

How to Cope with Environmental Uncertainty: An Integrated Flexibility Framework for Manufacturing Companies

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Abstract

Flexibility has received much attention, but an important question has not been answered: How can a company properly derive the needed flexibility based on environmental uncertainties?

The contingency theory states that there has to be a fit between a company's structure and its environment. This leads directly to the conclusion that in uncertain and unknown or quickly changing conditions a company should be more flexible than in stable environments to cope with these changes. Traditional structures in manufacturing companies, such as derived from mass production, are no longer sufficient to ensure success in today's business landscape. The future of manufacturing companies seems to lie in more flexibility.

Flexibility is a multi-dimensional concept and every company seems to have a different understanding of it. To cope with these different understandings, we have developed a conceptual framework to derive the needed degree of flexibility from the environmental context and to break it down into different forms of flexibility. Based on this framework, a balanced scorecard will be developed for the controlling of changes in flexibility. The use of the framework will be demonstrated by means of seven case studies from European manufacturing companies.

Introduction

Global competition, rapidly changing technology, and shorter product life cycles have contributed to making the current manufacturing environment extremely competitive. Organizations face significant uncertainty and continuous change. Traditional manufacturing approaches, such as mass production systems, are no longer sufficient competitive weapons by themselves (Koste & Malhotra, 1999; Skinner, 1969).

The future of production in high cost countries seems to lie in a superior flexibility enabling industrial companies to provide technically advanced customized products at competitive costs and grasping opportunities when they arise. The only way to respond to low-cost standardized items from abroad is to offer wide varieties of technologically superior or customized products aimed at specific market niches (Gerwin, 1993).

The goal of this paper is to show companies how they can evaluate the required types of flexibility to stay competitive in their specific environment. Therefore we are introducing an integrated framework.

The paper starts with the introduction of the used methodology, followed by a literature review. In the third part, the integrated flexibility framework is introduced and different types of flexibility are derived from the framework.

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Methodology

Research sites

The research is based on an action research project involving seven manufacturing companies in Western Europe. All of them are confronted with an increasingly complex and dynamic environment. Action research, which was developed by Lewin (1946), is a model for responding to problems perceived in social action. Lewin originally defined action research as an approach that "consisted in analysis, fact-finding, conceptualization, planning, execution, more fact-finding or evaluation; and then a repetition of this whole circle of activities; indeed a spiral of such circles" (Dickens & Watkins, 1999; Lewin, 1946). In practice, action research is a circle between analyzing a situation and reconceptualizing or reframing that situation (Dickens & Watkins, 1999).

Action research is seen as a valid method for examining the plausibility of theories or to formulate new hypotheses (White, Greenwood, & Lazes, 1991). We first conducted a desk research to build a framework in theory and afterwards used action research to validate the findings. The starting point of the paper was the fact that through globalization in combination with more demanding customers the environment of manufacturers in Western Europe has become more and more competitive and dynamic, therefore demanding more flexibility. We have developed a framework to figure out what types of flexibility are needed to stay competitive as Western European manufacturer. The framework was discussed with the companies and the respective processes were carried out in all companies separately. The findings have been analyzed and projects to implement the flexibility types have been prepared and carried out.

Unit of analysis

The unit of analysis is separated in two main modules.

The first is the decision-making process of how flexible a company has to be in a dynamic and fast changing environment and includes the three phases: environmental analysis; analysis of the strategy as well as the external success criteria (ESC); the capabilities and the needed flexibility of how to reach the strategy.

The second module includes methods of how to achieve the derived level of flexibility as well as the controlling of the change of the flexibility level. This module (phases four and five) includes the derivation of measures to deliver flexibility in the specific cases and the development of performance measurements summarized in a balanced scorecard of flexibility.

Data collection

During the period of decision-making the authors participated in more than 15 internal workshops at top and middle management level of each company participating in the research project. These workshops covered a variety of topics and have been documented by internal protocols. All records were reviewed by the participating employees and managers in order to ensure valid and accurate documentation. The observation process also included critical semi-structured review discussions with the internal project team as well as with middle and top management.

Theoretical introduction

The research question necessitates a discussion of the various theoretical foundations. The research is based on the related aspect of flexibility, especially concepts to analyze the amount of flexibility needed in a specific environment.

The conducted research on flexibility is quite diverse and there are different definitions. The following section highlights different flexibility discussions and illustrates our understanding of flexibility.

Upton (1994) defined flexibility as "the ability to change or react with little penalty in time, effort, cost or performance" and Hitt *et al.* (1998) defined strategic flexibility as "the capability of the firm to pro-act or respond quickly to changing competitive conditions and thereby develop and / or maintain competitive advantages."

Strategic flexibility is necessary when the organization faces unfamiliar changes that have far-reaching consequences and needs to respond quickly. The issues and difficulties relating to strategic flexibility are by definition unstructured and non-routine. The signals and feedback received from the environment tend to be indirect and open to multiple interpretations, "soft" and "fuzzy" (Volberda, 1996).

