MOTOR VEHICLE RECALLS: TRENDS, PATTERNS AND EMERGING ISSUES

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By

Hilary Bates
Warwick Business School,
University of Warwick,
Coventry, UK.
Hilary.Bates@wbs.ac.uk,

Nick Oliver*
Centre for Business Research and
Judge Institute of Management,
University of Cambridge,
Trumpington Street,
Cambridge CB2 1AG, UK
Tel: 01223 338179
Fax: 01223 339701
n.oliver@jims.cam.ac.uk
* to whom correspondence should be addressed

Matthias Holweg
Centre for Business Research and
Judge Institute of Management,
University of Cambridge,
Trumpington Street,
Cambridge CB2 1AG, UK
Tel: 01223 760583
Fax: 01223 339701
m.holweg@jims.cam.ac.uk

Michael Lewis
Operations and Supply Group
School of Management
University of Bath
Bath BA2 7AY, UK
m.a.lewis@bath.ac.uk

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Abstract
This paper examines patterns and trends in motor vehicle safety recalls using a dataset based on 23.1 million vehicles registered in the UK between 1992 and 2002. A safety recall occurs when vehicle manufacturers call vehicles that have been sold and are in use back to their dealerships for safety-related remedial work. Safety recalls can be costly for car makers, and potentially harmful to brand and image. The data show that the incidence of vehicle recalls has been increasing – between 1998 and 2002 there was an average of over 120 recall incidents per annum in the UK, compared to less than 50 per annum between 1992 and 1994. Total numbers of vehicles recalled show no trend over time, but absolute level of recalls year on year is very high: 10.8 million vehicles were recalled during 1992-2002, representing 47% of all vehicle registrations in the period. Moreover, there are substantial differences in recall rates between different car manufacturers, suggesting that recall rates may be a useful final indicator of process performance in the car design-and-production chain. European and American producers have recall rates that are nearly three times greater than their East Asian counterparts. This paper offers some suggestions for corporate differences in propensity to recall, and concludes with an agenda for further research.

Keywords: Automobile industry, reliability, manufacturing, management

JEL: L62, L6, M1

Motor Vehicle Safety Recalls: Trends, Patterns and Emerging Issues

The automotive industry faces many challenges. It suffers from long-term over capacity, with the inevitable depressing effect on profitability. A spate of mergers and acquisitions in the industry, amongst both vehicle manufacturers and component makers, is one consequence of this. Further rationalization amongst incumbents in the developed world seems inevitable, especially as new entrants in the developing world continue to create new capacity. In such an environment, anything that risks damage to brand value or drives up operating costs is obviously highly undesirable.

One such phenomenon is safety recalls. If car manufacturers identify post-production safety concerns with their vehicles they may undertake a vehicle safety recall whereby they try to locate every affected vehicle in order to have faults rectified, at no cost to the owners, at franchised garages. Vehicle safety recalls are, by definition, significant events: they are carried out in the name of protecting drivers, passengers and the general public but for vehicle manufacturers (and component suppliers) they can be expensive and adversely impact carefully cultivated brand value. In November 2003 for instance, a UK tabloid newspaper reported a recall by French car maker Peugeot-Citroen with the headline “Brake Scare on 270,000 Motors” and opened the article with the words “FRENCH car giant Peugeot is recalling 270,000 models because the brake pedals could FALL OFF” (*The Sun*, 21 November 2003).

Some of the most dramatic examples of the dynamics and consequences of vehicle recalls to date are found in the US. For example, during the 1980s, it was alleged that the Audi 5000 model (sold as the Audi 100/200 series in Europe) was prone to “sudden acceleration” at low speed. The company denied that there was a problem, but the effect on sales was dramatic. With nearly 1,800 claims of unintended acceleration incidents in the 1980s, Audi became synonymous with the term "sudden acceleration." According to the Centre for Auto Safety, despite several deaths, dozens of injuries, five related recalls and a Swedish Defence Agency study showing that cruise control malfunctions could cause sudden acceleration, Audi claimed that "pedal misapplication" caused the incidents but lost 80% of its US market share in the US as a consequence of the episode [1]. One of the most significant cases of recent years was an alleged problem with tyres on the Ford Explorer, in which it was claimed that Explorers were prone to roll following a tyre blow out. Firestone recalled 14 million tyres in 2000 and analysts estimate that this particular recall cost about $750 million - not counting any liability associated with any lawsuits. This incident led to a dispute between Ford and Firestone, the manufacturer of the tyres. The opening

lines of an article about the Ford/Firestone incident in the *Washington Post* indicate the often emotive nature of reports concerning vehicle safety issues:

> "From the beginning of the Firestone tire recall, Ford Motor Co. officials have insisted that *the accidents that killed 101 Americans, most of them in Ford Explorers*, are a Firestone tire problem" (*Washington Post*, 9 October 2000). [Our emphasis].

