

# **An Engineering Perspective on the Design of Manufacturing Organisations**

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## **Abstract**

Despite an extensive body of knowledge about organisational design for manufacturing, the question remains what organisational structures fit best with which competitive priorities and which capabilities of resources, also caused by a lack of comparative studies. Four characteristics of organisational design suggest that the structure of manufacturing organisations is a result of inductive and teleological methods, similar to product design and engineering. None of the four traditional approaches embeds principles of the engineering perspective. To demonstrate the suitability of the 'engineering perspective', action research at a manufacturer of agricultural equipment has been undertaken. The interplay between the analysis and the organisational redesign yields not only insight about the effectiveness of this fifth approach but also about the limited relevance of the four traditional perspectives. Perhaps the design of organisational structures for manufacturing organisations is best served with derivations of the principles and methods of engineering.

## **Keywords**

Decision making, evolutionary models, mutations, outsourcing

## **1 Introduction**

According to Shirazi et al. (1996, p. 199), the efforts in developing organisational structures date back to the 1940s but could also be attributed to earlier periods. In this perspective, knowledge about organisational design for manufacturing goes back to the Arsenal of Venice, according to some (e.g. Leijonhufvud, 1984, pp. 3–4), and to Frederick Taylor, according to others. In the opinion of Voss (2007), the first study is *De Re Metallica*, written by Georgios Agricola in 1556, which describes processes and operations management for the process industry, particularly the mining industry. These early notions are often descriptive, directed to one method and could be considered as best practice. The tradition of best practice has continued today, with the most notable example being 'lean production' (Womack et al., 1991), despite serious concerns being raised about the value of best practices (for example, Edge and Richards [1998] and Purcell [1999] for human resource management, and Davies and Kochhar [2002] for manufacturing practices). Therefore, it may be worthwhile to explore if there are approaches for organisational design of manufacturing organisations.

### **1.1 Background**

Given the limited reach of best practices, the question remains what organisational structures fit best with which competitive priorities and with which capabilities of resources. This has led to a considerable stream of publications about the so-called manufacturing capabilities (e.g. Swink and Hegarty, 1998; Ward and Duray, 2000), about specific concepts, such as lean production (for example, Åhlström, 1998) and about world-class manufacturing (for instance, Hayes and Pisano, 1994). Notwithstanding efforts to link manufacturing capabilities to organisational design (for example, Safizadeh et al., 2000), the evidence remains weak what the 'best options' for organisational structures are for a given firm.

Hence, this paper argues that an engineering perspective on organisational design of manufacturing is (formally) lacking. The position is commensurate with the stance of van Aken (2004), and van Aken and Romme (2009) about 'design' in management science. It does not support Pandza's and Thorpe's (2010, p. 178) contention that 'irreversible solutions' are created, because akin engineering the design of the organisation solutions created by this process can be accepted or discarded by stakeholders. In this perspective, it should be mentioned that the culture of



engineering is often seen as different to that of management; in terms of Schein (1996, p. 19) they should be seen as complementary. To this end, this paper attempts to amalgamate the engineering approach with management science with the purpose of developing methods for the design of organisational structures for manufacturing organisations.

## **1.2 Research Objectives**

By seeking the amalgamation of the engineering approach with management science, the study adds to the extant literature by its reflection on methods for organisational design for manufacturing in addition to demonstrating the perspective of design and engineering for it. In doing so, it aligns with the call for problem-solving by Holmström et al. (2009, p. 66) and Sagasti and Mitroff (1973, p. 696). This is also relevant for a practitioner orientation in research, as called for by Baldrige et al. (2004, p. 1072) and Tranfield et al. (2004), albeit in different ways. Moreover, a number of studies (e.g. van Aken, 2004; van Aken and Romme, 2009) have advocated the incorporation of 'design science' into the arsenal of management science; the design of organisational structures could be an 'easy' application of such thinking. Third, to achieve this, a case study is presented as a combination of the case study methodology (for instance, Flyvbjerg, 2006) and action research (for example, Coughlan and Coughlan; 2002, Meredith, 1998; Voss et al., 2002). Therefore, this study combines problem solving during action research with incorporating principles from design and engineering science.