Flexibility has been recognized as a multi-dimensional concept (Gerwin, 1993) that can be either reactive or proactive in nature (Koste & Malhotra, 1999). The reactive nature of flexibility addresses the environmental

uncertainty (Slack, 1983). The proactive nature of flexibility allows an organization to pro-act in uncertain market conditions and fulfill customer expectations in a particular industry (Upton, 1995).

Flexibility can also refer to potential, actual and required flexibility of an organization (Koste & Malhotra, 1999). Actual flexibility stems from utilization of the plant and is determined on the basis of experience. Potential flexibility indicates what occurs given the existing plant design if external conditions are appropriate. Requirements represent strategic management's determination of how much is needed of a particular type of flexibility (Gerwin, 1993).

Flexibility is often referred to as related to manufacturing systems. In particular, manufacturing systems must be capable of adapting to shifting product demands, shorter product life cycles, higher product variety, shorter delivery times and higher quality. In this context, both investing in flexible technologies as well as adopting flexible production control practices are increasingly recognized as being critical to the success of any manufacturing organization (Benjaafar & Ramakrishnan, 1996).

Although flexibility is a well known topic, there seems to be no common understanding. Flexibility has not increased because an organization has developed a capability to deliver "better, quicker and cheaper" (Hamblin, 2002). Moreover, current definitions are imprecise. Swamidass (1987) has attributed the problem of understanding flexibility to three underlying problems: the scope of flexibility-related terms used by various authors overlap; some flexibility terms are aggregates of other flexibility terms; identical flexibility terms used by various authors do not necessarily have the same meaning (Bernardo & Mohamed, 1992).

We understand strategic flexibility as an instrument to support superior goals (viability). It needs to be derived from a permanent analysis of a firm's specific environment and allows for a determination of the level of flexibility needed. Flexibility is the ability to answer changes with changes. For this reason, a firm has to profoundly understand its actual situation (its competitive position). Strategic flexibility is especially important today as a response to environmental uncertainties (Gerwin, 1993). These uncertainties are more complex and dynamic than ever (Hitt *et al.* (1998), D'Aveni (1995), Bettis *et al.* (1995)). In order to address flexibility, manufacturing enterprises have to consider some of their characteristics as high investment costs, pressure for globalization and quickly changing markets.

Flexibility, as understood in this paper, is needed to make companies in fast changing and complex environments competitive. The problems identified above, e.g. flexibility not being measurable unless they are on the same level (Gerwin, 1993) are not a pitfall for this paper because the measures are defined and implemented on different and company-specific levels. This is also supported by the approach applied to theory building. Porter (1991) distinguishes between two broad alternatives to theory building, the approach of building a model or a framework. The model building approach has been characteristic for the last few decades. These models provide clear conclusions, but are highly sensitive to the assumptions underlying them and to the concept of equilibrium. The development of a framework, as done in this paper, has the advantage that the theory in the framework is contained in the choice of included variables, the way variables are organized, and the interactions among the variables. Moreover, it subsumes the way in which alternative patterns of variables and company choices affect outcomes. The equilibrium concept of a framework is imprecise, reflecting the continually evolving environment. If a company decides to strive for more flexibility, its decision will always be on the strategic level. The developed integrated flexibility framework is an ideal method to communicate the new vision and the strategic shift to more or less flexibility as well as the implementation and measurement of the strategic shift.

Flexibility concepts

The following section highlights five widely cited flexibility concepts (see figure 1). We will analyze them on their ability to support managers in deriving an appropriate level of flexibility. Based on the findings we will suggest our own framework.

Gerwin's (1993) framework (see Appendix A) involves five variables: environmental uncertainty, strategy, required manufacturing flexibility, methods for delivering flexibility and performance measurement. The framework, a unification of theoretical research on flexibility is targeted at exploring the interactions of the above-mentioned variables. Environmental uncertainty is the starting point of Gerwin's conceptual framework, including the idea that flexibility can be considered as a reactive and proactive response to the environment. Gerwin identifies, out of the framework's various path traces, four generic strategies labelled adaptation, redefinition, banking and reduction which have different implications for the required flexibility. Driven by the need to show manufacturing managers how to evaluate and change flexibility, Gerwin has developed a procedure for the implementation of the desired changes in flexibility. His procedure to make the conceptual framework applicable, to be seen as a rough guideline rather than a finished product, contains four phases. During the first phase, the managers identify the flexibility dimensions which need further investigation. To analyze the relevant flexibility gap the actual, required and potential flexibility will have to be determined in phase two. Phase three selects methods for closing the gaps and phase four involves continuous assessment (performance measurement).

Aaker and Mascarenhas (1984) describe a flexibility audit which includes an objective as well as a subjective assessment. In both assessments, fields such as Research and Development, Finance, Operations, Marketing, International and Managerial / Structure are discussed. Based on this audit, a company should be able to make a flexibility decision. The decision should be made in three steps which are the identification on the environmental changes, the evaluation of the potential environmental changes and the flexibility option for each identified and screened environmental change.

