

Inventory management in truck manufacturing : a case study

Citation for published version (APA):

Tilanus, C. B. (1984). *Inventory management in truck manufacturing : a case study*. (TH Eindhoven. THE/BDK/ORS, Vakgroep ORS : rapporten; Vol. 8405). Technische Hogeschool Eindhoven.

Document status and date:

Published: 01/01/1984

Document Version:

Publisher's PDF, also known as Version of Record (includes final page, issue and volume numbers)

Please check the document version of this publication:

- A submitted manuscript is the version of the article upon submission and before peer-review. There can be important differences between the submitted version and the official published version of record. People interested in the research are advised to contact the author for the final version of the publication, or visit the DOI to the publisher's website.
- The final author version and the galley proof are versions of the publication after peer review.
- The final published version features the final layout of the paper including the volume, issue and page numbers.

[Link to publication](#)

General rights

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal.

If the publication is distributed under the terms of Article 25fa of the Dutch Copyright Act, indicated by the "Taverne" license above, please follow below link for the End User Agreement:

www.tue.nl/taverne

Take down policy

If you believe that this document breaches copyright please contact us at:

openaccess@tue.nl

providing details and we will investigate your claim.

BIBL. TECHNISCHE
UNIVERSITEIT



9612422

EINDHOVEN

INVENTORY MANAGEMENT IN
TRUCK MANUFACTURING -
A CASE STUDY

by C.B. Tilanus

Report ARW 03 THE BDK/ORS/84/05

Preliminary and confidential
Eindhoven University of Technology
Dept of Industrial Engineering and
Management Science

Eindhoven, Netherlands

April 1984

Revised October 1984

INVENTORY MANAGEMENT IN TRUCK MANUFACTURING - A CASE STUDY

by C.B. Tilanus

Eindhoven University of Technology, Eindhoven, Netherlands

Abstract

In a case study of inventory management at a truck manufacturing company, it is shown that automation sets the pace for improvements in material requirements planning, that many stochastic elements remain in MRP and that management problems often outlive solutions offered by efficiency studies.

<u>Contents</u>	<u>Page</u>
1. Introduction	2
2. Miraculous multiplication of problems	5
2.1. Counting differences	6
2.2. Unplanned leakages	7
2.3. Planning	7
2.4. Forecasting	10
2.5. Delivery times	10
2.6. Buffer policy	13
3. Follow-up	15
3.1. One year later	15
3.2. Four years later	15
4. Conclusions	17
Acknowledgement	17
References	18

1. INTRODUCTION

The Netherlands boast of one automobile factory, Van Doorne's Automobiël-Fabrieken (DAF), started in 1928 by two brothers Van Doorne. The passenger car division was taken over by Volvo in 1976 but DAF Trucks Manufacturing Company stayed independent. The development of DAF Trucks output from its beginning in 1950 is shown in Figure 1. The introduction of a computerized material requirements planning system (MRPS) in 1978 was a Pyrrhic victory that entailed an actual output set-back [1].

DAF Trucks (1984) has about 8700 personnel, Dfl. 1700 million sales and a normal output capacity of 15000 trucks per annum. With 200 main types of truck, each of which has about 40 options, DAF trucks are strongly customized and the average run length is less than two trucks. A truck consists of about 4000 parts (monoparts in the firm's jargon). In total, there are 12000 code numbers of monoparts, of which about half are made by DAF's own factories and half are bought from all over the world. The complex assembly process, together with the individual trucks made to customer's order, make material requirements planning the heart of information processing at DAF Trucks.

The replenishing department is responsible for making available the purchased parts at the right time in the right quantities. It depends on sales forecasts from the commercial department, production plans from the production planning department and actual purchases by the purchasing department.

A moving plan is made every period of four weeks, one year ahead. The first three periods of the moving plan are fixed, i.e., the production plan to sales orders is definite. The later ten periods are variable, i.e., based on sales forecasts. As time moves on, a variable production figure four periods ahead becomes a fixed production figure three periods ahead. It was felt that at the transition from "variable" to "fixed", inadmissible jumps in the output figures occurred. Hence a Master's thesis project was initiated "to help improve the forecasts".

