uncertainty other than acknowledging the ways in which it constrains individual and institutional behaviour. And yet, as Adam (2006) argues, engagement with the future has profound consequences for the social sciences namely on how we study futures that can be foreseen but have yet to materialise. The most unproblematically accessible part of the future is what Adam (2006) calls *present futures*, the realm of technology planning, economics, management, organisational practices and so on. Brown and Michael (2003) made a similar point regarding the need to shift from looking *into* the future to looking *at* the future, or how visions of the future are mobilised now to marshal resources, coordinate activities and so on. As Adam (2006: 10) aptly puts it:

“Focus on present futures provides us with access to the social sphere of expectation, choice, selection, option and instrumentality. The present future is the base on which utopias are constructed. From the position of the present future we compose scenarios, produce foresight studies, and engage in horizon scanning”.

This section is thus concerned with how present futures have been addressed by different strands of the social sciences, with a particular focus on expectations. We start with economic theory before moving on to economic sociology and the sociology of technology.

The role of expectations in economic theory, namely in J. M. Keynes' (1936) general theory, has a long history and it is outside the scope of this paper to provide a comprehensive overview of this literature (but see Dequech, 1999). The discussion of expectations in economics is strongly linked to concerns with risk, uncertainty and an indeterminate, unknowable future. For example, Lachmann (1943) sees expectations as associated with purposeful action which requires the anticipation of situations and circumstances which need to be taken as given and must be treated as "data". Expectations must thus be understood as these states of mind that anticipate the context and circumstances surrounding future actions and their consequences. For another economist, George Shackle, pervasive uncertainty was not a problem to be eradicated but a necessary condition for human intelligence and imagination, being central to techno-scientific progress and innovation (Loasby, 2011).

Cyert and March (1963) devoted a whole chapter to organisational expectations in their classic study of business decision making. Expectations were regarded as entangled with wishes and hopes as well as subject to conscious manipulation by the sectional interests of organisational subunits. Expectations were thus not exogenously given as assumed in economic theory but part and parcel of decision making.

Beckert (2013a) remarks that sociology has taken a different route to addressing expectations. Choices and actions are seen as anchored in cultural scripts supplied by the networks and institutions in which actors are embedded. These scripts are a vital cog in socio-economic orderings by suggesting ways to act despite pervasive uncertainty. Furthermore, conventional scripts help individuals and organisations gain legitimacy in the eyes of other actors in the same socio-economic field (Beckert, 2010).

Beckert (2013a, b) proposes an alternative to institutionalist perspectives by introducing the notion of *fictional expectations*. For Beckert, *fictional expectations* refer to the present imaginaries of future situations which provide orientation to economic actors despite uncertainty and the incalculability of outcomes. *Fictionality* refers to the future being unforeseeable so that expectations, rather than being concrete forecasts or firmed up scenarios, are imagined future states of the world. The notion of *fictional expectations* is thus based on a pragmatic understanding of action. Actions are not seen as the realization of ends that stand outside action itself (the separation of means and ends) but as a progression, in which means and ends are formed and successively revised based on changing interpretations of the situation (Whitford, 2002).

More often than not, *fictional expectations* take a narrative form in the guise of stories, visions and scenarios about the future (Beckert 2013a, b). Beckert (2013a) sees calculation as a particular form of storytelling and as a way of providing legitimacy to decisions made under uncertainty. If actors assume that calculations are instruments that give shape to the future, Beckert (2013a: 235) sees them as “...tranquilizers against the paralyzing effects of having to act in unpredictable environments”. We will return to this matter later.

In the sociology of science and technology literature, Van Lente and Rip (1998) proposed that expectations are a source of change, helping to coordinate activities and building up agendas for technological development. Expectations are seen as being taken up in public or semi-public statements, narratives and scenarios. As narratives about future worlds, expectations contain plots where relevant actors are allocated roles and positioned in relation to an unfolding story line. As these plots take the form of public or semi-public statements, they can be drawn upon by others who react to the roles they have been allocated or contest the story line itself. As Deuten and Rip (2000) remark, a master narrative sometimes emerges out of these dispersed efforts by mutual adjustments amongst heterogeneous stories. Some building blocks get adopted, recycled and developed to become accepted ingredients in other stories thus generating a narrative infrastructure about the development of a technology.

Borup et al.'s (2006) review of the literature places expectations as foundational in multiple forms of coordination. These involve the coordination of different actor groups, different scales of organization and temporal forms of coordination. Expectations knot together technical, social and economic conditions as well as linking the inner and outer worlds of knowledge communities and techno-scientific fields. And, expectations are often embodied and circulated in material and durable forms such as prototypes, demos and so on.

Borup et al (2006: 286) define technological expectations "...as real-time representations of future technological situations and capabilities". Van Lente (2012) made a useful distinction between foresight and expectations. Foresight refers to a group of activities whose aim is both to identify promising technological pathways but also to engage a range of stakeholders around a common vision of the future. By contrast, expectations can be defined as more informal statements about the future that are inscribed in texts or other materials that circulate. Expectations are statements that help enact something, rather than predictions that may turn out to be true or false.

Once expectations are voiced and circulated, they may serve the purpose of coordinating multiple and distributed efforts, but they may also be appropriated for unintended purposes. The utterance of promises such as "we pledge to bring the first autonomous car to market by 2020," creates a sense of obligation by a leading car company directed at a variety of audiences, namely shareholders, suppliers, regulatory agencies, and governments as well as the general public. If the same statement is uttered by the same senior executive in front of an R&D department or a key supplier meeting, it creates more specific obligations, in terms of focused development programmes, technology roadmaps and so on. The same statement may also serve unintended purposes such as putting pressure on legislators and regulators to change existing highway rules. Van Lente (1993, 2000) argued that this turns promises into concrete requirements - the 'promise-requirement cycle' - and is crucial to understand the dynamics of expectations.

Expectations also display a temporal pattern often manifested in cycles of hype and disappointment. Inflating expectations is seen as essential to creating interest and mobilising support for new technologies, in the form of financial support, setting technical and political agendas leading to the creation of protected niches (Kemp et al, 1998; Borup et al, 2006). Early hype is often followed by disappointment, as early expectations are often overly deterministic, focusing on technological aspects and neglecting the many other factors (social, political, economic, cultural) on which the success of technologies depend.

Borup et al (2006) suggest that expectations often vary between different groups involved in technological development, depending on their level of understanding of the technology and perceptions of influence over its development. Thus expectations may be perceived as highly performative by groups that see themselves as having little understanding or influence over the outcome of development scenarios, seeing it as an inevitable march of progress. Paradoxically, those who are closest to technological development and the most confident public supporters of its potential are often the ones who are most equivocal and cautious about the potential of their field when interacting with their peers.

Borup et al (2006) ask whether expectations are essentially rhetorical or material in character. Put differently, do expectations inhabit a world of rhetoric and public pronouncements, or do they acquire a material character, becoming inscribed in a variety of texts such as official reports, prototypes, demo installations and so on? And what is the relationship between these different media in which expectations are inscribed and circulate?