Hitt *et al.* (1998) state that a new competitive landscape has arisen in the 21st century based on the technological revolution and the globalization of the last few years (see Appendix B). The new competitive landscape is characterized by an increasing strategic discontinuity and disequilibrium conditions, blurring of industry boundaries, hypercompetitive markets, extreme emphasis on price, quality and satisfaction of customer needs, increasing focus on innovation and continuous learning and changing career dynamics and employee expectations. To cope with this new competitive landscape, Hitt *et al.* demand strategic flexibility in each company. To develop this strategic flexibility, a company should build dynamic core competences, focus and develop human capital, effectively use new technologies, engage in valuable strategies and develop new organizational structures and culture.

Abdel-Malek *et al.* (2000) describe a method to gain more flexible manufacturing (FM) solutions. They divide the method in three phases. The first phase covers the identification of the environmental changes which includes a manufacturing flexibility audit (see Appendix C). In the second phase a flexible manufacturing solution is designed. This phase includes the steps of identifying potential flexibility, evaluate the needed flexibility, evaluate the needed level of the identified flexibility types, the generation of measures for the needed flexibilities and a detailed process plan for the implementation of the solution. The third phase is an economic analysis and contains the step of evaluation the potential benefits in economic terms. After these three phases, a company should know exactly what flexibility is needed in the specific environment and by then have implemented the flexibility as well as measured the economic value of the increased flexibility.

Suarez *et al.*'s (1991) framework consists of three interrelated sets of variables: (1) the different types of flexibility, (2) factors that affect a firm's need for each type of flexibility and (3) factors which affect the implementation of each type of flexibility at the corporate level (see Appendix D). The four general types of flexibility (the flexibility concerning mix, volume, new product and delivery time), chosen from the many types discussed in the literature, appear to have special relevance to linking operational capabilities with managerial strategy. The second part of the framework contains five factors affecting the need for flexibility (product strategy, competitor behaviour, demand characteristics, product life cycle, end-product characteristics). Having identified the relevant dimension and the company-specific need of flexibility, the next step will focus on the different ways of implementing each type of flexibility. Suarez *et al.* (1991) derive out of a literature review seven possible flexibility source factors for the implementation of the flexibility requirements analyzed above (production technology, production management techniques, product development process, workforce skills and training, labour policies, supplier and distributor relationship, accounting and information system). They conclude their framework with the hypothesis that there should be a measurable impact of the "fit" between the need for flexibility (1) and how well firms respond to these needs (2) in their performance.

Author	Environment	Strategy (external success factors)	Flexibility (internal success factors)	Methods for delivering flexibility	Performance measurement
Gerwin (1993)	Environmental uncertainty	Corporate strategy	Required manufacturing flexibility	Methods for delivering flexibility	Performance measurement
Aaker & Mascarenhas (1984)	Environmental changes		Evaluation of potential environmental changes	Flexibility options for each identified and screened environmental change	
Hitt <i>et al.</i> (1998)		Efficiently use new technologies; engage in valuable strategies	Build dynamic core capabilities; focus and develop human capital		
Abdel-Malek <i>et al.</i> (2000)	Identify environmental changes			Design a flexible manufacturing solution	Economic analysis
Suarez <i>et al.</i> (1991)	Environmental uncertainty	Need of flexibility based on external factors	Need of flexibility based on internal factors	Implementation of flexibility	

Figure 1: Comparison of the different frameworks

The need to figure out the environmental dynamics is a key factor of the analysis of Gerwin (1993), Aaker and Mascarenhas (1984), Abdel-Malek *et al.* (2000) and Suarez *et al.* (1991). According to the contingency theory, there has to be a fit between a company's structure and its environment (Drazin & van de ven, 1985). This leads directly to the conclusion that in uncertain and fast changing environments industrial companies need to be as flexible as possible to make changes. Whereas the analyses of Gerwin's (1993), Hitt. *et al.* (1998) and Suarez *et al.* (1991) involve the determination of external success factors to translate the environmental variables into the appropriate level of flexibility, this important connection is a missing link in the analyses of Aaker and Mascarenhas's (1984) and Abdel-Malek *et al.* (2000) respectively. The need of an element including the translation of the environmental variables or external success factors into organizational variables is reflected through the identification of this step by four out of five analyzed frameworks (except the procedure of Abdel-Malek *et al.* (2000)). The discussion of the set-up of the appropriate level of flexibility through measures is part of all analyzed frameworks (with exception of the research by Hitt. *et al.* (1998)).

Only Gerwin (1993) and Abdel-Malek *et al.* (2000) have identified the need of an ongoing controlling to ensure that the measures implemented are as goal-oriented as expected.

