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Is High Automation a Dead End?

Cutbacks in Production Overengineering

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Summary For quite some time it seemed the trend towards high automation in the wage-intensive German economy showed no signs of slowing down. However, in practice it turns out that more than a third of companies which have chosen automated solutions have not had their expectations fulfilled. Many of these companies have already made reductions in automation levels for particular subsystems. The most important reason for dissatisfaction is the lack of flexibility in highly automated systems. Flexibility requirements resulting from turnover fluctuations and production changes for new products can only be realized at considerable expense in highly automated systems. This is particularly the case in the area of assembly. Almost 50 percent of companies with strong turnover growth have already reduced their automation levels for material flow in assembly or plan to do so. These results hold true regardless of the size of the company.

Companies which have already reduced overengineering in production do not however simply return to pre-automation production concepts. Many companies succeed in putting experience gained into practical use and thus achieve improvements in rejection rates and on-schedule performance with a reduced and adjusted automation level.

Introduction

For some time the trend towards high automation showed no signs of slowing

The spread of automation in production for companies in a high-wage country such as Germany appeared in the past to be the only appropriate strategy for remaining competitive. Consequently the number of companies using highly automated production systems climbed at a stead pace. For example, the ten-year period between 1989 and 1999 saw the following increases:

- The share of companies using CNC tool machines, from 36 to 69 percent
- The number of companies with workpiece handling systems, from 5 to 20 percent
- The number of companies with automated tool handling systems, from 5 to 18 percent
- The share of companies with automated assembly systems, from 5 to 14 percent.

In spite of these rather remarkable growth rates there was also an growing number of opinions pointing out that unrestrained automation also means costly overengineering for many companies. These warnings took on more credence as individual reports came out describing companies which had installed automation solutions and were now removing the systems and investing in concepts with reduced automation levels. One early example of this was Hall 54 at Volkswagen in Wolfsburg, where the disadvantages of high automation were particularly impressive: The highly complex system was also extremely inflexible. The initially calculated economic advantages were quickly consumed by unplanned expenses such as link losses, idle time losses, high technical support needs, high conversion costs for new variants and the replacement capacities needed in order to satisfy demand.

First case-studies cast doubt on high automation levels

Recent years have witnessed an increase in the number of cases in which expensive automation solutions such as driverless transport systems were scrapped. When changing over to a successor product, highly flexible production facilities were replaced by concepts with significantly lower levels of automation. Does this mean that automation technologies are leading to a dead end? The answer to this question was the subject of the latest survey conducted by the Fraunhofer-Institute for Systems and Innovation Research ISI, with the support of the *Institut für Fabrikanlagen* (Institute of Production Systems) at the University of Hanover.

The survey focused primarily on the following questions:

Central questions

- What scope and what reasons can be attributed to the reversal of the level of automation in the German capital goods producing industry?
- Are there subsystems in production or corporate groups for which automation was particularly overdone ?
- What are the economic consequences of cutbacks in the degree of automation?

Scope and Reasons for Cutbacks in Levels of Automation

More than a third of companies has already reduced automation levels or plans to do so

As demonstrated in evaluations based on the ISI study "Innovation in Production", the reports mentioned above describing reductions in automation levels are indeed more than unique exceptions. Turning to companies in the capital goods producing industry who reported on their experiences with highly automated production systems, we find that more than a third (35 percent) indicate that they have already either partially or completely removed this equipment or at least plan to do so. Considering the probable reluctance of corporate decision-makers to acknowledge in such a survey having gone back on their own decisions, the actual extent of overengineering present in industry and the partially evident misinvestment take on remarkable dimensions.

