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Abstract: This article questions the stereotypes of Fordism and mass production. It does so by demonstrating that there is a contradiction between the stereotypes and the reality of Henry Ford's manufacturing practice in production of the Model T at the Highland Park factory between 1909 and 1919. Highland Park was not an inflexible factory which combined dedicated equipment, Taylorised semi-skilled workers and a standardised product. More positively, the article quantifies Ford's heroic achievement in taking two-thirds of the labour hours out of the product at the same time as he built more of each car. Ford used productive intervention to realise manufacturing flow through proto-Japanese manufacturing techniques which involved a commitment to continuous improvement.

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Introduction

> To give a name to a thing is gratifying . . . but it is also dangerous: the danger consists in one's becoming convinced that all is taken care of and that once named the phenomenon has also been explained (Primo Levi *Other People's Trades*).

So it is with 'mass production' where we have the name and the illusion that the phenomenon has been explained although the phenomenon has not even been described. But this problem is invisible in social science where the concept of mass production is increasingly invoked in texts which confidently assume that it has considerable explanatory power. With the decline of interpretive meta-theories like Marxism, organising concepts have colonised the discourse of social science and mass production is one of the more influential of these concepts for (post) modern times. It is alluring because it promises to explain so much. American and British manufacturing failure can be attributed to persistence with this obsolete system, whereas more successful manufacturing countries like Italy (and maybe Japan) have supposedly built their success on new systems of flexible specialisation or post-Fordism.

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Throughout this paper we will use Piore and Sabel's (1984) familiar and influential usage as a point of reference; mass production means long runs of standardised products made on dedicated special purpose equipment by Taylorised semi-skilled workers. Mass production in this sense is often used interchangeably with the concept of 'Fordism' which is a kind of historical shorthand for the manufacturing system that was discovered by Ford and then, supposedly, widely imitated. All the overlapping variant versions of the concept of mass production have their supporters and detractors and some authors, such as Hirst and Zeitlin (1991), would challenge the identification of mass production with Fordism. But the authors who dispute whether Ford should be the eponymous essence of mass production are all agreed on one point: Ford is the classic example because, as everybody knows, Ford invented the moving assembly line and built 15 million Model Ts all the same and 'any colour so long as it is black'.

Sceptics and critics, like ourselves, have questioned the usefulness of the concept (Williams *et al.* 1987), arguing that there is no reason why the defining characteristics should be bundled together as either mass production or flexible specialisation. Critics have also been exasperated by the empirical opportunism of the supporters of mass production who see confirming evidence everywhere and find ways of dismissing counter evidence. But, so far, none of the critics has questioned the classic example of Ford and the T, or even registered the point that the classic example is an unexamined stereotype which is not securely based on recent research.

The standard history of the Ford Motor Company, by Nevins (1954), is nearly forty years old and only deals incidentally with production as part of a larger story. Recent popular accounts of Ford (e.g. Womack 1990) draw heavily on the brief treatment of Ford's production methods in Hounshell's (1984) history of American manufacturing technology and Lewchuk's (1987) history of labour control in the British car industry. Both centre on the introduction of the moving assembly line in 1913–14; for Hounshell, the addition of the line constitutes mass production and for Lewchuk the line is an effective way of controlling worker effort. In a recent article (Williams *et al* 1992), we criticise this historiography, construct the first continuous series of cars per man year from 1909 to 1916 and demonstrate that there is no justification for the privilege of the line.

If the history of Ford production methods has never been written, that is not because the sources are limited and inadequate. On the contrary, the available sources are voluminous, rich and diverse. Contemporary technical journalists took full advantage of the company's openness about production methods and produced detailed accounts of Ford methods around 1914: Arnold and Faurote's (1915) book provides a process by process description of the factory, while Abell and Colvin's (1913–1915) *American Machinist* articles analyse machine shop practice in depth. *Ford Times*, the company's house magazine, provides an invaluable commentary and chronology after 1908. The archive at Henry Ford Museum in Detroit holds the written records of the company, oral reminiscences taped in the early 1950s and more than 10,000 photographs of Ford factories. The archaeological evidence includes the Highland Park site where many of the factory buildings survive in semi-derelict form.

Because Highland Park (1909–1919) is the best documented factory in the history of mass manufacture, it was possible for us to go back to the sources and analyse in detail what Ford did. The results of our research are striking: our conclusion is that Ford does not fit the stereotype of mass production because there is a huge discrepancy between the stereotype and Ford's heroic achievements at Highland Park. The mass production label is particularly unilluminating because it obscures the extent to which Ford's organisation of production at Highland Park was proto-Japanese. We do not wish to substitute one misleading label for another and therefore will put some emphasis on the differences between Ford and Japan, but, for researchers like us, who have worked in Japan on companies like Toyota and Nissan (Williams *et al* 1991a, 1991b mimeo), there are uncanny similarities between Highland Park and the current practice of the Japanese. Perhaps this is not surprising because, though eighty years separate Ford and Toyota, the structure of costs and the activity of multi-process manufacture is still basically the same. In the rest of this article we aim to illustrate the character of Ford's production methods, to demonstrate the discrepancy with the stereotype and to draw out the implications of our analysis for the concept of mass production.

Analysing Ford's Achievements

Ford got into mass manufacture by cutting the price of the Model T car which was introduced in the autumn of 1908. A fully equipped touring Model T cost around $950 in 1908 and 1909; just seven years later, in 1916, the comparable Model T cost $360. Our own generation has seen dramatically larger price cuts on electrical and electronic products like calculators and computers. But these price reductions are mainly achieved through the regular introduction of new models which incorporate fewer, cheaper, higher performance components. In mechanical engineering products the scope for price reduction is very much smaller because there has never been a mechanical innovation comparable to the integrated circuit. The Ford company was also peculiarly handicapped after 1908 because its marketing policy was to resist the introduction of new models. Furthermore a production policy of building more of the car in-house plus detail re-design undoubtedly increased the number of components in each T. In 1914, the touring T had 7,467 separate numbered T parts; by April 1917 this had increased to 10,102 T parts (Ford Archive: accession 125 boxes 1–20). So how did Ford achieve his price cuts?

The original design of the T plus the efficiency of Ford's existing manufacturing operation provided the basis for cost reduction. In terms of design, the T was unique because the car was light yet strong. These two contradictory qualities were reconciled through careful choice of materials: pressed steel covers and cases were used in engine and transmission, vanadium alloy steel was extensively used for stressed parts of the engine and chassis and every metal component in the car was heat treated (*American Machinist* June 1913). Early adverts for the T emphasised that this 20 horsepower, 1,200 pound car was, 'the equal of a 30 horsepower, 2,000 pound car' and would bring benefits of lower running costs to the owner (*Ford Times* October 1908). Light weight design also brought the benefits of potentially lower manufacturing costs to an organisation which was well placed to exploit them. Manufacturing is physically about the conversion of materials and financially about adding value; the problem of the activity is that converting materials usually requires a substantial labour input and adding value incurs substantial labour costs. The product cannot be sold cheaply if, as in a modern American manufacturing company, labour costs account for 70 per cent of each $1 of value added. In 1908–9 Ford started with the advantage that he was running a much leaner conversion operation; from 1909 to 1916 labour's share of value added in the Ford company averaged 31 per cent (Appendix: table 1 col. iii). The share of labour in value added is generally lower in the early stages of industrialisation, but Ford's performance was superior to that of manufacturing in the United States as a whole and in Michigan State, where labour's share was almost exactly 50 per cent in 1904 and 1908 (Lee 1957: tables M6 and M8).

If the new design of 1908 and the efficiency of in-house conversion established a basis for cost reduction, it took some time to realise this potential. Like all other manufacturers in the infant American auto industry, Ford in 1908–9 bought-in most of each car from less efficient outside suppliers. When the Model T cost $950 in 1909, $590 of the car was bought-in materials and components (Appendix: table 1 col. ii); at this time, the bought-in components included chassis frames, wheels, springs, finished bodies, soft tops and some of the engines. The $590 bill represented several tiers of embodied supplier labour and conversion profit. If Ford built more of the car in-house and maintained conversion efficiency, the potential for cost reduction was quite spectacular. Insofar as Ford turned $1 of bought-in materials into $1 of internal output and incurred only 30 cents of labour cost in conversion, most of the remaining 70 cents could be given away to the consumer in the form of a price cut. The catch was that these cost reductions could only be realised if if the Ford company built and operated a large, efficient manufacturing plant.

The new factory at Highland Park was designed to meet this need. Production of Model T components at the 60 acre site began when the first phase of building was completed in spring 1909 (*Ford Times* April 1909). The new buildings represented an explicit commitment to build more cars and to build more of each car in-house; *Ford Times* (July 1908) claimed that, 'in this plant everything from screws to upholstery that enters into Ford cars will be manufactured', and this objective was partly achieved. On our calculations, in 1909 68 per cent of the value of each T was bought-in and by 1915 the comparable percentage was 52 per cent (Appendix: table 1 col. iv). The physical change in the amount of the car built in-house was certainly larger than this because, in almost every case, Ford succeeded in replacing expensive bought-in components with cheap in-house conversion and this value change damps the shift in percentage terms. In most cases, the cost of the component was quickly halved when production was brought in-house and, significantly, Ford's suppliers were generally unable to match these reductions on components which continued to be out-sourced. These points can be illustrated by some random comparisons drawn from the April 1914 and April 1916 Model T cost books which list bought-in prices and estimate in-house costs. Amongst other components, top iron, (soft) top, hood and coil set were brought in-house during this period and their 1916 cost of production was estimated at 54 per cent of their 1914 purchase price. By way of contrast, the wheel set, carburettor and springs, which were still out-sourced in 1916, shows a purchase price reduction of just under 20 per cent over two years.