The elements of our integrated flexibility framework goes further than any of the frameworks introduced in the section above. Based on action research, the five elements, i.e. analysis of environment, identification of internal and external success factors, implementation of measures and finally the performance measurement were introduced. The framework is a holistic one and combines all strengths of the frameworks presented above. In addition, the framework overcomes the weakness that flexibility cannot be generated with a focus on the manufacturing level alone, but has to take the whole company into consideration. This can be done by defining the adequate activities, the needed supporting structure and the appropriate culture (Giddens, 1984). Therefore, the frequently analyzed manufacturing flexibility becomes one part of an overall flexibility. We have expanded the level of research to the corporate strategy which has a close interaction with the manufacturing strategy. This expansion of the research from the manufacturing to the corporate level is also supported by Suarez *et al.* (1991) who see the need for future research not merely at the level of manufacturing machinery or production lines but at multiple levels. Further research activities have been influenced by this shift of analysis scope and we had to analyze different organizational dimensions on their potential to deliver flexibility. Out of the analysis of thirty strategic projects, Friedli (2005) identified four relevant flexibility fields: scope, resources, structure and human resources.

The elements identified above have been translated into five phases introduced in the section below.

An integrated flexibility framework

To derive the appropriate level of flexibility from the environmental specifics as well as the positioning of the firm and to break it down into different forms of flexibility, we have developed an integrated flexibility framework.

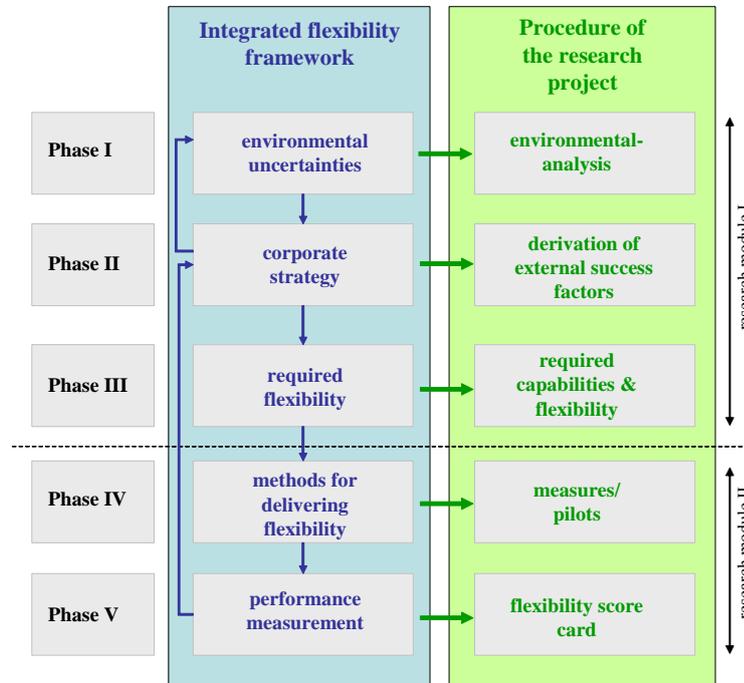


Figure 2: Integrated Flexibility Framework and Procedure

This framework contains five phases: environmental uncertainty, corporate strategy, required flexibility, methods for delivering flexibility and performance measurement. These phases and the procedure to make the framework applicable will be discussed in the following section.

Phase I contains the analysis of the environmental uncertainties to consider the factors determining the needed degree of flexibility. In analogy to the contingency theory, the framework assumes a fit between a company's structure and its environment (Drazin & van de Ven, 1985). This leads directly to the conclusion that in uncertain and unknown or quickly changing conditions a company should be more flexible than in a stable environment. Traditional structures in manufacturing companies, often derived from mass production environments, are no longer sufficient to ensure success in today's increasingly dynamic business landscape. The future of manufacturing companies seems to lie in more flexibility. To capture the relevant environmental factors influencing the appropriate amount of flexibility, a deep understanding of the relevant environment has to be generated which can be attained through a PARTS analysis (PARTS = Player, Added value, Rules, Tactics, Scope) (Brandenburger & Nalebuff, 1995). The PARTS analysis is a game-theoretical expansion of the industry analysis (Porter, 1985) where, in addition to the analysis of the players, the added value, tactics, rules and the scope of the players are analyzed. The game-theoretical expansion helps to anticipate the environmental uncertainties and builds the basis for the strategic discussion in phase II.

To achieve the desired fit of context and structure, the second phase contains the analysis of an appropriate corporate strategy. Swamidass *et al.* (1987) state that environmental uncertainty influences manufacturing strategy variables. Many other researchers also focus their analyses on the manufacturing strategy (e.g. Gerwin (1993), Koste *et al.* (1999)), the authors have expanded the perspective to cover the corporate strategy. The exploration of the suitable flexibility involves different corporate decisions including those on the product/service strategy, manufacturing, and human resources strategy and, derived from this, the decision on the organizational structure. The implications of these functional decisions are connected and cannot be analyzed on their own (Ghani & Jayabalan, 2000). To clarify the corporate strategy and the positioning of the company in the analyzed companies, possible strategic options based on the market analysis were discussed. These strategic options are based on external success criteria (ESC) as well as on internal success criteria (ISC) (Faulkner & Bowman, 1992) which we defined as capabilities. Faulkner *et al.* (1992) describe the ESC as perceivable factors that influence the buying decision, which vary from market to market (e.g. price, reliability, brand name or perceived quality). Comparing the ESC, which can be derived out of the environmental analysis, with the

corporate strategy helps to outline gaps between the formulated corporate strategy and the required strategy derived from the environmental analysis. The result of the second phase is a clarified strategy with clearly identified ESC based on the analyzed market specifications.