A Master's thesis project of the Department of Industrial Engineering and Management Science of Eindhoven University of Technology is

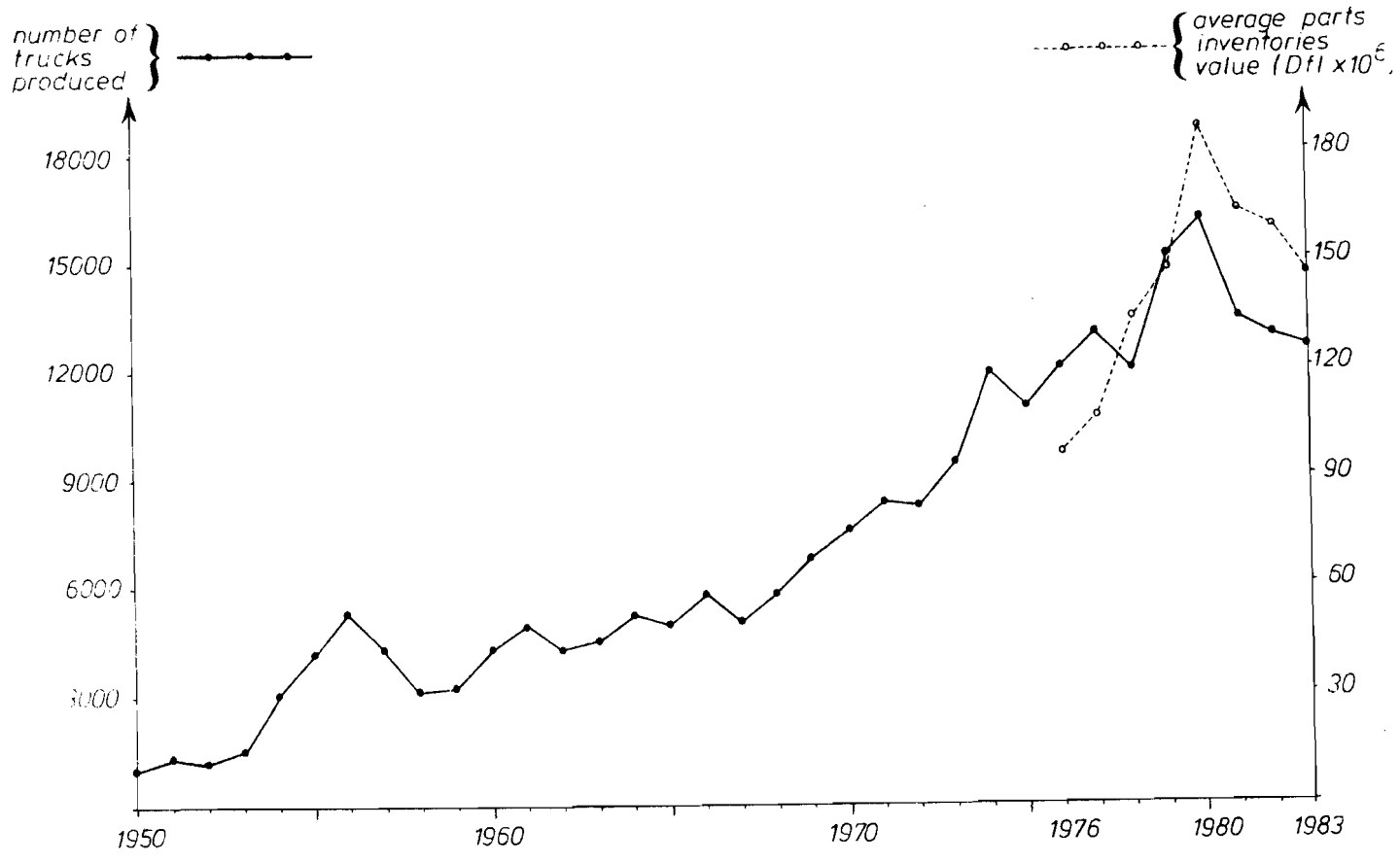


Figure 1. DAF Trucks output history and recent, relatively increasing parts inventories value (Eindhoven factory).

a nine-month to one-year project in a triangular relation, whereby a Master's student works in a firm or non-profit organization, cooperating with a tutor or project team of the firm, and supervised by a committee of the University.

The Master's thesis project [6] that was undertaken at DAF Trucks in 1980 is described in Section 2. It appears that the student encountered not one, but six problems, the original one being one of the less important. The follow-up in 1981 and 1984 is discussed in Section 3. What can be concluded from this case study is discussed in Section 4.

2. MIRACULOUS MULTIPLICATION OF PROBLEMS

To get a grasp of the forecasting problem, the student was soon sitting in the midst of the "replenishers" and making tables for a sample of individual monoparts similar to Table 1. It is worth noting that this was only possible thanks to one replenisher who had preserved his planning data, the other ten having thrown them away after use.