This paper therefore examines the prevalence of vehicle recalls, differences between car makers in propensity to recall, and sets out a future research agenda on the problem of recalls.

Previous Studies

Given the high profile of vehicle recalls, what research into recalls has already been conducted? Interestingly, virtually all existing studies, all US-based, have focused on the influence and nature of regulation [2], [3], [4] and the external and indirect costs associated with consumer, capital market and media reactions to vehicle recalls [4], [5].

The largest category of literature on recalls considers market share and share price as dependent variables, although the results of these studies are contradictory. Early studies of market reaction to recalls [6], [7] found all but the most severe recalls had limited influence on customer demand for new vehicles [8]. However, some work on the impact of recalls on used car values found that recalls had a substantial negative impact on the residual values of recall-prone models [9].

Work on the relationship between recalls and stock (share) price indicates that the damage to stock prices caused by recalls were actually greater than the direct costs of recalls [10]. However, this conclusion has been criticized [11] and challenged [3] on the argument that on an event-by-event basis 40% of reactions to recalls were positive. Others have re-asserted the predominance of the indirect costs of recalls, especially for certain types of recall [12]. Recalls affecting components such as airbags, for example, produce a more negative effect than those that affect other parts of the car, such as the heating system [13].

Given that recalls are public events, the influence of media reporting has also been investigated. For instance, *Wall Street Journal* coverage of recalls (a

widely used proxy measure) has been shown to have negative impact on sales of affected models [14]. Of course, media coverage of recalls tends to be driven by the size, severity and total costs (including punitive legal awards) of the recall [15], [16], so it may be these factors, rather than coverage per se, driving any effect on sales. Interestingly, many of the factors associated with 'successful' recalls, such as high response and repair rates, are also those associated with strongly negative consumer reaction to the recall (such as the recency with which the affected models have been launched, and the severity - and hence newsworthiness - of the hazards posed by the fault [4], [17].

The literature on recalls thus largely addresses 'economic' effects of recalls; not underlying causes, although Krueger and Mas' analysis of the previously mentioned Ford Explorer/Firestone tyre recall is an exception to this [18]. There is a limited literature that explores quasi-operational issues such as recall costs and processes but, again, many findings are confusing. For example, Dardis and Zent found Ford's infamous strategy for dealing with the 1978 Pinto problem, in which Ford concluded that the costs of the design change were likely to be greater than the costs of law suits against the firm, and therefore eschewed any design modifications, was ultimately cost-ineffective [19]. It has also been noted that production of defective vehicles is not necessarily unprofitable [3]. The review also reveals that vehicle recalls have received scant attention in Operations Management (OM) research. This is particularly surprising when noting the strong resonance between recall issues and what have historically been core OM concerns, such as how different firms and production development and manufacturing systems perform with respect to product quality. For example, there is evidence that Japanese manufacturers have fewer recalls than their US counterparts [12], a picture consistent with comparative studies of manufacturing productivity and quality [20], [21].

This paper therefore sets out to address three main questions.

1. Given the often high-profile nature of vehicle recalls, how prevalent are recalls, particularly when normalized for levels of vehicle registrations?
2. Is there any trend over time in numbers of vehicle recalls? If so, what might be the explanations behind any such trend?
3. Are there significant differences in recall rates between different manufacturers, and if so how might these be explained?

After presenting the results and discussing the strengths and limitations of the data, the paper maps out a future research agenda for this area.

Research Methods

The data presented in this paper comprise two main elements – data on vehicle recalls and data on vehicle registrations. The data on recalls were extracted from a publicly accessible database in the UK provided by the Vehicle and Operator Services Agency (VOSA). In the UK, car recalls are operated under a code of practice[1] agreed between VOSA and the car makers. VOSA operates a website (http://www.vosa.gov.uk/vosa/) which contains detailed information on vehicle recalls in the UK. This covers manufacturers, models, dates of production, details of the faults, and sometimes the Vehicle Identification Numbers (VINs) of the vehicles that are affected. The dataset covers vehicle recalls by over 40 vehicle manufacturers between 1992 and 2002. The data on vehicle registrations were obtained from *Just-Auto*, a commercial automotive intelligence company. The registration data are presented on a model-by-model for each year. In combination these two sources of data reveal that 23,099,246 new vehicles were registered in the UK between 1992 and 2002. The registrations data cover 507 models sold in the UK during this period. Note that the figure of 23 million vehicles represents the number of units registered between 1992 and 2002 – it is not a measure of the size of the vehicle parc.