The third phase of the integrated flexibility framework contains the analysis of the required flexibility based on the identified market dynamics. As during the second phase we expanded our focus from the manufacturing to the corporate level, this level has to be kept for the analysis of the appropriate flexibility. This expansion implies that different strategic and organizational dimensions have to be analyzed on their impact on strategic flexibility. To derive the appropriate amount of flexibility two analyses have to be carried out. The first analysis involves the deduction of the company's required and existing capabilities to fulfill the formulated ESC. The gap between the required and the existing capabilities gives input to the needed degree of change. The second analysis of the third phase involves the translation of the market dynamics and the corporate strategy into a required level of flexibility. The expansion from the manufacturing to the corporate level needs a definition of the relevant corporate dimensions where strategic flexibility can be influenced. Out of former research activities the authors identified four flexibility fields: scope, resources, human resources (HR) and structure (Friedli, 2005). The fields have two axes which make up a coordinate system.

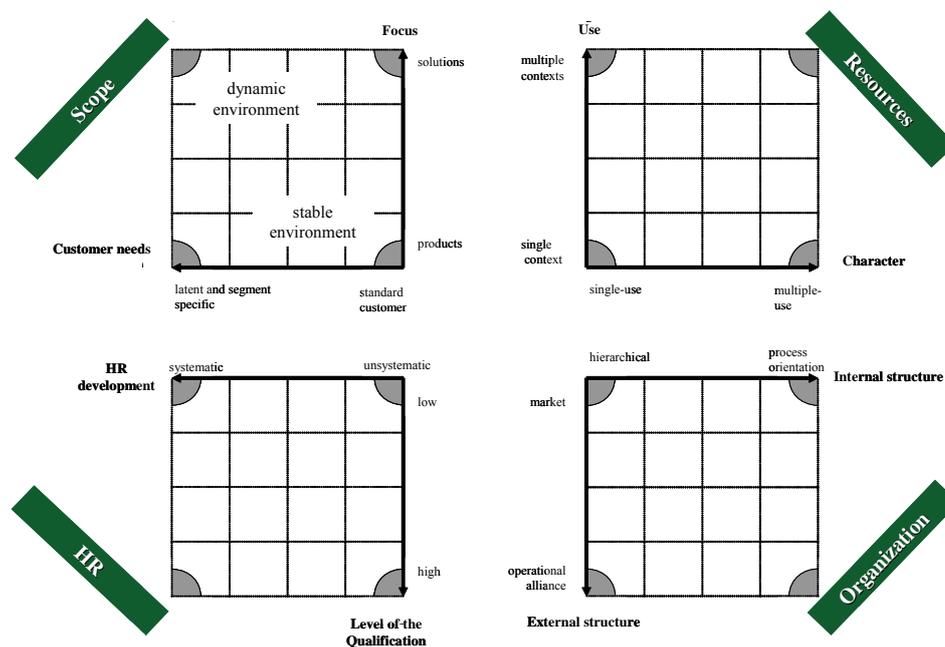


Figure 3: Fields of flexibility

The intersection point represents an appropriate alignment in a stable environment and the ambient point of the axis represents a dynamic environment. The axes are understood as areas of tension which reflect the dilemma of modern management (e.g. needed continuity versus required dynamics or customization versus standardization). With the positioning in these tension lines the appropriate level of flexibility can be described.

The positions on the axes reflect the interrelation between the environment and the corporate dimensions. As Drazin *et al.* (1985) state, the context and the structure must somehow fit together if the organization wants to perform well.

As stated by Friedli (2005), a company in a stable position can address standard customers with standard products. The company only acts in its own context and uses single-use resources. The level of employee qualification can be low and the employee development is unsystematic. The internal structure of the organization is usually hierarchical and in the external structure market conditions are normal.

A company acting in a dynamic environment has to address latent customer needs and the customers ask for solutions rather than products. The company acts in multiple contexts and uses multiple-use resources.