## **1.3 Scope and Outline of Paper**

It also means that the paper challenges research by contesting the effectiveness of existing approaches. Notably the contingency approach, the actor approach, the socio-technical approach and the systems approach have been recorded as approaches to the design of manufacturing organisations. However, lacking are studies that compare these approaches and those that consider case studies to reflect on the design and engineering. Particularly, case studies lack generalisation in this respect. Thus, there is still a need to consider what methods for design of manufacturing organisations suit best which contingencies.

Since the application of engineering principles and methods to organisational design has been under-researched, the first step is a narrative literature review. In this literature review four main approaches to organisational design are discussed. In the next section these four approaches are set off against principles of engineering. A case study is presented to demonstrate the principles of the engineering perspective on the design of organisations. A discussion of findings follows and the paper is concluded by reviewing limitations, considering implications for managerial practice and putting forward a research agenda.

## **2. Narrative Literature Review**

Whereas organisational design for manufacturing is mostly discussed from a specific design perspective, studies on methodologies are lacking. Cases in point that focus on a specific organisational design in manufacturing are group technology (for example, Bonavia and Marin, 2006; Gunasekaran et al., 2000) and lean production (e.g. Dankbaar, 1997; Safayeni et al., 1991; Sugimori et al., 1977). However, the onus of this study is on which of these forms is the most suitable for a given firm or unit of an organisation and how is this design adapted (or implemented) to suit best performance criteria (or manufacturing capabilities) and specific circumstances. To this purpose, now a discussion of the most common approaches to organisational design for manufacturing organisations will follow.

### **2.1 Contingency Approach**

As the first of four distinct perspectives on organisational design for manufacturing, the contingency approach takes a rational design approach. According to Hendry (1979, 1980) its characteristics are systematic diagnosis (ibid., p. 5) and representation of organisational processes (ibid., p. 6). Examples for this approach are the works of Drazin and Van de Ven (1985) and Khandwalla (1977). Also, ranges of typical structures for firms can be classified as part of this approach; for example, Mintzberg (1980, 1993) describes archetypes for hierarchical structures, blending positions, superstructures, lateral structures and decision-making systems. Already a while back Hendry (1980) discusses the pros and cons of this contingency approach referring to; according to him (ibid., p. 9), the practical implications are limited, which could be circumvented by relying on heuristics. Similarly, Sousa and Voss (2008) discuss contingency research for operations management but digress towards best practices. In all these works, generic structures are taken as starting point for organisational design (of manufacturing).

These generic structures as input for organisational design have a close link with the approach of practices. Practices are seen as 'the established processes which a company has in place to improve the way it runs its manufacturing business' (Collins et al., 1996, p. 577). The definition of best practice is even broader; for example Davies and Kochhar (2002, p. 290) describe it as 'an activity or action which is performed to a standard which is



better or equal to the standard achieved by other companies in circumstances that are sufficiently similar to make meaningful comparison possible'. Urgan (2007, p. 334) refers to a similar definition, while noting that a definition of practices often lacks in literature. Hence, sometimes these practices are taken as principles for the set-up of production and planning and scheduling; an example is inventory management. In this approach, the search for practices is seen as contingent on performance requirements and contextual settings. For performance requirements, see Ketokivi and Schroeder (2004). This type of research is not widespread. In this context, Sousa and Voss (2008, p. 703) point to contextual variables, as core of this approach that uses practices for organisational. Rather than taking generic structures as starting point for organisational design, practices are used to the same effect, even though often not well-defined.

## **2.2 Actor Approach**

Consequently, rather than focusing on a prescriptive approach, the second of the four perspectives, labelled here the 'actor approach', takes those involved as point of departure. An example is the study by Midgley et al., (1997), which provides a concise description of how this was used for the development of housing services for older people in the UK. Also, Akkermans (1993) shows how interaction with stakeholders can be beneficial for analysing business performance and implementing changes. In addition, some studies have considered mathematical approaches to structuring; a case in point is the study by Christensen and Knudsen (2010). Thus, it means that involving stakeholders can facilitate the design of organisations.

One of the most notable methods in the spectrum of design and engineering is participatory design, which could be applied to the design of manufacturing organisations, too. A case in point is the use of the 'production preparation process' (3P), associated with lean principles. The method involves users of the artefact in its design for production (e.g. Leitner, 2005) or the provision of healthcare (for example, Hicks et al., 2015; Nicholas, 2012). The conceptualisation can be equated with design for manufacturability. The focus of the applications is often the design of facilities (e.g. Weber, 2006). However, its evidence base in terms of outcomes and exact methods is relatively limited with regard to effectiveness.