At the same time as Ford was bringing production in-house, output of the Model T was increasing rapidly: the company which shipped 21,000 cars in 1910, shipped 199,000 cars in 1913 and no less than 585,000 cars in 1916 (Appendix: table 2 col. i). Factory space for this output could not be obtained simply by extending Highland Park. In Autumn 1912, the company announced a new policy of decentralising final assembly to 'branches' so that Highland Park could concentrate on the vital work of component production (*Ford Times* September 1912). By spring 1915, the company had opened 24 branch assembly plants in all 'the principal cities' and most of Highland Park's output left the factory as knocked down kits (*Ford Times* April 1915). When Ford policy was to cut the price to the consumers spread across a continental market, the policy of branch assembly had its own powerful logic. Up to 1912, the consumer paid a freight charge on top of the Detroit list price; West Coast consumers paid a substantial $75 premium for delivery to their local dealer. Branch assembly dramatically cut these freight costs; the freight rate per pound weight on kits was significantly lower than on finished cars (Jones 1916) and it was possible to pack more than 20 kits in a freight car which would only hold 3 finished cars (*Ford Times* February 1913).

In production engineering terms, this was heroic stuff: by 1915, Ford's company was building more of the car in a chain of new and extended factories that spanned the United States. Given these circumstances it would have been understandable if the company had incurred some penalty in terms of increased labour hours per car. Miraculously, however, as Ford moved into mass manufacture of the T, labour hours dropped out of the product at a rate which has probably never been equalled in the history of mechanical engineering. We have constructed a continuous series of labour hours per car from 1909 to 1916 by relating total number of employees (at Highland Park and branches) to cars shipped ex Highland Park in kit and built up form. The series based on employment totals from Nevins shows that from 1910 to 1916 total labour hours per car fell from over 400 to 130 hours (Appendix: table 2 col. iv); in just five to six years Ford took two-thirds of the labour hours out of the car. A variant series, based on *Ford Times* employment totals, shows an even more spectacular decline (Appendix: table 3 col. ii). Either way, Ford's early twentieth century American achievement makes the late twentieth century Japanese look like sluggards. Womack (1990) claims that, after 40 years of taking labour out, when the Japanese build a car they still require half the labour hours of their competitors in the West.

This reference to Japan is useful because it alerts us to the point that the preconditions of labour hour reduction were much the same at Highland Park as in Toyota City. The main labour savings were made by taking out indirect labour and operating with a very favourable ratio of indirect to direct worker hours. Reductions in direct (in-process) labour were not enough because the T, just like a modern motor car, contained only a modest amount of direct labour. The Model T Cost Books (Ford Archive: accession 125) show that in December 1913 there were only 61 direct labour hours in a Model T and by February 1916 the direct labour hours were down to 37. Ford's labour hour reduction was mainly achieved by *pari passu* reductions in the much larger input of indirect labour which maintained an extraordinarily favourable ratio of indirect to direct labour hours. After 1913 this ratio at Ford was 2.5:1. By way of comparison, the comparable ratio in Japanese manufacturing is now 4:1 (with Toyota standing at 1:1) and in modern American manufacturing it is now nearly 8 to 1. From our work on Japanese manufacturing (Williams *et al* 1989), we know that the number of indirects in any company is positively related to the level of stocks in manufacturing operations: in a high stocks factory, many indirects are employed as warehousemen, truckers and stock chasers. Thus, we would predict that Ford ran a low stocks operation.

Research confirms this supposition about Ford's stock levels: these were maintained at nearly Japanese levels which are much lower than those of modern American manufacturing firms. At company level, Ford's best ever achievement was stock equal to 6.5 weeks sales in 1914 (Appendix: table 4 col. i); this is more or less exactly the level of stock cover which Japanese manufacturing as a whole has been operating for the past twenty years and something like half the level of stock cover in modern American manufacturing. The Ford company does not steadily reduce stock cover and never achieves Toyota style stock cover equal to less than 2 weeks sales. But this 'failure' is hardly surprising given the nature of Ford's manufacturing tasks. Other things being equal, building more of the car in-house would raise stock levels and branch assembly inevitably led to long supply lines. These problems were aggravated by pronounced seasonal fluctuations in the demand for Ford cars; parts were stock piled in the branches 'during late fall and winter' so that the company could meet the spring sales peak (*Ford Times* April 1915). It is thus significant that, at plant level, Ford's Highland Park performance stands comparison with anything since achieved by the Japanese. By 1915, Highland Park was running with a stock cover of 3–5 days for major components like chassis frames or engines (Arnold and Faurote 1915:63) and, as early as 1913, buffer stocks between individual production departments were down to a 'few hours' with zero stocks inside the departments (*Ford Times* January 1913). By way of comparison, when we visited Toyota in 1988, panels were being made in batches equal to one and a half days requirement and buffer stocks between assembly and the satellite factories of Toyota and its suppliers were down to a few hours.

The implications are clear: Ford in Detroit in the 1910s discovered the benefits of so-called 'lean production', which is falsely assumed to have been first invented in Toyota City in the 1950s. The proto-Japanese character of Ford's achievement must cast doubt on the orthodox explanation of that achievement in terms of economies of scale. When asked to explain the dramatic reduction in labour hours, an economist would observe that a thirty fold increase in output, over seven years, inevitably creates new technical opportunities for any manufacturing company: as output rises, unit labour hours and costs can be reduced by substituting capital for labour and/or extending the Smithian division of labour. If you want to know the time, it may be wise to ask a policeman but if you want to understand manufacturing it is foolish to ask an orthodox economist. This is because the discourse of economics operates with a cake mix factorial concept of production that does not specify the problems and possibilities of multi-process manufacturing. This is certainly so in the case of Ford, where the two orthodox economic explanations (substitution of capital for labour and division of labour) have some force but identify necessary, rather than sufficient, conditions of labour hour reduction. At the same time, the orthodox explanations fail to identify the real dynamic at Highland Park which was continuous improvement in workflow via changes in layout.

Ford did substitute capital for labour. The Highland Park plant was, in its time, the best equipped car factory in the world. In some processes, like the foundry, high labour productivity was achieved by putting capital equipment at the elbow of semi-skilled workers (Arnold and Faurote 1915:327). As a result, the amount of capital per Ford worker increased steadily in the heroic period. The gross value of plant and equipment (excluding buildings) more or less doubled from $870 per worker to $1606 in 1917 (Appendix: table 4 col. ii). Nevertheless it was not feasible to eliminate a large amount of labour by buying in a line of machines. Automatic process technology for building cars without (direct) labour was not available; the engine transfer line and the robot body line had yet to be invented. The machine shop at Highland Park was full of bought-in machine tools whose manufacturers assumed one direct operative per machine plus back-up maintenance and hand trucking of work-in-progress. If Ford was to do better the company would have to learn how to use its equipment in a better way. Similarly, the elimination of indirect workers required a new approach to materials handling where investment in mechanical handling was not the only option.

If Ford's efforts were partly directed by the limits on what investment could do for the firm, much the same point could be made about the Smithian division of labour which again plays a positive and limiting role. What Smith described in pin manufacturer, Ford applied to car assembly. In piston and connecting rod assembly, for example, assembly time was halved when the operations which one man had carried out were subdivided between three operators and an inspector (Arnold and Faurote 1915:103). Even so the division of labour was far from the governing principle of the Ford factory because it was applied only to hand assembly work. In machine work on the engine, gearbox and chassis parts, Ford engineers pursued with tenacity and ruthlessness, the opposite principle of combining the operations performed at one setting or chucking of the materials. Thus, the Ingersoll milling machine used on the front axle body was modified to take two axle bodies at a time and made twenty four cuts for one clamping (Arnold and Faurote 1915:166).

More fundamentally, in multi-process manufacture the principle of division of labour is a source of productivity loss as well as gain. This was particularly so in the case of a complex product like the Model T. By 1915–16, Ford was manufacturing around 5,000 T parts in-house and the work of fabrication and assembly required several hundred thousand separate process operations. To take just one example, a pressed steel cover at the bottom of the engine carried the crankshaft and doubled up as an oil sump; no less than 78 separate operations were required to make this pressed steel cover (Arnold and Faurote 1915:82). Furthermore, although the touring T was a relatively light car, it did weigh 1200 lbs: by way of comparison, the lightest European car in current production is the three door Citroen AX which weighs in at 1400 lbs (*Autocar* 18 August 1988). When the Ford company was producing 1000 cars a day by early 1914, it was shipping 625 tons of metal out of the factory each day and that weight had to be handled many times in between production stages. With a complex heavy product like the T, disintegration of production and unnecessary labour expense was the corollary of multi-process production. The smooth flow of production could not be sustained if in-process labour time was wasted on walking or waiting because the work was not immediately to hand and extra indirect labour would be required to handle any stocks that accumulated between processes.

In itself, the minute division of labour only increased the disintegration of production. It was therefore necessary for Ford to back up the division of labour and mechanisation with layout changes which improved in-process layout and inter-process workflow. Significantly, the reduction of walking and waiting time in-process was an explicit company objective. Thus in October 1912 *Ford Times* announced,

> every extra motion, every trivial waste of time on the part of any workman must be eliminated. It is the solution to this problem of "waste motion" both with men and machines, which to a very large degree makes it possible for Ford to put on the market such a high grade car at such an extremely low price.