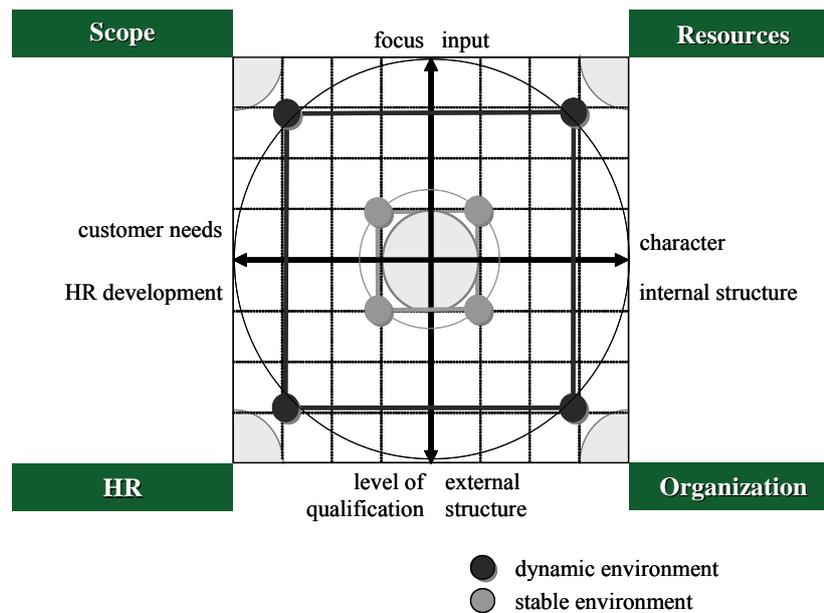


Figure 4: Actual and appropriate level of flexibility

The employees need to have a high qualification level to fulfill all requirements and the employee development is systematic. The organization is usually process-oriented and with external partners, operational alliances are formed.

The four dimensions described above cover multiple kinds of flexibility and help to structure the discussion of an appropriate flexibility. The knowledge of their capabilities with respect to the ESC allows the company to determine their position in the flexibility dimensions and therefore to derive the level of the appropriate and existing flexibility. Whereas the actual capabilities are needed to figure out the actual position of the company, the identified ESC and the needed capabilities determine the future level of flexibility.

Phase IV of the integrated flexibility framework contains the methods for delivering flexibility which we made applicable through the derivation of measures to close the gap between the existing and the appropriate degree of flexibility. The gap has been analyzed in the flexibility dimensions described above and forms the basis for discussing the required measures. As mentioned above the four flexibility dimensions are interrelated. To avoid unknown influences between the different kinds of possible measures they have to be analyzed in their interdependencies which can be conducted with the help of a software supported procedure. Thanks to the software analysis, we were able to derivate the interactions and define the sequence of the implementation of the dedicated measures. Each of the derived measures influences different types of flexibility (e.g. supply flexibility, product mix flexibility, etc.) which the companies have to build up to reach the appropriate level of flexibility.

Phase IV results in a catalogue of company specific types of flexibility and a set of measures which have to be implemented to reach the needed degree of flexibility, derived from the environment.

Fields of flexibility	Flexibility dimension	Flexibility type
Scope	Focus	R&D-Flexibility Volume-Flexibility Product-Flexibility Product-Mix-Flexibility
	Customer needs	Supply-Flexibility Supply-Chain-Flexibility
Resources	Character	Machine-Flexibility Technology-Flexibility Infrastructure-Flexibility Employees-Flexibility
	Input	Expansion-Flexibility Process-Flexibility
Human Resources	Development	Workforce deployment-Flexibility
	Qualification	Workforce deployment-Flexibility
Structure	Internal Structure	Process-Flexibility Layout-Flexibility
	External Structure	Delivery-Flexibility Sourcing-Flexibility Transportation-Flexibility

Figure 5: Flexibility Type

Phase V contains the performance measurement. The goal of phase V is the development of performance indicators to measure whether the required flexibility is reached or not. The performance indicators are summarized in a balanced scorecard of flexibility which allows the control of the changes in the degree of flexibility.

Conclusions

Out of different interviews on top management level, there is an obvious need for a procedure to implement the appropriate level of flexibility. Although a lot of industrial companies are concerned with the topic of flexibility, there is no common understanding of how to determine how much flexibility the company really needs. The desk research and action research activities carried out with seven manufacturing companies have led to an integrated flexibility framework structuring five phases (environmental uncertainties, corporate strategy, required flexibility, methods for delivering flexibility and performance measurement).

The developed integrated flexibility framework highlights the coherence of the appropriate level of flexibility and the market dynamics as well as the corporate strategy. The conducted action research has shown that out of the recognized market dynamics the seven manufacturing companies have identified market specific external success criteria (ESC) leading to different but coherent appropriate levels of flexibility. In addition, the research results confirm the need for a comprehensive analysis of the environmental dynamics to find out the appropriate level of flexibility.

The analyzed structural fields of flexibility have led to a set of flexibility types which a company has to implement to change the amount of flexibility. The highly interactive behavior of the measures, which are needed to reach the appropriate degree of flexibility, supports the assumption that there is a need to raise the level of the analysis from a manufacturing to an organizational level.

The company-specific definition of the needed type of flexibility and of the appropriate level enables the measuring of flexibility. The research activity has led to a set of flexibility types with corresponding flexibility figures which builds the basis for the feedback loop. Because of the derived balanced scorecard of flexibility the integrated flexibility framework can be used on an ongoing basis.