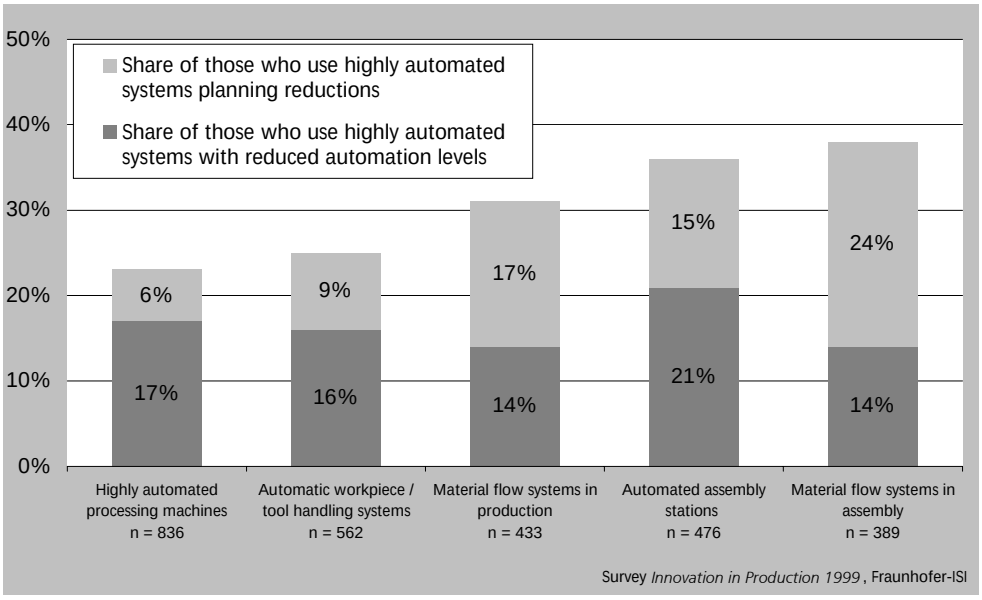


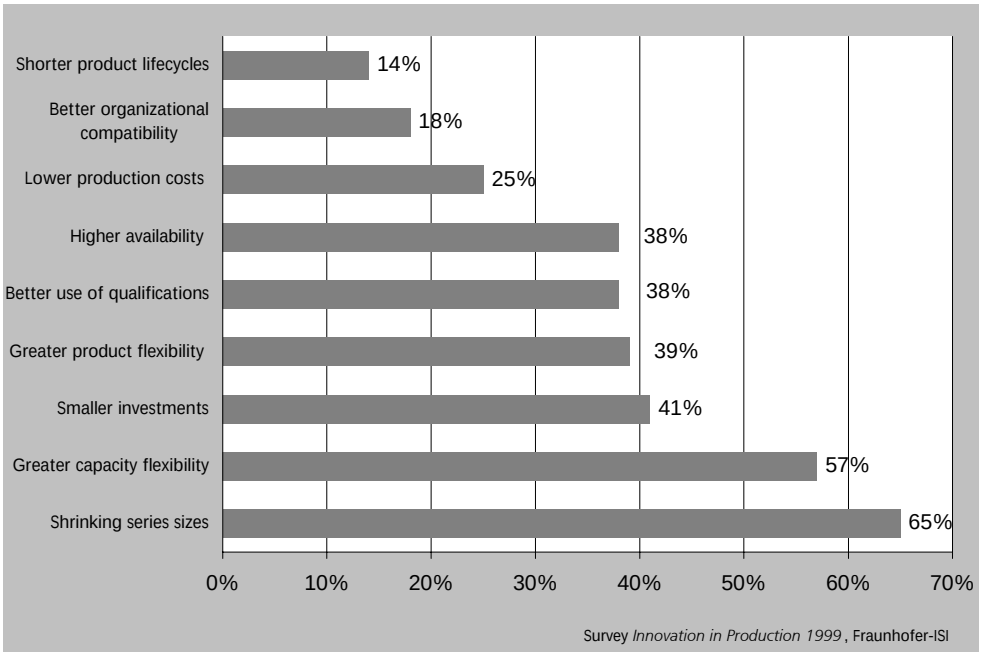
Figure 1: Cutbacks in automation levels by subsystem

Analyzing the extent of automation solutions reaching over and above economic objectives according to production subsystems, the following picture emerges:

Assembly automation as achilles heel

In the case of highly automated processing machines, the area where the most advanced automation levels are found in the companies surveyed, relatively speaking we find the lowest levels of overengineering. 58 percent of companies surveyed reported experience with highly automated processing machines. Amongst this group only 17 percent indicated that they had already completed reductions in automation levels, with another 6 percent planning to do so. This amounts to 23 percent of respondents dissatisfied with the situation. For automated workpiece and tool handling systems (38 percent of the companies surveyed reported involvement with these systems), a similar share of companies indicated negative experiences (25 percent). Automated material flow systems in production appear to cause problems most frequently. Amongst the just under one third of respondents indicating experience with these automation solutions, 31 percent said that they were unhappy with the systems. Automated assembly stations appear to be even more problematic. Of the one third of companies reporting prior experience with such automation solutions, 36 percent have reached the conclusion that they have overdone the level of automation.

Figure 2: Reasons for reducing automation levels (n = 355)



The main reason for dissatisfaction with past automation investments is apparently the **inflexibility** of the systems in the light of changing market conditions. Two thirds of the companies with implemented or planned investments in automation level reductions indicated that highly automated systems could no longer handle today's declining series sizes in a cost-effective manner. 57 percent of companies required a level of flexibility to accommodate fluctuations in capacity which they do not believe highly automated systems can pro-

vide. 39 percent of the companies reported that the necessary flexibility in the production of various components could not be achieved with highly automated systems. Shorter product lifecycles were cited by 14 percent of companies. Overall, the "flexible automation" seen in past decades as the key to increased productivity now appears unable to completely satisfy the flexibility demands of today's market.

Flexible automation does not yet meet flexibility requirements

A second matrix of reasons arises directly from **economic variables**. The investment requirements associated with highly automated systems are not regarded as feasible by 41 percent of the companies surveyed. The susceptibility of automation solutions and the consequent low availability was accepted as a sufficient argument against high automation levels by 38 percent of companies in the study. 25 percent of the companies said that production costs as a whole spoke in favour of a lower degree of automation.

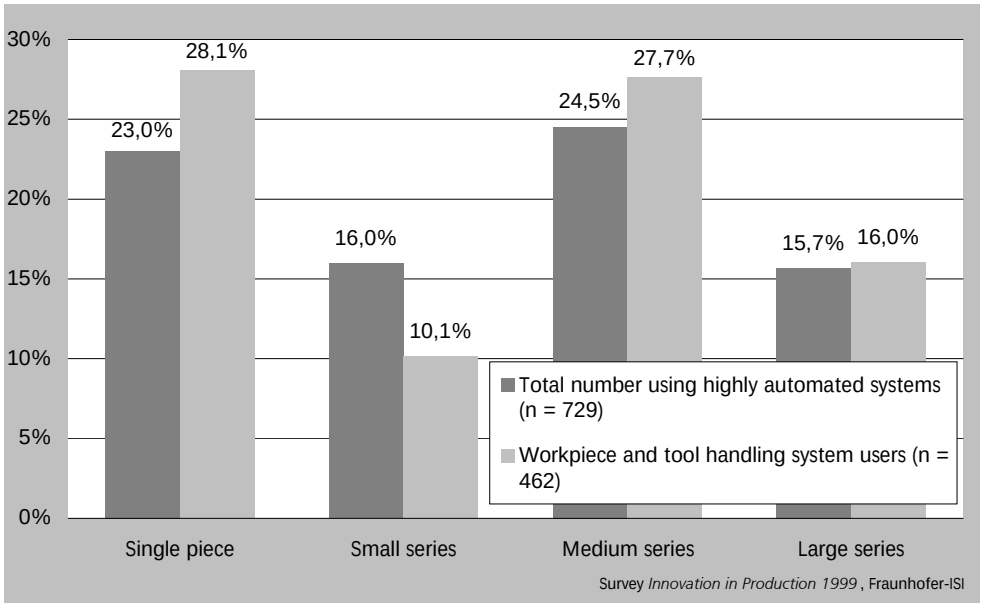
Last but not least, companies which have already reduced their automation levels or plan to do so cited the **incompatibility** of highly automated systems **with new production concepts** as their motive. The greater significance attributed over the last few years to human resources as a competitive factor is evident in the responses of 38 percent of companies, These companies intend to provide an adequate field of activity for existing personnel qualifications; it is felt that this can be attained more easily with an appropriately adjusted level of automation than with the highest automation levels. New organizational solutions in production such as groupwork and production segmentation were listed by 18 percent of the companies responding as the motive for automation cutbacks. The significance of the individual reasons varies only slightly in the context of individual subsystems.