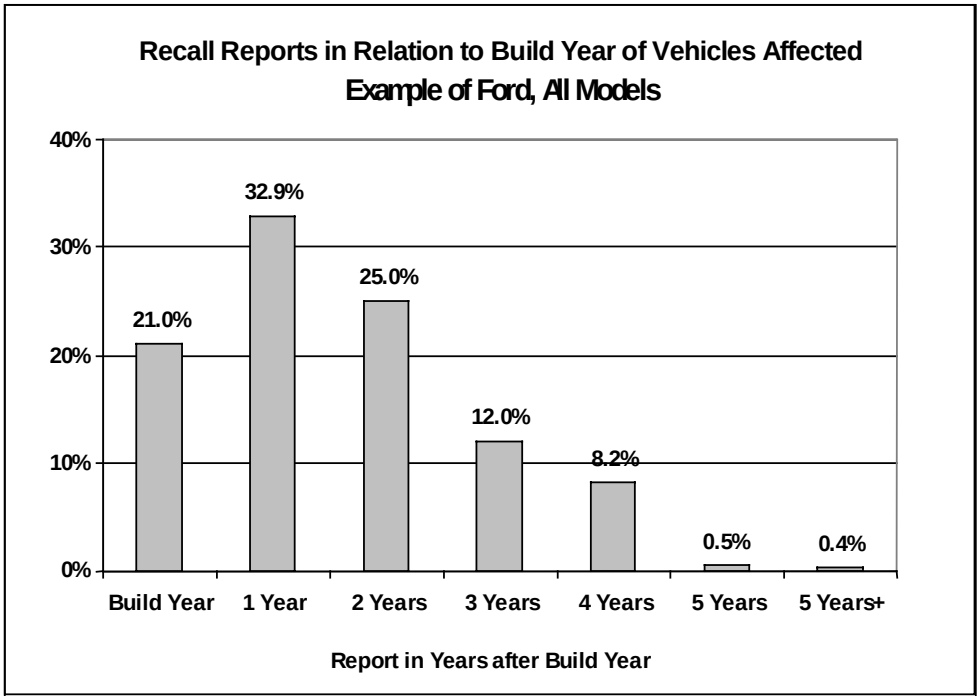
The recall analysis covers 40 vehicle manufacturers, and a total of 493 different models, which account for 99.7% of the UK market in 1992-2002. Several small-scale vehicle manufacturers were excluded from the analysis due to inconsistencies in the data for these firms. These exclusions included TVR, Rolls-Royce, Caterham, Westfield, and Morgan. These account for the discrepancy between the number of models in the two datasets.

There are a number of methodological issues in aligning the recall and registration data, coming as they do from two different datasets. Vehicles recalled may be spread over build periods that stretch over several years. The recalls database does not indicate which vehicles were built on which dates and therefore it is necessary to make a proportional split of vehicles over the build period in order to link it back to the registration data, which are provided on the basis of calendar years. In some cases, build dates are not provided at all, and in others several models from the same manufacturers are recalled under the same notice, making it difficult to ascribe a precise number of recalled units to each model covered by that recall.

To complicate matters further, there is a considerable time lag in the recall incidents. Once a safety-relevant issue is discovered, the car manufacturer issues a recall. Recalls may occur in the build year of the vehicle, or some years after the vehicle has been registered. Figure 1 shows the delay in recall reports

in relation to the vehicle build date, in other words how many years after the vehicle had been produced the fault was reported.

Figure 1: Delay of Recall Reports in Relation to Vehicle Build Date



As can be seen, approximately 50% of safety recalls are initiated a year or more after the vehicle has been built, though 80% occur within three years of the build date. For the underlying analysis in this paper recall incidents were recorded in the year the recall notification was issued through VOSA. Recall volumes, however, are attributed to the calendar year in which a vehicle is built. Thus, a certain yet unavoidable distortion is introduced into the dataset, given that the entire vehicle production of one calendar year is not sold in the same period. Sales registrations in January, for example, will contain a certain amount of vehicles produced in the final months of the previous year.

The longer the period covered, the less likely it is for lag to be a problem, partly because most recalls occur in the early years of production of a new model, partly because long data periods may include the complete life of a model and

therefore all registrations and all recalls attributable to that model. This error term is negligible when several years of data are considered, especially given an average product life cycle of 5-7 years in Europe [21]. However, the problem of lag means that annual figures for recall rates need to be treated with some caution.