The elimination of indirect stock handling was another explicit objective; as a senior Ford engineer observed in 1913, 'trucking is expensive and all its labour is non-productive' (Bornholt 1913). The double objective of eliminating unnecessary labour within and between processes was vigorously tackled by investing in handling equipment and by re-designing layouts so that work in progress travelled shorter, more direct, routes.

From Nevins (1954) through Braverman (1974) to Hounshell (1984) and Lewchuk (1987), scholarly accounts of Ford emphasise the moving assembly line which was first used in magneto assembly in the spring of 1913, applied to final assembly in the latter half of 1913 and then transferred to production of various sub-assemblies like dashboard, front axle and body and top. Undoubtedly, the moving line boosted productivity after 1913, but, as we argue elsewhere (Williams *et al* 1992), the moving assembly line centred view of Ford is unreasonable and should be revised. Ford had already taken 150 labour hours out of the car before the assembly line was introduced in 1913; on our calculations, 63 per cent of the 1910–1916 labour hour reduction and 70 per cent of the material cost reduction was achieved without benefit of assembly lines. Furthermore, the moving assembly line was only one device in a whole battery of mechanical handling and transfer devices which were introduced at Highland Park after 1910; these systems included craneways and an overhead monorail which played an equally important role at different stages of production.

The nature and function of the different mechanical handling systems can be pieced together from various issues of *Ford Times*. By spring 1915, moving, chain driven, lines had been applied extensively in final assembly, body and trim; at this time the factory had one and one-half miles of moving line which was roughly half manufacturing conveyor and half transfer conveyor. (*Ford Times* April 1915). But in the machine shop, the main transfer device was a one and a quarter mile long overhead monorail (*Ford Times* April 1912) which had been constructed somewhat earlier; by early 1914 this monorail system shifted 1400 tons of work in progress each day into, through and out of the machine shop to final assembly in building H. For the delivery of bought-in materials and components to the shops, strategically sited craneways played an increasingly important role. From Autumn 1910, a craneway and storage area 56 feet wide and 860 feet long bisected the main machine shop (*Ford Times* November 1910, January 1913). When new six storey buildings (W, X and Y) were constructed in 1913–1914, two narrower 40 foot craneways were placed between the buildings so that materials could be transferred directly between rail cars and projecting freight balconies which were set into the face of each building.

The preoccupation with Ford's moving lines is all the more misplaced because the company's philosophy was not only to mechanise handling in a variety of ways but also to eliminate transfer and handling wherever possible by re-designing layouts so that work in progress travelled shorter, more direct, routes. The conversion of Highland Park into a short travel factory required careful attention to three separate issues: the sequence of shops on the Highland Park site; the positioning of machines close together and in order of use within each shop; and the development of simple direct methods of inter-process transfer. The significance of the no-investment or low investment layout changes was appreciated by contemporary observers like Colvin of the *American Machinist*, but has been largely lost in later scholarly accounts which are preoccupied with the romance of the moving assembly line. In our view, layout changes are the hidden dynamic in a process of continuous reorganisation of workflow which dramatically reduces the inherent disintegration of multi-process production and generates large savings in indirect and direct labour requirements.

It is difficult to generalise about the sequence of shops at Highland Park because, over the period 1909–1916, the factory was regularly extended and, with the exception of the machine shop, the buildings were used and re-used for a variety of productive purposes. The general plan of the factory in Autumn 1912 does however indicate the company's commitment to setting shops in a logical sequence (*Ford Times* October 1912). At this time, the shops in Highland Park were laid out on a West to East axis along which work in progress travelled to final assembly. For example, in the machine shop, cutting departments were on the West side of the main craneway with engine and gearbox assembly on the East side. One step further East, on the other side of John R Street, was the four storey H building where final assembly took place on the ground floor; many of the body parts and sub-assemblies were made or stored on the upper three floors of this building before travelling down freight elevators to final assembly. If the three dimensional shop layout of the factory was logical, so was the detail of layout inside the shops.

In laying out shops, Ford's philosophy was to put the machines close together and in order of use. Visitors to the shops commented that the machines and workers were jammed together more closely than in other American factories. In 1913 Colvin wrote, 'I do not know of a place where more men are worked together in the same area, although the Baldwin locomotive works are in the same class' (*American Machinist* 5 June 1913:761). On our calculations, the 5,500 machine tools, which filled the shop in 1913, had a floor area of 55 square feet per machine including access aisles and inter-process storage space. The machine shop also included babbiting and annealing furnaces as well as enamelling tanks because the company's practice here and elsewhere was to arrange machines, regardless of function, according to 'sequences of use' (Bornholt 1913:1276–7). Arnold and Faurote (1915:223) reported that, in the production of distributors, the furnace that produced the aluminum distributor body was placed at the beginning of the line at third floor level; the foundry fed rough castings, at the rate required by the day's build schedule, directly into the machining operations from which finished cases moved straight into assembly.

When machines were placed close together and in order of use, Ford obtained spectacular reductions in work travel, stock levels and indirect labour requirement. The engine block casting, for example, originally travelled 4,000 feet between finishing operations; after putting the machines close together and in order of use, the block casting travelled just 334 feet (Arnold and Faurote 1915:38). A senior Ford engineer argued that the in-sequence, short-travel layout in engine block machining reduced stocks to nearly one-twelfth the level required by a long-travel layout with machines grouped according to function. He also calculated that, when production was running at 1000 blocks a day, the short-travel layout saved the handling of 480 tons of work in progress which would have required the full time services of 24 hand truckers (Bornholt 1913:1276–7). Furthermore, with the machines jammed close together it was possible to introduce simple direct inter-process transfer devices like gravity slides. Along with roller beds and racks of pipe and angle iron, gravity slides were used everywhere for inter-process transfer at Highland Park. These simple transfer devices not only eliminated indirect truckers but also boosted direct labour productivity and line capacity (Arnold and Faurote 1915:105).

The aim and result of layout improvement was what the Japanese call '*kaizen*' which in this context means continuous step by step improvements in workflow which progressively take labour out (Williams *et al* 1991a).

The conventional emphasis on the moving assembly line in 1913–14 is again misleading because it suggests a once and for all series of changes, when Ford's real achievement was to institute permanent progress. Any detailed examination of Ford practice shows how the Highland Park engineers were never satisfied with any given layout and expected to achieve continuing cost reductions.

The development of the moving assembly line is itself a good illustration of the company's commitment to continuous layout change, for the chain driven final assembly line was the culmination of years of progressive experiment with final assembly methods. It is mistaken to assume that, before the moving assembly line was introduced, Ford operated an inefficient and unchanging bay assembly system with one gang building the whole car. By 1911, the company was operating a moving gang system in the early stages of final assembly. Specialist gangs moved down a line of cars and fixed the same components on each station; Colvin observed that, 'each man or gang does his own part and goes to the next stand to repeat the operation' (*American Machinist* June 5 1913). In the later stages of assembly the company used a buggy system whereby part-finished cars were rolled along on their wheels between successive operations (*Ford Times* March 1914). The idea of the moving assembly line grew in an evolutionary way out of these earlier innovations. Before the chain driven line was introduced, archive pictures show a pull along line where cars ran with one rear wheel in a jockey frame that was located in a steel channel.

The Toyota-like ability of Ford to generate continuing cost reductions is best illustrated by considering the case of the 'motor' or engine plus gearbox power train of the T. Machine shop cost reduction was the main focus at Highland Park from 1909–12 because the T could not be sold cheaply as long as the engine and gearbox were expensive to manufacture. By April 1914, Ford was building each power train at a total cost of $61 for materials, labour and overhead; this was a remarkable achievement when in 1914 Ford was paying nearly as much ($55) to buy-in a light open touring body (Ford Archive: accession 125 boxes 1–20). By 1913–14, attention had shifted to final assembly which had become a bottleneck because, 'at this point we found that we were making parts a hell of a lot faster than they could put them together on cars' (Klann 1955:55). Even so the reductions in power train cost continued; the 'motor' which cost $61 in April 1914 cost only $53.15 in April 1916 and more than 80 per cent of this cost reduction was achieved by reducing the internal costs of labour and overhead (Ford Archive: accession 125 boxes 1–20). When the company started from such a low cost level in 1914 a further 13 per cent motor cost reduction in two years is eloquent testimony to the culture of *kaizen* inside the Ford company which Sorensen aptly described (1956:128) as, 'an organisation which was continuously experimenting and improvising to get better production'.

Ford and the Stereotype of Mass Production

After analysing Ford's productive achievements, we can now turn to measuring the difference between Ford and the stereotype of mass production. The stereotype has three elements which the supporters of the mass production concept would expect to find at Highland Park: dedicated equipment; Taylorised semi-skilled workers; and a standardised product. These elements fit together in the stereotype to sustain the working assumption that the mass production factory or enterprise is rigid and inflexible; if they were present at Highland Park, this would imply that the factory could not be easily used to produce variety and could not easily be changed over from one product line to another. In this section we will argue that the three elements cannot be found at Highland Park.