Rip (2009) builds on the notion of expectations as “fictive scripts” first introduced by de Laat (1996, 2000), and suggests that these scripts cannot be reduced to rhetoric. Scripts are also material, in the sense of being embodied in durable materials that shape what is possible and realistic to achieve in the future. As Rip (2009: 412) explains: “Material narratives create agendas, and storylines that continue into the future. [...] Our landscapes have become filled up with cables, pipelines for oil and gas, just as well as roads, and now also masts for mobile telephony, related to the “cells” covering the territory. They were shaped by what we wanted to realize, now they shape what we can do, and how we can develop further”.

Earlier, Berkhout (2006) noted that the purpose of visions is to either endorse or criticise the present and suggested that expectations are often generated to justify change in the present in ways that are never politically neutral or innocent. Using the example of hydrogen vehicles, Bakker et al (2011) observe that many emerging technologies are systemic in nature and thus require the alignment of the expectations of a multitude of actors and organisations. The development of these systemic technologies depends on the efforts of heterogeneous and often distributed groups of scientists and engineers who work on interrelated problems and may require periodic contact at least. This is what Rappa and Debackere (1992) call technological communities, a definition that Bakker et al (2011) suggest fits the wide range of scientists and engineers who work in parallel to develop the various components of what might be called the hydrogen automobility future.

Because of the fragmented and dispersed nature of this technological community, different visions of the future of the hydrogen automobility future circulate within a broader, infrastructural vision of the future of hydrogen energy systems. As Bakker et al (2011) note, the range of component technologies that make up the hydrogen automobility future are mirrored by a chain of interdependent and yet differing expectations. Whilst the feasibility of the hydrogen automobility future and more broadly, a hydrogen-fuelled future depend on positive expectations regarding the development of individual components (e.g. fuel cells, storage systems), the credibility of each singular development effort is dependent on the expectations regarding the development of a whole system.

In turn, technological communities are often in competition for funding, public support and so on, with other communities peddling different solutions to the same problems (e.g. hydrogen-fuelled versus electrical battery cars). These communities wage their battles on what Bakker et al (2011) call *arenas of expectations* involving the experience, knowledge, and interests of the proponents of alternative technological solutions.

The battle of expectations is seen as part of a collective, interactive process involving not just those who advocate and select technological options. As Bakker et al (2011: 150) note: "These multi-actor interactions take place at scientific conferences and journals, in the wider media, committees, research councils, and so forth".

These observations suggest the need to pay closer attention to the multitude of arenas through which expectations are set, circulated and contested. In particular, we are interested in how the media and analysts, experts, academics, think tanks and consultancies of various guises play a role in the shaping expectations and constitute privileged vehicles for the circulation of expectations across a wide range of constituencies.

The role of the media, in particular, has featured prominently in studies related to the construction and stabilisation of new categories in markets. Rosa et al (1999), for example, focus on the role of stories as vehicles for building consensus around the representations of new products and novel product categories. In their view, product categories are fashioned, maintained, and transformed through public and private discourse in which the general and specialist media play key roles. Anand and Peterson (2000) focus on market information regimes as the medium through which producers observe each other and make sense of their world. In these regimes, "...information typically takes the forms of sales reports, inventory information, trade magazine reports of "hot selling" items, newspaper articles, rumours or gossip with connections to past, present, and future courses of

action” (*ibid*: 272) Kennedy (2005) focuses on the role of press releases as a way of shaping collective market sensing in novel product categories. However, the focus of this literature is on the construction of intersubjective agreements that help stabilise new product categories and help them gain legitimacy in the eyes of others.

Pollock and Williams (2009) focus on the role of industry analysts in shaping expectations about the development of technological fields and the evolution of markets in highly dynamic contexts. Their study of IT markets concludes that the knowledge produced by consultancy organisations such as IDC or Gartner is increasingly relevant in a context where both suppliers and user communities struggle to make sense of continuously changing technology and market offerings. These organisations are constantly striving to stabilise the contours of markets by offering participants ready-made ways to classify vendors and their offerings (e.g. the Magic Quadrant). In doing so, these representations of the marketplace begin to constitute the very reality they describe – i.e. they have performative effects. These effects can be observed when vendors start to portray themselves using the dimensions supplied by those market maps and customers use the same tools to compare rival offerings.

In conclusion, we wish to retain a number of issues emerging from the literature review. Expectations constitute representations of future technological contexts and capabilities and market possibilities for those technologies. But, they are also representations with a performative character – they actively participate in the construction and development of the scenarios they narrate. And as such, they have a strong political character. As Rip (2009) noted, they include projections of futures deemed possible and desirable. Expectations are inscribed in a variety of materials with different degrees of credibility vis-à-vis specific audiences – e.g. foresight reports might have higher impact on policy-makers whereas engineers will be more interested in working prototypes. Lastly, as the development of technologies require evermore distributed and fragmented efforts, different actors use a variety of channels to articulate and circulate their expectations. These often take the form of textual narratives (e.g. reports, case studies, news items) about the technologies and their benefits, as well as the changes required to accommodate them within existing socio-technical landscapes. However, we know comparatively little about a number of important questions:

- 1) What is the content of these textual narratives, what claims and arguments do they deploy and what audience are these aimed at?

- 2) What is the role of different media (e.g. academic papers, press items, think-tank and consultancy reports) in conveying expectations and helping to construct narratives about the future?
- 3) What types of actors are involved in setting expectations and how do their activities cohere or diverge from each other?

Methodology

Our empirical case relates to the ongoing development of autonomous vehicles, more specifically self-driving or driverless cars. Narratives of a future populated with driverless cars have been around for a while. A magazine article published in the *Electronic Age* in 1958 and suggestively entitled “Electronic Highway of the Future” painted this vision in vivid tones:

“Some day in the future when you drive onto a superhighway, you’ll reach over to your dashboard and push the button marked “Electronic Drive.” Selecting your lane, you’ll settle back to enjoy the ride as your car adjusts itself to the prescribed speed. You may prefer to read or carry on a conversation with your passengers—or even to catch up on your office work. It makes no difference for the next several hundred miles as far as the driving is concerned”.ⁱ

The technological solution to bring about this reality would rely on a gradual introduction of electronic equipment in the highway system and vehicles that would eventually lead to a driverless experience. Drivers would only have to take control once they left the highway.

The development of autonomous vehicles has not been limited to passenger cars. An early example is the Parisian *Aramis* project described in Bruno Latour’s (1996) eponymous book. *Aramis* was an advanced form of personal transport developed for RATP (Régie Autonome des Transports Parisiens) between 1969 and 1987, by the French defence company Matra. *Aramis* was designed to combine the most attractive aspects of personal and public transport, with small, driverless carriages combining to form a flexible train that would change configuration whilst in transit. Users would stand in stations and summon carriages from passing trains which would later re-join the train via contactless links. The flexible nature of the train would remove unnecessary stops and transfers, combining some of the best aspects of passenger cars with the sound benefits of public transport.

Current visions of driverless cars can more appropriately be seen as an evolution of an existing artefact – the conventional passenger car. In the last few decades, cars have literally been swamped with all forms of electronic systems. From engine management systems, to trip computers, and self-diagnostic tools, passenger cars have evolved to the point where they can be seen as a complex assemblage of mechanical and electronic systems. In the more recent past, we have seen

automakers adding further technologies such as Bluetooth connections, GPS navigation systems, in-vehicle infotainment, as well as a host of driver assistance aids (e.g. blind spot information systems, traffic sign recognition, lane keeping, adaptive cruise control).

