Micro Factory Retailing; an Alternative, More Sustainable Automotive Business Model.

In 2000 we launched a new alternative automotive business model, Micro Factory Retailing (MFR), which, although still marginal, has nevertheless already inspired a number of automotive businesses. MFR is based on networks of small dispersed, combined assembly, retail and aftercare or lifetime management (e.g. maintenance and repair, parts supply, upgrade, vehicle management and takeback) facilities that could operate car use under a product-service system (PSS), whereby ownership is retained by the company and users pay for their use.

Approximately 20 years on from when the first germs of this innovative idea were sown is a good time to revisit the concept and its subsequent fortunes. This paper traces through the early history of ideas and developments for MFR; to its current situation and practice. Sustainability is a major aspect of MFR. I present this work on the car and innovations from my experiences and growth in understanding.

Background on "Selling" the Micro-factory retailing business model

Our approach is unlike that of most business academics in that we are primarily sector specialists, rather than discipline-based, or even discipline-focussed. The sector covers a range of activities and disciplines, from engineering, design, marketing, human resource management, supply chain management, to politics and legislation. This approach has also been evident from our methodology in that we maintain a continuous dialogue and exchange of ideas with the automotive industry and those who regulate it (Wells and Nieuwenhuis 2017).

Unfortunately, we have often found the business academic literature is somewhat out of touch with the latest developments in the automotive sector. The academic literature on the sector appears more like historical accounts than current account; or able to contemplate alternative business models. In view of this situation, we found academic publishers and reviewers initially quite unreceptive to these ideas and decided to air them first to business and practitioner audiences. This took the form both of publications (Wells and Nieuwenhuis, 2000) as well as conference papers to industry audiences. These ideas were invariably well received, although they did lead to many debates.

MFR was a difficult sell, since examples and precedents did not exist, which of course are thin for most alternative business models. Similarly we were often asked, if these ideas are so good, then why do Ford and General Motors not adopt them. Again, the answer is obvious, as these ideas run precisely counter to and in fact challenge and undermine their existing business models. We decided, therefore, to use academic conferences (e.g. Nieuwenhuis 2002) and an academic book as first steps in broadening the appeal of this alternative business model (Nieuwenhuis and Wells, 2003), with academic journal articles emerging much later (e.g. Wells and Orsato, 2005; Nieuwenhuis and Katsifou, 2015).

Origins – initial ideas

In 1996 I bought a new mountainbike and it occurred to me that here was a very interesting business model. The company whose name appeared on the frame – in this case Proflex – actually made very little of this bike. Although the design was theirs, as was the development work behind the springs for their unique Girvin full suspension system, most of the rest came from named suppliers. Suppliers whose name remained on the product, such as Mavic for the rims and Shimano for the gears. The bike itself was built in Taiwan by a subcontractor. Due to its modularity, the bike could be upgraded in various areas and in due course featured a Selle Italia saddle, for example. In the automotive industry – which is our specialism – examples of this kind of work were very limited. You might see the name of a design house – e.g. Pininfarina, Zagato – on a car, or even 'Handling by Lotus' on an Isuzu, and occasionally the name of a tuning firm such as Alpina or AMG, but beyond this, the final assembler's name, BMW, Mercedes-Benz, or Ford was dominant.

At this time, we were struggling to understand mass car production and traced this right back to its origins in the early 20th century. This review process involved extensive archival research in Europe and the US. It had struck us that mass production was a barrier to sustainability in cars due to the sheer number of cars added to the planet's roads each year. We were exploring possible alternative automotive business models, focussing in the first instance on appropriate manufacturing systems.

This bike was a manufacturing system and business model that combined a degree of mass production of standardised components that was then shared by a number of competitors. The bike firms still retained their brand integrity and brand awareness in the market despite doing very little themselves. This vertically disintegrated industry still managed to show significant diversity and differentiation in the market, despite this business model. Could this approach be applied to automobiles?

Environmental challenges to mass production

While many in the environmental community – including academics – advocated an abandoning of the car as the only way forward on our quest for greater sustainability, we felt this was a non-starter.

If people were going to persist in their pursuit of automobility, how could this be delivered in the most sustainable manner? This was the era of Amory Lovins 'Hypercar' concept (Lovins 1995; Von Weizsacker, et al. 1998); other initiatives such as the Clinton-Gore administration's Partnership for a New Generation of Vehicles (PNGV) also existed. It was an era of much experimentation, including new materials, which necessitated new manufacturing techniques. GM's EV-1 electric sportscar, for example prompted the creation of a completely new manufacturing system, the Lansing Craft Center, while mainstream car production was also increasingly homing in on lower volume manufacturing approaches (see Nieuwenhuis and Wells, 1997).

