We know technological disruptions unfold in non-linear fashion and have profound impacts across society. Yet so often we fail to anticipate them, and even when we do, we still fail to act. Why is this?
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IN THIS PAPER WE EXAMINE THE NATURE OF TECHNOLOGICAL DISRUPTIONS AND WHY WE OFTEN FAIL TO ANTICIPATE THEM IN OUR FORECASTS. WE ALSO DISCUSS A MAJOR DISRUPTION COMING TO THE TRANSPORTATION INDUSTRY AND, MORE BROADLY, WHAT CAN BE DONE TO MAKE BETTER DECISIONS AHEAD OF FUTURE DISRUPTIONS ACROSS MULTIPLE INDUSTRIES.

Current methodologies used to measure and analyse disruption are flawed and lead to a failure to anticipate technological disruption.

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The horse-to-car disruption unfolded in the face of what seemed to be insurmountable barriers or brakes on systems change: in 1905, the industry lacked a supply chain, manufacturing capacity, petrol stations, an oil industry, paved roads, trained mechanics and even people who knew how to drive. Yet the car would soon go on to reshape global society, becoming an intractable part of life around the world. Extraordinary as this sounds, it describes the nature of technological disruptions: they happen quickly, unfolding in a non-linear S-curve shape, and have profound impacts across society.

DISRUPTION STARTS WITH TECHNOLOGICAL CONVERGENCE

Developments in steel and rubber production and oil exploration and refining, as well as the invention of the Otto combustion engine and the pneumatic tire, were all needed before a fully-functioning automobile was possible. This technological convergence also enabled new business models and processes, such as the moving production line and the development of standardised parts, in addition to car loans, all of which made the car cost competitive.

The resulting increased demand attracted more investment, supporting the development of economies of scale, causing costs to continue to drop and capabilities to improve. Public opinion, initially sceptical of cars as dangerous or expensive toys, quickly moved to fascination and desire as cars came to symbolise freedom and success. Following the creation of jobs and wealth, the government became supportive, funding roads and supporting the development of the oil industry. All were powerful accelerators of growth which helped to establish feedback loops.

THE IMPACT OF THE DISRUPTION RIPPLED OUT ACROSS SOCIETY

Not only did the horse-to-car disruption result in huge value creation in the emerging manufacturing, retail, parts supply, auto finance and insurance industries and destruction in the declining horse husbandry, carriage and buggy whip industries, but it also transformed associated industries. In agriculture, tractors improved production, trucks increased time to market, expanding the reach of the farming industry, and the sale of food itself transformed as shops moved from town centres to supermarkets and malls. New opportunities arose for motels, fast food and so on. Raw materials industries also changed as oil, steel and rubber came to replace animal feed (grain), wood and iron.

The impacts did not stop there, instead rippling out even further to redefine infrastructure and urban design, affecting where we lived, where we worked, where we built hospitals, schools, factories and so on. The car went from a nice-to-have to a necessity. It solved serious environmental and health problems caused by horses, such as the elimination of disease-spreading piles of manure from city centres. However, it also introduced other more serious problems, such as air pollutants and road deaths. It transformed our culture and society, changed the basis of 20th century geopolitics and contributed hugely to the US’ rise to global dominance.

TECHNOLOGICAL DISTRUPTION

IT TOOK THE CAR LESS THAN 20 YEARS TO GO FROM UNDER 5% OF THE VEHICLE FLEET IN 1905 TO OVER 95% IN 1925.
OVERLY SIMPLISTIC MEASUREMENT MASKS THE TRUE NATURE OF DISRUPTION

The answer lies in part in the prevalent forecasting tools and techniques we employ. To generalise grossly, when forecasting the future, we often begin by looking back to a point in the past and draw a straight line to today. We then extrapolate the line forward into the future. This works as an approximation of the future if you are at point A below (Figure 1). But as we approach periods of change, such as at point B, it becomes woefully inadequate.

SYSTEMS ARE TOO COMPLEX AND INTERCONNECTED TO ISOLATE

Another linked mistake we make by doing this is to ignore systems’ complexity. We look at one part of the system in isolation to see the effect of one variable change on another, but assume all other parts of the system stay the same, or in scientific terms, “all else remains equal”. But outside of a laboratory this is nonsense. Small changes in a complex system can have profound impacts as the response of all other parts of the system amplifies them. These feedback loops are what accelerate and widen change.