Table 1. Planned and actual use of monoparts*; example of code number 623313

Period planned in:	Period planned for:																
	'79													'80			
	1	2	3	4	5	6	7	8	9	10	11	12	13	1	2	3	4
'79 1	9	10	18	18	16	17	10	18	24	21	21	18	18				
2	12	5	18	12	17	22	22	9	20	23	20	20	13	21			
3	(+5)	9	12	12	18	22	22	9	20	23	20	20	13	21	15		
4			13	4	18	27	22	9	20	23	20	20	13	21	15	13	
5				5	7	27	31	9	20	23	20	20	13	21	15	16	20
6					2	21	31	17	15	16	20	19	12	13	15	17	14
7					(+43)	20	22	17	29	16	20	19	12	13	15	17	14
8							19	13	29	23	20	19	12	13	15	17	14
9								11	32	23	32	16	6	13	15	17	14
10									38	17	32	27	6	11	13	14	11
11									(+30)	21	28	27	8	33	36	36	34
12											30	25	8	34	36	36	34
13												28	9	30	38	36	24
'80 1													16	23	38	37	22
2													(-2)	28	33	37	33
3															38	32	33

* The figures on the diagonals from the bottom up designate the following:

- Figures in parentheses: "counting differences" between actual and registered inventories, as established in the period indicated by the column heading;
- Lowest full diagonal: actual use in the period indicated by the column heading;
- Next higher diagonal: planned use for the current period, as indicated by both column and row heading (first "fixed" period);
- Next higher diagonal: planned use for the current + 1 period (second "fixed" period);
- Next higher diagonal: planned use for the current + 2 period (third "fixed" period);
- Higher diagonals: forecasted use up to 13 periods ahead ("variable" periods).

It is evident from Table 1 (and the men on the spot told the student immediately) that the transition from "variable" to "fixed" is not the only problem, and not the main problem. If we follow, for example, column 9 of Table 1 from the bottom up, we encounter several differences:

- The lowest figure in parentheses (+30) is a so-called "counting difference", as established in period 9 of 1979 for this monopart. Counting differences are elaborated in Section 2.1.
- Actual use (38) differs from planned use (32) for period 9 of 1979. Differences between actual and planned use are discussed in Section 2.2.
- The transition from "planned" to "current" brings a difference of $32 - 29 = 3$, even though both should have been "fixed". This problem is dealt with in Section 2.3.
- The transition from "variable" to "fixed" (the original problem) means a jump of $29 - 15 = 14$, and in the series of forecasts for period 9 of 1979, jumps occur of $15 - 20 = -5$ and $20 - 24 = -4$. This is discussed further in Section 2.4.

2.1. Counting differences

Foremost of the replenishers' problems is what are euphemistically called counting differences, in the firm's jargon. A counting difference is a disparity between the inventory of a certain code number as administrated in the material requirements planning system and as actually established (counted). More than twenty possible causes of counting differences have been distinguished, most of which are part of the aftermath of the introduction of the MRPS. For the purposes of this study, the MRPS was to be regarded as given.

A sample of counting differences was considered and the mean absolute counting difference was 19%, if counts were made after three periods.

Absolute differences increase (less than proportionally) with time between counts, so that inventories may either increase indefinitely unnoticed, or decrease until a stock-out occurs and finally a so-called zero report is signalled by the Central Parts Storage.

The proposed solution was to employ more counters to count stocks more regularly. Taking account of the inventory carrying costs of positive counting differences and inventory stock-out costs caused by negative counting differences, the "optimal" number

of counters to be employed was estimated at eight (see Figure 2).

2.2. Unplanned leakages

The main reason why actual use often differs from that planned for the current period is unplanned leakages. Figure 3 shows some of them. The demand for service parts is in part planned, in part unforeseen. Losses are usually unobserved and a more or less taboo topic within DAF, but the country's leading newspaper wrote in December 1983 that DAF Trucks had announced special actions against fraud [5].

The most important unplanned leakage is service parts requested at short notice. Given the fact that profits made on service parts by far exceeds the contribution to profits of the same parts assembled in new trucks, there will certainly always remain unplanned leakages to charm the life of replenishers.

2.3. Planning

Although production should be at fixed levels during the current plus the next two periods, changes occurred nevertheless, particularly at the transition from the "current plus one" to the current period. The main reason for this was, mirabile dictu, the transition from one set of parts lists to another one. For material requirements planning for all future periods, the Master Specification File was used. This contains parts lists from the perspective of construction, where a branch in the explosion tree is e.g. a brake system, which is subsequently exploded. For material requirements planning for the current period, the Engineering Parts List was used. This contains parts lists from the perspective of production, where a branch in the explosion tree is e.g. a cabin, which is assembled as a whole and contains parts of the brake system. Never did the two match.