Appendix

Appendix A

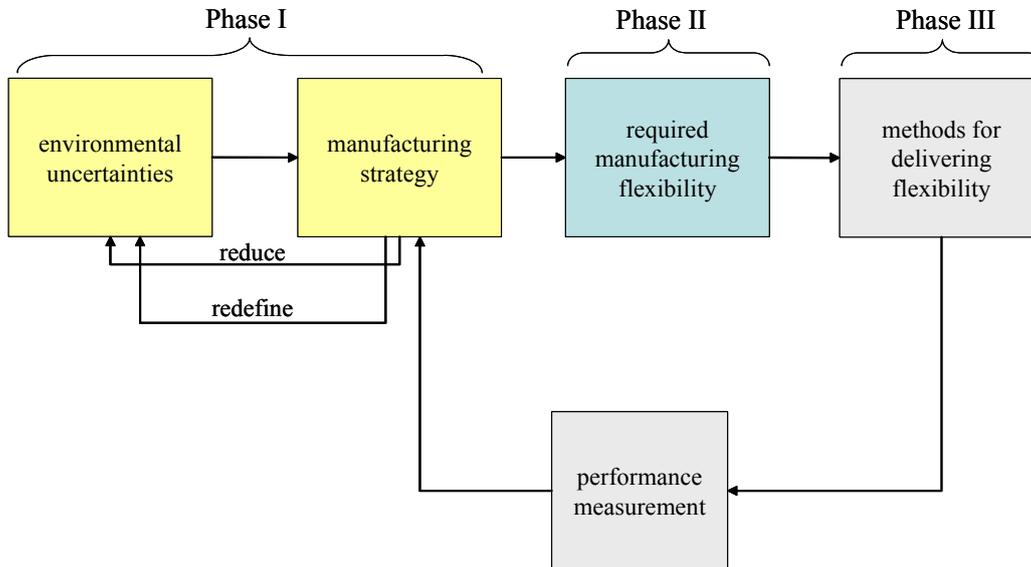


Figure 6: Gerwin 1993

Appendix B

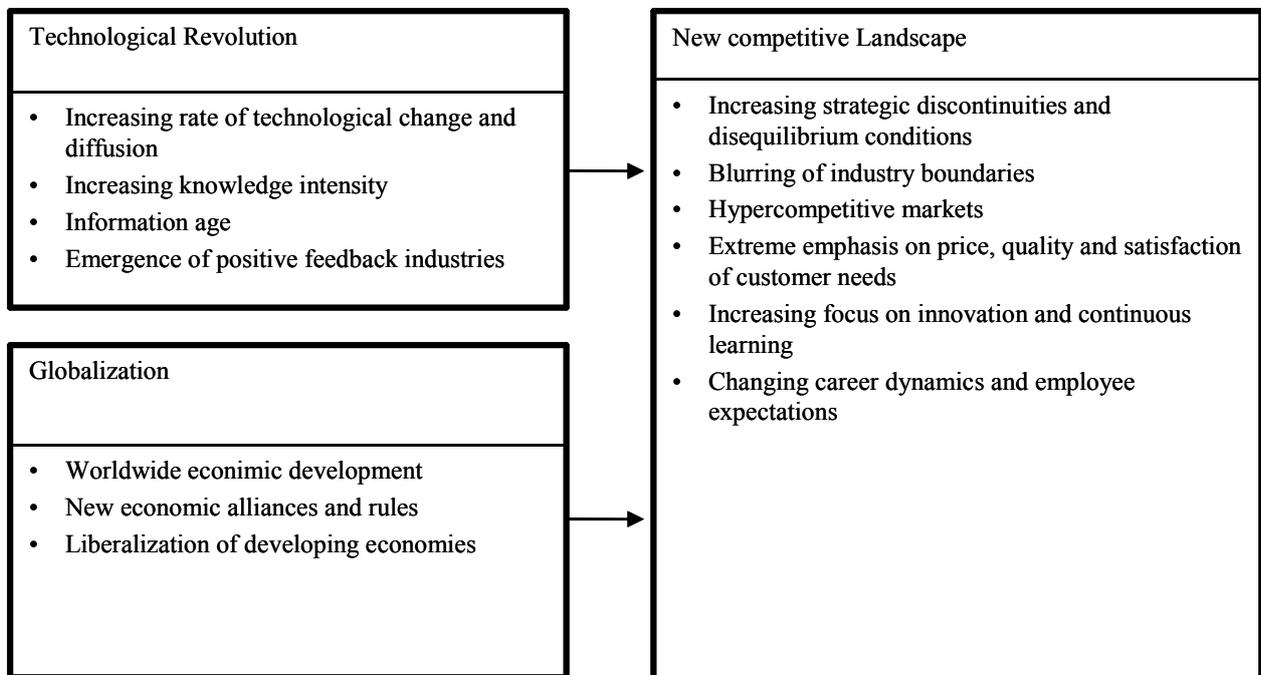


Figure 7: Hitt et al. (1998)