However, it occurred to us that the existing 'fire-and-forget' mass production system also missed other tricks. Considering the lifetime income stream of a car, the actual mass producers only managed to capture a relatively small slice of revenue (Figure 1). Moving towards a new business model that, instead of generating income only from selling cars, parts and finance, made money by capturing a much greater proportion of that lifetime value stream. This holistic capturing of value seemed to make a lot more sense, while at the same time easing that pressure to 'move the metal', which made the existing business model inherently unsustainable.

Figure 1

This new business would involve an integration of manufacturing and retailing in a manner that did exist in the early years of the industry. It was essentially made obsolete by the move to mass production, with its high levels of investment, particularly in Budd-style all steel body technology (Nieuwenhuis and Wells 2007) and its attendant economies of scale. This situation forced the industry into centralising manufacturing and separating manufacturing from retail and distribution. We were again looking at the core technology of car making – the Budd all-steel body – as the principal barrier to a new business model.

Budd's all-steel body

Cars started life as craft-made products in that they were made one-by-one manually with each vehicle being different, and each component being unique, as it was adapted to its neighbours in the subassembly. This method has often been described as the 'European System'. Very rapidly, major suppliers were set up, particularly in France, able to supply engines, gearboxes, axles and other key components, allowing standardisation (Jeal, 2012). This process also allowed the number of brands to mushroom in the early years of the 20th century.

The key building blocks of cars were now readily available to all. Many firms assembled cars from bought in components and limited themselves to adding their own name. The modular construction of cars at this time made this possible. This approach was used by Ford to develop its Model T.

The mass car production of today is very different from the way the Ford Model T was built at Highland Park, Michigan. The Model T, was based on a modular approach to car making as used by the previous generation of craft builders: separate chassis and separate, wood-framed, coach-built, or 'composite' body. Modern mass produced cars are made quite differently. They use all-steel 'monocoque', or 'unibody' construction, whereby a structural metal box fulfils the functions of both body and chassis. This technology was made possible by Budd and Ledwinka's invention, around 1912, of the all-steel welded body and the press and jig technology that came with it. Thus, modern mass car manufacturing in many ways owes at least as much to Edward Budd and Joe Ledwinka, as to Henry Ford (Nieuwenhuis and Wells 2007, Nieuwenhuis, 2014).

Budd's steel body technology requires very high initial investments. But once these initial investments are made, low unit costs at high volume production occur – each car made is cheaper than under the previous craft-based system. This idea is the basic economy-of-scale paradigm where a sufficient number of cars is made to recoup that very high initial investment.

Budd's innovations therefore constitute the basis for the economics of car making, notably its economies of scale (Nieuwenhuis and Wells, 2003, 2007). The main change being from the manufacture of modular cars from largely in-house components at Ford's Highland Park plant, to the manufacture of steel bodies, assembled into cars from largely outsourced components and sub-assemblies in a typical modern mass production car plant.

If we consider how cars are made today and the investments required to make them, it is clear that the largest areas of investment are in developing and making internal combustion engines, and in making and painting bodies. It is the latter more than the former that allows the differentiation of cars in the market.

When we think of a car factory, we have in mind an assembly plant. A car assembly plant's primary activity is the making and painting of car bodies and then assembling these into finished cars by using largely bought-in components. Many of the parts Ford spent so much effort into making more efficiently are today sourced from suppliers. Modern car manufacturers outsource some 60% to 80% of the value of their cars. Hence a modern car assembly plant is typically subdivided into the following processes, which, combined with internal combustion engines, the industry regards as its core activities:

1) Press shop – where the sheet steel is pressed into panels.

2) Body shop or Body-in-white – where these panels are welded together to form bodies.

3) Paint shop – where these steel bodies are painted.

4) Pre-assembly – where wiring and piping and other components are fitted to the body, culminating in 'the marriage' where the powertrain is mated with the 'unibody'.

5) Trim or Final assembly – after fitting the powertrain (engine + transmission) the car can be put on its wheels and finished inside and out.

The principal investments in an assembly plant involve the first three processes – the making and painting of steel bodies. As bodies tend to change far more often than castings or powertrain components, these body-related investments have to be repeated regularly, with those elements not replaced, at least reconfigured, reprogrammed and updated. These investments are such and the resulting breakeven points so fundamental to the business of mass car production that these 'Buddist' investments, combined with investments in powertrain (engine and transmission) now determine the economics of car making.