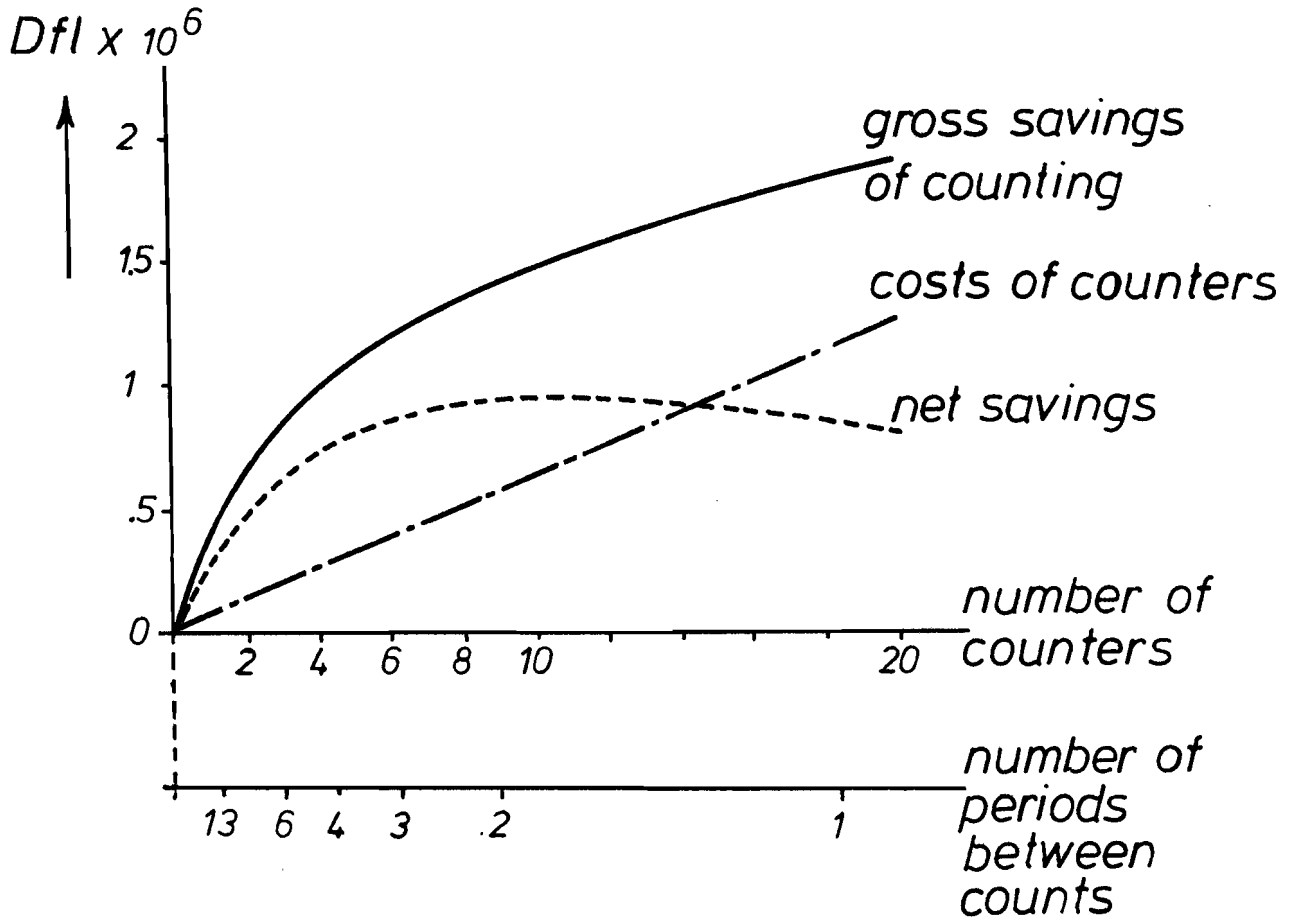
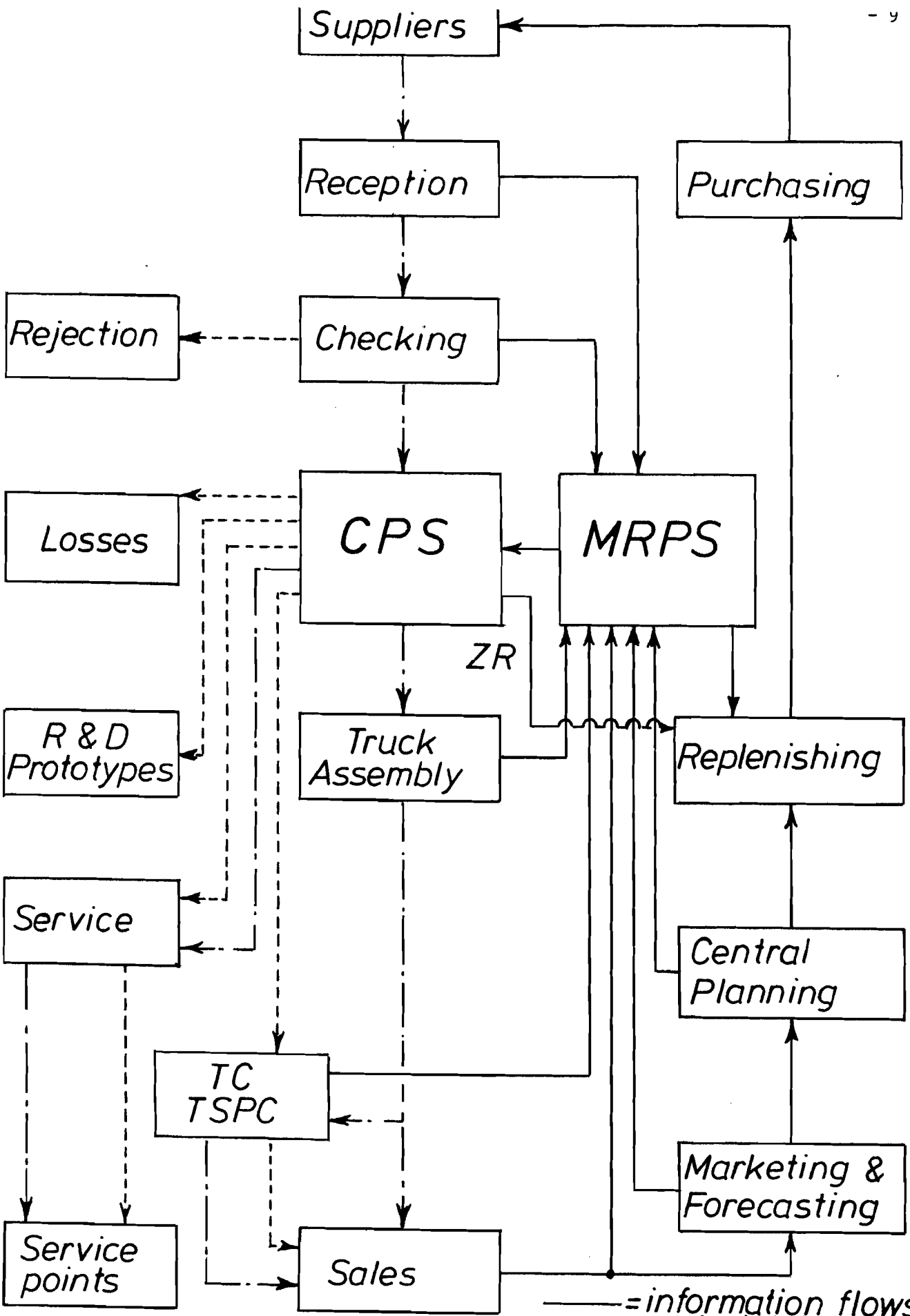