Where Has the Level of Automation Been Pushed too High?

Reduction of automation levels is not equally relevant for all companies: It turns out that for example the **series size** produced is not only a factor in the decision to use highly automated systems; cutbacks in the level of automation also vary depending on series size. Especially companies with highly automated systems in single-piece and medium-series production have made large cutbacks in automation. These companies appear to have implemented automation solutions on a large scale which were not however suitable for specific series sizes. This is particularly true for automated workpiece and tool handling.

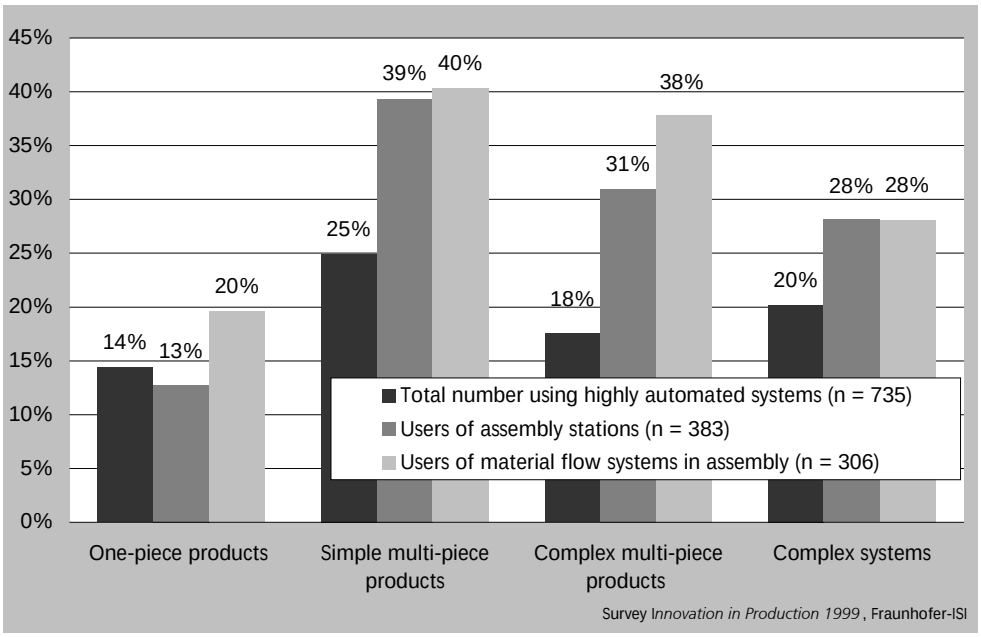
Curtailment of automation in particular for single-piece and medium-series production

Figure 3: Reductions in automation levels by series size



In addition to series size, **product complexity** also affects automation levels. Overengineering is particularly common in assembly systems for products of medium-range complexity, as can be seen in the proportion of companies with corresponding cutbacks in the level of automation.

Figure 4: Reduction of automation levels by product complexity



Company size also has considerable bearing on the use of highly automated systems. Thus the share of companies with highly automated systems ranges from 65 percent for smaller companies with less than 100 employees to 74 percent for medium-sized companies and 86 percent for large companies with over 500 employees. This difference results from the broader implementation

possibilities at larger companies, further magnified by the larger series sizes often encountered at larger companies. The share of companies with highly automated systems who have reduced their automation levels is however between 22 and 23 percent for all company sizes. The problem of overengineering thus appears not to be a problem specific to smaller or larger companies.

Connection between strategic orientation and reduction of automation

The use of highly automated systems as well as reductions in the level of automation are closely linked to corporate strategic orientation in terms of **investments in new machines**. As the importance of investments in new machines drops, the number of companies with highly automated systems also drops significantly from 83 percent to 33 percent.