## **2.3 Socio-Technical Approach**

The socio-technical approach (e.g. Emery and Trist, 1972; de Sitter et al., 1997) is the third of the four perspectives on design of organisations. Socio-technical approaches to organisational design underpin two and systems theories one of the five approaches mentioned for information systems design by Avison et al. (1999, pp. 94–5). The socio-technical philosophy has been stressing the integration between technological and human aspects for the design of operational processes. Also, others point to this, such as Love et al. (1998, pp. 945–7). Nevertheless, the meeting of overall performance requirements seems to be a weakness of socio-technical design, since it is hardly addressed.

Socio-technical design is associated with group technology. For example, Dekkers (2018) amalgamates with an approach to analysis and design of organisations.

## **2.4 Systems Approach**

Akin to socio-technical approaches, the focus of system theories has been on participatory processes rather than a systematic design approach. For example, the soft systems methodology (Checkland, 1981; Checkland and Scholes, 1990) emphasises the steps for analysing 'human activity systems' and does not see it as a 'hard' systems approach with its focus on design; similarly, Morgan (1997, p. 99) sees the use of system theories as an extension of a dialogue to improve performance. Note that the popular Viable Systems Model (Beer, 1972, 1979), based on system theories, has a conceptual orientation. However, the blending of socio-technical design and 'hard' system theories (as an aid to decision making, according to Laszlo and Krippner [1998] or information systems design [e.g. Mumford, 2000]) may prove an avenue for arriving at a basic approach for organisational design; its use has been limitedly reported.

## **2.5 Evaluating the Four Approaches**

It should be noted that sometimes other authors combine elements of these approaches. For some specific cases, this might have happened without authors acknowledging it fully. In addition, some of the principles for design of lean manufacturing systems have been connected to socio-technical systems design, e.g. Dankbaar (1997) and Niepce and Molleman (1998). However, no studies exist that provide an extensive comparison about the appropriateness of these methods.

Furthermore, these approaches lead limitedly to so-called 'technological rules', seen as keystone for 'design science' in management. This term 'technological rules' means 'a chunk of general knowledge, linking an



intervention or artefact with a desired outcome or performance in a certain field of application', according to van Aken (2004, p. 228). Perhaps the term is not described adequately, but refers in the context of organisational design for manufacturing to the performance linked to organisational structures. Note that also Schmenner and Swink (1998) provide these rules in the form of theories but these have not been tested either. It implies that 'technological rules' for organisational design have been weakly developed.

Also, there is lack of formal methods. Even for specific sectors the lack of works on organisational design has been mentioned. For example, Lega (2007, p. 258) remarks that there is a significant lack of works on 'design issues' in the literature on organisational design for integrated delivery systems in health care. Ruffini et al. (2000) note this deficit in literature, although they attribute it to organisational theory and approaches of operations management being insufficient for organisational design; it also appears in van Aken (2004, 2005) and Pandza and Thorpe (2010) in a generic perspective. It means that an integrated approach for organisational design hardly exists that tackles all these facets.

### **3. Design in Management Science**

In addition to the lack of adequate comparative studies for the four established approaches, the characteristics of organisational design have been poorly considered.

#### **3.1 Defining a Design and Engineering Perspective**

As already noted by some scholars (e.g. van Aken, 2004; van Aken and Romme, 2009; Pandza and Thorpe, 2010), though sometimes from opposing views, a design and engineering perspective takes meeting requirements as starting point. These can be elicited from the actors in the company. The requirements are used to compare solutions for a given problem and then the selected solution is detailed. The iterative nature of processes during product design and engineering (for instance, Chao and Ishii, 2003, p. 2; Pahl et al., 2007, pp. 126, 410–38; Radhakrishnan and McAdams, 2005, p. 378) implies that early decisions may be revisited later and might be changed due to incorporate progressive insight about requirements, and available technological capabilities; it can be assumed that this applies to the design of manufacturing organisations, too.