Research Findings

Five main variables were constructed from the dataset. These are:

1. *Total volume of vehicle recalls per manufacturer per annum***.** The total number of vehicle recalls in a given year. This refers to the cumulative total for all vehicles for that manufacturer for each calendar year. If the same vehicle is recalled multiple times during the year, then volume counts each of these as separate recalls. 'Vehicle recalls' are not therefore synonymous with 'number of vehicles recalled'.
2. *Total volume of vehicle recalls per manufacturer per annum per 100,000 registrations*. This normalizes the measure described in (1) for numbers of registrations.
3. *Total numbers of recall incidents per manufacturer per annum*. This refers to the number of separate recall incidents per year, independent of how many vehicles or models are affected by each incident. Thus a single recall stemming from a common problem that affects three different models would count as one recall incident. Thus 'number of recall incidents' effectively equates to 'number of recall announcements'.
4. *Number of recall incidents per annum per 100,000 vehicles registered.* This takes the measure described in (3) and controls for the number of vehicles registered in a given year. This is important in order to distinguish between any increase in recalls attributable to a general increase in numbers of vehicles sold, and real increases in the frequency of recalls.
5. *Number of models offered by each manufacturer***.** This refers to the total number of models offered over the 12 year period. This is useful as a diagnostic measure and is used to explore the relationship between product variety and propensity to recall.
6. The results are presented in three parts. First, we examine trends in recalls over time. Secondly, we examine absolute levels of recalls and differences in recall rates by different manufacturers. Thirdly, we explore how the complexity of product ranges (manifested by numbers of different models offered to the market by each manufacturer) is related to propensity to recall.

Absolute Levels of Recalls and Trends over Time

Between 1992 and 2002 there were 838 separate vehicle safety recall incidents in the UK representing a cumulative total of 10,752,093 vehicle-recalls, an average of 977,463 per year. The volume of vehicle recalls represents 47% of all vehicles registered during that period. One might conclude from this therefore that the average probability of a specific vehicle being subject to a recall is nearly 50%. However, this is not entirely accurate. A significant proportion of vehicles are recalled more than once, so the probability of an individual vehicle being subject to a safety recall is accordingly lower.

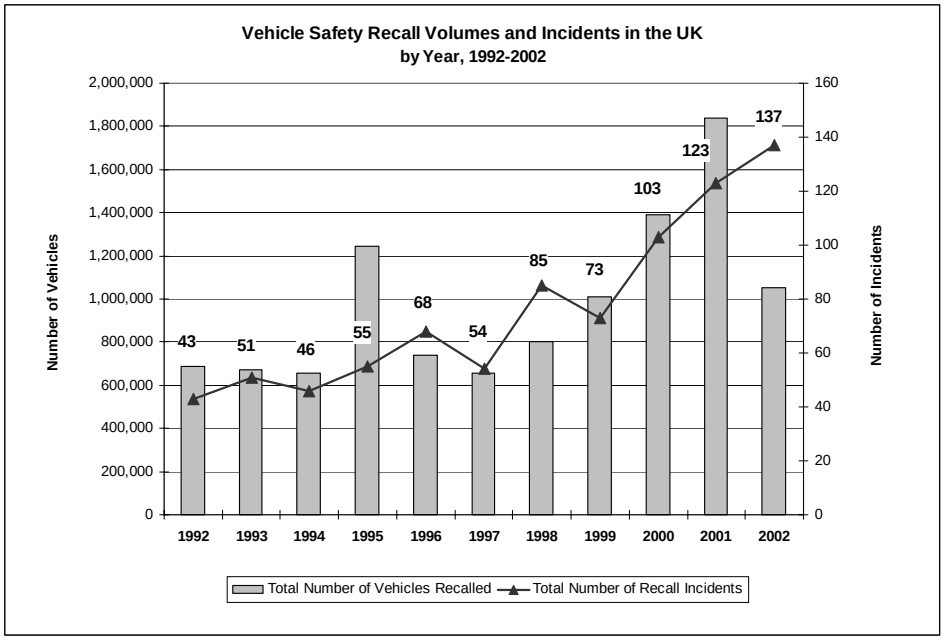
It is not possible to derive the exact figure for this from the VOSA database as the VIN numbers of the vehicles affected by the respective recalls are not always recorded. Nevertheless, it is possible to estimate the interval of the probability that a particular vehicle registered in the period between 1992 and 2002 will be subject to at least one (or more) safety recalls during this period. The upper bound of this interval assumes that all recalls recorded. We therefore define V_{ij} as the recall volume of a given recall incident i for vehicle manufacturer j, and the overall registrations for the period for a manufacturer i as $R_{i.}$ The upper bound of this interval assumes that all recall incidents affect different vehicles, i.e. not a single vehicle is recalled more than once. However, as vehicles can be recalled more than once, as since one recall incident can affect more than one model of the manufacturer in question, the lower bound of the interval assumes a maximum overlap of the recall incidents. This assumes that all recall incidents at a given manufacturer are subsets of the single largest recall incident that occurred during that period. As shown in the equation, these assumptions allow for the quantification of the likelihood that a vehicle registered in the period between 1992-2002 in the UK will be recalled with a probability of at least 12%, with the maximum possible recall volume being equal to 47% of all vehicles registered.