SILOED EXPERTISE LEADS TO FALSE CERTainty

Another factor in our failure to anticipate and act on change relates to our tendency to over-rely on a narrow group of experts in only one particular area or silo, instead of a broad range of viewpoints, which provide a more accurate picture of the system as a whole. Deep sector or subject knowledge is, of course, hugely valuable, but often disruption comes from outside of a sector. Narrow, siloed expertise, built up in periods of incremental progress, can also lead to a false certainty that the future will be an extension of the past. As a result, experts often see only a very narrow range of future possibilities.

In order to make decisions across every part of society – to plan our pensions or investments, our energy, food or education systems, our cities, geopolitics, social, economic, climate or monetary policy – we need better analysis of the future or at the very least, a better appreciation of the exploding range of possible scenarios. Without it we are decision-making in the dark. So how can we do this better?

Figure 1: Limitations of forecasting
SOLAR ENERGY: AN EXAMPLE OF FORECAST MISTAKES

Global solar energy capacity has grown exponentially at 40% per year since 1995. Yet each year, the projections of the International Energy Agency (IEA) in the World Energy Outlook report remain linear. And each year the agency crosses out the linear projection from the previous year and raises it incrementally in parallel fashion only to repeat the same mistake again. In the context of the electric power market as a whole, the IEA’s linear projections do not appear unreasonable, given solar is a relatively small part of total market capacity at just over 1% today. The IEA has this percentage rising to 10% in 2040.

If we instead extrapolate based on the current 40% growth rate, we see a complete disruption of the market by the 2030s.

Whether or not we plan our future based on the linear or exponential growth of solar over the next decade has profound implications. For investors, reliance on linear solar projections represents trillions of dollars in value destruction in the current system, and opportunity missed in the new system. For business leaders, the difference between these two outcomes is profound in terms of the future cost of energy, affecting this sector as well every other sector of the economy. It impacts the structure of the market as well as infrastructure required. For policymakers, these two scenarios result in very different geopolitical power dynamics. For all of us, it also dictates vastly different trajectories for climate change with radically different solutions required under each.
THE FUTURE OF TRANSPORT

WE SEE A NUMBER OF CORE TECHNOLOGIES ARE RAPIDLY DEVELOPING IN MULTIPLE SECTORS.

Improvements to these technologies in one sector feedback and catalyse disruptions in other sectors (for example, improvements to batteries related to electric vehicles (EVs) are contributing to disruption in the electric power market).

Disruption in transport will come from the convergence of batteries, sensors, artificial intelligence, computer processing, communication technologies, together enabling the formation of autonomous electric vehicles (A-EVs). This convergence is also enabling new business models and value chains. When combined with a business model innovation – ride hailing – A-EVs further enable Transportation-as-a-Service (TaaS) or robo-taxis. This form of transport will be an order of magnitude cheaper than the current system.

THE TAAS MODEL CHANGES EVERYTHING

Under this model, we as individuals no longer own the vehicle. There is no down-payment. We no longer have to drive it, insure it, maintain it, park it or fuel it. The costs of ownership stay with the fleet owner. Instead of completing 10k miles per year, sitting idle 95% of the time, fleet-operated vehicles will now complete 100k miles per year. Robo-taxis pick us up and drop us off while we pay a competitive cost per mile for use. This order of magnitude difference in cost is what initially drives the disruption.

VEHICLE DEGRADATION AND UTILISATION WILL DRIVE FAVOURABLE ECONOMICS

Vehicle degradation is what will make TaaS so cost effective. An EV with just 20 moving parts compared to 100s or 1000s, is a far simpler technology than a petrol car. Simply stated, there is far less to go wrong. This lack of degradation has two major effects: EVs last much longer and they are much cheaper to maintain. From high utilisation users today, data show EVs currently last 500,000 miles. As the incentives shift towards increasing vehicle lifetime within a decade, we could see vehicles completing one million mile lifetimes.