There were elements of fixity in Ford's capital equipment, most notably in the buildings at Highland Park which are a concrete disproof of the vulgar Foucauldian assumption that it is usually easy to choose appropriate architectural forms. Although the machine shop and foundry were housed in single storey sheds, most of Ford's shops were housed in multi-storey factory buildings of a type familiar in turn of the century Detroit, Berlin and Manchester. This conventional choice was hardly surprising because the original 865 feet long four storey building at Highland Park was already designed and under construction when the Model T was going into production in autumn 1908 (*Ford Times* January 1909). Ford's architect, Kahn, was responsible for the bold modernist aesthetic of glass curtain walls and for the clever detailing in the provision of ducted services like heating, compressed air and gas. He also brought to the project the Kahn family's obsession with reinforced concrete; the multi-storeys were off the form, reinforced concrete structures rather like modern multi-storey car parks. The result was a factory complex where transfer of work in progress between floors was a constant problem, even in the later 1913–14 six storey buildings, where freight elevators were backed up with craneway access to each level. As the massive floor decks could not be cut, by 1913–14 Ford's engineers were knocking out Kahn's glass curtain walls so that they could hoist and drop up and down the sides of the buildings. This is the background to a much-reproduced photograph of the H building body drop on John R Street in 1914; the bodies which were trimmed on the first floor are being ramped down outside the building to street level where finished chassis are coming off the assembly line on the ground floor (Ford Archive: PO 242). Its complement is a never-reproduced archive photograph taken in the same year, which shows bought-in, part finished bodies being ramped up from a supplier waggon on Manchester Street for trim and finishing on the first floor of building W (Ford Archive: PO 5304).

If the buildings at Highland Park did introduce an element of rigidity, the machinery inside the buildings was flexible in the sense that it was mainly re-usable. Ford did use some purpose built dedicated equipment like the machine which automatically painted rear axles (Arnold and Faurote 1915:308), but most of Ford's metal working was done on bought-in, series built lathes, drills, millers and presses. Manufacturers like Cincinnati or Ingersoll delivered a stripped down tool minus the expensive multi-speed gearboxes and universal clamps that a job shop would require. Ford engineers then added special jigs and fixtures which (temporarily) adapted a machine for a single task. As *Ford Times* (October 1912) observed,

> a trained observer is at once struck by the number of jigs throughout the big machine shops . . . . By use of jigs a standard tool can be adapted to do special work and it is, of course much cheaper to buy a standard tool than to have one built to order.

This kind of 'single purpose' equipment was generally used in other early twentieth century American machine shops which made interchangeable parts; the jig or fixture guaranteed interchangeability because it automatically set the same depth and angle of cut for each successive workpiece. Interchangeability boosted productivity because it allowed Ford to eliminate the fitter's role and to minimise inspection and rectification of finished assemblies. Single purpose tools had important additional advantages because Ford engineers could cheaply and easily re-use the equipment for a different purpose by changing the jigs and the drive sprockets which set operating speed. In the case of transfer equipment, the principle of reusability was even more important because all layouts were provisional and temporary. Ford's solution was to build transfer devices like slides, racks and roller beds out of standard sections which could be dismantled and re-assembled in a different configuration; the gravity slides, for example, were made out of lengths of pressed steel troughing which bolted together just like the parts in a child's construction kit (Arnold and Faurote 1915:274).

If the equipment at Highland Park was not dedicated, in this respect the stereotype is simply untrue. Much the same can also be said about the claim that Highland Park workers were Taylorised; a claim which has been challenged in the specialist literature (e.g. Hounshell 1984:249–52), but which is elsewhere endlessly repeated as though it was unproblematically true. Here the discrepancy between the stereotype and the reality of labour control at Highland Park is somewhat subtler but the issues raised are important. It is undoubtedly true that Ford was obsessed with labour utilisation and, more specifically, like a later generation of Japanese mass manufacturers, privileged efficient labour utilisation over capital utilisation. This is entirely understandable because the (payroll) cost of labour in mass manufacture is usually much greater than the (depreciation) cost of capital. On our calculations, this disproportion was quite spectacular in the

Ford company where, between 1910 and 1916, depreciation averages just 5 per cent of payroll (Appendix: table 4 col. iii). The privileging of labour utilisation was asserted in all the Ford company's practices about manning and machine use; if, for example, the company had excess capacity on a line, Ford preferred to shut down one machine and save the labour, rather than run all the machines slower (*American Machinist* June 5 1913:761). The issue is not *whether* Ford was preoccupied with labour utilisation but *how* the company secured this objective.

At Highland Park, Ford did not use the formal apparatus of Taylorism; time study had little influence because Ford favoured simpler more direct ways of driving the workforce. Two key company agents informally determined the workpace: output norms were routinely set and checked by 'the working foreman' who could do every job on the line and regularly covered for workers when they took a toilet break; when the company wanted to raise the output norm in a particular process, loyal company men called 'pace setters' were brought in to show that the job could be done faster (Klann 1955:10). Some contemporary observers concluded that Ford had the substance if not the form of Taylorism; Colvin (*American Machinist* 1913:149) argued that the assembly of rear axles was, 'one of the interesting propositions which show that motion study has been carefully looked into whether it is called by that name or not'. But, in our view, this interpretation misses significant differences between Ford and Taylorism at the same time as it fails to specify the nature of Ford's labour process regime.

The aim of the working foreman and the pace setters was not to define a semi-permanent scientific standard but to raise the output norm in a continuous way. In a factory of immigrant workers,

> one word every foreman had to learn in English, German, Polish and Italian was 'hurry up'. It was '*putch putch prenko*' in Polish, '*mach schnell*' in German and '*presto presto*' in Italian (Klann 1955:54).

Furthermore, although most of the workers were semi-skilled, there was never a rigid separation of execution and conception. Ford did not operate a formal suggestion scheme, but foreman or line worker suggestions about productive improvements were encouraged and workers who made useful suggestions could expect to be promoted. Klann (1955:117) recalled that this was certainly so in the machine shop which he supervised from 1912–17,

> A lot of these ideas came from the men as well as from people in supervisory positions. Lots of them came from the men. You went and asked the men for an idea and then tried it out. If it worked, you thanked him for it, or maybe made a foreman out of him.

The line between execution and conception was always permeable when Ford was a rapidly expanding company which lacked a professionally qualified management cadre. Many senior managers were recruited from the ranks and Klann's career progress, from line worker to senior manager in fourteen years, illustrates the possibility of rapid promotion. Klann was taken on as a machinist in Ford's Piquette plant in 1905; after a short stint in the tool room, in 1907 he became a roving pace setter before being promoted to assistant in charge of motor assembly in 1910; by 1919 Klann was assistant superintendent (or second in command) of the whole Highland Park factory.

More generally the label 'informal Taylorism' is misleading because it fails to specify the quasi-Japanese character of the labour control regime which Ford operated (Williams *et al* 1991a). The Highland Park regime imposed two general requirements on the workforce: they had to be infinitely flexible about the definition of the task to be performed and, at the same time, had to acquiesce in progressive de-manning of most operations. Ford workers had to accept endless changes in the labour process because workforce flexibility at this point was a crucial precondition of productive reorganisation. In assembly, tasks were increasingly subdivided to the point where, for example, different workers spot painted the fixing bolts on the left and right side of the chassis (Arnold and Faurote 1915:150). On the machine lines, tasks were combined to create multi-tasked workers who, as in modern Japan, sometimes tended more than one machine. In the machine shop, for example, some single fixture machines were placed face to face so that one worker could turn to re-load a first machine while a second ran to the end of its cycle (*American Machinist* October 1914).

With or without layout change, de-manning was a way of life in Ford's factory as it is now in Japan. The de-manning was particularly ruthless in final assembly because the company compared assembly costs at Highland Park and the branches each month and least cost assembly methods were enforced by de-manning. Klann (1955:300) recalled that when Highland Park assembly costs were above those of the Kansas City branch, the Kansas city foreman was brought up to Detroit,

> he said 'my gosh, I can't find anything wrong round here except down there I've got two men where you've got three. In putting bodies, I've got three men where you've got four'. He pulled a man off that job. By the time he got through he pulled off six or seven different men and we brought our cost down to where his cost was.

Under this regime of *kaizen* through labour intensification, management's prerogative over the labour force was infinite (and had to be so). As Arnold and Faurote (1915:328) observed,

> workmen are studied individually and changed from place to place with no cause assigned, as the bosses see fit, and not one word of protest is every spoken.

Any worker who refused instructions was sacked on the spot. Highland Park was not unionised and the company's labour control regime was designed to prevent informal resistance through practices such as 'soldiering'; for the individual Ford worker, the only available resistance option was quitting the job. As there was an external labour market in Detroit, this option was popular and, in the early years at Highland Park, Ford faced a serious problem about high rates of labour turnover which reached a phenomenal 70 per cent in 1913 (Meyer 1981:162). High wages, especially the $5 day introduced early in 1914, were an attempt to square the circle and resolve this problem. The $5 day was never simply an economic choice, it was the first of Henry Ford's social experiments which turned him into an American hero who was something more than a car maker, but high wages did have an economic function in Ford's labour control regime and, by early 1914, they also had a coherent economic basis. Ford could afford to double the hourly rate and offer shorter working hours because the company had been so successful in taking labour hours out of the car. In 1909 when hourly earnings were 28 cents and there were 400 hours of labour in a T, Ford's in-house payroll costs were $100 for each car produced. By 1915, earnings had doubled to 55 cents but, with just 125 hours of labour in a T, the in-house payroll cost was just $64 for each car produced (Appendix: table 4 col. (iv)).