$$P_{upper} = \frac{\sum_{i=1}^{n}\sum_{j=1}^{m} V_{ij}}{\sum_{i=1}^{n} R_i} = 0.469 \qquad P_{lower} = \frac{\sum_{i=1}^{n} \operatorname{Max}_{j=1}^{m}(V_{ij})}{\sum_{i=1}^{n} R_i} = 0.119$$

The VOSA database unfortunately does not permit further refinement of the interval, but the authors conducted interviews with vehicle manufacturers to obtain estimates of the probability of single vehicle being recalled. The interviewees confirmed the overall high levels of recall incidents and volumes, and estimated the probability of a specific vehicle being subject to one or more recalls at around 25% - close to the centre of the theoretical range of 12-47%.

Figure 2 shows the number of recall incidents per annum between 1992 and 2002, and the total number of vehicle recalls for the same period. There appears to be an upward trend in the absolute volume of vehicle recalls per annum between 1992 and 2001, but this falls back to close to the long run average in 2002. However, when vehicle recall volumes are normalised for levels of registrations, there is no evidence of any trend, upwards or downwards, over time.

Figure 2: UK Recall Incidents and Number of Vehicle Recalls 1992-2002

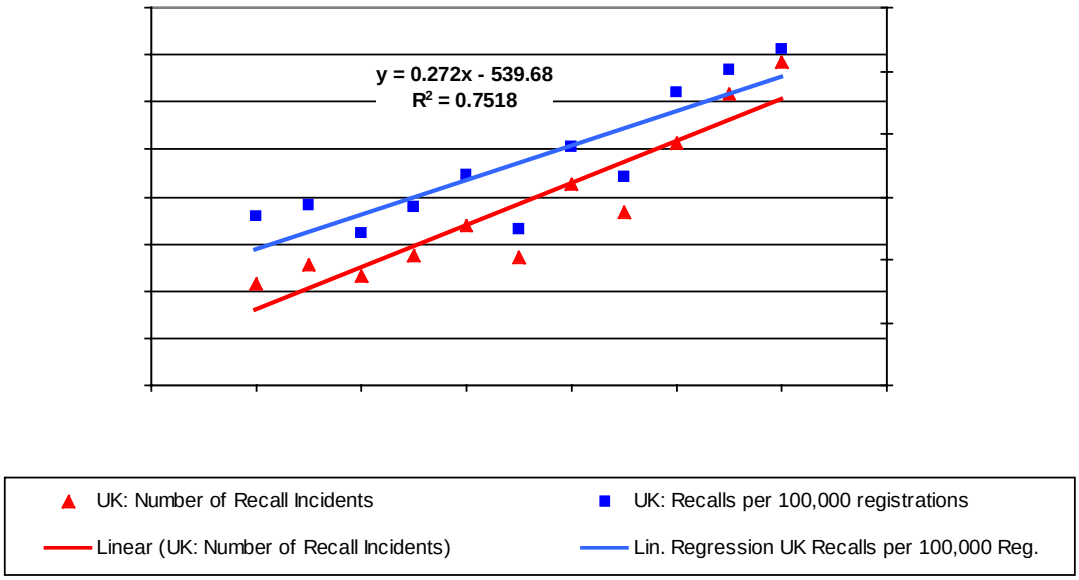


Considerable variation in the number of vehicle recalls from year to year is also apparent, typically due to a small number of incidents that affected very large numbers of vehicles. This is apparent, for example, in 2000 and 2001, in which the large peaks were driven by just three separate recall incidents affecting several models in the GM-Vauxhall range.

However, although there is no trend in recall *volumes* over time, the number of recall *incidents* shows a fairly consistent rise over the last twelve years, showing a two to threefold increase between the period 1992-4 and the period 2001-2. Of course, one possible explanation for this is that the UK car market was growing during this period, and that these figures simply reflect an underlying rise in vehicle registrations.

To test this, the number of recall incidents per annum were normalised by creating an index of "recall incidents per 100,000 new vehicle registrations", thus controlling for any increase in vehicle registrations. The results of this are shown in Figure 3.