Thrift (2004) has characterised these trends in terms of three movements. First, human qualities were externalised onto machines (e.g. computers with 'memories' and 'intelligence') and human interactions have taken on machine-like qualities (e.g. the creation of technology-enabled social 'networks'). Secondly, knowledge about human and technological-based practices has become locked in ever tighter reflexive loops. Finally, the development of cars has become one site where these cumulative developments have led to the creation of hybrid entities where the boundaries between human and machine-like qualities have become distributed in ways that defy sharp distinctions between them. The plethora of driver assistance aids mentioned above suggests to Thrift (2004) that we are moving ever closer to the Latourian notion of a delegate (Latour, 1992: 235): "first, it has been made by humans; second, it substitutes for the actions of people and is a delegate that permanently occupies the position of a human; and, third, it shapes human action by prescribing back". In a similar vein, Beckmann (2004) suggests that driver 'intelligence' is often presented as a question of equipping the driver with ever more technological aids. Without these delegates, drivers do not qualify as 'intelligent'.

The shift towards driverless passenger cars is thus less of a radical jump than might have been assumed only a few years ago. Campbell et al (2010) provide a comprehensive review of the work that led to driverless vehicles. In particular, they show how a series of competitions sponsored by the US Department of Defense (Defense Advanced Research Projects Agency (DARPA) led to the gradual development of vehicle capabilities to sense their immediate environment, classify the objects that they detected whilst being able to execute complex manoeuvres that stayed within the bounds of the relevant highway rules. The major technological challenge consisted in developing capabilities to react to unexpected situations due to either failures in the vehicle systems or the behaviour of agents in the external environment. The ability to navigate these complex situations has required the integration of a variety of technologies from computing, to robotics, electrical and control engineering (Campbell et al, 2010).

At the same time, the fit of driverless cars with what Urry (2004) calls the current automobility system is less clear. The automobility system is a powerful complex constituted through socio-technical linkages amongst car parts and accessories; petrol refining and distribution; road-building and maintenance; hotels, roadside service areas and motels; sales and repair workshops; suburban

house building; advertising and marketing; urban design and planning, etc. To this we should add a complex set of traffic rules and legislation, a highly developed system for driver training and certification as well as a complex system of insurance dedicated to evaluating traffic and driver risks. In short, the insertion of driverless cars in the existing socio-technical landscape will need to navigate a maze of highly interconnected markets, rules and regulations, highway and urban design, etc. These characteristics make this case particularly interesting regarding our interest in expectations. Driverless cars are a future widely foreseen but has yet to materialise – and indeed, may never materialise. It engages a variety of actors and audiences. Many of its alleged benefits and potential consequences have been and will in all likelihood, continue to be debated and contested by experts and lay people alike. And those consequences cannot be easily categorised *a priori* as being say, social, technological, economic or environmental.

Our data collection started in the late Spring of 2012 and was sparked off by the initiative to write a report to accompany a policy paper on market-making produced by the Big Innovation Centreⁱⁱ. The Big Innovation Centre is part of the Work Foundation, incorporated in Lancaster University, a research, consultancy and policy think tank located in London. As part of this exercise, we amassed an archive of academic papers, think tank and consultancy reports as well as a wide range of press clips related to the development of driverless cars. Through our authorship of the above mentioned report, we generated a number of press clips ourselves as different types of media (newspapers, magazines, radio stations) contacted us for comment on policy and technological developments.

The clips and references were collected mostly in electronic form and stored in Evernote, a multi-functional piece of software that allows note-taking as well as clipping, storing and organising any type of web pages. The clips were then classified and tagged with multiple codes. The search function within Evernote allowed us to search for keywords and themes within and across notes as well as retrieve all notes with particular tags.

For the purposes of this paper, we have focused our analysis on clips that covered the following issues:

- 1) Broad overview of developments, debates and summaries of the state-of-the art regarding technological, market or regulatory developments in relation to driverless vehicles
- 2) News items from firms and organisations (e.g. automakers, automaker suppliers) directly involved in developing technologies related to driverless vehicles.

- 3) News items related to obstacles or fears related to the introduction of driverless vehicles in the existing automobility system or the changes required in the automobility system to accommodate these vehicles.

Constructing a Driverless Future

An alliance of consultancies, think tanks and academics provide most of the material related to the broad overviews on developments of driverless vehicles. Two reports published in the last two years, stand out as standard-bearers of the driverless car cause. The first, entitled *Self-Driving: The Next Revolution* (2012) was the product of a collaboration between KPMG and the Centre for Automotive Research (CAR), a non-profit US organisation. The second report entitled *Preparing a Nation for Autonomous Vehicles Opportunities, Barriers and Policy Recommendations* (2013) is a collaboration between US academics and the ENO Transportation Centre, another think tank. Both reports follow a similar structure and attempt to provide an authoritative and comprehensive account of the current state of affairs, the benefits of the widespread introduction of driverless vehicles and barriers to implementation.

There are two main widely quoted reasons as to why driverless cars should be introduced.

- 1) *Fewer accidents.* A significant proportion of accidents and loss of life on the roads are due to human error. Reducing or eliminating human intervention in driving passenger vehicles should drastically reduce the accident toll.
- 2) *Fewer traffic jams.* Driverless cars are much better adapted to higher volumes of traffic, as they would be able to travel at higher speeds whilst keeping shorter distances between vehicles. Decreased congestion and better overall fuel economies will be achieved as a result.

We will address these two issues in sequence even though they are clearly interlinked.

The KPMG/ CAR report places fewer accidents as a major reason for introducing driverless cars, citing prior research on the number of annual vehicle crashes in the US as 6 million in 2010 making it the leading causes of deaths amongst the 4-34 age group. Nearly 3 million people were injured in car crashes in the same period. The report also cites research by the American Automobile Association estimating that car crashes cost Americans \$299.5 billion per year. Human error is held as responsible for 93% of crashes. The report cites a presentation by an official of the National Highway Traffic Safety Administration proposing that the goal of automated cars is “crash-less cars”.ⁱⁱⁱ Similarly, Volvo’s painstaking research into accidents led the company to proclaim a few years ago that their ultimate aim is to design cars that do not crash.^{iv}

The ENO report, which attracted a fair share of media attention^v, follows in the same footsteps although it sounds more cautious notes regarding the potential to reduce road deaths. It works with the assumption that driverless cars would be better equipped to eliminate some of the causes of fatal crashes, namely alcohol, distraction, drug taking and fatigue, which together account for 40% of deaths. In addition, it warns that there are still technological challenges in getting driverless cars to recognise all forms of road hazards and that in some cases, liability for these types of incidents could be a substantial barrier to implementation. The expectation of crash-less vehicles should be replaced by a more realistic target of bringing down fatality rates (per person-mile travelled) closer to those seen in aviation and rail, or 1 percent of current rates.^{vi}

