Breaking the Path Dependency of the Internal Combustion Engine

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'Nothing we can do can change the past, but everything we do changes the future.'

- Ashleigh Brilliant

The dominance of the internal combustion engine appears to be waning. Recognition that oil, the driving force behind the internal combustion engine, is a limited and therefore unsustainable resource has provided the impetus for the development of alternative powertrains. In this paper we consider how the internal combustion engine controls the market, while identifying the barriers for change, and, finally, examine the potential replacement of the internal combustion engine with a sustainable alternative.

The Characteristics of the Conventional Network

In order to assess whether a fundamental change can be induced, we must first consider the complex design of the existing automotive industry. Since its advent over a century ago, the industry has evolved into a sophisticated network using large economic scale and scope effects, which were entailed by the absence of alternative systems. The interrelation between the entities in the industry and the size of the infrastructure form the two most crucial factors for consumers because they determine the limits of consumer choice and, thereby, their individual utility.

From the suppliers' perspective, the size of the conventional network determines the degree of scale effects which reflects the lower costs of producing larger quantities, and, conversely, the higher costs incurred in producing smaller quantities. In this simple calculus, the point of critical demand for firms represents the ideal production level to aim

for and, therefore, a target for achieving the individual utility levels required to entice as many consumers to the network.

Besides this, the car industry is also dominated by scope effects. In contrast to scale effects, scope effects pertain to the cost benefits firms acquire as the scope of their operations increase. These are usually achieved by creating synergies across products and rationalizations that are made possible as a single firm offers more products and services to a consumer.

The conventional automotive industry network, based on the internal combustion engine (ICE), has reached a self-reinforcing dominance over any other powertrain technology. This is because of the increasing utility for all key stakeholders and a larger, more cross-linked, network, along with a critical demand that is usually satisfied. The first triumph of the ICE over electric propulsion was back in the late 19th century and the length of this dominance has added to its strength.

The Crux of Changing the Automotive Industry

Table 1 enumerates the most crucial factors for the five key stakeholders in the automotive industry. As each key stakeholder in the current market is influenced by economies of scale, reaching critical demand, and thereby ticking most of the boxes, it is plausible that any new technology must also meet these prerequisites for successful implementation.

The main barrier for reaching the critical demand are the many interrelations of the various stakeholder groups suggesting that a change from petroleum to other fuels needs to start early as well as be adopted broadly for it to succeed. If either the process of reaching the critical demand or aligning the key stakeholders to the same objectives - thus the establishing of economies of scope -takes excessively long, the entire industry will rely on the status quo. The validity of this simple insight was proven by the failure of several progressive market launches, such as the General Motors EV1 (in the mid-1990s). Firms and inventors routinely disregarded the dynamics of the market and the need to break the existing cycle where current decisions are strongly influenced by previous decisions; they ignored the power of inertial decision making also known as path dependency.

		ICE				EV	Fuel Cell	Hybrids (any kind)
		Petroleum Fuel	Hydrogen	Bio Fuel	LPG			
Producers	Early mover advantage	✓	✓	✓	✓	✓	✓	✓
	Helping to meet Regulations for Emissions	×	✓	✓	✓	☐	☐	✓
	Coverage of R&D costs	✓	✓	✓	✓	☐	☐	✓
Consumers	Efficient use of 100% Green Energy	×	×	×	×	☐	☐	×
	Unlimited range of driving	✓	☐	☐	☐	☐	☐	✓
	Convenience of refilling	✓	✓	✓	✓	☐		✓
	Affordable initial costs	✓	✓	✓	✓	☐	?	✓
	Low costs for driving	×	☑	☐	☑	☑	☑	☑
	Adequate residual value when new technology is available	✓	✓	✓	✓	☐	☐	☑
	Variety of attractive cars	✓	✓	✓	✓	☐	☐	✓
	Tax savings		☑	☐	☑	✓	✓	☑
Infrastructure	Setting of standards (to serve all clients)	✓	✓	✓	✓	☐		☐
	Enough customers to be profitable	✓	✓	✓	✓	☐	☐	✓
	Needs other IS suppliers to be part of a network	✓	☑		☑	☐	☐	☑
Regulator	Emission Reduction (Kyoto)	×	?	?	?	☐	☐	?
	Additional job Creation	×		?	×	☐	☐	?
Energy Supplier	Peak demand meets peak supply	×		☐	×	☐	☐	×
	Security for their long term investments	✓	☐			☐		☐

TABLE 1: THE FIVE KEY STAKEHOLDERS AND THEIR MOTIVATION FOR SWITCHING TO AN ALTERNATIVE POWERTRAIN

✓: Has already been realized
×: Cannot be achieved with this technology
☐: Currently not realized
☑: Already realized but could be improved
?: Due to high complexity, it cannot be said whether this can be achieved

Path dependency is always associated with high switch-over costs for both suppliers and consumers because the new technology has not been developed over the same timeframe as the existing technology. The magnitude of these costs increases the uncertainty as to whether the shift towards a new technology is cost effective, reliable and credible. Indeed, the recall of the EV1 after a few months proved that insecure consumers and manufacturers were unable to relinquish the path they were on whether or not the new path was more efficient economically or perhaps even the right one to adopt ethically.