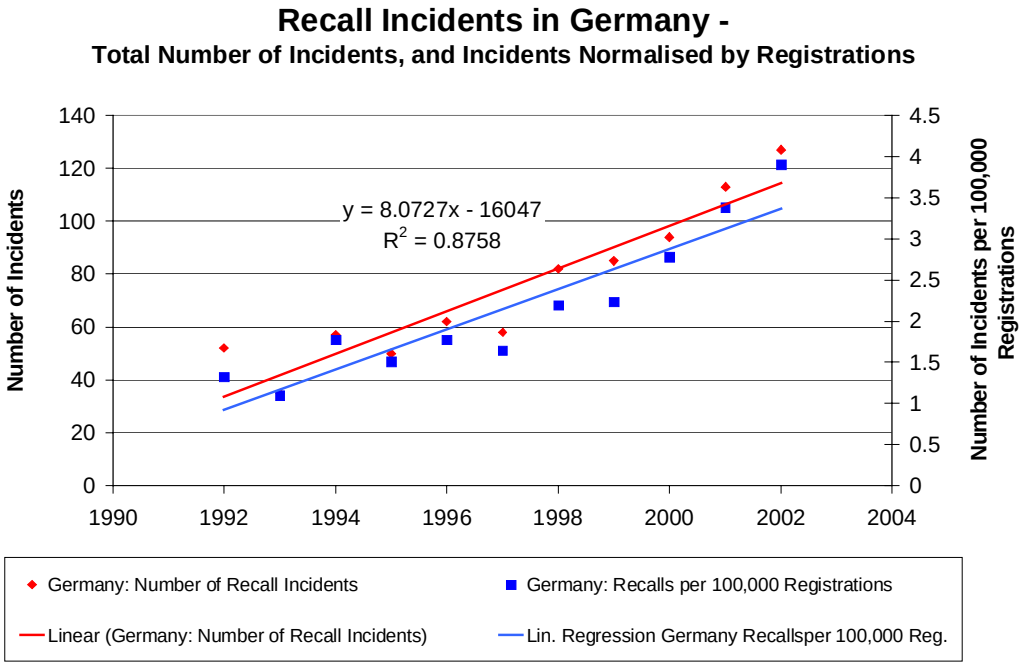
Figure 3: Upward Trend on Recall Incidents (UK)



Even when normalized for numbers of annual registrations, recall incidents show the same pattern of increasing over time, from two to three incidents per 100,000 registrations in 1992-1995 to around five in 2001-2002. Regression analysis shows a positive, linear annual increase of recall incidents in the order of 26%, with a regression coefficient of R^2=78%, demonstrating a clear trend of increasing vehicle recalls.

Similar trends are apparent in other markets too. In Germany for example, the KBA agency recorded a constant increase in vehicle safety recalls from 52 incidents in 1995, to 144 in 2003, affecting 939,884 vehicles in 2003 (KBA 2003)[2], as shown in Figure 4 [22].

Figure 4: Upward Trend on Recall Incidents (Germany)



Recalls Rates of Different Vehicle Manufacturers

Vehicle manufacturers vary enormously in terms of both the volumes of vehicles that they produce and also the variety of models that they produce. For example, the average number of registrations per annum over the 11-year period vary from 125 vehicles for Maserati to 393,538 vehicles for Ford, with an average of 52,346 registrations per annum across all manufacturers. As is to be expected, high volume manufacturers, with high levels of registrations tend to show high volumes of recalls, but there are exceptions to this.

Table 1 ranks vehicle manufacturers according to "recall volumes as percentage of registrations", which shows recall rates controlling for sales volume.

Table 1: Ranking of Manufacturers: UK Recall Volumes as Percentage of Registrations (1992-2002)

Ranking	Manufacturer	Recall Volumes as % of Total Registrations
1	FERRARI	150%
2	BMW-Mini	110%
3	LAND ROVER	103%
4	JEEP	95%
5	ASTON MARTIN	90%
6	VAUXHALL	79%
7	LOTUS	78%
8	CHRYSLER	74%
9	VOLKSWAGEN	69%
10	LANCIA	66%
11	MASERATI	63%
12	VOLVO	53%
13	MITSUBISHI	52%
14	FORD	51%
15	FIAT	51%
16	SAAB	50%
17	CITROEN	49%
18	BENTLEY	39%
19	DAIHATSU	39%
20	AUDI	35%