Importantly, if any one of us owns an EV or A-EV lasting 1m miles in the old model, it would be of no benefit. At 10k miles per annum it would last 100 years - corrosion and obsolescence would hit it first. But in the high utilization TaaS model, doing 100k miles per year, the increase in lifetime comes with an economic benefit. And with a new metric ($ per mile) this means fleet operators can spread the upfront cost of the vehicle over 1m miles of lifetime, with each mile costing just 1/1,000,000th of the upfront cost. This represents a massive reduction in the largest cost of ownership. Furthermore, we will see a 90% drop in maintenance costs through reduced degradation and automation of maintenance, a 70% drop in fuel costs and ultimately a 90% drop in insurance costs (as autonomous vehicles become vastly safer and fleet owners wield more power). Together this produces a cost per mile that looks like Figure 2.
On this cost profile alone, TaaS stands to disrupt the new car ownership market, both petrol and electric. But it is also less than half the operating cost of a petrol vehicle, in terms of the cost of fuel, insurance and maintenance. This means even if cars were free, they couldn’t compete with TaaS. On this basis, TaaS has the potential to disrupt not just the new car market but the whole of the existing stock. In other words, for most users it will not make economic sense to continue to own a vehicle. This saving of $6k per year for the average US family will ensure there is ready market for this service. And these figures are conservative as they ignore both the value of time spent driving, now freed up, and the potential for these cars to make revenues from other sources, such as advertising, entertainment, grid support services and more, which could lead to free transport in cities, similar to the Google business model of giving away the search service and monetising the user.

**USER ADOPTION AND FEEDBACK LOOPS WILL OVERCOME INITIAL RESISTANCE**

How quickly are we likely to adopt TaaS? This is where we must consider feedbacks and systems dynamics. Like all new products and services, TaaS initially will face strong resistance. The incumbent system is deeply embedded with supply chains and economies of scale holding it in place. Public opinion also supports car ownership with many people who love their cars. The new system in contrast lacks both. These all act as barriers or brakes on disruption. Furthermore, those threatened by disruption might seek to influence public opinion, law or regulation, which is another brake (negative feedback) on adoption.

But despite this resistance, we expect a large number of people to adopt this service as it becomes available. Early adopters will include those who currently can’t drive, who can’t afford it or face disabilities, current taxi or ride hailing users, and those who value their time and would rather be driven. It only takes a few to begin to kickstart the accelerating feedback loops needed to make TaaS ever cheaper and easier to use, and car ownership ever more expensive and difficult. As adoption begins, the brakes will weaken and accelerators will strengthen. Examples include:

- **Investment**: Tens of billions of dollars of investment are moving from petrol cars to electric and autonomous vehicles as existing players rush to catch up with the outside disruptors.

- **Economies of scale**: These will grow as network effects create a winner-takes-all dynamic and a rush to market, along with the possibility of price wars. At the same time economies of scale in petrol cars will reverse, increasing costs and shrinking margins.

- **Used car death spiral**: As people switch and begin to sell their cars, used car prices will plunge as the market gets swamped, making new cars more expensive by pushing up lease payments for new cars (which are based on residual values). New car demand will drop, leading to reversing economies of scale driving new car prices up further.

- **Public opinion**: People are currently highly sceptical of AVs. Every Tesla or Uber crash is front page news. Meanwhile, many of us love our cars and can’t imagine giving them up. But fast forward just a decade or so and we will become increasingly comfortable with AVs. The public will see and try them and, eventually, it will become clear they are safer than human-driven cars. Maybe then, every time a child is killed by a human driver, that will become the front page news. It will be perceived as unacceptable and unnecessary. It might be that public opinion turns against human drivers and the political tides turn to ban or restrict human drivers – if spiralling insurance costs don’t achieve the same end first.

**IMPLICATIONS – RIPPLE EFFECTS**

The impact of the car-to-TaaS disruption will ripple across society. Starting with the value chain, there is huge opportunity for platforms, sensors, operating systems, etc. At the same time, we see other parts destroyed, such as car hire, manufacturing, car insurance, etc. The ability to monetise the user and create alternative revenue sources might determine the winners and the losers. In adjacent industries, we anticipate trucks will experience a similar disruption, and cheaper, more convenient TaaS alternatives to impact short-haul aviation. In raw materials, the impact is negative for steel and oil, positive for cobalt and lithium.

Lower-cost transport will affect other industries including retail, manufacturing, agriculture, energy and communications. It will also transform the built environment and infrastructure. As an example, we see 30% of cities in the US freed up from parking requirements creating extraordinary potential.

The economic benefits are also huge: savings of $6k per household in the US is equivalent to $1trn in disposable income. There is potentially an additional $1trn in productivity gains from time freed from driving put to productive uses. There will be huge social benefits, such as job creation, access to transport, less accidents, cleaner air to set against incumbent job losses, which we can mitigate if we anticipate them. A rapid decarbonisation of transport will also affect the trajectory of climate change, along with geopolitics notably with the shift away from oil.
As technologies related to transport and other areas continue to improve in a cascading, self-reinforcing process, we will see sector after sector of the economy disrupted. The impact of these concurrent disruptions will compound and interact with each other creating change on a scale never seen before. This will have a profound impact on the economy and society over the next decade or two.

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