Figure 2. Estimate of optimal number of counters.



————— = information flows
 - - - - - = material flows
 = unplanned leakages

Figure 3. Information flows, material flows and "unplanned leakages".
 CPS = Central Parts Storage; MRPS = Material Requirements Planning System;
 ZR = Zero Report, the notorious message to Replenishing that items have got
 out of stock; TC = Technical Centre; TSPC = Truck Sales Processing Centre.

The proposal was to eliminate either of the parts lists and this was the only proposal implemented during the Master's project - the time was ripe for that decision and the Master Specification File was eliminated.

2.4. Forecasting

The original problem consisted of the fluctuations in the forecast output figures, especially at the transition from "variable" to "fixed" planning periods. No way was found to "improve the forecasts".

It was proposed to fix sales four periods ahead, because a number of important parts had delivery times of three periods and orders could then be adjusted to revised planning numbers. However, this proposal was commercially unacceptable.

Forecasts are not really revised every period, but on average once every three periods. It was proposed to update forecasts more often, in order to smooth out fluctuations, but this never materialized.

2.5. Delivery times

One problem replenishers complained about was that the delivery times of parts suppliers were unreliable. This problem was less serious than expected, although it brings in another stochastic element in material requirements planning.

Under overall contracts with suppliers, parts are to be delivered on call. DAF Trucks passes on its MRP results to its suppliers. Between thirteen and three periods ahead demands are forecast and "variable", up to three periods ahead demands are "fixed".

Figure 4 shows the deviations between actual and planned weeks for a sample of 4547 deliveries. Most arrive in the current period (0 to -3 weeks). Little arrives more than one period (4 weeks) late. Those deliveries that were added to the calls at the tran-