As far as car accidents are concerned, the authoritative World Health Organisation (WHO) report on Road Traffic Injury Prevention (2004) painted a depressing worldwide picture on the role of road traffic injuries as a cause of death across age groups. Road accidents represented either the second or third leading cause of death in the 5-44 age bracket in 2002, with forecasts predicting a significant leap in these figures (as much as 65%) up to 2020. In economic terms, the report placed the cost of road crash injuries at roughly 1% of gross national product (GNP) in low-income countries, 1.5% in middle-income countries and 2% in high-income countries.^{vii}

The report argues that road traffic injury prevention and mitigation should be given the same attention and scale of resources that is currently paid to other prominent global public health issues. It also makes an important and seldom recognised argument about policy interventions and public attitudes related to deaths on the road. The wide use of the term “accident” conveys the impression of something that cannot be predicted or prevented – a random event. The report deliberately uses the term “crash” instead of “accident”, to focus the attention on the fact that crashes are a tractable problem and remedial action can be taken. Beckmann (2004) notes how accidents become normalised within the automobility system. Once a crash happens, emergency services and accident specialists clear the road, victims are taken to hospitals, cars are repaired or condemned to the scrapyard, those deemed responsible for crashes are tried and locked up, and so on. In short, accidents are removed from roads to another part of the automobility network, finding their way into hospitals, courts, police logs, road accident statistics and the pages of newspapers.

But, as the WHO report reminds us, even if human error constitutes a major cause of road accidents, we should not assume that it can be separated from the environment in which human behaviour takes place. Errors can also be mitigated by changing the outside environment rather than attributing them solely to human dispositions and frailties.^{viii} In addition, Patrick Lin, a specialist in Robot Ethics, writing in the *Wired* magazine argues that the calculus of saving lives is not so

straightforward.^{ix} It is unlikely that autonomous vehicles will end all traffic-related deaths. Accidents will still happen due to hardware (e.g. misaligned sensors) or software problems (e.g. bugs) as well as more common human errors (e.g. lack of compliance with service schedules). And the expected reduction of fatalities does not necessarily mean that it concerns a fall in the numbers of deaths for the same population. The numbers quoted refer to a net saving of lives – i.e. autonomous vehicles could save a large number of lives due to common causes and yet being implicated in the loss of lives due to currently unforeseeable causes. In short, comparing figures related to accidental deaths on the road before and after the introduction of autonomous vehicles should not absolve us from confronting the need to anticipate and plan for new dangers.

The second issue cited as a major drawback of the current automobility system is congestion. A report by the UK think-tank Centre for Economics and Business Research (2012) entitled “The Economics of Gridlock” attempted to quantify the costs of heavy road traffic through peak commuting periods in the UK, France and Germany.^x The report broke down these costs in terms of direct and indirect costs. Direct costs relate to the cost of fuel while staying idle in traffic and lost working hours and/or lost leisure time due to longer working hours. Indirect costs relate to the higher prices that all households have to bear, independently of whether they are car commuters, due to the businesses having to pass on their higher transport costs to final consumers. The total costs of congestion were estimated at nearly €5 billion for the UK, € 5.5 billion for France and €7.8 for Germany. In the US, the growing percentage of the population living in urban areas and the growth of multi-car households is adding to congestion and creating problems for urban planning. Estimates for the US quote figures of US\$ 101 billion dollars in combined delay and fuel costs.^{xi}

Ben-Joseph (2012) claims that parking lots in some cities cover as much as one third of the metropolitan footprint and bemoans the relative neglect of their design and function. Worse still, Donald Shoup, a Professor of Urban Planning at UCLA, claims that an increasing percentage of traffic within urban areas is caused by drivers looking for a parking space.^{xii}

Self-driving cars can help in this regard too. These vehicles should be able to travel closer together, occupying less space on the roads, allowing for smoother braking and finer speed adjustments. The European Commission project known as SARTRE - Safe Road Trains for the Environment – has already demonstrated that driverless vehicle trains in motorways seem to work safely. Cars in these trains are fitted with features such as cameras, radar and laser sensors - allowing a “carriage” vehicle to monitor the “locomotive” and other vehicles in their immediate vicinity. The most interesting aspect of this project is to show that there is little or no change required in either the vehicles or the infrastructure for these trains to work. All that is required is a wireless network between cars in the

train and the appropriate software to ensure that, for example, gaps between vehicles travelling at speed (~83 km/h) remain at around 6 metres.^{xiii} These features will turn into fuel savings and possibly reductions in traffic shockwaves propagation too.^{xiv} In addition, self-driving cars should be able to navigate intersections more efficiently and safely.

But these benefits are largely dependent on the share of self-driving cars on the roads. In other words, they depend not only on autonomous vehicle capabilities but on vehicle-to-vehicle communication capabilities as well as vehicle-to-infrastructure communication.^{xv} The ENO report suggests that, if 10 percent of all vehicles on a given road segment are self-driving, there will likely be one such vehicle in every lane at regular spacing during congested times, which could potentially alleviate congestion for all road users. However, if this percentage drops to less than one percent, the impact would be non-existent or negligible. But, even if adoption is high, realising the benefits of reduced congestion would require the implementation of cloud-based systems and vehicle-routing paradigms and protocols at a city or regional level. The rate of adoption of self-driving cars matters for other reasons too. The cost of the enabling technologies is still too high and it would take a significant manufacturing scale to bring the prices of self-driving vehicles close to conventional cars. These poses interesting issues for both the supply and demand side of the equation.

On the supply side, it is not clear who is best positioned to act as systems integrator of these technologies (Prencipe et al, 2003). Whilst Google has been attracting the lion's share of publicity on the development of self-driving cars, namely the testing of and the push for licensing prototype vehicles on public roads^{xvi}, other actors in the current automobility system have been active in pushing and testing their own developments. Established car makers such as Mercedes-Benz, BMW and Volvo have worked on developing component technologies, often in collaboration with major suppliers, for years. Mercedes latest S-Class models combine an on-board camera with long, medium and short-range radar that triggers the vehicle to brake in reaction to unexpected events such as pedestrian suddenly stepping into the road. On motorways, adaptive cruise control ensures that it maintains a constant distance from the vehicle in front.^{xvii} Volvo are currently testing self-driving cars in Gothenburg in a joint project with the Swedish Transport Administration, the Swedish Transport Agency, Lindholmen Science Park and the City of Gothenburg.^{xviii} Elsewhere, the electrical vehicle pioneer Tesla is announcing its own ambitious plans in this area.^{xix} Large suppliers to the automotive industry such as Bosch and Denso also see themselves are particularly well-positioned to take a critical role in future developments. The head of development at Bosch is quoted as saying that: "Driver assistance functions will require many more electronics and sensors in the car. Suppliers are better able [than carmakers] to build the necessary economics of scale".^{xx}

There are also likely to be tricky comparisons between upfront and operating costs on the demand side. Whilst a fully autonomous vehicle is likely to be expensive, its upfront costs need to be balanced against potentially lower insurance and fuel costs with further savings possible in parking charges in some environments.^{xxi} A JD Power survey in 2012 found that 20 percent of all vehicle owners say they "definitely would" or "probably would" purchase it in their next vehicle after learning the estimated market price of US\$3,000. Before learning about the price, interest was at 37 percent.^{xxii} The survey also found that vehicle owners are nearly as likely to select fully autonomous driving mode as they are to select semi-autonomous driving technologies such as emergency stop assist (\$800) or traffic jam assist (\$800). Interestingly, as the ENO report authors note, the cost of adding a full set of semi-autonomous driving technologies to a top-of-the-range executive car would probably cost four times as much the estimated market price for a car equipped with fully autonomous driving mode.