The 1920s and 1930s were the key phase for the roll-out of this technology. By 1925, Budd all steel technology already had a 50% share of US body production (Courtenay, 1987: 22). This share was largely due to the fact that in 1925 Ford adopted Budd all-steel technology at its new River Rouge facility, having earlier outsourced all its bodies due to its inability to mass produce them (Post, 1961).

With Ford's and Budd's innovations, mass car production was possible and the final element involved the means to create a mass car market. This was the contribution of General Motors (GM), which introduced large-scale vehicle finance through its foundation in 1919 of the General Motors Acceptance Corporation. During the 1920s GM also introduced the trade-in as a down payment on a new car and the manufacturer and dealer-run used car business. In addition to these innovations, GM developed the concept of a product range, allowing customers to gradually trade up from a Chevrolet, via Oakland (later Pontiac), Buick, Oldsmobile, La Salle, to Cadillac. In addition, it focussed much more on styling, colour – enhanced by Dupont's majority shareholding in GM – and appearance and it promoted the idea of planned obsolescence through the annual model change (Flink, 1988).

The next step was the phasing out of the separate body and chassis; as both were now made of steel, they could be welded together into a light and stiff box-like structure, the 'monocoque' or 'unibody'. While it brought the need for greater accuracy as well as the problem of assembling the car after the unibody was built – which requires greater care on the part of assembly workers to avoid damage to the painted body – its advantages in terms of weight, structural integrity and manufacturability were such that today nearly all mass produced cars are made in this fashion (Nieuwenhuis and Wells, 2003). Because of the exceptionally high capital investments involved, it forced the industry into a production-led business model whereby the entire model came to be driven by the needs of the manufacturing system.

Toyota's 'lean' production merely refined this model by re-integrating it more closely with the market, but it is still not truly demand-driven. Plants have to produce at levels sufficient to reach the economies of scale inherent in these high capital investments, whatever the demand for their products.

Alternative Automotive Production Models

Sabel and Zeitlin (1985, 1997) have pointed out that mass production was not an inevitable outcome of developments in the early 20th century. Alternatives were and could have been equally viable. Eighty years or so on, one option seemed to be abandoning the all-steel body by revisiting some of these alternatives and possibly adopting different car manufacturing technologies. These new technologies were normally reserved for low volume, high end cars such as Ferrari, Aston Martin, Rolls-Royce, as well as heavy trucks and buses. Combining this characteristic with more of the retail, distribution and aftermarket activities, appeared to be more profitable.

The advantages are several. First of all, the abandoning of Budd all-steel body technology avoids the very high investments in capital equipment needed for this (press shop, press tools, body-in-white, paint). Although this step meant abandoning high volume production, it does allow for a dispersed network of local assembly facilities. This network could be rooted in local communities, cater for local tastes and needs, but could benefit from economies of scale in components and subassemblies such as powertrain that could be shared by a number of notionally competing manufacturers. This idea is much like the mountainbike model. Ironically, Ford used a not dissimilar model for the Model T, which – consisting as it did of a set of mechanical components, but no body – was often shipped to local markets as a kit for local assembly and for locally-made bodies to be fitted.

The term Micro Factory Retailing (MFR) was coined for this new model. This seemed like an apropos term and the term has stuck. We then began to refine and nuance the business model. We found that some low volume manufacturers already used elements of the new model.

In this context our UK base was helpful, as firms like Morgan Motor Company and Lotus are of particular interest. Contrary to popular belief, their products – despite being built in much lower numbers – are no more expensive than their mass produced or volume produced competitors. In essence, they have offset high capital investment against higher investment in skilled labour. The only penalty is an inability to produce at higher volumes, but also the absence of any need to produce in high volumes to recoup their investment costs. Here lay the core of a new business model.

Micro Factory Retailing

The Morgan Motor Company business model relies on making low volumes of durable cars tailored to the requirements of individual customers (Nieuwenhuis and Katsifou, 2015). In a world increasingly in need of sustainable consumption and production, this business model resonates. This resonance exists, despite the fact that Morgan's business model dates back a hundred years.

About 60-70 million cars are produced worldwide each year, a practice that is clearly unsustainable. In the longer term, if car making is to survive, then all car manufacturers will have to move towards a business model closer to that of low volume manufacturers. Lower volumes would be produced, but the business would survive by helping keep the cars on the road after the initial sale, extending the life of the automobile.