The idea that the model T was a standardised product is a final misunderstanding which rests on a series of misconceptions about the changing nature of the American market for cars from 1910 to 1925 and about the possible lines of response for a manufacturer like Ford. The concept of product life cycle is slippery, but it is clear that the car was not a mature product when the T was introduced in 1908. When the T went into volume production in 1909, American cars were open, gas-lit, crank-started and artillery wheeled. By the time the T ran out in 1927, American cars were closed, electrically lit, self started and balloon tyred on demountable rims. Ford could not have maintained its position in the market for cheap cars if it had ignored these changes. The company, did however, have a choice about how to respond to changing market requirements; Ford could either incorporate the necessary changes in regularly introduced new models or develop and refine its existing model. Like most subsequent manufacturers of relatively small, cheap cars, Ford in the 1910s and the 1920s chose the second option of development to prolong the life of the existing model. It is worth nothing, in this context, that Ford of Europe's smallest model (the Fiesta) has recently been replaced after a production run of fourteen years which is not so different from the T's eighteen years. The difference is that, because the car market around World War I was changing so much more rapidly, Ford at Highland Park had to make a major commitment to continuous refinement and development (rather than occasional facelifts). As a result the model T of 1926 was, part for part, more or less completely different from the T of 1908; that is hardly surprising when by 1913 the company was making more than 100 T part specification changes every month (Ford Archive: accession 575 box 5).

The body of the T was never standardised because the T was not one car but a changing range of cars and trucks. From 1912 to 1926 the range was available in black only. This restriction of choice reflects the Ford company's low stocks productionist priority; the legend is that black paint dried more quickly and black body panels could be handled and moved on more promptly. In all other areas of body design the Ford company's policy was to extend the market for the T by offering consumers choice and change. Right from the start the company produced several different body types; the first price lists feature a two seat roadster, four seat tourer, and a closed 'town car'. When a separate load bearing chassis frame was an integral part of the T design, it was cheap and easy for Ford to develop new and existing body styles. Regular styling changes transformed the square upright town car of the 1910s into the neat soft edged sedan of the 1920s whose passengers sat fashionably in (not on) the chassis. From 1910 onwards the T range included a low volume, high style variant, the 'torpedo roadster' which was the Corrado or Calibra of its day. Utility variants like the T delivery van and the T truck followed in due course, and from 1914 onwards the company continuously listed a bare chassis so that customers could have literally any body they liked on a T. If the body variety was potentially infinite, it was also true that, before World War I, the vast majority of Ford customers chose factory-bodied open tourers and roadsters; in April 1916, for example, 97 per cent of cars sold were tourers or roadsters (Ford Archive: accession 125 box 6). This was mainly because Ford never revolutionised the building of closed bodies whose cost of manufacture was 3–4 times larger than that of an open body (Ford Archive: accession 125 box 3 and 7). Between 1909 and 1916, a closed town car always cost $235–250 more than an open tourer and, in this period, buyers of cheap cars were not prepared to pay that kind of premium for a closed body.

It is superficially more plausible to argue that the power train and chassis of the T were standardised. Like Beetles in a later period, all T's shared a distinctive identity because some increasingly idiosyncratic mechanical features were maintained throughout the model's life; in the case of the T, the identifying features included thermo-syphon cooling, a two speed planetary transmission and exiguous two wheeled brakes. Nonetheless the T power trains and chassis were not all the same. The chassis was always built in several different forms. Early customers for the car could, for example, choose between 56 and 60 inch tracks, while later purchasers of the truck were, in effect, offered a package of heavy duty modifications which involved a re-located engine in a reinforced chassis frame which carried a worm drive rear axle. Furthermore, the basic design was developed through innumerable specification changes so that, when ordering engine or chassis parts, it was always necessary to specify year of manufacture and type of body. Towards the end of the T's model life, Fahnestock (1968:69), the leading independent technical writer on the T, concluded, 'the fundamentals are unchanged but many details have been improved', and this verdict appears to be an understatement if we set it against Fahnestock's (1968:229, 252) own account of the development of one major system, like the vehicle electrics. There were three major re-designs of the magneto ignition system in the first ten years of production during which the car also acquired electric lighting. In 1919 Ford jettisoned the magneto principle and offered the car for the first time with a modern coil and points ignition system that included battery, dynamo and starter. The final major change came in 1922 when Ford re-designed the wiring harness and all the electrical junction boxes and connectors. In design terms, the power train and the chassis of the model T was the automotive equivalent of George Washington's axe.

Ford's Model T did not succeed in the market for so long because it was a standardised product, but because it was a stretchable product. Continued success in the early 1920s, when production peaked at 2 million units a year, demonstrated Ford's competence in stretching a robust basic design. The process was nevertheless reaching its limits because like many mechanical engineering products the model T put on weight as it was re-designed and developed. Mechanical improvement raised the original 1918 weight of a touring T from 1200 to 1662 pounds by 1925, while the addition of a closed sedan body, which customers now preferred, raised the kerb weight to 1900 lbs (Van Doren Stern 1955:164–7). The extra weight spoilt the car: deterioration in the power to weight ratio could only be met by fitting lower axle ratios which increased fuel consumption, mechanical wear, noise, vibration and harshness. The necessary replacement was delayed while the ageing Henry Ford tried to develop an automatic gearbox and a new X8 engine. The mechanically mundane Model A of 1927 represented a grudging admission that such refinements could not be brought to the low cost mass market of the 1920's.

If the Model T was stretchable our argument implies that the Highland Park factory was flexible up to a point. When Highland Park combined variable layouts with re-usable equipment and a malleable workforce, the factory could have been used for turning out a wide variety or mix of volume manufactured engineering product. Ford's strategy was to develop the T range and thus the company never exploited this potential in peace time, but the flexibility of Highland Park was conclusively demonstrated in World War One when, 'practically all Ford machinery was dismantled and re-arranged to produce war material' (Ford Archive: photo caption PO 2296). In the account which follows, the facts are taken from Ford Bryan's (1990) *Beyond the Model T* which provides the only published account of this neglected but significant episode; the interpretation is, of course, our own.

For the Americans, World War I lasted only 18 months from April 1917 to November 1918. In this brief period Model T production dropped by more than one third and the spare margin of capacity at Highland Park was used to build a marvellous assortment of military equipment: 825,000 steel helmets, 5,000 state of the art Liberty V12 aero engines, around 25 sets of 2,500 hp marine boilers, steam turbines and reduction gear, and a two and a half ton tank powered by two Model T engines. This achievement is all the more remarkable when it is recalled that, during this period, Ford opened a new factory at River Rouge which initially concentrated exclusively on war production. The Ford company also had a substantial design input into several of these war time projects; the 600ft Eagle submarine chaser was designed entirely in-house and the prototype was actually built in a craneway at Highland Park before being moved to River Rouge where Ford planned to build, outfit and launch the hulls for a series of more than a hundred vessels.

The nature of wartime demand was such that the Ford company had to make a difficult shift from medium to heavy engineering. In terms of dimensions and weight, the V12 aero engine and the marine reduction gear were physically very much larger than anything that went into a T; the sudden increase in component size and weight created new problems in processing and transfer. At the same time, the Ford company faced a spiralling bill for materials, especially heavy steel plate. Both the submarine chaser and the tank were basically exercises in steel fabrication and assembly; the Eagle hull was constructed entirely by riveting cut, flat steel plate. As Ford did not make steel in-house, purchases as a percentage of sales increased from 54 per cent in 1915 and 1916 to 75 per cent in 1917 and 1918 (Appendix: table 1 col. iv). When the company faced new physical problems about conversion and was financially forced back into the old practice of buying-in, it is hardly surprising that conversion efficiency plummeted and labour's share of value added shot up to crisis levels; labour's share of value added averaged 31 per cent in the Ford company between 1909 and 1916 before jumping to 61 per cent in 1917 and 89 per cent in 1918 (Appendix: table 1 col. iii).

Highland Park was not a universal conversion apparatus; Ford could get wartime heavy metal out of the door only at the substantial cost in terms of lower conversion efficiency. In mechanical engineering, productive flexibility is never costless and infinite. This is a point which we have made elsewhere (Williams *et al* 1987) when criticising romantic accounts of the flexibility of modern robotised car body building. With old or new technology in mechanical engineering the relevant consideration is whether the production facilities can change over at moderate cost and then efficiently build a new product which is physically different but within the conversion parameters defined by the weight, size, materials and process requirements of the old product. Ford's attempt to get into the fighter aircraft business suggests that Highland Park did meet the relevant test of conversion efficiency.

In late 1917 Ford approached the US military with an offer to build 150,000 fighter aircraft for the Allies at a price of 25 cents per pound weight. The offer was immediately rejected as another one of "crazy Henry's" stunts because the military believed it was impossible to build aircraft so cheaply. A closer consideration of the facts suggests that Ford's offer was a carefully considered and genuine bid to fill his factory space with a war product which he could build efficiently and profitably. The single seater fighter aircraft was the military product which most nearly fitted the Model T conversion parameters. By 1918 the fighter to beat was the Fokker DVIII: modestly sized and relatively light weight, with a fuselage length of twenty feet and a wingspan of twenty seven feet, the 100 hp monoplane weighed around 1700 lbs (excluding pilot, two machine guns and ammunition). In conversion terms, a fighter like the Fokker was a flying T with more engine and less chassis.

The offer to build this kind of new product for a price of 25 cents per pound weight gives a real insight into Ford's conversion calculations and assumptions about flexibility. The company had already approached this level of conversion efficiency in pre-war production of the model T; in 1916, the 1200 pound touring T was listed at $360 and the selling price (including Ford's profit and dealer margin) was therefore 33 cents per pound weight, which *kaizen* would have continued to reduce. In this context, the offer to build fighters at 25 cents per pound signified Henry Ford's personal belief that his factories could change over from the T and build, with increasing efficiency, any mechanical engineering product which shared the conversion parameters of the T.