#### **3.2 Four Characteristic of a Design and Engineering Perspective on Organisational Design**

What does the design and engineering perspective mean for the design of manufacturing organisations? First, the setting of competitive priorities, often called manufacturing capabilities, or poor performance is its starting point. Second, the organisational structure needs to be adapted to specific business models, technologies, resources and supply (and sometimes available facilities), though not to be confused with the more generic contingency approach. Third, principle solutions need to be transformed into detailed solutions. Fourth, detailing principle solutions is an iterative process resulting from infeasible or unacceptable trade-offs during successive stages. These characteristics suggest that the structure of manufacturing organisations is a result of inductive and teleological methods, similar to product design and engineering (from eliciting requirements to detailed instructions for production and use); this conjecture raises the question whether an engineering perspective is a more appropriate representation for the design of organisations than the four traditional approaches.

These characteristics also confirm that factually none of the four traditional approaches embeds any of the principles of the engineering perspective. In addition, there are some disagreements about the effectiveness of specific organisational design approaches (e.g. Fiss, 2007; Winter, 2010) and specific organisational designs (e.g. Adler and Cole, 1993; Berggren, 1994). In that sense, the design and engineering perspective provides a more coherent view on stages and iterative cycles.

### **4. Research Methodology**

To demonstrate the suitability of the engineering perspective based on the characteristics of organisational design, action research has been undertaken at a manufacturer of agricultural machinery.

#### **4.1 Rationale for Action Research**

The choice for action research as an appropriate method is rooted in three reasons. The opportunity to investigate the production at this company is both a deviant case and a critical case at the same time, using Flyvbjerg's (2006, p. 230) terminology. The study can be considered deviant since the agricultural industry is characterised by seasonal demand and production; this causes specific problems with forecasting and capacity planning. The case is also a critical case owing to the fact that the approach to analysis and design of the organisational structure might be applicable to a wider range of instances for production. The second reason for action research comes from Meredith



(1998, p. 452) who states that case studies and field research will yield contextual richness that otherwise is more difficult to attain. Finally, action research also allows feedback on the intervention (Westbrook, 1995, p. 9), and such could lead to reflection on its effectiveness and in this case also about deliberations on the method followed. Thus, the case allows to investigate the analysis and design of organisational structures for production, albeit in a specific context, and to evaluate both the effectiveness of the intervention and the 'design and engineering' approach.

## 4.2 Data Collection

In that respect, the case represents an in-depth-study of 8 months, comprising of both the analysis of the specific problem of the company and the detailing of the solution. Interviews have taken place with the management team, relevant department managers and operational staff. The collection of data and the interviews were repeated and complemented until a complete picture emerged of (i) the performance of manufacturing (ii) the operational control mechanisms for managing production and (iii) organisational structures, incl. lay-out. Additionally, the analysis was continued until there was a clear relationship between the original problem statement and root causes. After the analysis, a principle solution was designed and eventually implemented. Hence, this case study describes the initial phase of the analysis to the implementation and decisions that were made during these stages.

The single case study discussed in this paper meets the four criteria for evaluating quality of empirical research design commonly used in social research that can be found in Yin (1994, pp. 33–38): construct validity, internal validity, external validity and reliability. Triangulation (Jick, 1979, p. 602) was used for construct validity by using observations, quantitative data and interviews. In addition, triangulation provides 'greater insights than [...] a single research methodology' (Mangan et al., 2004, p. 565) and helps to minimise potential self-reporting bias. Internal validity was found by comparing the results of this study with those of other published materials in academic literature. Subsequently, external validity was inherent in this study because it allowed cross comparison and validation between the three cases. Finally, reliability was achieved as the data collection and case analysis was closely monitored by two academics with the help of key personnel from the case organisation. Hence, the case study provides a sufficient base for the in-depth investigation.

## 5. Case Study

To demonstrate the suitability of the engineering perspective based on the characteristics of organisational design, action research at a manufacturer of agricultural machinery serves as example; the company experienced problems with aligning inventory of finished products with seasonal demands and the related planning of production. The study covered the analysis of the existing organisational processes and structure, the evaluation of principle solutions, the redesign based on the most effective structure, the layout and the implementation of the solution.

### 5.1 Case Description

The company is part of conglomerate that is one of the largest specialised producers and distributors of agricultural equipment and viticulture implements in the world. This specific subsidiary, about 200 employees, produces various agricultural machines of three types: mowers, sprayers and spreaders. The annual production figures were: 8.398 spreaders, 4.762 mowers and 452 sprayers. The investigation was narrowed down to the production process of two mowers: one that is pulled by a tractor (KM) and one that is mounted on the tractor (FM); each of them were delivered in varying sizes and with different options.

