CORVINUS UNIVERSITY OF BUDAPEST

THE EFFECT OF CONTINGENCY FACTORS ON THE USE OF MANUFACTURING PRACTICES AND OPERATIONS PERFORMANCE

PH.D. THESIS

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Budapest, 2012

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The effect of contingency factors on the use of manufacturing practices and operations performance

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Introduction[1]

This PhD thesis investigates the question: ***Among manufacturing companies, what is the effect of certain manufacturing contingency factors on the extent that certain manufacturing practices are used, and what are the implications of this effect on operations performance?*** This topic raises fundamental questions that should be answered. How can we define the following: manufacturing, contingency factor, manufacturing practice, operations performance? I will answer these questions as the thesis proceeds. I provide greater detail about contingency factors in Chapter 1, and discuss manufacturing, manufacturing practices and operations performance in Chapter 2.

Choice of topic

As I describe in Chapter 2, existing research on contingency factors in the field of *operations management* (from now on: OM), more specifically in relation to manufacturing practices, is not widespread, making this a significant topic. In the introduction, I will highlight significant aspects related to this phenomenon. In the field of OM, Sousa and Voss (2008) wrote about the poor state of research on contingency factors. They note that an increasing number of recently published studies cast doubt on the notion that manufacturing practices create universal results, i.e., companies that apply the same manufacturing practices often achieve different results. The authors of these studies explain the different outcomes by highlighting the context-dependency of the practices. Contingency theory–which investigates contingency factors from the perspective of organisational theory and design–was previously applied in the field of OM. The seminal contingency theory studies were introduced to the field of OM through the studies of Skinner and led to the contingency paradigm of manufacturing strategy, which states that if the external and internal consistency of manufacturing strategy decisions exists, a firm will increase its performance (Skinner, 1969). Although manufacturing practices and their use were not investigated from this angle, it was a logical choice to focus on manufacturing practices from a contingency theory point of view.

[1] The writing of the thesis was supported by TÁMOP 4.2.1.B-09/1/KMR-2010-0005 sz. CUB research project.

The choice of topic identifies several research problems simultaneously. First, there is a research gap in the field of OM concerning contingency factors (Sousa and Voss, 2008). Second, there are numerous contradictory statements within the existing knowledge of contingency factors, which raise questions about the generalisability of certain theories. Third, there are numerous untested hypotheses, models, propositions and concepts within theories that consider contingency factors and that are not necessarily related to manufacturing. I will write about these in Chapter 1 in more detail.

The topic of my research fits into the *European research tradition.* The history of OM thinking has been significantly influenced by the USA since World War II, which of course affected the European development as well. Nonetheless, there were ideas from Europe that spread throughout the world. Among these ideas was the contingency theory school (born in the 1960s), which made a connection with the field of OM through Woodward (1965). Woodward uncovered the different factors of OM and technology contingencies in manufacturing organisations (Karlsson, 2009). The future development of the contingency theory school was significantly influenced by the so-called Aston studies. (Pugh et al., 1963; Pugh et al., 1968; Pugh et al., 1969a; Pugh et al., 1969b)

I will answer my research question primarily by using a *survey questionnaire*. Hence, my research has a European approach but addresses the question in an American manner. In American research, large surveys are very popular in a single industry where the aim is to reach statistical significance and reliability while investigating narrow research questions very deeply with quantitative methods and large databases. In Europe, the methodology is the opposite in many ways–many researchers work in or close to the industry. Longitudinal studies with broad topics and small samples are frequent. The output is more descriptive and is a hypothesis-creator rather than a hypothesis-tester. In addition to the survey, I also conducted interviews with OM experts, and I used these interviews to evaluate the results.

In the remaining parts of the introduction–before the actual theoretical and empirical examinations–I describe the frame and schedule of the research, clarify the most significant questions that arise and present the research question and the structure of the thesis.