A KPMG study reporting the results of focus groups suggests that existing drivers can appreciate the benefits of self-driving vehicles and are increasingly willing to pay for semi-autonomous driving extras when purchasing conventional cars.^{xxiii} But even KPMG, an enthusiastic cheerleader for self-driving cars, recognises that significant obstacles and uncertainties remain. To cite but two examples, it is not clear how liability laws will have to change in order to accommodate instances in which autonomous vehicles are involved.^{xxiv} What would happen in the case of a collision between say, a driven and a driverless car, or even between two driverless cars? What would insurers be prepared to cover and what types of arguments would the law be prepared to hear in cases of damages and personal injuries? And what exactly would insurers insure? Drivers will still matter, at least as owners of vehicles with ultimate responsibility for their maintenance, with the possibility that manual overriding will take precedence over driverless features as far as the law is concerned.^{xxv}

A joint report by Internet security firm McAfee and Wind River calls attention to the security risks involved in embedded car devices.^{xxvi} The report argues that experiments such as the Google driverless car and smart roads (e.g. equipped with traffic or speed sensors) demonstrate the potential of coordinated, connected communication with in-car electronic systems with other vehicle's systems and the infrastructure. However, little has been done so far to ensure the security of these systems. The increasing use of embedded and connected devices in cars could lead to serious problems from remote attacks via Bluetooth to the hacking of private data stored in the car's infotainment system. The reassuring note is that the development of vehicle-to-vehicle and vehicle-to-infrastructure communication protocols include security concerns in the initial development phase.^{xxvii}

Discussion: what does the driverless car case tell us about expectations?

As we discussed earlier, expectations about the future of driverless cars provide a variety of narratives about both the future and the present of the automobility system. The strength of these structures, as Lane and Maxfield (2005) suggest, lies in their subtle combination of teleology and indeterminacy. The teleological element within a narrative structure, leads the audience towards a recognised destination whilst indeterminacy leaves room for twists, turns and surprises along a route that cannot be mapped in advance.

The two major aspects of the narrative infrastructure around the future of driverless cars have provided some useful empirical material to reflect on our research questions. The first aspect of note is the content of these textual narratives. The plots centre on two major problems of the current automobility system that driverless cars will either mitigate or remove altogether. In this plot, humans are both perpetrators and victims. As far as road safety is concerned, the example we will focus on, the narrative is narrowly constructed around human frailties and limitations. Humans make poor judgments, are easily distracted, use mobile phones at the wheel, drink and drive, etc. These claims are backed up by statistics showing that humans are indeed the major cause of accidents and calculations on the economic costs of these tragedies. The interplay between words and numbers are central to this narrative (Holmes, 2006). Numbers play a key role in characterising the existing state of affairs and building credible scenarios for the future in terms of lives saved, costs removed from the automobility system and so on. Words frame these statistics and projections, providing causal-like explanations as to how we move from a crash-infested system to a virtually crash-free future. In short, calculations are not external to the narrative and do not simply have a placebo effect, soothing the anxieties of those making decisions under great uncertainty (Beckert, 2013a, b). Calculations are an integral part of these narratives, providing credibility and legitimacy to claims about the future, and linking together all forms of inscriptions across long networks in our case (Latour, 1987).

The central plank of this narrative is thus that intelligent assistance provides the bridge between now and this expected future. As Beckmann (2004) notes, in the 'ideal' hybridized traffic-world such as the one painted by driverless car narrative, accidents would only occur if entities began to mistrust each other. Once drivers start mistrusting their assistance tools and take control, they put themselves and others at risk. Thus, as Beckmann (2004: 91), remarks "...the more stable the trust, the higher the degree of hybridity, and the lower the risk of being involved in an accident. The more

hybridity there is, the safer traffic gets; perfect hybrids don't crash". Conversely, when an accident occurs, hybridity was either imperfect, the merging between human and vehicle systems had stopped, or was flawed at the time of the accident. The only reported Google car crash happened when a human was in control, as we are frequently reminded.^{xxviii}

In Callon's (1998) terms, this narrative frames crashes and their causes in relatively narrow terms. The overflows in this case are plentiful and cannot be easily hidden. It is worth reminding ourselves that most of the efforts directed at improving road safety so far have focused on other factors rather than on human error. As the WHO report makes clear, influencing human error are external factors such as the design of roads, the design of vehicles and in particular, their ability to protect passengers in the event of crashes, traffic rules and the strength of the enforcement of traffic rules.^{xxix} And, paradoxically, if humans need to be removed from the existing system as far as it is technologically possible, their agency presenting huge safety risk, paradoxically they are still needed for other purposes. Even if the legislatures that have proved more favourable to accommodate driverless vehicles such as the Senate of California insist on a key role for humans, much like that of an airline pilot when the autopilot is turned on: "The driver shall be seated in the driver's seat, monitoring the safe operation of the autonomous vehicle, and capable of taking over immediate manual control of the autonomous vehicle in the event of an autonomous technology failure or other emergency" (California's Senate Bill 1298, Vehicles: autonomous vehicles: safety and performance requirements).

In terms of our second research question, the role played by different media and channels in sustaining a narrative about the future of driverless cars is particularly interesting. As we have shown in the previous sections, there has been no shortage of media interest in stories on this topic. The KPMG report "The Self-Driving Revolution: Are we ready?" features data, using the company's proprietary data intelligence tool to capture unstructured web data, showing a significant surge in conversations on this topic from June 2012 onwards.^{xxx}

All players involved in developing technological solutions connected to driverless cars seem to find no trouble in placing media stories, be it in daily newspapers, weekly magazines, radio and to a lesser extent, TV stations. The narratives in the media are split news items and with more analytical commentary pieces, which tend to be rather infrequent. News items on driverless cars have been generated fairly regularly over the last couple of years mainly as a result of novel initiatives regarding technical or testing developments – e.g. Audi is testing a driverless model in Nevada – as well as regulatory changes – e.g. California Senate passes new bill on autonomous vehicles. Media

interest also extends to reports such as the one we produced for the Big Innovation Centre and to interviews with experts.

The tone of these reports is generally positive, if not enthusiastic. To return to an earlier section of this paper, expectations often display alternating cycles of hype and disappointment (van Lente and Rip, 1998). Hype is manifested through overly deterministic technological trajectories, whereas disappointment comes when other factors (social, political, economic, cultural) on which success depends, are taken into account.