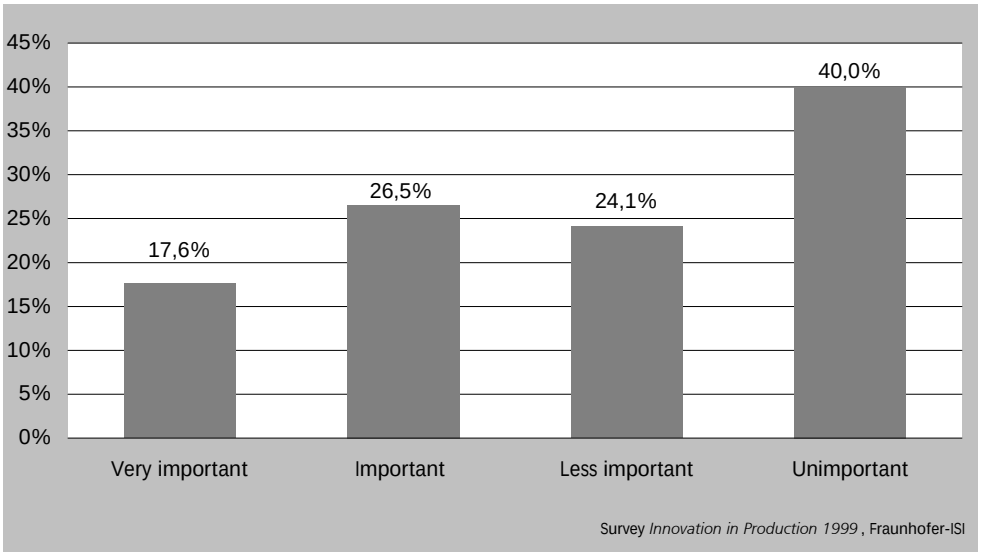


Figure 5: Users of highly automated systems with reduced automation levels by importance of investments in new machines (n = 840)

However, the share of companies which have reduced automation levels or plan to do so increases from 18 percent to 40 percent as the importance of investments in new machines drops. There are various possible explanations for this relationship: On the one hand it is conceivable that companies which have had negative experiences with highly automated systems consequently judge future investments in new machines to be unimportant and concentrate instead on organizational activities. But the inverse causal relationship is also possible: Companies for which investment in new machines are of great importance are more oriented towards system optimization.

Job-shops particularly dissatisfied with their automated assembly stations

A further reason for automation cutbacks, in particular for assembly stations, appears to be the **type of production**. About 30 percent each of companies using automated assembly stations in production based on customer orders and companies producing for stock responded that they have at least in part removed the systems or plan to do so. In preproduction and final assembly after order reception the rate is considerably higher at 45 percent. In this area in particular, recent years have seen a drastic increase in the number of variants. Furthermore delivery reliability has also grown considerably in importance, resulting in extremely high flexibility demands placed on production. Companies which produce for stock, however, have not experienced as great an increase in the number of variants and can also buffer against sales fluctuations using the stock of finished goods. The customer's influence is most clearly evident in assembly, the final stage in manufacturing a product.

It can also be seen that companies achieving a relatively small amount of their turnover through **product innovation** are less likely to make use of highly automated systems than companies whose turnover relies more fully on product innovation. The latter group appears to have more substantial problems here: Companies with particularly innovative product ranges (over 20 percent of turnover through product innovation) exhibit considerable difficulties in the use of automated assembly stations and automated material flow in production. Approximately 40 percent of companies surveyed reported having made negative experiences in both subsystem areas. The close connection between product innovation and process innovation requires especially flexible automation solutions which are however significantly more expensive and may not be cost-effective in comparison to a reduced automation level. Only modularly structured assembly systems which can be easily converted to accommodate the introduction of a new product can lead to greater satisfaction for these companies.

Automated solutions too rigid for changes in turnover and products

Product innovation is not the only factor requiring greater flexibility than automated solutions can frequently provide: **Changes in turnover** can also lead to similar problems. This can become particularly difficult in connection with the adaptation of automated material flows in assembly. Increases or decreases in turnover and the associated changes in utilization of capacity are apparently very difficult to accommodate with automated material flow systems. But the growth of market dynamics and the turbulent market environment require companies to maintain constant flexibility in capacities.