The Failure to Emulate Ford's Achievement

If the concept of mass production has generated a series of misrepresentations about Ford's achievements, it has also promoted a misconception about the emulation of those achievements; it is generally believed that Ford's practice was a model which was widely emulated in America and other parts of the world. In this section we will argue that the reality was rather different; even in America there was only limited imitation and transference of Highland Park practice. The trajectory of American manufacturing after World War I was determined by the fact that most firms, including the later Ford company, turned their back on the achievements of Highland Park. Whatever reservations we may have about Chandler's (1962) history of American business, it does indirectly register a powerful truth: from the 1920s onwards, many American firms were increasingly preoccupied with organisational issues and forms of financial and strategic calculation which have little to do with the hard driving productionism of Highland Park. When management hierarchies and financial control displaced focused production engineering, the model of success became 1920s General Motors as a corporation rather than 1910s Highland Park as a factory.

The idea of imitation and transference is immediately plausible because by 1914 Ford's Highland Park factory was the most famous industrial site in the world whose visitors included technical journalists and public figures as well as managers and engineers from other companies. But many of the visitors to Detroit in the 1910s, like those who made the journey to Toyota City in the 1980s, left with a limited understanding of what they had seen and returned home to engage in various forms of symbolic modernisation; as with 'Japanisation' in our own time, many imitators of Ford were doomed to disappointment because they fastened on elements of his superior manufacturing practice and credited these elements with a magic efficacy. The Fiat company, for example, built a multi-storey factory at Turin in imitation of Highland Park without realising that this architectural form was one of Ford's half-solved problems. For most firms outside America, Ford's mass manufacturing practice was, in any case, of limited immediate relevance because they served relatively small national markets. American firms supplying a continental market had a different set of opportunities, but few of them faced the overwhelming demand pressure which generated and legitimised Ford's productionism in the 1910s.

Ford faced an insatiable market demand for the T, a product which in its heyday was always oversold. The aim was to supply a robust, easy to drive motor car at an ever lower price which extended the market. The company succeeded to the point where it had an unassailable position in the market for cheap new cars; in 1914 Ford made 96 per cent of all American cars sold at less than $600. When cars were open and roads were poor, there was strong seasonal variation in demand. But year on year, the policy of price cuts stimulated a phenomenal increase in demand; the company, which shipped 14,000 cars in 1909, shipped 585,000 cars in fiscal year 1915–16 (Appendix: table 2 col. i). Cost cutting through productive reorganisation was so successful that each car out of the factory still represented $100 profit for Ford, even in 1916 when a touring T sold at $360 (Appendix: table 5 col. iv). A constant profit on a falling price meant higher margins; return on sales increased from 21 to 31 per cent between 1910 and 1916 (Appendix: table 5 col. v). Seldom in the history of mass manufacture has any company ever had a stronger incentive to crank low cost output through its factories and, as we have seen, this was what Ford's engineers did. At the same time, sophisticated financial methods were used to generate extra cash flow and profit; Couzens, for example, operated a financial system under which the cars were built from materials bought on thirty days credit and always sold cash on delivery, so that the company often banked the receipts before suppliers were paid (Seltzer 1928:130). Nonetheless, between 1909 and 1916, (low cost) production was the one over-riding problem that had to be solved.

By the mid-1920's, the Ford company like others in the car business, faced a more complex hierarchy of productive, market and financial problems where the possible and necessary points of intervention were less clear cut. With some justice, observers of the late 1920s argued that the Ford company's continued productionism was an anachronism in this increasingly complex environment. As Seltzer (1928:121) wrote just after the introduction of the Model A,

> the enormous material and technical resources of the Ford Motor Company had, perhaps too long been directed at the single task of augmenting and perfecting its manufacturing organisation. Too little attention had been paid to the changing character of the automobile market in recent years.

The Ford company had always paid close attention to distribution, but, by the 1920s, General Motors was using marketing to adjust product characteristics to consumer demand: this kind of response was necessary and functional for enterprises which faced weaker and/or more complex demand patterns. The verdict of history confirms the intuitions of contemporaries about the limits of simple productionism; the lesson of the Model T, just like the VW Beetle, is that successful production of a people's car is only a passing phase in the development of a motorised society. As Kuhn (1986) argues, by the mid-1920s Ford's output was flat and his market share was being undermined by cheap second hands and the development of ever more sophisticated and powerful closed cars. Within ten years of its greatest achievements, the Ford company was no longer a shining example but a cautionary tale.

When this point has been made, it still does not explain why many of the production innovations of Highland Park should have been lost in the fifty years after 1920. In the late 1970s, when American engineers like Schonberger (1980) visited Japanese factories, they saw, for the first time, new Japanese manufacturing practices which were (at least partly) independent rediscoveries of Highland Park practice. The list of reinventions includes: cheap modification of general purpose equipment; machines close together and in order of use; pull through production; low stocks; and multi-tasked workers all operating in a Ford-like culture of *kaizen* through layout change and de-manning. A variety of external and internal factors can be invoked to explain America's loss of productive expertise. Externally, we would put considerable emphasis on institutional conditions and the pressure on public corporations to earn profit for shareholders; Ford uniquely emancipated his company from these pressures by buying out his shareholders and never borrowing from the banks, so that the family owned company was, for better or worse, free to pursue its own productionist priorities. Internally, we would argue that the transference of Highland Park manufacturing practice was never straightforward because the Ford factory's manufacturing task was artificially simplified, and because the Ford company never consolidated its achievement into a set of management techniques that could be adopted by suppliers and competitors.

Ford's manufacturing task was artificially simplified because, for nearly twenty years from 1908 to 1926, the company produced developed versions of the one power train and chassis. Quantitively, the philosophy of design stretch required many changes, possibly as many changes as if the company had produced a changing variety of non-T models. But the quality of the changes was different and distinctive as long as the company persevered with stretching the T. The necessary design changes were typically piecemeal and cumulative as old-specification T parts were replaced with new specification T parts. Of course, the company had to buy or make old-specification parts for after- market replacement sales. But, in practice, this was never a major problem because Ford's spares business was relatively modest; between 1910 and 1916, 91 per cent of the company's turnover came from selling new cars (Appendix: table 6 col. i). For nearly twenty years, Ford did not have to produce a changing family of engines and chassis with different dimensions and limited commonality; the company's engineers were able to work on the task of perfecting multi-process manufacture without regular changeover.

Cycle set up was an issue of considerable importance at Highland Park. The machining of engine and gearbox parts involved a multiplicity of sequential operations where one of the key limits on throughput efficiency was the amount of unproductive time which the company wasted on clamping the workpieces at each process stage. As Colvin explained in his 1913–15 account of machine shop practice, cycle set up time had been reduced in a variety of ways; we would add the point that most of these techniques have since been re-discovered in Japanese manufacturing. Ford used what the Japanese would now call 'one touch' quick acting clamps (*American Machinist* 1915:971) and generally favoured gravity location on steel tables (*American Machinist* 1915:1059); both cylinder head and block machining began with the drilling of bolt holes which provided points of location when the gravity tables were fitted with steel dowel pins (*American Machinist* 1913:841). Ford also developed 'multiple tooling' so that several cuts could be made at each clamping; in engine block production, the millers were ingeniously set up for 'double milling' of top and sides with the vertical cutters followed up by horizontal cutters (*American Machinist* 1913:843). The company also developed fixtures which allowed each cutting machine to finish many workpieces in a single pass; the millers and grinders skimmed 15–30 engine blocks at a single pass and, with small workpieces like the valve lifter, no less than 104 pieces were ground at each pass (*American Machinist* 1913:227).

At the same time changeover was never a major problem at Highland Park. The manufacturing task was such that the machine shop seldom lost time because the machine tools were being adjusted to process a workpiece of different type and dimensions. This kind of changeover was only necessary on a small number of machines like the five Bliss 900 ton presses which were worked in tandem; on this line, dies were regularly changed so that the presses could produce batches of different panels like crank cases or running boards (*Ford Times* June 1913). But, in the context of the Highland Park machine shop, these machines were very unusual because they were so fast acting; the heavy press line work rate of five strokes per minute (*American Machinist* 1914:49) was not much slower than the work rate of six to eight strokes per minute on comparable equipment in a modern car press shop (Williams *et al* 1991a). On the other hand, the machine shop was generally fitted out with belt driven 'single purpose' cutting machines whose cycle times were substantially longer than those of modern NC or CNC equipment; cycle times were further extended by Ford's general practice of running the machines slow so as to reduce the wear on cutters and drills. As Ford had an increasingly large volume throughput in the machine shop, the requirements of his manufacturing task and the characteristics of the available technology were together accommodated by doubling up identical machines which continuously processed one part.

It was (and is) possible to make two distinctive readings of Ford's machine shop practice. The imaginative reading would characterise it as an exemplary effort to reduce unproductive time through techniques of rapid set up which could be adapted elsewhere to reduce changeover time. The literal reading would emphasise that Ford's manufacturing task was unusual and his practice therefore contained few lessons for machine shops whose problem was changeover. This second literal reading appears to have triumphed in American manufacturing in the 1920s. In companies like GM which produced a changing family of models, high stocks were used to disguise unresolved problems about slow changeover; through the 1920s, General Motors ran with stocks equal to fifteen weeks sales cover whereas Ford in the early 1920s ran with stocks equal to seven weeks sales cover. This difference in performance is particularly interesting because companies like General Motors tried to buy in Ford's production expertise by recruiting senior Ford production men; in the 1920s, GM's expanding Chevrolet volume car division was headed by Knudsen who had supervised Ford's assembly branches before World War One. If energetic and competent executives like Knudsen were unable to reproduce the Highland Park achievements outside the company, the implication is that the application of Ford methods was difficult. This difficulty was hardly surprising when the discoveries were based on a break with existing management knowledges and were never consolidated into a new, transferable body of management techniques.