For the incumbent path dependency to be broken, a significant portion of the market must shift to support the alternative technology thereby providing the new technology with the benefit of scale and scope economies that form the linchpin of path dependent dynamics. Without the interdependent operation of manufacturers, gas stations, energy suppliers and government, firms are unlikely to convince consumers to adopt the technology, especially because all alternatives have some comparative disadvantages to the ICE, such as the limited range electric vehicles provide. It was argued that the majority of consumers do not drive more than 70km per day, and therefore would not be bothered by the limited range. However, history has shown that consumers want to feel independent and, hence, do not want to be limited.

Such a comprehensive shift of the entire market needs either an especially long time to develop, potentially leading to stagnation before the critical demand is reached, or a quick and potent alignment of interests across all stakeholders. Seeking an alignment has additional benefits such as setting a standard in an early stage of production and, hence, reducing costs and increasing demand for all suppliers. However, the realization of a genuine alignment is difficult.

Are Hybrids the Remedy?

Hybrids appeared to be the remedy to this stalemate. As shown in Table 1, they appear to represent a compromise that ticks off many of the constraints and requirements while potentially achieving a few yardsticks where the traditional ICE looks relatively weak. They present a propulsion system that can utilise the advantages of the ICE network and,

simultaneously, be more environmental friendly. All their disadvantages when compared with 100% electric vehicles including higher weight, lower efficiency and performance, complex engineering and a high price due to two engines are outweighed by one advantage: consumers do not lose the utility of the conventional large-scale network. Nevertheless, hybrids fail to change the automobile industry fundamentally as they are inherently still dependent on oil.

The Case of Better Place

Better Place, a firm led by Shai Agassi, is emerging as a frontrunner in taking the wheel and steering the automotive industry on a new path by expressly addressing the network disadvantages that alternative powertrains must contend with. They are endeavouring to switch from the path of the internal combustion engine and instigate the electric engine as its successor. The challenge for Better Place is to move from the initial demand, created by greater awareness about our environment, to economical, profitable mass production. This challenge contains five steps to success: an alignment of all key stakeholders, the lowering of barriers to join the network, an increase of convenience for consumers, the creation of a critical demand and, finally, the generation of scale and scope effects.

Better Place appears to have realized these requirements. It offers customers zero-emission cars, low fuel costs, a subsidised new car and, above all, a high convenience of driving and recharging. All these advantages are aligned with the knowledge of the conventional fuel network. Customers do not have to change how they drive because they get the convenience of a network of refill stations with high area coverage. This provides the freedom consumers desire and possess with the conventional network.

The business model works very similarly to that of the mobile phone industry. Better Place generates economies of scope by building the entire infrastructure and aligning the various key stakeholders to the same aim, while only acting as the operator. The cars are built by Renault-Nissan, and the customer signs a contract with Better Place and 'buys miles'. The more miles a consumer purchases, the more the car’s price is subsidised. Although

consumers own their cars after purchasing them, the batteries remain the property of Better Place resulting in lower initial costs.

Recharging will be done in several ways including plug-in recharging when vehicles are parked, or swapping the entire battery at purpose-built stations rapidly during longer journeys, meeting the need of an unlimited range when driving. In Israel, the first country of implementation, the company will install 100,000 charging points by 2010 and 500,000 by 2011, along with 100 battery-swapping stations ('Electric evangelist' 2009). This allows consumers to travel anywhere and any distance within the country, retaining the advantages of the internal combustion engine.

Better Place's Impact on Energy Suppliers

In contrast to other electric power vehicles, which receive part of their energy supply from fossil fuel sources, Better Place's infrastructure guarantees the use of 100% green energy. This is achieved by providing energy suppliers with a viable option as the batteries in vehicles would act as storage for the energy network during off-peak periods. Green energy is generally expensive because of the high losses of energy due to the inability to store the excess energy generated. Storing the energy allows for its use later, essentially making the energy generation more efficient as more energy is captured. As green energy generation becomes more efficient, the costs will continue to decrease as more means of generation are implemented, making the market more attractive to energy suppliers.

Looking Ahead

Although Better Place is more economical and less expensive than current models, the speed of implementation depends highly on government policies and taxation systems, influencing consumers' utility and thus giving them incentives to select the electric technology.

The few inherent threats to the use of electric powertrain are adequately compensated by the many advantages this alternative technology presents. Better Place is the first company whose business model could lead to a complete shift in the automotive industry. They have