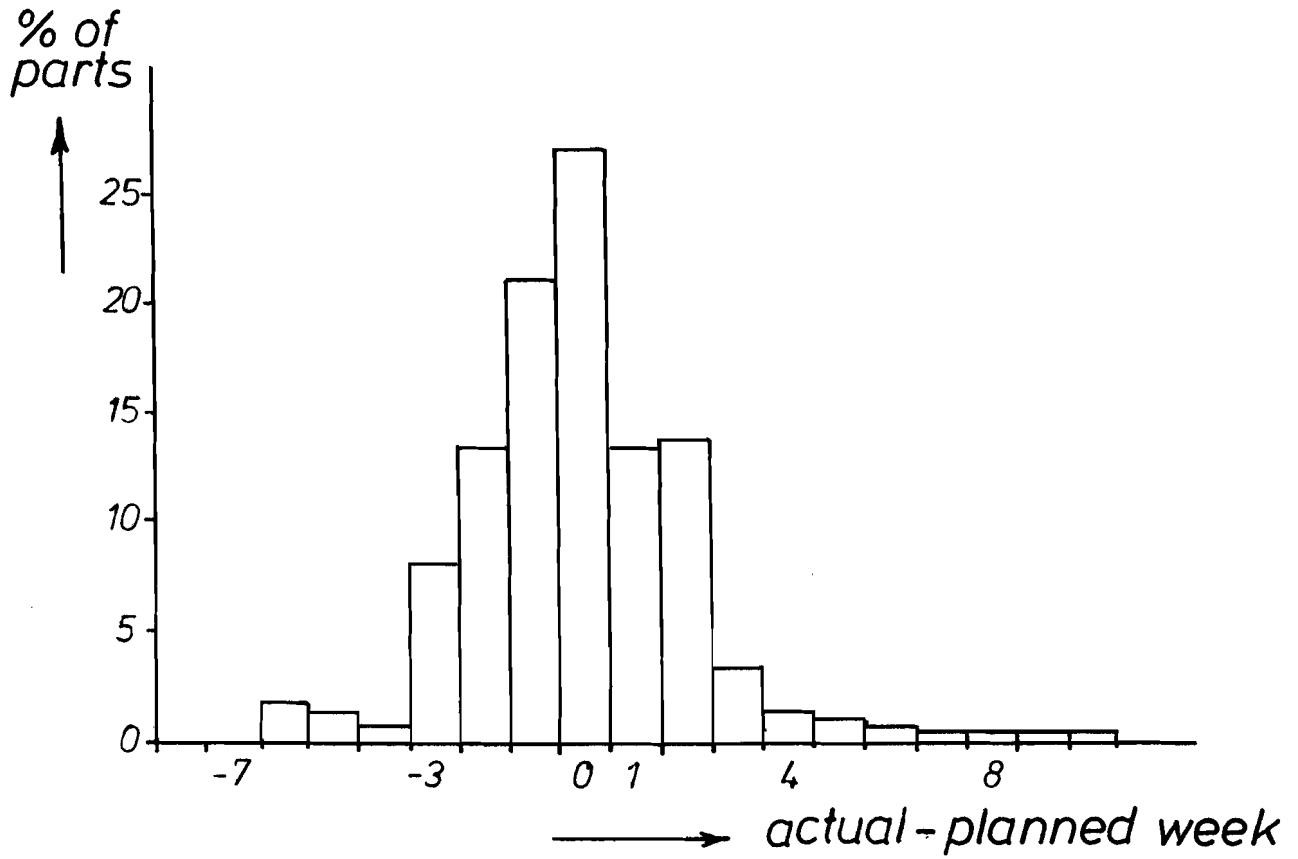


Figure 4. Deviations in weeks of actual from planned week for sample of 4547 deliveries.