### 5.2 Analysis of Performance and Processes

The seasonal demand for mowers had resulted in a strategy of keeping products in stock for swift delivery to customers. This strategy was induced by competitive pressures, in which short delivery times and competitive pricing were the most essential ingredients for sales in the market for agricultural equipment, with relatively low margins. To this purpose, as a first step in the analysis, the sales, production and inventory levels were looked at for the two types of selected mowers, see Figure 1. These figures show that the inventory of mowers ready for sale is relatively high, 31% on an annual basis. It could also

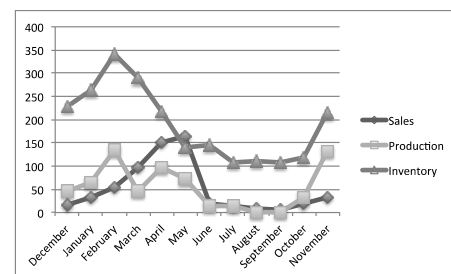


Figure 1: Monthly figures for sales, production and inventory of KM and FM mowers (in units).



be hypothesised that the (method for) forecasting is inadequate. To evaluate its adequacy, the forecast for individual variants was compared with actual sales for a period of four months. It showed that the forecast at an aggregate level did not match with actual sales; 21% more sales were recorded. This was caused by deviations of the forecasted sales for individual types ranging from 50% to 250%. Furthermore, ten new variants were introduced and two phased out compared to the original forecast containing only ten types. In addition, the production of the FM and KM mowers was affected by seasonal demand. The assembly of the mowers started at the end of October and finishes at the end of June. As could be expected, the production peak was positioned slightly ahead of the sales' peak of the mowers. Because efforts in the past to improve forecasting had had little effect, the only realistic option was to increase the responsiveness of production, while reducing inventory levels.

To corroborate the initial findings, further analysis took place of the make-to-stock strategy with regard to costing and expenditures. First, it appeared that within window of 12 months, 21 mowers from the inventory had been converted to enable sales; these conversions took place during peak periods in spring and early autumn. The company did not record expenditures well, but it was known that these conversions had disrupted planning of the regular production, including supply of materials and work allocation. Second, a costing was carried out of inventory levels in relation to the cost price. Uncertainty about underpinning data was caused by the storage of finished mowers externally to the plant; these expenditures and costing were hidden in regular budgets. Using estimating techniques, the consensus was that costs of inventory should be put at about 15% of the cost price. Third, it became clear that the floor space was used at its maximum capacity; management indicated that they did not want to increase use of floor space and consequently ruled out any investments for such. These findings implied that costs related to inventory are relatively high due to incongruences between forecasting and actual production, and that a solution to a responsive production system was to be found within the current production facility.

### **5.3 Bottlenecks Production Processes**

The investigation continued with reviewing order processing and searching for root causes related to inventory levels of stocked mowers. At the highest level of aggregation, the production processes for the two types of mowers have equal transformation steps. At a more detailed level, differences do exist between their production processes, however, these do not have any impact on findings for the overall control of the production process. The analysis arrived at the following findings for the order processing:

- Because orders are not always congruent with stocked mowers, sometimes the delivery times are very long or costly (make-to-order or conversion from stock) or the product will not be made at all.
- Due to the seasonal influence there is an alternating over- or under-capacity present in the factory.
- The analysis of the supply of raw materials, parts and components revealed:
  - Some materials and some parts have long lead times.
  - Some parts are delivered beyond the scheduled dates.

For the delivery of finished products and stock replenishment, it was concluded that:

- The inventory levels exceed the required minimum levels largely due to inaccurate sales predictions and to safeguarding against loss of sales revenue caused by unavailability.
- The wrong machines are kept in inventory during sales peaks resulting in conversion of already finished mowers into types requested by clients.
- The mowers are getting more complex and more varied, making them even more expensive to keep at stock. This indicates the need to develop a control and production system that reduces stock to acceptable levels.
- The capacity of the manufacturing process is insufficient to cover seasonal peaks, making make-to-stock inevitable.

Moreover, in the existing assembly line, production management and workers struggle daily to free necessary workspace for parts and assembly activities.