The British magazine *The Economist* ran a feature in late 2012 which not only endorses driverless cars in terms of a wide range of benefits they can provide, including reviving the traditional country pub heavily hit by drink and drive laws, but also warned readers that the future is arriving in dribs and drabs.^{xxxii} In other words, the driverless car will have revolutionary consequences but is itself the product of a slow evolution. Better still, many of building blocks are already familiar to us and thus the last steps towards full autonomy will be relatively modest and arrive earlier than we think. There will be losers in this process too, mainly amongst those whose job it is to drive vehicles (e.g. taxi drivers). But, in the Schumpeterian evolutionary frame that underpins this story, these are contemporary equivalent of the blacksmiths, farriers and buggy-whip makers that largely disappeared as a result of the introduction of the motor car. Similarly, the KPMG report draws on socio-technical systems theory (Geels, 2005), namely the role of niches in protecting and nurturing innovations, as well as Rogers' *Diffusion of Innovations* (1962) to remind readers that the adoption of the conventional car was neither immediate nor straightforward.

Lastly, we address the issue of who is involved in setting expectations regarding the future of driverless cars. A range of consultancies and the media, as mentioned above, have been instrumental in creating a narrative of a fast, linear technological evolution towards a driverless future followed by a long, socio-economic revolution with virtually no drawbacks. To quote a recent feature in TIME magazine, "Driverless Cars are coming, whether we like it or not".^{xxxiii} One effect of these stories has also been to neglect or eclipse other stories related to parallel technical developments in the car industry such as alternative fuels and engines (e.g. hydrogen cars) as well as alternative forms of transport. Even when novel and small scale experiments such as the one currently being developed in the English city of Milton Keynes for self-driving pods to move alongside special pathways, is being framed within the broader discourse of autonomous vehicle being let loose on the roads.^{xxxiii}

Google has been bullish about the development of the technologies and one of its founders, Sergey Brin has been quoted as saying that the technology could be available from 2018.^{xxxiv} But, even if Google has played a key role in developing the software that makes driverless car possible, it is not clear whether it intends to create its own marque and if so, how it will do it (e.g. in partnership with an existing car assembler). Automakers have been both conspicuous in terms of their extensive testing as well as their forecasts regarding when fully autonomous vehicles might be introduced. These estimates are usually framed in terms of market introduction of new models and they usually pick a date in the range 2020-2025.

A German automotive supplier paints an evolutionary picture where we will move from partially automated in 2016, to highly automated in 2020 and fully automated vehicles in 2025.^{xxxv} Intel who is looking to equip driverless cars with its chips predicted 2022, in late 2012, as the date for wide market availability.^{xxxvi} The IEEE, the world's largest professional organization for engineers, picked autonomous vehicles as the most promising form of intelligent transportation in late 2012, predicting that they will account for up to 75 percent of cars by 2040.^{xxxvii} Insurers appear to be far more cautious in predicting when driverless cars will be widely available and warn of problems regarding decisions about liability in the case of accidents. The president of the US Insurance Information Institute, Robert Hartwig was predicting in early 2013 that it would take 15-20 years to see driverless cars on the roads.^{xxxviii}

As in the case of hydrogen vehicles (Bakker et al 2011), we can identify arenas of expectations where a multitude of actors with different experience, knowledge, and interests are involved in setting expectations as part of a collective, interactive process. But, unlike hydrogen cars, the setting of expectations seems less centred on technological options and more on who can deliver fully-tested and safe driverless vehicles and by when, as well as what changes need to be made to the existing automobility landscape in order to accommodate driverless vehicles.

Conclusions and Implications

The findings presented above contribute to our understanding of the way expectations shape markets in three key ways. First, our findings show how representations of expectations are used to show future value – whether social or economic. Our findings show how text and numbers are gathered together and represented to enable comparison of alternative worlds: World A (now) and World B (the future). An important characteristic of these representations is that the texts offer a persuasive argument for why World B is worth the effort of engagement and investment. In the case of the driverless car presented here, two arguments are privileged; fewer deaths on the road and

fewer traffic jams – both resulting in cost savings but both offering social value too. In this sense, the sociology of expectation help actors give value to their actions now by creating clear associations with possible future returns (Beckert 2013a). This builds on the sociology of expectation literature by additionally showing how actors calculate their role and potential returns in broader socio-technological systems of innovation and change (cf. Callon & Muniesa, 2005; Geels, 2005; Geels, 2007).

The second contribution of this work relates to our deepening understanding of the role of narrative as a market-making device. By understanding how multiple narratives from multiple actors co-exist beyond the attentions of the media, we gain a better understanding of how and maybe even why the media choose to privilege positive or negative expectations at any given time. Our findings suggest the possibilities for switching from positive to negative headlines exist as different market actors' expectations are foregrounded and headlined in the press. At the moment, much of the coverage around the driverless car is positive. But, come the day we live with the driverless car and begin to integrate it into our everyday lives, the unexpected consequences of their use are likely to lead to media coverage privileging already existing narratives about possible problems with liability and insurance. Such observations contribute to our understanding of expectations as performative devices that shape what actors focus on when developing and adopting new technologies as well as suggesting that cycles of positive and negative expectations are likely to be part of any unfolding narrative as we encounter the unexpected through our practices that begin to include new technical objects. As noted, these overflows are not easily hidden (Callon, 1998).

Building on Deuten and Rip (2000), we suggest that both positive and negative expectations can form building blocks of narratives that sustain and become consistent as values or concerns of multiple and disparate actors with varied forms of expertise and roles in future markets. The case of the driverless car shows how these expectations are being recycled and developed, becoming accepted ingredients in the stories of different actors and are thus generating a powerful narrative infrastructure about the development of the driverless car. Observation presented here of both the multiple and fragmented narratives across an emerging socio-technical network, together with the recognition that some components of the narratives endure by becoming the building blocks for a broader infrastructural narrative, has important implications for how markets and innovators gather together and make use of such narratives in order to frame and circulate their own powerful expectations (cf. Cyert & March, 1963). To build on the work of Anand and Peterson (2000) and Kennedy (2005), we need further research to understand the power of expectations as market information. We need to unpack the opportunities and implications that expectations might have

for learning about markets that don't yet exist. Such understandings are likely to open up choices as action need not be solely anchored in the cultural scripts of existing networks but perhaps in those of network extensions or new networks (Beckert 2013a). The role of narratives in representing and performing new networks, as part of the process of market innovation, seems worthy of further inquiry.

Finally, our findings reveal something of the types and roles of actors in setting expectations. Our findings show *how* actors with different roles (as social custodians, as technological innovators, as entrepreneurs, as consumers, as commentators) shape expectations through their own areas of expertise that they bring to the imagined market. We also show how actors' pickup and share key building blocks that form part of their own narrative of expectation, that then act to stabilize the infrastructure narrative of the imagined market across actors. This mixture of individual and collective action also helps actors make use of expectations in committing actors (themselves and others) to certain kinds of market action. In line with the studies of Van Lente (1993, 2000), we suggest that the representation of expectations to specific audiences helps to transform general imaginations into specific promises with concrete requirements. This was in evidence with the commitment of the Californian legislature's bill to change traffic laws so that the Google car could make use of the freeway. In this way, expectations are understood by actors as fairly fluid or at least plastic and the move to defining pathways of technological development and social change, together with the process of enrolling actors to act in alignment with this common vision can only come once the expectation infrastructure has been stabilized in some way (cf. Borup et al, 2006). It could be that the actors that are able to identify and stabilize the components of the narrative that frame the market they imagine are the actors most likely to succeed in the shaping what the market becomes. This can have significant implications for the geographies of markets (and importantly, as many national governments argue, of the suppliers and production bases for those markets). In the self-driving car market, what the market will become remains to be seen. What is more certain is that expectations about technical and market developments will continue to play a key role to in this market-making process.