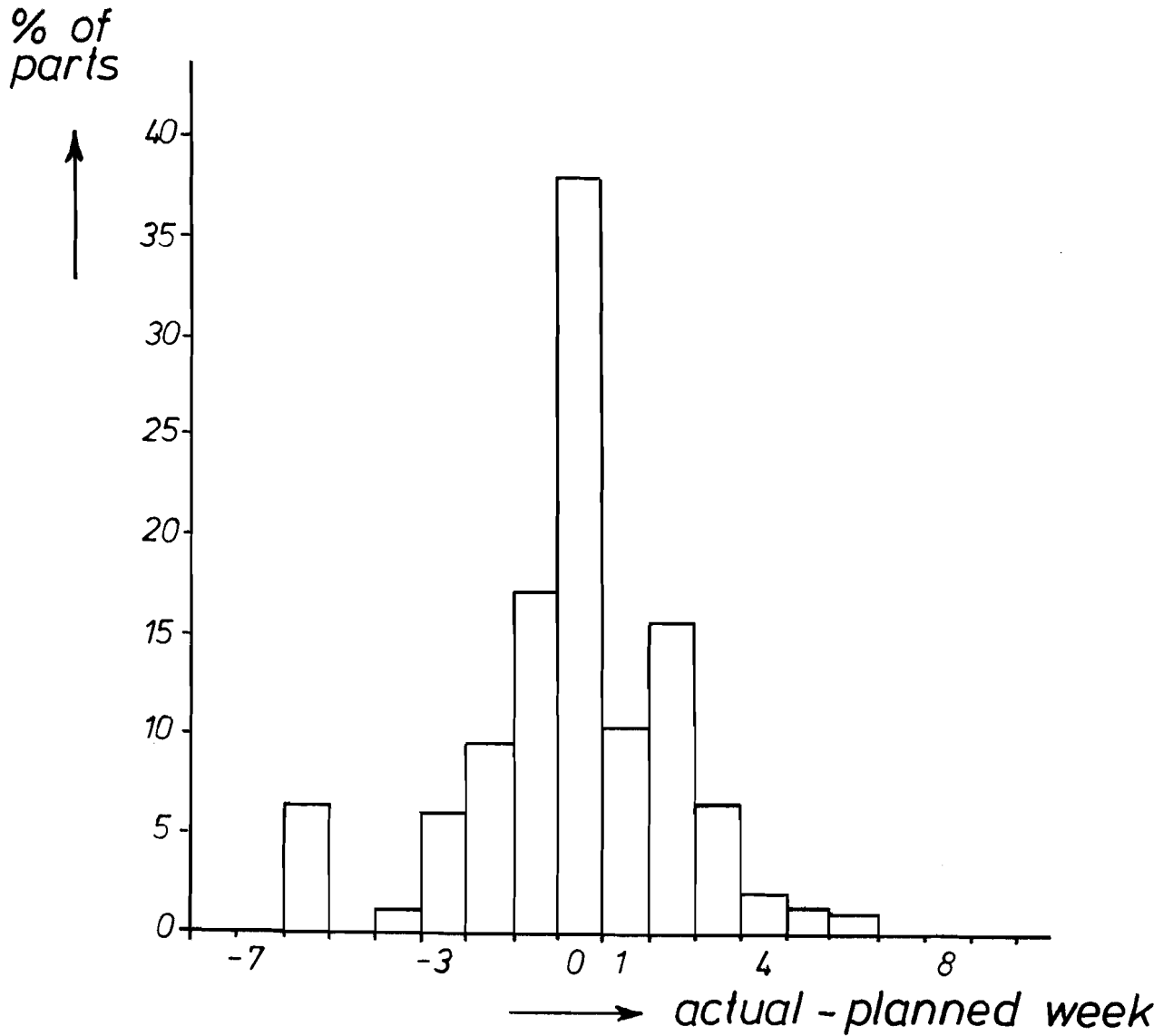


Figure 5. Deviations in weeks of actual from planned week for sample of 1096 items added to the calls at the transition from "variable" to "fixed".

sition from "variable" to "fixed" (three periods ahead) do not perform worse than average; see Figure 5. Incidentally, parts added to the calls during the "fixed" three planning periods have less prompt delivery times, but then, suppliers cannot be blamed.

2.6. Buffer policy

It is well-known that uncertain and stochastic elements remain in material requirements planning systems [4, 7, 8, 9]. Safety stocks are needed according to statistical inventory control concepts, taking account of economic order quantities.

The ABC-classification in use was based on values of money turnover; see Table 2. It was felt that not only money turnover should be the criterion for classification, but also the number of parts used per period. The consideration was that if numbers are large, stocks can be relatively smaller than if numbers are small, money values being equal. A new, two-dimensional ABC-classification was proposed (Table 3) and a concomitant inventory policy (Table 4).

Table 2. Inventory policy in equivalent time units based on old ABC-classification

Category	Turnover (Dfl.)	Order quantity	Reorder level
A	> 40,000	1 period*	3 weeks
B	7000 - 40,000	1 period*	3 weeks
C1	900 - 7000	3 periods*	3 periods*
C2	250 - 900	6 periods*	3 periods*
C3	< 250	1 year	3 periods*

* Periods of 4 weeks

Table 3. Proposed ABC-classification

Unit price (Df1.) Units per period	> 100	10 - 100	< 10
	> 500	} A1	B1
50 - 500	B2		C2
10 - 50	A2	} B3	} C3
1 - 10	A3		
0 - 1	A4		

Table 4. Proposed inventory policy based on new ABC-classification

Category	Units/ period	Unit price (Df1.)	Buffer (% of turnover)	Number of items	Buffer value (Df1. × 1000)
B1	> 500	10 - 100	2	44	320
B2	50 - 500	10 - 100	6	305	1,069
A1	> 50	> 100	7	137	7,853
A2	10 - 50	> 100	12	159	4,323
C1	> 500	< 10	16	907	3,295
B3	< 50	10 - 100	19	695	805
A3	1 - 10	> 100	38	169	4,939
C2	50 - 500	< 10	46	1069	2,206
A4	0 - 1	> 100	58	93	337
C3	< 50	< 10	100	1012	549
p.m.*	-	-	-	1610	-
				6200	25,696

* Not in use

3. FOLLOW-UP

As a rule, few proposed solutions to management problems are implemented during the academic year of a Master's thesis project. The described case study was no exception. The following sections describe follow-ups after one year (1981) and after four years (1984).