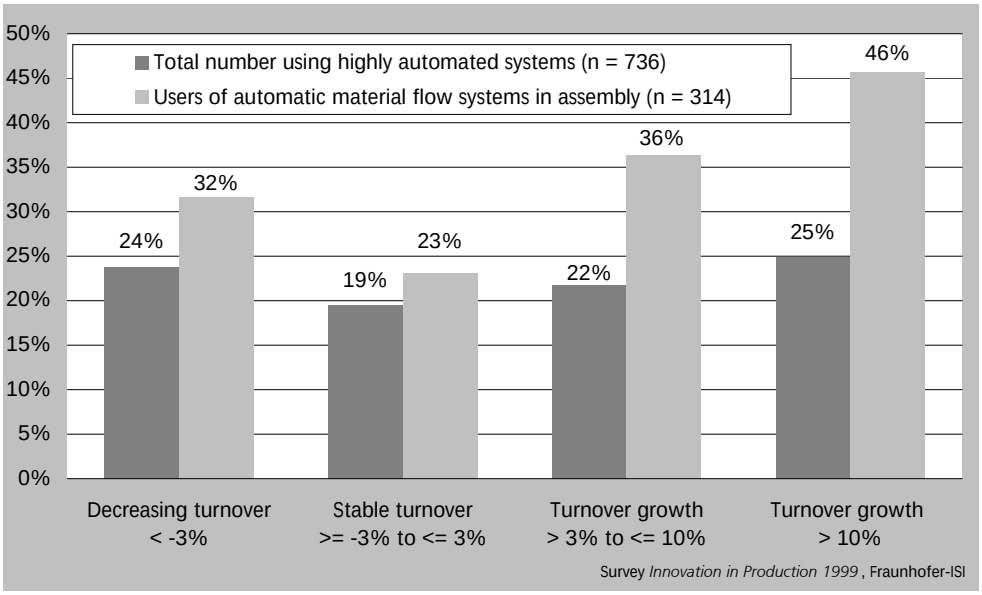


Figure 6: Reduction of automation levels by annual growth in turnover

Economic Effects of Reductions in the Level of Automation

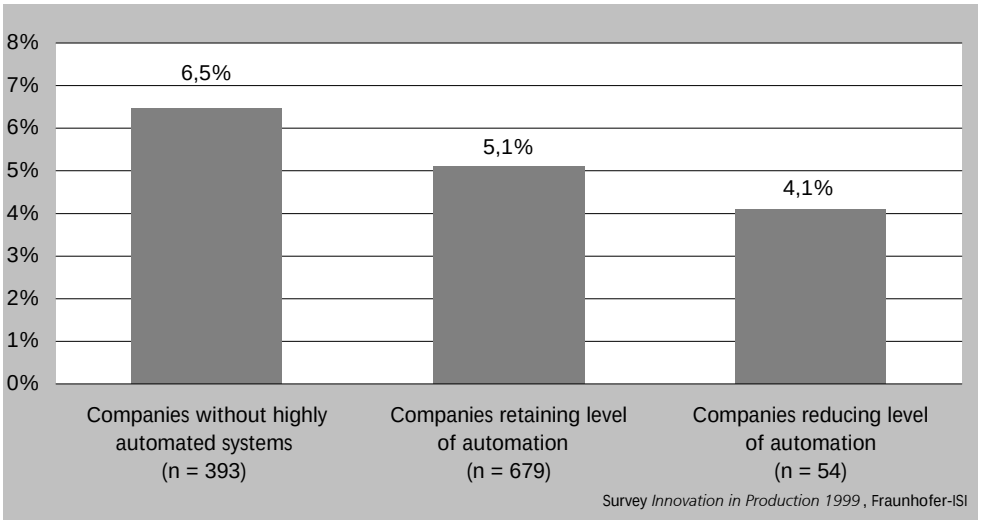
A variety of effects may be connected with reductions in the degree of automation motivated in particular by the need to increase flexibility. In order to ascertain if and to what extent such effects are present at companies which have retired highly automated solutions in favour of concepts with reduced automation levels, the performance capabilities of these companies was compared with the average values of companies still operating their highly automated solutions. The performance characteristics of companies which as yet have not installed any automation solutions were included as a third reference point in this comparison:

Reduced and adjusted automation levels can even increase quality

The **quality** of components produced apparently does not suffer due to the reduction of automation levels. Although automation solutions are frequently introduced with the aim of guaranteeing constant quality levels, companies with highly automated systems actually exhibited significantly higher rejection rates (5.1 percent) than a comparable group of companies which had already completed automation reduction measures (4.1 percent). Here it also became evident that retirement of automation which has overshot the original production quality targets does not mean a return to the production conditions which were prevalent before the introduction of automation (6.5 percent).

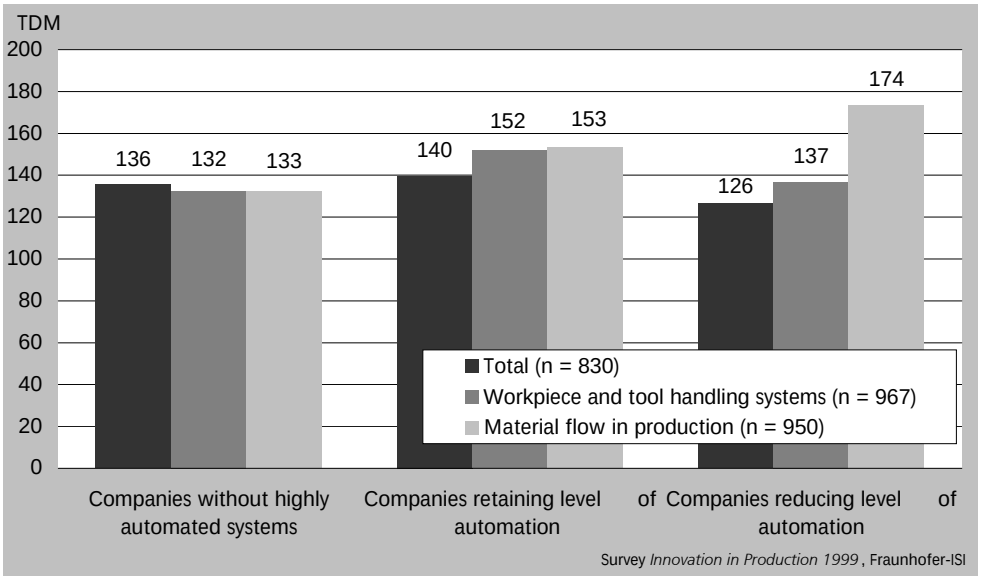
Much to the contrary, companies with adjusted automation solutions succeed in attaining higher levels of quality production than in the past. This effect appears independently of series size and company size.

Figure 7: Rejection rates with use of highly automated systems (n = 1126)



Surprisingly, the **productivity** of the production structures measured in terms of value added per employee suffers only minimally from cutbacks in automation. Companies with highly automated systems were found to have an average value added per employee of DEM 139.7 thousand. Companies which have invested in the reduction of automation levels showed a corresponding value of DEM 126.4 thousand, a statistically insignificant difference.

Figure 8: Value added per employee (in dem thousand) with implementation of highly automated systems



Productivity Increases Through Automation Often Consumed by Additional Costs

Interestingly enough, companies without automation solutions do not lag behind in terms of productivity, with an average value added per employee of DEM 135.7 thousand. These numbers clearly show that productivity gains

through high automation in production are often consumed by costs arising in connection with planning and realization of these concepts in upstream areas.

This idea is also supported by consideration of the amounts of **overhead** incurred at these companies. Companies with highly automated production concepts have average overhead levels above those of companies which have reduced the level of automation in their solutions. This becomes especially evident and statistically significant in the comparison of companies with and without automated material flow systems in assembly.