References

- Adam, B. (2006), Futurescapes: Challenge for Social and Management Sciences, keynote paper delivered to Retrosapes and Futurescapes – Temporal Tensions in Organizations International Conference, Palazzo d' Aumale, Terrasini, Sicily, 21 - 23 June, 2006
- Anand, N. and R. A. Peterson (2000). "When market information constitutes fields: Sensemaking of markets in the commercial music industry." Organization Science **11**(3): 270-284.

- Araujo, L, Mason, K. and M. Spring (2012), *Self-Driving Cars. A Case Study in Making New Markets*, The Big Innovation Centre, London.
- Bakker, S., Van Lente, H. and M. Meeus (2011). "Arenas of expectations for hydrogen technologies." Technological Forecasting and Social Change **78**(1): 152-162.
- Beckert, J. (2013a). "Capitalism as a System of Expectations. Toward a Sociological Microfoundation of Political Economy." Politics & Society **41**(3): 323-350.
- Beckert, J. (2013b). "Imagined futures: fictional expectations in the economy." Theory and Society **42**(3): 219-240.
- Beckmann, J. (2004). "Mobility and safety." Theory, Culture & Society **21**(4-5): 81-100.
- Berkhout, F. (2006). "Normative expectations in systems innovation." Technology Analysis & Strategic Management **18**(3-4): 299-311.
- Borup, M., Brown, N., Konrad, K. and H. Van Lente (2006). "The sociology of expectations in science and technology." Technology Analysis & Strategic Management **18**(3-4): 285-298.
- Brown, N. and M. Michael (2003). "A sociology of expectations: Retrospecting prospects and prospecting retrospects." Technology Analysis & Strategic Management **15**(1): 3-18.
- Callon, M. (1998). *An Essay on Framing and Overflowing: Economic Externalities Revisited by Sociology. The Laws of the Market*. Edited by M. Callon. Oxford, Basil Blackwell: 244-269.
- Callon, M. and F. Muniesa (2005). "Peripheral Vision: Economic Markets as Calculative Collective Devices." Organization Studies **26**(8): 1229-1250.
- Campbell, M., Egerstedt, M., How, J.P. and R. M. Murray (2010). "Autonomous driving in urban environments: approaches, lessons and challenges." Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences **368**(1928): 4649-4672.
- Cova, B., Prévot, F., & Spencer, R. 2010. Navigating between dyads and networks. Industrial Marketing Management, **39**(6): 879-886.
- Cyert, R. M. and J. G. March (1963). *A Behavioral Theory of the Firm*. Englewood Cliffs, NJ, Prentice-Hall.
- de Laat, B. (1996), *Scripts for the future : technology foresight, strategic evaluation and socio-technical networks: the confrontation of script-based scenarios*, PhD thesis, University of Amsterdam
- de Laat, B. (2000). *Scripts for the Future: Using Innovation Studies to Design Foresight Tools*. In Contested Futures. A Sociology of Prospective Techno-Science. Edited by N. Brown, B. Rappert and A. Webster. Aldershot, Ashgate: 175-208.
- Dennis, K. and J. Urry (2008). After the Car. Cambridge, Polity Press.
- Dequech, D. (1999). "Expectations and confidence under uncertainty." Journal of Post Keynesian Economics **21**(3): 415-430.
- Deuten, J. A. and A. Rip (2000). "Narrative infrastructure in product creation processes." Organization **7**(1): 69-93.
- Ford, D., & Håkansson, H. 2006. The Idea of Business Interaction. IMP Journal, **1**(1): 4-27.
- Geels, F. W. (2005). "The dynamics of transitions in socio-technical systems: A multi-level analysis of the transition pathway from horse-drawn carriages to automobiles (1860–1930)". Technology Analysis & Strategic Management **17**(4): 445-476.
- Geels, F. W. (2007). "Transformations of Large Technical Systems: A Multilevel Analysis of the Dutch Highway System (1950-2000)". Science, Technology & Human Values **32**(2): 123-149.

- Geels, F. W., Kemp, R., Dudley, G. and G. Lyons, Eds. (2011). Automobility in Transition? A Socio-Technical Analysis of Sustainable Transport. London, Routledge.
- Geiger, S., Kjellberg, H., & Spencer, R. 2012. Shaping exchanges, building markets. Consumption Markets & Culture, **15**(2): 133-147.
- Holmes, D. R. (2009). "Economy of words." Cultural Anthropology **24**(3): 381-419.
- Kemp, R., Schot, J. and R. Hoogma (1998). "Regime shifts to sustainability through processes of niche formation: The approach of strategic niche management." Technology Analysis & Strategic Management **10**(2): 175-195.
- Kennedy, M. T. (2008). "Getting counted: Markets, media, and reality." American Sociological Review **73**(2): 270-295.
- Keynes, J. M. (1936). The General Theory of Employment, Interest and Money. London, Macmillan.
- Lachmann, L. M. (1943). "The role of expectations in economics as a social science." Economica **10**(37): 12-23.
- Lane, D. A. and R. R. Maxfield (2005). "Ontological uncertainty and innovation." Journal of Evolutionary Economics **15**(1): 3-50.
- Latour, B. (1987). Science in Action. How to follow Scientists and Engineers through Society. Cambridge, MA., Harvard University Press.
- Latour, B. (1992). Where are the Missing Masses? The Sociology of a few Mundane Artifacts. Shaping Technology / Building Society. Studies in Sociotechnical Change. Edited by W. E. Bijker and J. Law, The MIT Press: 225-258.
- Latour, B. (1996). Aramis of the Love of Technology. Cambridge, MA., Harvard University Press.
- Loasby, B. J. (2011). "Uncertainty and imagination, illusion and order: Shackleian connections." Cambridge Journal of Economics **35**(4): 771-783.
- Mom, G. (2004). The Electric Vehicle. Technology and Expectations in the Automobile Age. Baltimore, MD., John Hopkins University Press.
- Pollock, N. and R. Williams (2009). "The sociology of a market analysis tool: How industry analysts sort vendors and organize markets." Information and Organization **19**(2): 129-151.
- Prencipe, A., Davies, A. and M. Hobday, Eds. (2003). The Business of Systems Integration. Oxford, Oxford University Press.
- Rappa, M. A. and K. Debackere (1992). "Technological communities and the diffusion of knowledge." R&D Management **22**(3): 209-220.
- Rip, A. (2009). "Technology as prospective ontology." Synthese **168**(3): 405-422.
- Rogers, E. M. (1962). Diffusion of Innovations. New York, Free Press.
- Rosa, J. A., Porac, J.F., Runser-Spanjol, J. and M.S. Saxon, (1999). "Sociocognitive dynamics in a product market." Journal of Marketing **63**(SISI): 64-77.
- Rosenberg, N. (1976). "On technological expectations." Economic Journal **86**(343): 523-535.
- Selin, C. (2008). "The sociology of the future: Tracing stories of technology and time." Sociology Compass **2**(6): 1878-1895.
- Thrift, N. (2004). "Driving in the city." Theory, Culture & Society **21**(4-5): 41-59.
- Urry, J. (2004). "The 'System' of Automobility." Theory, Culture & Society **21**(4-5): 25-39.