3.1. One year later

The material requirements planning system, which had been introduced in 1978 and which was taken for granted for the inventory management study in 1980, was gradually improved.

The major proposal of the study, from which the largest savings were expected, had been to employ an "optimum" number of eight "counters". It turned out that after one year, eight counters were actually at work. It was hoped that this number could be reduced to four after the MRPS had been sufficiently improved.

Unplanned leakages were still a problem, as were fluctuations in the forecasts and the "fixed" plans. There was much pressure to bring inventories down, irrespective of the proposed ABC-classification, which had been introduced with modifications. This resulted in a 30 per cent decrease in inventories. Consequently, a general drive was going on to increase the punctuality of suppliers.

3.2. Four years later

When a follow-up was made with DAF Trucks after four years, the direct project tutor, as well as his boss and the latter's director, had left the company and the Master's thesis could not be found. After reading a copy from the University library, the present

manager gave the following verdict.

Most of the problems were still familiar, but most of the solutions were out-dated. The MRPS had been vastly improved. Updates were now made interactively via decentralized terminals. This had improved insight into the inventory system and had eliminated most of the "counting differences". Besides, the Parts Transaction System, introduced in 1983, would also monitor the whereabouts of parts and would compensate a shortage at one place with an excess at another.

Unplanned leakages were still a problem. A new watertight system against losses was envisaged. Forecasting and planning were still subject to variations and delivery times could be improved. The two-dimensional ABC-classification had been dropped again. Pressure from the top to decrease inventories was changed in a drive to increase flexibility to the market, with supervision of all cost-elements in the material flow.

A newly introduced Increased Flexibility System handles proposed changes within the "fixed" time span of three periods. The system provides a list of critical parts and their availabilities. Before a change is accepted, the replenishing and purchasing departments must give their consent.

The MRPS has now been so much improved and has taken over so many planning functions that the name Material Requirements Planning System is justified. Studies are going on to introduce, in part, a Kanban system [3] and combine it with the MRP system [10].

4. CONCLUSIONS

A case study of inventory management in truck manufacturing has been described, with a follow-up after one and four years.

The case study provides (further) evidence that:

- firms have short memories - data are sometimes saved by chance;
- problems do not come singly - it may be necessary to answer unasked questions;
- sometimes the problems remain when the solutions are forgotten;
- material requirements planning systems need to be supplemented by statistical inventory control;
- automation sets the pace for inventory management;
- inventory management is affected by outside pressures from the business cycle, handed down by top management, irrespective of efficiency or optimization studies from within.

ACKNOWLEDGEMENT

Most of the work of this case study was done by the then Master's student, Herman Post, and reported in his Master's thesis [6]. Thanks are due to M. de Zeeuw and J. Kloosterboer for tutoring the study, to their successors T. Mulder and R. Fröger for comments, and to DAF Trucks for approving the publication of this case study after due lapse of time.

REFERENCES

- [1] DAF Trucks, Annual Report 1978, Eindhoven, 1979.
- [2] DAF Trucks, Annual Report, 1983, Eindhoven, 1984.
- [3] Hall, R.W., Driving the Productivity Machine: Production Planning and Control in Japan, Research Report, American Production and Inventory Control Society, 1981.
- [4] Miller, J., "Hedging the Master Schedule", in: L. Ritzam et al. (Eds.), Disaggregation Problems in Manufacturing and Service Organizations, Martinus Nijhoff, Boston, 1979, 237-256.
- [5] NRC-Handelsblad, "DAF wil fraude gaan bestrijden" (DAF to fight fraud), 14 December 1983.
- [6] Post, H.N., Voorraadbeheersing voor de truckmontage van DAF Trucks B.V. (Inventory management for truck assembly at DAF Trucks Company), Eindhoven University of Technology, Dept. of Industrial Engineering and Management Science, 1980.
- [7] Timmer, J.P.J., Bertrand, J.W.M., and Monhemius, W., "Production and inventory control with the base stock system", Report EUT/BDK/12, Eindhoven University of Technology, 1984.
- [8] Whybark, D.C., and Williams, J., "Material Requirements Planning under uncertainty", Decision Sciences 7 (1976), 595-606.
- [9] Wijngaard, J., and Wortmann, J.C., "MRP and inventories", to be published in European Journal of Operational Research.
- [10] Wortmann, J.C., and Monhemius, W., "Kanban - its use as a final assembly scheduling tool within MRP II", in: J.P. Brans (Ed.), Operational Research '84, North-Holland, Amsterdam, 1984, 566-580.