The break with the existing body of management knowledge was quite explicit because Henry Ford disliked and discouraged all fixed forms of corporate organisation and rejected all the approved forms of management calculation. Henry cultivated the persona of the 'Yankee mechanic' and employed hard-driving production engineers in a project-centred, flat and informal organisation. At Highland Park there was no organisation chart and few job titles, Ford did not share the modern American preoccupation with defining who is responsible for what and who reports to whom. Employees who had worked for the company for several years were often confused about the status and responsibility of senior managers. Thus a Ford tool designer struggled to define the roles of Martin and Sorensen who are labelled as 'factory superintendent' and 'assistant superintendent' in Ford's office photographs, 'I believe that Sorensen and Martin were considered on a par, I never could figure out exactly' (Pioch 1955). A Ford metallurgist, who joined the company in 1915, did figure out that Martin was, 'the man who was really in charge of manufacturing' but remained confused about the responsibilities of his two assistants, Sorensen and Avery, 'as far as I know there were no particular areas that each one was assigned to' (McCloud 1955:8).

Equally striking was Ford's rejection of all existing forms of management calculation, especially cost accounting. This again reflected Henry's personal view that, 'a lot of cost accounting people was unnecessary overhead' (Hutchins 1957:23). In 1919 the Chicago accounting firm of Thompson and Black recommended a larger accounting department and, shortly afterwards, work began on a new building to house the enlarged department. When Ford found out he personally ordered the contractor to fill in the ground work saying, 'we don't need any cost department' (Hutchins 1957:24). The company only acquired a cost centre system at the insistence of the American government in World War I when Ford became a defense contractor (Husen 1955:7). Before that, there was only a rudimentary product costing system which mainly inputted to financial reporting. In 1914, when the company had 13,000 employees, its cost department included just eight employees of whom three were stenographer operators (Husen 1955:8–9). The cost department could be so small because, just as in a modern Japanese company, Ford's production control was based on simple, direct physical measures. In effect, the factory was scheduled on the basis of a daily production stint; as Colvin observed, in the machine shop, 'every machine has an allotted daily output – and each foreman receives a daily schedule of work to be turned out by his department' (*American Machinist* 5 June 1913:761). And, as Husen recalled (1955:8–9), cost comparisons were never used as a basis for day by day production control, 'the foreman compared the actual production of each employee with the number of pieces established as a target'. The *kaizen* benefits of higher targets were measured very simply in physical and financial terms by calculating the savings in labour time and then, after applying the hourly rate, expressing the saving in terms of labour cost. In words which could be taken from our 1988 interviews with Toyota shop managers (Williams *et al* 1991a), Klann (1955:145) explained how these measures operated when he supervised motor assembly at Highland Park,

> we would go to work and mark the number of men we had in the shop. We would mark how many hours they worked. We divided the men by the number of motors we built, so many hours per motor. We watched minute cost.

Ford's informal organisation and direct forms of calculation were highly effective but they had their limits. If Ford engineers broke with existing management techniques, unlike a later generation of Japanese, they never institutionalised their discoveries into a set of techniques which would regulate Ford operations and could be applied elsewhere in the factories of suppliers and competitors. The failure to institutionalise is most obvious in the case of stock control where Ford never developed a regulatory system. Like everything else at Highland Park, de-stocking was an improvised response. Levels of factory work in progress were reduced by short travel layouts in a factory which was struggling to meet demand and to clear factory space for more machines. As Arnold and Faurote (1915:63) explain, the Highland Park factory was originally planned to run with twenty five days of stock cover, but by 1915 the company was actually running on three to five days stock. The company had learnt to live with permanent stock shortage by creating the role of 'stock chaser' who was responsible for getting part batch deliveries rushed forward to down stream processes which were running out of parts. This non-system worked to maintain production with low stocks as long as insatiable demand pulled through ever more output but it concealed a basic weakness. Ford had no regulatory techniques or system for enforcing low stocks in an enterprise which faced weaker demand; if the pressure of demand slackened, then stocks would rise to whatever level could be accommodated between processes and in off-line storage.

Ford's incentive to promote transference was reduced because, unlike modern Japanese mass manufacturers, the company was not interested in improving the productive competence of its suppliers. As we have argued Ford's policy on components was to reduce costs by cutting out inefficient suppliers and bringing the work in-house. If Ford found an efficient supplier then the company tried to internalise the benefits, as in the case of Keim Mills, a New Buffalo company which supplied Ford with steel pressings. In 1911 Ford purchased Keim Mills and shortly afterwards moved the press machines and key workers by rail to Highland Park where they became the nucleus of Ford's press department. After World War I, the policy of bringing work in-house was pressed harder with the construction of an all-new factory at Rouge which quickly supplanted Highland Park. As we will now argue, the development of Rouge sealed the fate of the precarious, unconsolidated experiment at Highland Park because Rouge represented a different principle of mass manufacture.

Rouge was the realisation of Ford's long standing policy of building more of the car in-house. After World War I, the 150 acre Rouge site was originally developed as a conversion plant which supplemented Highland Park manufacturing and branch assembly; Rouge turned iron ore, coal and lumber into castings and floor boards. The transfer of many Highland Park departments to Rouge in 1925 and the beginning of steel production in 1926 marked the point when Rouge became the world's first fully integrated car plant. Here Ford made everything from steel and glass to leatherette in a factory where raw materials were delivered to the dock and finished cars rolled out at the other end of the factory. Fairly obviously, this exhausted the possibility of further cost reduction through displacement of inefficient suppliers; it was no longer possible to cut the price of the car by doing more of the work in-house. Even materials cost was now directly controlled by Ford because the company's ships and railroads carried materials from Ford owned mines, factories and plantations to the docks and sidings of Rouge.

Ford could only continue along a trajectory of cost reduction, if the company refined and developed the cost-reducing techniques of mass manufacturing. At Rouge, production engineers rose to the challenge by constructing the world's first interconnected car factory; all work transfer problems were to be solved by using moving conveyors and every manufacturing operation (including steel and glass making) would be performed continuously on an interconnected set of conveyors. In terms of manufacturing technique, Rouge represented the triumph of the conveyor over all other forms of material handling; by the mid-1920s, there were no less than twenty seven miles of conveyor at Rouge (Nevins 1957). By way of contrast, Highland Park used a varied range of handling devices and at the same time tried to eliminate handling so that the total mileage of conveyor was very much smaller. In Highland Park's final stage of development after 1922, the longest conveyor system was the 'christmas tree' conveyor which ran for three and a half miles from the foundry through the machine shop to final assembly (Klann 1955:157–61).

It is wrong to suppose, as Hounshell (1984: chap. 7) does, that Ford's manufacturing system at Rouge had a limited capacity for product changeover. The six month halt in production in 1927 when the Rouge was changed over from the Model T to the Model A was caused more by the Ford organisation's increasingly arbitrary decision making than by the Ford factory's productive inflexibility. When the Model T was discontinued in May 1927, the company had still not ordered new body tooling, constructed running prototypes or even finished design work on the replacement. In these circumstances, the changeover from T to A was managed remarkably smoothly and quickly, partly because the re-usability of Ford's single purpose machine tools was once again triumphantly vindicated; no less than three-quarters of the machine tools used in T production were re-used in A production (Hounshell 1984:293). The real problem was that Rouge constrained process improvement. The system of interconnected conveyors was designed to deliver whole factory *kaizen* automatically whenever the belts were speeded up. But this gain was always more hypothetical than real because it depended on virtuoso production engineering to keep the whole system up and running and on the external condition of a market which would absorb increased output. If Ford could solve the internal problem, the company could not lift the external constraint which pressed as soon as Chevrolet became a major force in the cheap car market. Meanwhile, the Rouge system of interconnected manufacture made dialectical single process *kaizen* obsolete. The objective of single process improvement was lost as soon as all processes moved at one uniform pace, and the instrument of layout change was ruled out by a conveyor system where individual conveyors were all dedicated to the transfer of particular materials and components. In each case, the design of the belt and its fences presupposed a material or component with specific characteristics and dimensions. Paradoxically, the layout of Rouge was fixed by its endlessly moving lines.

Conveyorisation of everything undoubtedly generated substantial once and for all cost savings; it eliminated the labour expense of truckers at a very reasonable operating cost because the amount of power required to move the belts was modest. But the conveyorisation of everything closed off the old style of Highland Park continuous improvement and inaugurated the degeneration of Western mass manufacturing which continued as other car companies imitated the integrated form but not the interconnected substance of Rouge in factories like Volkswagen Wolfsburg, which can be plausibly represented as Rouge with buffers. Significantly, the major Japanese car manufacturers after World War II tried to realise the ideal of manufacturing flow in a different way through a system which was not vertically integrated.

Conclusion

The concepts of mass production and Fordism (like their opposites flexible specialisation and post-Fordism) were designed to meet a meta-theoretical imperative rather than an empirical need. In our view, they represent the post-Marxist continuation of a Marxisant tradition of interpreting the genesis and resolution of economic and political crisis in the advanced capitalist countries; these concepts allow a section of the intelligentsia to conserve the form of a Marxist discourse whose substance has become unacceptable. Nevertheless, the discrepancy between theory and evidence has become an increasing embarrassment to the intellectual protagonists of concepts like mass production. Recently, they have tried to rationalise the discrepancy by arguing that their organising concepts, 'are ideal typical models rather than empirical generalisations or descriptive hypotheses about individual firms, sectors or national economies'. Hirst and Zeitlin (1991:5) defend flexible specialisation, in these terms, while Teague (1990: 42) uses more or less exactly the same formulation in defence of regulation theory, whose, 'purpose is . . . to build ideal types or frameworks which can be used to assess or investigate economic development'. With the theory thus immunised against disproof, it is possible to make two comfortable assertions: first, it is asserted that concepts like mass production and Fordism provide a positive basis for research into manufacturing (Teague 1990:50); second, it is asserted that the range of empirical variation in case material represents a hybrid 'mix' of elements of mass production and its opposite (Hirst and Zeitlin 1991:5).