Van Lente, H. (1993). Promising technology: the dynamics of expectations in technological developments, PhD thesis, University of Twente-Enschede.

Van Lente, H. (2000). Forceful Futures: From Promise to Requirement. Contested Futures. A Sociology of Prospective Techno-Science. Edited by N. Brown, B. Rappert and A. Webster. Aldershot, Ashgate: 43-63.

Van Lente, H. (2012). "Navigating foresight in a sea of expectations: lessons from the sociology of expectations." Technology Analysis & Strategic Management **24**(8): 769-782.

Van Lente, H. and A. Rip (1998). Expectations in Technological Development: An Example of Prospective Structures to be filled in by agency. In Getting New Technologies Together. Studies in Sociotechnical Order. Edited by C. Disco and B. van der Meulen. Berlin, Walter de Gruyter: 203-229.

Whitford, J. (2002). "Pragmatism and the untenable dualism of means and ends: Why rational choice theory does not deserve paradigmatic privilege." Theory and Society **31**(3): 325-363.

Womack, J. P., Jones, D.T. and D. Roos (1990). The Machine that Changed the World. New York, Rawson Associates.

Endnotes

ⁱ [http://blog.modernmechanix.com/mags/ScienceDigest/4-](http://blog.modernmechanix.com/mags/ScienceDigest/4-1958/electronic_highway_of_the_future/electronic_highway_of_the_future_0.jpg)

[1958/electronic_highway_of_the_future/electronic_highway_of_the_future_0.jpg](http://blog.modernmechanix.com/mags/ScienceDigest/4-1958/electronic_highway_of_the_future/electronic_highway_of_the_future_0.jpg)

ⁱⁱ Araujo, L, Mason, K. and M. Spring (2012), Self-Driving Cars. A Case Study in Making New Markets, The Big Innovation Centre, London.

ⁱⁱⁱ Maddox, John, "Improving Driving Safety Through Automation," NHTSA, 2012 available at <http://www.roboticscaucus.org/Schedule/2012/Automationforsafety-CongressionalroboticsCaucus-Maddox7-25-12.pdf>

^{iv} http://www.newyorker.com/reporting/2013/11/25/131125fa_fact_bilger

^v <http://www.washingtonpost.com/blogs/wonkblog/wp/2013/10/23/heres-what-it-would-take-for-self-driving-cars-to-catch-on/>

^{vi} Fagnant, D. and K.M. Kockelman (2013) Preparing a Nation for Autonomous Vehicles Opportunities, Barriers and Policy Recommendations, Report for ENO Centre for Transportation, available at: <https://www.enotrans.org/store/research-papers/preparing-a-nation-for-autonomous-vehicles-opportunities-barriers-and-policy-recommendations>, p. 4

^{vii} World Report on Road Traffic Injury Prevention, World Health Organization, Geneva, 2004, available at: http://www.who.int/violence_injury_prevention/publications/road_traffic/world_report/summary_en_rev.pdf, p. 5

^{viii} World Report on Road Traffic Injury Prevention, p. 10

^{ix} <http://www.wired.com/2013/07/the-surprising-ethics-of-robot-cars/>

^x http://www.transportworks.org/sites/default/files/assets/documents/2012-M12-101212-Cebr_Economic_Cost_of_Gridlock_Report.pdf

^{xi} KPMG and Centre for Automotive Research, Self-Driving Cars: the Next Revolution, available at: <http://www.kpmg.com/US/en/IssuesAndInsights/ArticlesPublications/Documents/self-driving-cars-next-revolution.pdf>, p. 31

^{xii} <http://shoup.bol.ucla.edu/CruisingForParkingAccess.pdf>, http://www.uctc.net/access/38/access38_free_parking_markets.pdf

^{xiii} <http://news.bbc.co.uk/1/hi/8349923.stm>

^{xiv} ENO Centre report, p. 5

^{xv} ENO Centre report, p. 5

^{xvi} See e.g. <http://www.bbc.co.uk/news/magazine-18012812>, <http://www.economist.com/news/special-report/21576224-one-day-every-car-may-come-invisible-chauffeur-look-no-hands>,

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- ^{xvii} <http://www.ft.com/cms/s/0/f15854b6-195c-11e3-83b9-00144feab7de.html#axzz2eQZ8YzI7>
- ^{xviii} <https://www.media.volvocars.com/global/en-gb/media/videos/136297/drive-me-self-driving-cars-for-sustainable-mobility>
- ^{xix} <http://www.ft.com/cms/s/0/70d26288-1faf-11e3-8861-00144feab7de.html>
- ^{xx} <http://www.ft.com/cms/s/0/ae1ebda2-46cf-11e3-9c1b-00144feabdc0.html>
- ^{xxi} ENO report, p. 10
- ^{xxii} <https://pictures.dealer.com/jdpower/efd04f1a0a0d02b700ad8bb40bba5337.pdf>
- ^{xxiii} KMPG, Self-Driving Cars: Are We Ready? Available at:
<http://www.kpmg.com/US/en/IssuesAndInsights/ArticlesPublications/Documents/self-driving-cars-are-we-ready.pdf>
- ^{xxiv} <http://online.wsj.com/news/articles/SB10001424127887323854904578264162749109462>
- ^{xxv} California's Senate Bill 1298 (Vehicles: autonomous vehicles: safety and performance requirements.
- ^{xxvi} <http://www.mcafee.com/us/resources/reports/rp-caution-malware-ahead.pdf>
- ^{xxvii} ENO Centre report, p.13
- ^{xxviii} ENO Centre report, p. 4
- ^{xxix} World Report on Road Traffic Injury Prevention, p. 71
- ^{xxx} KMPG, Self-Driving Cars: Are We Ready? p. 6
- ^{xxxi} Schumpeter. The Driverless Road Ahead, <http://www.economist.com/news/business/21564821-carmakers-are-starting-take-autonomous-vehicles-seriously-other-businesses-should-too>
- ^{xxxii} <http://time.com/90385/driverless-cars/#>
- ^{xxxiii} <http://www.theguardian.com/technology/2013/nov/07/driverless-cars-coming-to-milton-keynes>
- ^{xxxiv} <http://www.popsci.com/cars/article/2013-09/google-self-driving-car>
- ^{xxxv} http://www.continental-corporation.com/www/pressportal_com_en/general/ov_automated_driving_en/automated_driving_intro_en.html
- ^{xxxvi} http://www.computerworld.com/s/article/9232722/Autonomous_cars_will_arrive_within_10_years_Intel_CT_O_says
- ^{xxxvii} http://www.ieee.org/about/news/2012/5september_2_2012.html
- ^{xxxviii} <http://www.bloomberg.com/news/2013-02-06/self-driving-cars-more-jetsons-than-reality-for-google-designers.html>