### **5.4 Development of Criteria for Design Alternatives**

The criteria that the solutions for the responsive production systems will have to meet were:

- A short delivery time of end products to the customers; the target off-season and sales peak.
- The mower production process should be able to operate as both assemble-to-order and assemble-to-stock. The seasonal sales do not allow solely assembly-to-order because of the difference between off-season sales levels and sales peaks.
- A reduction of costs mainly through a reduction of inventory. Current costs include the costs of inventory, the conversion costs, and the costs of operational logistics at the shop floor.



### **5.5 Generation of Solutions**

The solutions to solve the bottlenecks covered an ERP system, a production line only, group technology and a redesign of the assembly process based on a production line for frames with docks for final assembly.

### **5.6 Detailing of Chosen Solution**

The redesign of the assembly process consists of the following adjustments:

- Assembly of the machines in a dock structure.
- Changing the customer order entry point aka customer order decoupling point (for an explanation of these points, see: Dekkers, 2006; these are ).
- Modification of the organisation and the control of the production process.

By producing in a dock, the mix-flexibility of the process increases. The proposed structure (one module dock, one T-dock, one R-dock, one kart-dock, and one final assembly dock) has a nominal capacity of one hundred mowers a month. Because of the seasonal influence, a stock level of 115 mowers is required, just before the peak of the sales season. The number of orders remains relatively constant throughout the year which has the following advantages:

- Less docks are required and a larger part of the assembly is done by the company's employees rather than involving large numbers of workers recruited through employment offices.
- The assembly of series of specific types is still possible.
- The stock levels can be regulated much more easily.
- The process can be adjusted quickly when the reliability of the sales prognoses increases.

Changing the Customer Order Entry Point means changing AgriCo from a make-to-stock company to an assembly-to-order company. The Customer Order Entry Point is placed before the final assembly. As a consequence, during the season it will be possible to produce a subassembly and all the required parts for final assembly for an order in just one day. Off-season, it will be possible within two or three days.

The production process before the Customer Order Entry Point will be initiated by the forecasts, the process after the Customer Order Entry Point will operate on orders. The main control principles in the entire process are: adjusting the intake of orders, giving orders priority and steering of capacity.

### **5.7 Actual Implementation of Solution**

When this proposal is implemented, the final stock will decrease with at least 50%, while the stock in between sub- and final assembly will only increase with 12%. The process will be easier to control and AgriCo's own staff can do a larger part of the assembly. This implies a reduction of costs with at least € 136.000,- .

The embedded case study concerns the processing of orders in production and the management of supply. The trigger for this investigation was the increasing difficulty of materials being available for specific customer order. The study covered the analysis of the existing organisational structure, the evaluation of principle solutions, the redesign based on the most effective structure and the implementation of the solution.

Initially, ERP, then implemented.

## **6. Discussion of Findings**

The solution is not a straightforward solution that needed to be modified. This confirms the design and engineering perspective that solutions are iteratively detailed to fit with the requirements of the specific situation under consideration.

For that purpose, a systematic process for analysis and design was used, underpinned by systems theories for process modelling. In alignment with Worren et al.'s (2002, p. 1233) statements about pragmatic theories, the description of the case study was extensive to show how the solution was created. The approach followed is commensurate with the stance of van Aken (2004), and van Aken and Romme (2009) about the position of 'design' in management science. It does not support Pandza's and Thorpe's (2010, p. 178) contention that 'irreversible solutions' are created, because akin engineering the design of the organisation was determined in advance of its realisation; hence, the firm of the case study could also have decided not to implement the proposed structure. In fact, it did so, when first purchasing an ERP system and when that did not resolve any of the performance issues for manufacturing, implement this solution. It may well be that design of organisational structures for manufacturing will benefit from systematic analysis and design adopted from engineering.



## **7. Concluding Remarks**

The interplay between the analysis into root causes and the redesign of the organisational structure, yields not only insight about the effectiveness of this fifth approach but also about the limited relevance of the four traditional perspectives. The case study highlights that the organisational structure is best approached from an engineering perspective. This approach can be complemented with the socio-technical approach to capitalise on the capabilities and skills of employees. Hence, the core of the design of organisational structures for manufacturing organisations is best served with derivations of the principles and methods of engineering. Furthermore, the degrees of freedom and heuristics also explain why seemingly similar organisations might arrive at significantly different organisational structures.

### **7.1 Limitations of Study**

Since it is difficult to prove that one method works better than another one, it is not possible to deduce from a single case what outcomes could be achieved. The only way to compare would be using the same case for different methods; *'the best material model of a cat is another, or preferably the same, cat'*, said Norbert Wiener, one of the founders of cybernetics, together with Rosenblueth (1945, p. 320). Since this is not feasible, the comparison between the five approaches will consist of different cases with different methods.