Our research on Ford raises questions about the ideal type alibi and destroys the comfortable assumption about the fruitfulness of research based on concepts like mass production and Fordism. The massive disjuncture between Ford's achievements and the concepts of mass production and Fordism is an obvious problem. After all, Ford and the T is the classic case of mass production and Ford's practice is generally supposed to represent the apotheosis of its identifying characteristics. We may recall an analogy from the experience of an earlier generation of social scientists. For non-Weberians, the discrepancies between the 'protestant ethic' and Benjamin Franklin's life did constitute evidence which damaged the ideal type construct. If the apotheosis is not so, and the classic case does not fit, those who have not invested their intellectual capital in the construct will quite reasonably ask what is the point of the construct?

At the same time it is hard to see how the concept of mass production can provide a fruitful basis for further research into the theory or history of manufacturing. In theoretical terms, this is because mass production distracts us with inessentials and irrelevancies and, at the same time, crucially fails to identify the springs of dynamic cost reduction in features like layout change and low stock production. Researchers who are pre-occupied with mass production and its hybrids will literally not know what to look for when they study firms and industries. In historical research, the concept of mass production is equally misleading because it promotes a bogus periodisation and suppresses important issues about continuity and discontinuity. Researchers who are pre-occupied with mass production will not ask the serious questions about the conditions under which diffusion of Ford's flow practice failed, or about how the Americans apparently lost the art of productive intervention between 1920 and 1950 just before it was rediscovered in Japan.

For all these reasons, mass production is an idea whose time has gone.

Our own recent work on Japan, as well as on Ford, demonstrates that a series of important problems, about the logic and development of manufacturing, are open to investigation; but not by those who cling to the simplicities of organising concepts like mass production.

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STATISTICAL APPENDIX ON THE FORD MOTOR COMPANY, 1909–19

Table 1 Ford Revenue, Costs and Value Added, 1909–19

	Model T output (i)	Material cost per T $ (ii)	Labour share of value added % (iii)	Purchases as % of gross output (iv)
1909	13,941	590	27.7	68.2
1910	20,738	544	32.7	62.2
1911	53,800	348	27.3	61.1
1912	82,500	407	29.1	61.1
1913	199,100	319	31.9	60.0
1914	249,700	371	30.3	58.0
1915	368,599	255	30.5	52.4
1916	585,400	262	39.1	55.5
1917			61.1	72.3
1918			89.1	76.6

Sources:

col. (i) Output of the model T is obtained from the company's shipping ledgers in Ford Archive: accession 463, box 1.

col. (ii) Material cost per T is calculated by dividing Model T output (Ford Archive: accession 463, box 1) into total material purchases (Ford Archive: accession 157).

col. (iii) Value added is calculated by subtracting purchases (Ford Archive: accession 157) from gross output (Ford Archive: accession 96, box 8 and 10). Total labour costs are given in Ford Archive: accession 843.

col. (iv) Material purchases are taken from Ford Archive: accession 157 and gross output from Ford Archive: accession 96, box 8 and 10.

Table 2 Ford Cars per Man and Labour Hours per Car, 1909–16

	Cars shipped (i)	Number of employees (ii)	Cars per man year (iii)	Labour hours per car (iv)
1909	13,941	1,655	8.4	357
1910	20,738	2,773	7.5	400
1911	53,800	3,976	13.5	222
1912	82,500	6,867	12.0	250
1913	199,100	14,366	13.9	216
1914	249,700	12,880	18.8	127
1915	368,599	18,892	19.5	123
1916	585,400	32,702	17.9	134

Sources:

col. (i) Numbers of cars shipped from Highland Park in built up or kit form for assembly in branches. The total number of cars shipped is taken from the company's shipping ledgers in Ford Archive: accession 463, box 1.

col. (ii) Number of employees at Highland Park and in American branch factories which assembled kits from Highland Park. The total number of American employees is taken from Nevins (1954:648).

col. (iii) Cars per man year is calculated by dividing total number of cars shipped by number of employees.

col. (iv) Labour hours per car are calculated on the assumption of 3,000 man hours up to and including 1913, when factory workers worked six ten-hour days in each of 50 weeks. From early 1914, after the introduction of the eight hour day, we assume 2400 hours when factory workers worked six eight-hour days for each of 50 weeks. This last assumption improves the 1914–16 performance slightly because branch assembly operations worked a nine hour day after 1914.

Table 3 Ford Cars per Man, Variant Series 1909–13

	Average number of employees (i)	Cars per man (ii)
1909	2,190	4.9
1910	3,672	5.8
1911	4,100	8.4
1912	7,042	10.8
1913	16,000	12.5

Note:
This table is based on the totals of 'average number of employees' given in the June 1913 issue of *Ford Times*; for the early years, the *Ford Times* totals are higher than those given in Nevins (1954) and used in table 2. Calculations based on the *Ford Times* employment series therefore show the company starting from a much lower level of physical productivity in 1909 and in 1910. This reinforces our argument that much of the gain in cars per man year came before 1913–14. It is also worth emphasising that the series does not show the stagnation of productivity in 1911–2 which Lewchuk (1987) emphasises.

Table 4 Ford Stock Turn, Fixed Capital and Payroll per Employee

	Stock turn in weeks (i)	Value of plant per employee $ (ii)	Depreciation as % of payroll (iii)	Payroll cost per car $ (iv)
1909	10.7	875	1.1	84
1910	9.4	1055	5.5	100
1911	8.8	999	6.3	55
1912	8.9	1140	5.9	65
1913	7.4	915	4.9	61
1914	6.5	1695	5.2	65
1915	7.9	1646	5.4	64
1916	8.7	1353	4.1	70
1917	9.3	1606	5.1	—
1918	8.1	2126	6.4	—

Sources:

col. (i) Stock turn expresses average value of stocks in terms of the number of weeks sales cover. Average stock figures are taken from Ford Archives: accession 96, box 8. Sales revenue is taken from Ford Archive: accession 96, box 10.

col. (ii) The value of plant per employee is calculated by dividing total value of plant (excluding buildings) in the Ford Motor Company by number of employees. The value of plant is taken from Ford Archive: accession 96, box 8. Employee figures are taken from Nevins (1954:648).

col. (iii) Depreciation figures are taken from the company accounts in Ford Archive: accession 96, box 8; and payroll from Ford Archive: accession 843.

col. (iv) Wage costs per car are calculated by dividing cars shipped into total payroll costs. Cars shipped are taken from Ford Archive: accession 463, box 1 and payroll from Ford Archive: accession 843.

Table 5 Ford Model T Profitability

	Profit 000's $ (i)	Cars shipped 000's (ii)	Profit per car $ (iii)	Price of Touring T $ (iv)	Profit as % of selling price (v)
1909	3062	14	218	850	26
1910	4163	21	198	950	21
1911	7339	54	136	780	17
1912	13543	83	163	690	24
1913	27089	199	136	600	23
1914	24698	188	131	550	24
1915	25532	247	103	440	23
1916	57157	506	113	360	31

Sources:

col. (i) Consolidated profit of the Ford Motor Company is taken from Ford's company accounts in various years. In the 1909–16 period this is effectively the profit on production and assembly for the American market. Only after 1920 do overseas activities become important.

col. (ii) The years used in calculating cars shipped and profit from 1909 to 1913 are calendar years. The company then changes its accounting period so that we calculate cars shipped and profit over nine months in 1914, 10 months in 1915 and finally for fiscal 1915/16 which ends on July 31. In each case the total number of cars shipped in the relevant accounting period has been abstracted from the company's Highland Park shipping ledgers in Ford Archive: accession 463, box 1.

col. (iii) Profit per car is calculated by dividing cars shipped from column (ii) into total profit from column (i).

col. (iv) Prices of the Touring T in dollars. This is the price of the Touring (soft top, four seat) Model T which was by far and away the most popular model variant in the early years. In most years there were autumn price cuts and we have taken the usually higher price which prevailed for most of the year. Car prices are taken from Ford Archive: accession 157.

col. (v) The margin on selling price is calculated very approximately by dividing column (iii) into column (iv).

Table 6 Ford Turnover by Activity, 1909–1919

	Car manufacture as % of sales (i)	Parts and repairs as % of sales (ii)	Sundries as % of sales (iii)
1909	85.5	9.0	6.4
1910	91.6	7.4	1.3
1911	91.4	6.5	1.9
1912	93.8	5.3	2.0
1913	92.9	5.4	1.8
1914	95.5	6.0	0.6
1915	91.0	8.1	0.9
1916	87.2	11.3	1.5
1917	87.4	12.6	—
1918	82.1	17.9	—
1919	76.8	23.2	—

Sources:
This breakdown of sales turnover by activity is taken from Ford Archive: accession 96, box 10. The percentages in the two main categories add up to 100 from 1909 to 1916 only with the inclusion of a 'sundries' balancing item. After 1916 'sundries' are presumably allocated to new car manufacture or parts.