Theoretical approach

My research is nomothetic, deductive and quantitative (Babbie, 2003):

- *nomothetic,* because my research intends to find partial explanations for classes or groups of situations or events as efficiently as possible by using one, or only a few, variables. The nomothetic model (in contrast to the idiographic approach) uses a probabilistic approach of causality; i.e., under optimal circumstances, when certain factors are present, a certain type of phenomenon will occur with significant probability. The criteria of causal relationships for nomothetic explanations were proposed by Lazarsfeld. According to these criteria, the following are necessary:
  - the cause must precede the consequence;
  - between two variables there should be an empirical relationship; and
  - the observed empirical relationship between two variables should not be explained by the influence of a third variable.

  If we include more variables in the nomothetic model, it will improve the explicative power up to a point; however, above a certain number of variables, the model becomes too complex and is no longer useful. Therefore, although numerous contingency factors may be included in my research, my intention in Chapters 1-2 is to narrow the analysis to a limited number of identifiable and, from a manufacturing point of view, highly relevant contingency factors.
- *deductive*, because I proceed from the general to the unique; i.e., from a hypothesised relationship towards observations, from which I verify the actual existence of the anticipated relationship.
- *quantitative*, because my data, which were used for statistical-mathematical analyses, have a numerical and analysable form from the start.

Other significant issues

In my research, the **unit of** analysis–as can be seen later–is the manufacturing plant, while the *population* is the totality of manufacturing plants operating in ISIC 28-35 industries.

Concerning the time dimension, I will conduct a **cross-section analysis**. I will also examine the **reliability and validity** of the variables and methods. The operationalisation of the variables is based on a survey that is described in Chapter 4.

Characterising the literature review

I acquired the necessary information for the research from the literature review in addition to the aforementioned survey and interviews. This literature review is critical because if it is performed well, then the review provides the following:

- it presents the existing knowledge; it is critical and supports the collected, existing survey data;
- it provides a theoretical frame that underpins the data presentation and the additional analyses;
- it identifies gaps in the existing knowledge, and based on these gaps, it proposes adequate research plans and questions (Wake, 2010).

I started with significant sources in my research: with literature provided by Professor Harry Boer (contingency theory, works by Mintzberg) and with seminal studies about manufacturing practices thanks to my supervisor, Krisztina Demeter. This literature was supplemented by the literature I collected during joint research projects and conferences, a critical review of relevant journals and keyword searches with Scholar Google.
After finishing the draft thesis, I conducted a second deep review phase. By using an extended professional list of OM journals, I selected those that are, or can be, related to manufacturing (which means that I omitted journals with an engineering, logistics or supply chain management focus). The list of journals from the second phase, and the process and results are found in Appendix 1.

My role as a researcher

Croom (2009, p. 65) cites Eilon (1974) about research archetypes. The researcher should identify his/her role(s) because the type of role can significantly affect the research process and the thinking about the research. The seven archetypes are listed as follows:

- Chronicler: a detached observer whose function is to record a series of facts or patterns of behaviour for posterity;
- Dialectician: a participating observer who aims for an objective view through dialogue;
- Puzzle-solver: primarily more interested in the intellectual activity associated with solving a well-structured problem than the process of data collection;
- Empiricist: employs scientific models;
- Classifier: attempts to interpret existing knowledge and research;
- Iconoclast: challenges existing knowledge;
- Change-agent: prime objective is to change the system.

In my research, I mix the roles of the *chronicler, puzzle-solver and classifier*. These archetypes are similar in the way that they do not interact with the system or the problem domain (much like the iconoclast and contrary to the dialectician, empiricist and change-agent). If we take a look at the archetypes and how they approach the problem, we can say the following:
- the chronicler attempts to study the phenomenon without prejudgement and adopts an outside passive role;
- the puzzle-solver is eager to tackle problems suggested by others and the level of abstraction interests him/her;
- the classifier is interested in organising and categorising the data, while the data gathering process is of no concern. The classification is often based on his/her own value judgements.

Logic of the research

Figure 1 shows the logic of my thesis along with the research question I intend to answer. The research question is preceded by two literature review blocks.