References

- Aaker, D. A., & Mascarenhas, B. (1984). The need for strategic flexibility, *Journal of Business Strategy* (Vol. 5, pp. 74): Emerald.
- Abdel-Malek, L., Das, S. K., & Wolf, C. (2000). Design and implementation of flexible manufacturing solutions in agile enterprises. *International Journal of Agile Management Systems*, 2(3), 187-195.
- Benjaafar, S., & Ramakrishnan, R. (1996). Modelling, measurement and evaluation of sequencing flexibility in manufacturing systems, *International Journal of Production Research* (Vol. 34, pp. 1195): Taylor & Francis Ltd.
- Bernardo, J. J., & Mohamed, Z. (1992). The measurement and use of operational flexibility in the loading of Flexible Manufacturing Systems, *European Journal of Operational Research* (Vol. 60, pp. 144).
- Bettis, R. A., & Hitt, M. A. (1995). The new competitive landscape, *Strategic Management Journal* (Vol. 16, pp. 7-19).
- Brandenburger, A. M., & Nalebuff, B. J. (1995). *The Right Game: Use Game Theory to Shape Strategy*. HBR.
- D'Aveni, R. A. (1995). Coping with hypercompetition: Utilizing the new 7S's framework. *Academy of Management Executive*, 9(3), 45.
- Dickens, L., & Watkins, K. (1999). Action Research: Rethinking Lewin. *Management Learning*, 30(2), 127-140.
- Drazin, R., & van de Ven, A. H. (1985). Alternative Forms of Fit in Contingency Theory. *Administrative Science Quarterly*, 30(4), 514.
- Faulkner, D., & Bowman, C. (1992). Generic strategies and congruent organisational structures: Some suggestions. *European Management Journal*, 10(4), 494-500.
- Friedli, T. (2005). *Technologiemanagement: Modelle zur Sicherung der Wettbewerbsfähigkeit*. Berlin: Springer Verlag.
- Gerwin, D. (1993). Manufacturing Flexibility: A Strategic Perspective, *Management Science* (Vol. 39, pp. 395): INFORMS: Institute for Operations Research.
- Ghani, K. A., & Jayabalan, V. (2000). Advanced manufacturing technology and planned organizational change. *Journal of High Technology Management Research*, 11(1), 1.
- Giddens, A. (1984). *The Constitution of Society*. Cambridge: Polity Press.
- Hamblin, D. J. (2002). Rethinking the management of flexibility - a study in the aerospace defence industry. *Journal of the Operational Research Society*, 53(3), 272.
- Hitt, M. A., Keats, B. W., & DeMarie, S. M. (1998). Navigating in the new competitive landscape: Building strategic flexibility and competitive advantage in the 21st century, *Academy of Management Executive* (Vol. 12, pp. 22): Academy of Management.
- Koste, L. L., & Malhotra, M. K. (1999). A theoretical framework for analyzing the dimensions of manufacturing flexibility, *Journal of Operations Management* (Vol. 18, pp. 75-93).
- Lewin, K. (1946). Action Research and Minority Problems. *Journal of Social Issues*, 2(4), 34-46.
- Porter, M. E. (1985). *Competitive Advantage - Creating and Sustaining Superior Performance*. New York.
- Porter, M. E. (1991). Towards a Dynamic Theory of Strategy. *Strategic Management Journal*, 12, 95-117.
- Skinner, W. (1969). Manufacturing--missing link in corporate strategy, *Harvard Business Review* (Vol. 47, pp. 136): Harvard Business School Publication Corp.

- Slack, N. (1983). Flexibility as a Manufacturing Objective, *International Journal of Operations & Production Management* (Vol. 3, pp. 4): Emerald.
- Suarez, F. F., Cusumano, M. A., & Fine, C. H. (1991). Flexibility and Performance: A Literature Critique and Strategic Framework. *Working paper*.
- Swamidass, P. M., & Newell, W. T. (1987). Manufacturing strategy, environmental uncertainty and performance: a path analytic model, *Management Science* (Vol. 33, pp. 509): INFORMS: Institute for Operations Research.
- Upton, D. M. (1994). The management of manufacturing flexibility, *California Management Review* (Vol. 36, pp. 72): California Management Review.
- Upton, D. M. (1995). What really makes factories flexible? *Harvard Business Review*, *Juli-August*, 74-84.
- Volberda, H. W. (1996). Toward the Flexible Form: How to Remain Vital in Hypercompetitive Environments, *Organization Science: A Journal of the Institute of Management Sciences* (Vol. 7, pp. 359): INFORMS: Institute for Operations Research.
- White, W. F., Greenwood, D. J., & Lazes, P. (1991). Participatory Action Research: Through Practice to Science in Social Reserach. In W. F. White (Ed.), *Participatory action research* (pp. 19-55). London: Sage.