Ranking	Manufacturer	Recall Volumes as % of Total Registrations
21	PORSCHE	34%
22	SEAT	33%
23	MAZDA	32%
24	PEUGEOT	28%
25	SKODA	28%
26	MERCEDES	25%
27	MG-ROVER	25%
28	NISSAN	24%
29	RENAULT	23%
30	HYUNDAI	23%
31	TOYOTA	21%
32	ALFA ROMEO	21%
33	DAEWOO	20%
34	HONDA	20%
35	JAGUAR	19%
36	SUZUKI	12%
37	PROTON	10%
38	KIA	5%
39	ISUZU	0%
40	SUBARU	0%
Average		**47%**

There are several points to note from this. First, the range of recall rates over the 11-year period is very large – two manufacturers (Isuzu and Subaru) had no recalls at all, but several (Ferrari, BMW-Mini, Land Rover and Jeep) had recall rates close to, or even above, 100%. This raises interesting questions about the drivers of corporate propensity to recall.

Second, there is no obvious pattern to the ranking, in terms of what types of manufacturers are prone to recalls. The companies with the very highest recall rates– Ferrari, LandRover, BMW-Mini - tend not to be high volume producers, which implies a link between craft, non-standard production and propensity to recall. However some very high volume producers such as Vauxhall (GM) and Volkswagen also appear in the top 10 companies in terms of recall rates. A link between recall rates and product development process, in particular shortness of product development lead times is possible, but is beyond the bounds of this paper to explore in detail.

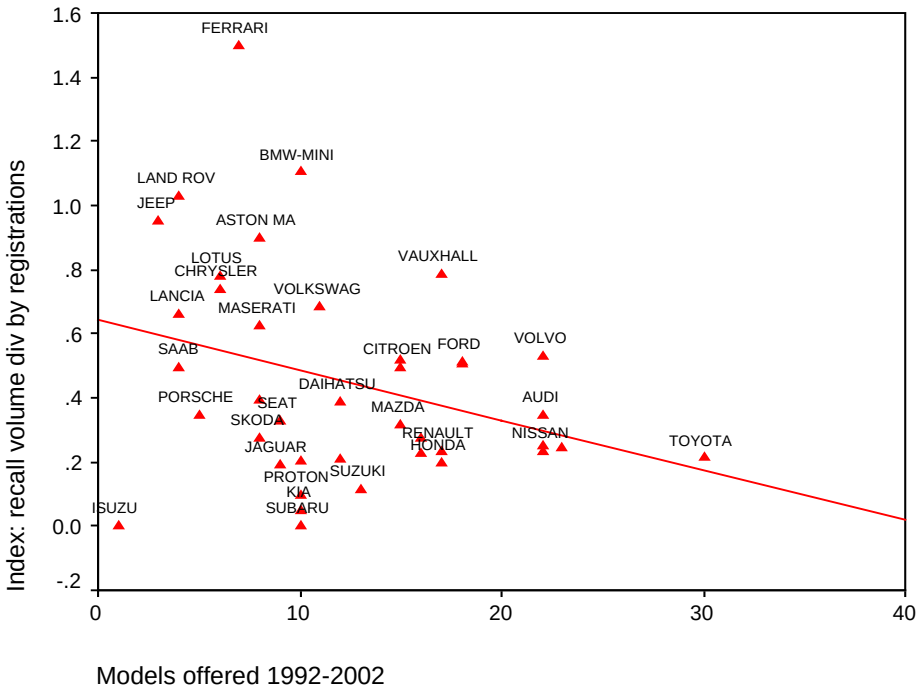
Third, it is striking that eight of the 10 companies with the lowest recall rates have East Asian connections, either in terms of ownership, or manufacturing location, or both. Five of these eight are Japanese-owned. If one regards recall rate as another indicator of product quality (in the sense that the problems that recalls are supposed to solve represent errors of commission or omission in design, manufacturing, or component supply), then these findings are consistent with others that have demonstrated performance superiority on the part of Japanese vehicle producers with respect to product quality [20].

The registration data show that the number of models offered by each manufacturer over the period of 1992-2002 varies considerably across manufacturers, from 30 models (Toyota) to one model (Isuzu), with an average of 12.3 models per manufacturer. On the grounds that product variety drives product and process complexity, which in turn increases the risk of errors and hence recalls, it seemed possible that higher variety would be associated with higher recall rates.

One might expect product variety, as measured by the numbers of different models produced by a manufacturer to be linked to propensity to recall, and this seems to be the case, with the number of recall incidents per manufacturer showing a positive relationship (adjusted $R^2 = .198$, with a significant t-value of 3.26) with number of models. Thus, at first sight there is a statistical relationship between product variety and propensity to recall, but a weak one. More models mean greater design, manufacturing and supply chain complexity, which in turn are likely to mean more errors.

Give this link between volume and recalls, we also examined the relationship between 'recall volumes as a percentage of registrations' and number of models offered. This is shown in the scatter plot in Figure 5.