First block: Which are those contingency factors that can be considered the most significant ones, based on previous experience?

This question is answered in Chapter 1. During this process, I briefly overview the significant field of work on contingency factors. This is followed by a detailed description of the identified contingency factors from two points of view: a view from organisational theory (and contingency theory) and a view from strategic management. I provide my arguments concerning these choices in Chapter 1.

Second block: How do these identified contingency factors appear in the field of OM, and how can they be interpreted?

This question is answered in Chapter 2, where I examine how these contingency factors can be interpreted by the language of OM as manufacturing contingency factors, and I also review the OM literature concerning manufacturing contingency factors and the recent problems that have been identified during the investigation of these factors.

Research question: Do manufacturing contingency factors influence the use of manufacturing practices at manufacturing companiesand their operations performance? If yes, how? What kind of contingency factor–manufacturing practice configurations can be identified, and how do these configurations influence operations performance?

This question will be examined using statistical analytical methods. The research question will be transformed into testable hypotheses, which will be presented in Chapter 3 along with the associated research model.

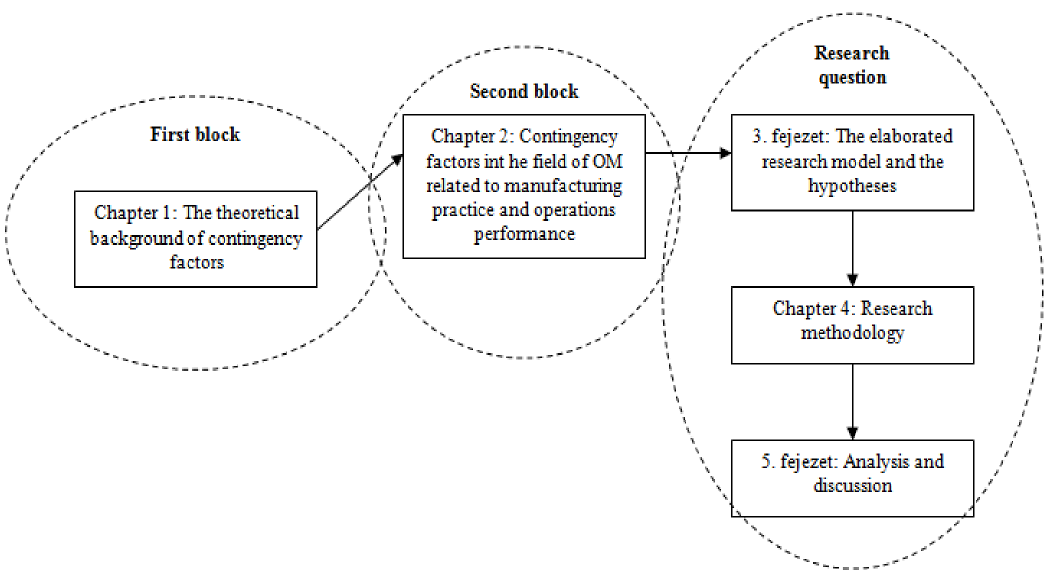

Figure 1: Logic of the research

Finally, I present the structure of the thesis. Chapter 1 describes the basic literature and seminal studies on contingency factors, with special attention to the contingency theory and strategic management approach. I identify those contingency factors which should be considered the most significant factors according to the literature.
In Chapter 2, I provide a discussion of the identified contingency factors in the field of OM, and in Chapter 3, I present the research model, the hypotheses that will be tested and the methods of the empirical analysis. Chapter 4 describes the questionnaire that provides the data for the empirical analysis.
In Chapter 5, I analyse the data, test the hypotheses and discuss the results. This is followed by a summary that highlights the most significant results of the thesis, presents the limits of the research and provides suggestions for possible future research.
The thesis is completed by the references and appendices.