Morgan produces fewer than 1500 cars a year. Morgan can be regarded as using a partial version of Micro Factory Retailing, or MFR (Wells and Nieuwenhuis 2000; Nieuwenhuis and Wells 2003, 2009). The MFR business model offers a number of key advantages over Ford-Budd style mass production. These advantages make it inherently more sustainable in economic, social and environmental terms. Some of the main reasons and MFR characteristic for these advantages include:

- Investments in productive capacity – a micro factory would typically have a capacity of around 5,000 units a year – are incremental, expandable in line with market demand. Surplus demand is managed through waiting lists – a process used by Morgan. This situation also ensures continuity of both production and employment.
- The incremental expansion of capacity means that new plants can be added to develop new markets, while new products or variants can be introduced incrementally, resulting in risk reduction.
- Customers can be shown around the plant and meet the people who make their car, and can thereby feel 'closer' to the product. This has long been a feature of the Morgan approach, and is even used by more mainstream volume car makers trying to build brand loyalty: including Mercedes-Benz, VW, Porsche, and BMW.
- The factory becomes the location for repair, spare parts, upgrading, restoration and modification. This allows the manufacturer to tap into the elusive but potentially very profitable aftermarket revenue stream, while allowing the car to 'grow' with its owner thereby enhancing retention and vehicle lifespans for greater sustainability.
- The factory can undergo a transition over time from an essentially new car production focus, to one more involved in service and repair. Thus, the factory does not depend solely on the sale of new cars. Bristol Cars has exploited this model well (Parsons, 2002; Balfour, 2009).
- The inherent flexibility of small-scale manufacturing provides better customer care, as well as shorter lead times, and late configuration.
- The model builds stronger worker commitment to the product and to customers. This results in more satisfying work for staff, and better quality levels with all the benefits this entails. It also

builds higher skill levels in local communities.

- This manufacturing approach can take advantage of local small scale suppliers adding content appreciated by local markets. At the same time, modular supply strategies combined with commodity or off-the-shelf purchasing can reduce cost and achieve economies of scale where these are most appropriate, such as in powertrain – with the advent of electronic vehicles, increasingly: batteries, controllers and electric traction motors.

- Modular construction allows quick and easy product up-grades. Thus, technologies that meet the latest environmental and safety standards can often be retrofitted – a major area of obsolescence in the current system – while the vehicle can also be tailored to changing customer needs and wants.

- Small scale manufacturing processes have a lower environmental impact compared with traditional high-volume manufacturing (Schumacher 1973). Lower site impact: a modern car plant occupies several square kilometres of land. Compared with this, Morgan operates from a classic 'light industrial' facility.

  MFR facilities meet social and political objectives by creating local employment in high-value manufacturing activities. At a time when mass production jobs are being globalised, the MFR approach makes a key contribution in retaining those skills and adding value within the local market. The MFR facility does not necessarily sell the car, but would be equally viable as manager of a product-service system, whereby it would own the car and sell a mobility service to the user under a leasing-style arrangement.

Impact of MFR

Even at an early industrial development stage this alternative business model seems to have gained interest. After presenting these ideas at industry events and publishing in practitioner journals, businesses, potential start-ups and existing low volume manufacturers approached us with a keen interest in the MFR model.

Using our established methodology (Wells and Nieuwenhuis, 2017) we ended up working on an iterative basis with a number of firms, with varying degrees of contact and regularity of meetings. These firms include Morgan Motor Co., Gordon Murray Design – whose 'i-Stream' manufacturing model was inspired by MFR, Welsh hydrogen car developer Riversimple and American open-source car design company Local Motors. All of these organizations could envision the MFR model benefits from multiple perspectives and reasons. They adapted and adopted elements of MFR, or used our work to justify their existing business model.

The justification of their existing business was particularly the case for UK low volume specialist producers who often struggled to convince potential investors – more used to the economics of mass production car companies – that their business model was viable. Riversimple is advocating a product-service system (PSS) approach as part of its business model. They have enhanced the MFR concept by adding a novel governance approach that includes a body of 6 'custodians' who represent different stakeholders, such as the Environment, Customers, the local community, staff investors and commercial partners/suppliers. These act as an independent body guiding the business. Riversimple argues this allows them to 'see in all directions' (Riversimple, 2017).

Local Motors has enhanced the model by recruiting potential buyers as product developers on an open-source design basis. It has also pioneered the use of additive manufacturing in this context and has in fact adopted the term 'microfactories' for their dispersed network of facilities (https://localmotors.com/microfactories/) . Such contact with industry has allowed us to refine at least aspects of the model over the intervening years (e.g. Wells and Orsato, Wells, 2013, Nieuwenhuis 2014, Nieuwenhuis and Katsifou, 2015).

Responses from the academic community were initially less sympathetic; and more critical. Holweg and Pil (2004, 194), for example, directly challenged the idea as presented in Wells and Nieuwenhuis (2000). Recent academic work tends to be more positive towards the feasibility of distributed manufacturing models, at least in the longer term. Holmström et al. (2016), for example, recognise the inevitable outcome of developments such as additive manufacturing on future manufacturing models.