That variety applies also the contingencies for which cases which solutions are optimal. Because of the design and engineering perspective, both the analysis and the design use heuristics. If the actor or stakeholder approach was followed further convolution might be due to interventions of the company and the actors; in this case, this already happened through the delay for the intervention. When the other chosen solution, the ERP-system, did not bring the expected improvement in performance, only then this more intricate solution was implemented.

Finally, even though this study takes a snapshot of an organisation, the long-term effects of the solution are not known. Hence, the solution of changing the organisational design should be placed in the context of its long-term development. Greiner (1998) does so for a wide range of organisational aspects but his study connects weakly to the structure of organisations, specifically for manufacturing. Building on the thoughts of Greiner, Dekkers (2005, p. 379) proposes to connect organisational structures to transitions during the growth of organisations. However, a better connection needs to be made between changes in organisational structures of an organisation as intervention and long-term performance of companies.

### **7.2 Implications for Managerial Practice**

Moreover, practitioners might benefit from the approach because it does not take a rigid choice as starting point, but rather relies on further considerations during the stage of detailing principle solutions that sometimes results in iterations for the most suitable organisational structure. The study supports Holmström et al.'s (2009, p. 81) plea that theoretical knowledge improves the solution (and the analysis in this case). That also means that perhaps not the specific solution is the focus but how academics and practitioners can work together to create knowledge (see Susman and Evered, 1978; Tranfield et al., 2004). In this case the co-production of knowledge addressed an approach for operations management.

Furthermore, the systematic approach to the analysis and design of organisations may be helpful in achieving improvements. Though the particular approach was based on systems theories, the generic steps of analysis and design are applicable across a wide range of settings for organisational structures for manufacturing.

### **7.3 Implications for Teaching Operations Management**

The systematic approach to analysis and design of organisation accords with Dunne's and Martin's (2006, p. 521) call for inclusion of design thinking in management education. The cases demonstrate that contingencies influence the specific solution or implementation for organisational design. It is important to note that this goes beyond the often two-dimensional approaches to structuring in textbooks about operations management; the figures in the textbooks of Jacobs and Chase (2014, p. 151) and Slack et al. (2010, p. 92) are cases in point for this perhaps outdated, simplified view. Such a two-dimensional approach to design of organisation reeks of a positivist approach and befits less the post-positivist approach of case studies and field studies. And the approach for design of organisations may align well with the advantages of problem-based learning, particularly for knowledge integration (Smith, 2005, p. 363). Therefore, it may be that organisational design has been undervalued for management education, because it relies more on both heuristic and systematic approaches to organisational structures.



## **7.4 Directing Research**

Finally, given the limited precedence in literature, further research is necessary on the design and engineering perspective, though the participatory view might be initially prevalent and present due to the nature of organisational design. This further research can hardly be resolved by positivist studies; more adequate approaches will be action research and case studies, adding to the methodological pluralism as advocated by Flynn et al. (1990) and Meredith et al. (1989) for operations management and Jackson (1999) for management science in general.

Further research should lead to include also guidelines and adequate descriptions of the methods used for organisational design of manufacturing. That also concerns which 'technological rules' informed by which theory involved. Furthermore, the trade-offs during design and the iterations should be reported, too. Finally, there should be clear statements about the outcomes and performance improvements.

## **7.5 A Final Thought**

Whereas many in management science will have the viewpoint that this is a social science, for the design of organisational structures, an engineering perspective may be more beneficial. That requires that those that critically review extant literature on this matter to take a wider perspective.

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## **Biography**

**Rob Dekkers** is a Reader in Industrial Management at the Adam Smith Business School (University of Glasgow). He holds a doctoral degree and master's degree from Delft University of Technology. Before joining Delft University of Technology in 1992 he has worked as internal management consultant, production manager and senior project manager. From 2006 he was employed at the University of the West of Scotland and from 2014 at the University of Glasgow. He has (co-)authored more than 150 interdisciplinary contributions about innovation and technology management, industrial networks, manufacturing strategy, operations management and system theories. Furthermore, he is actively engaged in the provision of doctoral workshops, particularly the IFPR Early Career Researchers and Doctoral Training Programme.