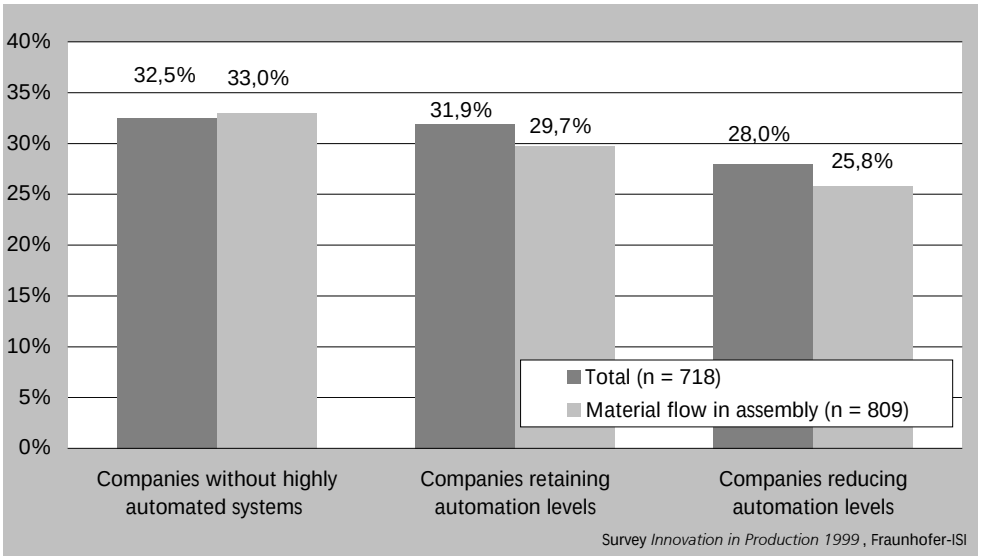


Figure 9: Overhead ratio with use of highly automated systems

Expectations of increased flexibility connected with reductions in the degree of automation may also manifest themselves in that companies are better able to meet **delivery scheduling** obligations. With shrinking series sizes and a growing number of variants, it should be expected that highly automated production systems would be pushed to the limits of their flexibility, which would in turn have a negative effect on delivery reliability. In order to investigate this, the share of orders delivered on time was measured. Here it could be seen that in particular automation of assembly represents a bottleneck for on-schedule performance: Companies with automated assembly stations were able to deliver 86.8 percent of orders on time, while companies with automated material flows in assembly delivered 86.5 percent of orders on schedule. At companies in which the automation level had again been reduced, on-time delivery rates was at 90.9 and 92.6 percent respectively. This difference, which may seem of little significance at first glance, indeed has far-reaching consequences: While an on-time delivery rate for approximately 86 percent of orders might place a company among the worst in its industry, a rate of around 92 percent on-

schedule performance could put a company into the top third of the best players.

Conclusion

The study has shown that current automation concepts in many cases can not ensure the necessary levels of flexibility. Smaller series sizes and substantial changes in turnover in the past few years have exposed the limitations of automation in the classical sense. The solution to the dilemma appears however to lie not only in new concepts for flexible automation, but also primarily in new solutions in organizational and logistics areas. Here the objective must be achieving substantial improvement without the superfluous overengineering phase, thus realizing automation solutions which are appropriately adjusted from the very start. These adjusted automation solutions can only have low fixed system costs and should be designed for flexibility, e.g. through the use of modular structures. Rental and leasing concepts for highly automated systems may also help to resolve this dilemma in the future.

The Innovation in Manufacturing Survey 1999

The Fraunhofer Institute for Systems and Innovation Research has been conducting a survey on *Innovation in Manufacturing* every two years, beginning in 1993. Firms of the capital goods industry in Germany are studied. Objects of examination are the manufacturing strategies pursued, the application of innovative organisational and technological concepts in production, questions of personnel deployment and qualification as well as (for the first time in 1999) the cooperation behaviour of the companies. In addition, performance indicators such as productivity, flexibility, quality and returns are collected.

This Newsletter No. 22 is based on data from the survey 1999, for which 9.823 firms were addressed in autumn 1999. By December 1999 1.442 firms had returned a usable, completed questionnaire (response rate: 14,7 per cent). The responding firms present a representative cross-section of the German capital goods industry.

If you are interested in previous Newsletters of the ISI Innovation of Manufacturing Survey or in special analyses of the new data, please contact:

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