There are other socio-economic industrial evolutions such as other more decentralising trends in the economy. Distributed electricity generation through small dispersed wind farms, solar panels on house roofs, as well as trends towards smaller manufacturing units in a range of industries including tyres, steel and brewing are all examples (Wells, 2013). In this respect, then, although Holmström et al. (2016) present their paper as merely setting a future research agenda in this area, the MFR concept appears to be gaining increasing credibility even in academia.

Conclusions

In conclusion, in any future sustainable automotive ecosystem, therefore, we would envisage a version of micro factory retailing as being one of the dominant business models for the supply and use of motorised personal mobility.

MFR is based on networks of small dispersed, combined assembly, retail and aftercare or lifetime management (e.g. maintenance and repair, parts supply, upgrade, vehicle management and takeback) facilities that could operate car use under a product-service system (PSS) whereby ownership is retained by the company and users pay for their use.

This business model would supply local markets, sourcing from local suppliers, while being rooted in local economies and in tune with local needs. MFRs would also source standardised modules globally from larger, more centralised facilities that would be able to achieve economies of scale in modules such as powertrains, for example. This process could entail some transport over longer distances, although this would involve smaller subassemblies and modules, rather than complete cars. In fact, it could easily be applied not just to private cars, but also to more dedicated shared car-club cars (e.g. Autolib's Bluecar), dedicated taxis, or public transport modes such as buses, or commercial vans for local conditions.

The cost of transport and supply chain complexity for shared mass produced components and subassemblies would have to be offset by the advantages of economies of scale. It is conceivable for some of the mass car manufacturers in the current mass production industry to become module suppliers in such an alternative model. It is even conceivable that some of these mass producers become MFRs themselves, or spin off existing MFR-like operations to become their core activities, although the precise nature of the product would have to change as well to more environmentally optimized vehicles (Nieuwenhuis and Wells, 1997, chapter 7).

Also in a PSS the actual cost of the product is less important, as this can be recovered over several leases over many years – durability and upgradability become key criteria – the need for a 'cheap' car is therefore much reduced, making expensive new technologies more viable, as is suggested by the Riversimple business model (Riversimple, 2017).

One of MFR's main distinguishing features in relation to the current mass production system is that it would break through the 'monoculture' of large centralised factories making a standardised, relatively undifferentiated product in very large numbers and at relatively low cost. Low cost and manufacturing-push make these cars effectively disposable, with short useful life-spans of only 10-15 years. These large facilities draw on global supply networks and supply global markets. They may be compared with the farms of the wheat-belt of the US and Canadian prairies in that they too are monoculture-based, supply world markets with cheap standardised grain and draw in supplies – in the form of oil based pesticides, herbicides and fertilisers – along global supply lines. This model too is now considered by an increasing number of observers to be ultimately unsustainable (Benyus, 1997; Diamond, 2005). Jeffries (1997, 5) gives the example of the monoculture of potatoes in Ireland in the 1840s and the resulting famine as an example of the negative consequences of such an approach in agriculture.

The change process from mass production to MFR is difficult to predict, however, as system change may happen suddenly after a long period of apparent stability (Walker and salt, 2006; Perrings 1998). It is also important to note that as the existing system becomes less able to fulfil the needs of the market or the economy in the broadest sense, change becomes inevitable.

As Perrings (1998, 506) observes: 'The economic value of a system in some state depends on its ability to maintain the flow of goods and services for which it is valued given the shocks or disturbances it faces. The source of disturbances may be either anthropogenic or "natural"'.

In our context we could see these disturbances as being generated by the dual forces of market pressure and the need for greater sustainability. Peterson (2000) discusses a model for ecosystem change first proposed by Holling (1986) and developed further by Gunderson et al. (1995). Their cycle moves through rapid growth, conservation, collapse and reorganisation. In the stable phase – the Ford-Budd automotive system during the 1950s and 1960s for example – the system becomes increasingly dependent on the persistence of its existing structure. This makes it vulnerable to anything that might upset it by releasing its organised capital. This kind of system is increasingly stable, but, Peterson (2000) argues, over a decreasing range of conditions and this therefore reduces the resilience of the system. In this respect, then, as the current system has largely favoured efficiency over resilience (Walker and Salt 2006) it may ultimately not need a massive shock to prompt its transition to an alternative system. The latter may well involve the MFR business model in view of its greater inherent sustainability in social, environmental, but also ultimately in economic terms.

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