Figure 5: Recall Volumes per Registration by Number of Models Offered



Adjusted r^2 = .073, with t-value of 2.02

The companies below the line show fewer recalls relative to the number of models offered (the proxy for product variety) than those above the line. The further to the right in terms of its position on the scatter plot, the more product variety a company has to handle. Toyota, for example, has the highest product variety of all but is near the bottom of the field (31 out of 40) in terms of volume of recalled vehicles as a percentage of registrations. This suggests an ability on Toyota's part to simultaneously offer relatively high variety whilst retaining tight control of product development and manufacturing processes. At the opposite extreme are Ferrari, Landrover and Jeep who despite having low model variety still suffer from very high numbers of recalls.

Discussion and Conclusions

Recalling a vehicle can be a costly business for car makers, suppliers and dealers, both financially and in terms of reputational damage. More than one million vehicles have been recalled each year of the past five years in the UK, and it is estimated that over 30 million vehicles have been recalled in the UK since 1979. Consequently it is surprising that so little attention has been devoted to the underlying causes of vehicle recalls. Some research has been reported into the impact of recalls on share prices and demand, but little is know about the factors that drive levels of recalls. Overall, we estimate that one in four vehicles in the UK suffers at least one recall during its life, and some will be recalled a number of times. Moreover, an upward trend in safety-relevant recall incidents is apparent in the UK, a pattern mirrored in data from Germany. The volume of vehicles affected as a percentage of registrations is, on average, fairly stable.

A detailed analysis of the reasons behind these patterns is beyond the purposes of this paper. We therefore propose the following research agenda for this area.

1. *Why are recall incidents increasing over time?* There are number of possible explanations of this, but these fall into essentially two categories – those that relate to the vehicles themselves (ie an increase in safety-related problems) and those that relate to the environment (e.g. changes in the threshold for reporting such problems). For example, it may be that manufacturers are more fearful of litigation than they used to be, and that this has increased their propensity to recall, even though there are no more faults with their vehicles now than was the case 12 years ago. On the other hand, it is well documented that product development lead times in the automotive industry have been falling, and are set to fall further [23], [24]. Is one of the side effects of faster times-to-market that the vehicles have more faults when they get to market?

2. *What are the reasons behind the substantial differences in recall rates between manufacturers*? As Table 1 demonstrates, there are enormous differences between car makers in their propensity to recall, and there appears to be a geographical effect. East Asian producers comprise one third of the dataset, but represent eight out of the 10 companies with the lowest recall rates. Why is this?

3. *How do recall rates relate to product development processes and lead times*? The importance of this question is implied by (1) and (2) above. Do companies that have short product development lead times show higher recall rates? Is a high recall rate a consequence of curtailed problem-solving during the development cycle? How is that some manufacturers, such as Toyota, appear to

be able to simultaneously enjoy low recall rates, high product variety and short product development lead times, whereas others cannot?

4. How do recall rates relate to other developments in the automotive industry? In efforts to drive down costs, most automotive manufacturers are attempting to squeeze more use out of a reduced number of platforms [25]. This increases the complexity of coordination across teams working on different models, and also means that a given platform has to bear an increased number of model configurations. Could increased recalls be a consequence of this? Similarly, more and more development (and manufacturing) is moving out to systems suppliers, who themselves are having to develop new skills as systems integrators. Are increased recalls a consequence of this trend?

5. *How do recall rates relate to other measures of product quality*? This paper has assumed that recall rate does represent a meaningful measure of corporate performance, that in turn can be understood by examination of environmental conditions and organizational and product factors. How do recall rates relate to other measures of quality and efficiency, such as development and manufacturing efficiency and other measures of quality and customer satisfaction?

We argue that further research is needed into product recalls. A continuing growth of recall incidents also implies risk to the public in terms of vehicle safety. Here, the differences between the manufacturers and need to be further investigated, taking into account the differences in model range, production volumes, and their manufacturing and design practices in order to establish the root causes for this concerning trend.

Notes

[1] Although an informal agreement, a manufacturer notifying VOSA of a safety defect is allowed limited access to normally confidential national registration records to enable them to contact the owners about the problem. VOSA estimate that approximately 85% of vehicle recalls are voluntary actions on the part of the car makers, 15% are initiated by VOSA due to issues identified by dealers, vehicle owners, the Trading Standards Authority, or other bodies, such as consumer groups.

[2] In Germany, all recalls must be registered with the federal KBA agency. The KBA agency makes much less detailed information on recall incidents available than is the case with VOSA– hence the use of this data as a simple ‘triangulation’ device.

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