Before I present the theoretical literature on contingency factors, I would like to thank those people without whom this thesis could not have been completed. First of all, I would like to thank my supervisor, Krisztina Demeter for her continuous support and help, both professionally and personally. I would also like to thank Professor Harry Boer from Aalborg University for providing me with essential literature during the initial phase of my research and making it possible to spend time at Aalborg. I also thank Zoltán Kovács and Gyula Vastag, who critically reviewed my draft thesis and made remarks that helped to increase the niveau of the final version of the thesis.
Numerous institute colleagues took the time to comment on previous versions of this thesis, and I would also thank them for their remarks and ideas. Special thanks goes to the team who created and managed the IMSS questionnaire, without which the thesis would surely not look like this; to Erzsébet Kovács, who improved my knowledge about statistics; to Judit Simon, who made it possible to twice participate in the course of Professor Jörg Henseler, who taught me the PLS method; and last but not least to my interviewees and the people who helped me organise the interviews (and who unfortunately cannot all be named), because their insights made the discussion and the interpretation of the results much richer and more interesting.

1. The theoretical background of contingency factors

This chapter first defines contingency factors, and the evolution of contingency factor research will be introduced including the primary disciplines researching this topic. In particular, contingency theory and the discipline of strategic management will be discussed as the theoretical basis of this research. The most significant and influential contingency factors will be identified, and the primary authors, literature and references will be described. More specifically, (1) differences between the academics' different definitions of contingency factors will be revealed, and (2) the lack of empirical results in connection with this topic will be emphasised. At the end of the chapter, the general concepts of 'fit' and 'equifinality' are discussed in connection with contingency factors, and the concepts will be adapted for manufacturing contingency factors in this research.

1.1. Definition of contingency factors

There are many synonymous terms represented in the relevant literature that lack clear definitions. Here are a few examples:

- contingencies may be intra- and extra-organisational (Donaldson, 2001); moreover Donaldson (2001) names three basic contingency factors: task uncertainty, task interdependence and organisational size;
- context as the totality of contingencies (Baranyi, 2001);
- situational or contextual factors (Dobák, 2006; Dobák–Antal, 2010);
- contextual factors (consisting of organisational and contingency factors) (Sila, 2007);
- external environmental variables (González-Benito, 2002); and
- environmental, organisational and managerial contexts (McKone et al., 1999).

In this paper, all environmental conditions and long-lasting organisational capabilities and factors will be identified as 'contingency factors' (according to Dobák–Antal, 2010), even if the referred literature uses a different term to describe the same content.

1.2. Origins and primary tendencies of contingency research

Research on contingency factors first appeared in the 1950s in different, isolated fields of science. The development of contingency theory was initiated by empirical studies in the field of sociology, which found that many existing forms of organisational bureaucracy could not be described by Weber's bureaucracy theory. In the 1950s, a new opinion became widely accepted in the management literature, suggesting that no general organisation principles exist. This conceptual change was also indicated by numerous management related sociological studies (Kieser, 1995a). The interest in contingency factors started to increase when environmental issues first appeared in strategic management literature. Environmental context is represented in numerous theories of strategic management (e.g., Mintzberg (1998, 2005) Ten Schools of Thought), although the role of the environment is only emphasised in The Environmental School (consisting of contingency theory, population ecology theory and institutional theory). The first and second theories contain biology related analogies (Mintzberg, 1998). Moreover, the discipline of industrial organisation should also be mentioned, which describes the theory of imperfectly competing markets.

Hereinafter, contingency theory and strategy management will be discussed in detail, as the theoretical basis of this thesis. A short summary about the less relevant fields (industrial organisation, population ecology theory, institutional theory) is found in Appendix 2.

1.2.1. Contingency theory[2]

Contingency theory was developed by improving previous concepts (Taylor, Fayol and Weber), which described recommendations that appeared effective under any circumstances. However, contingency theory supposes that under different circumstances different solutions may prove effective (Dobák–Antal, 2010). This can be considered one of the primary insights of the theory, because instead of propagating universally applicable organisation-management principles, the theory tries to demonstrate that different circumstances require different organisational structures (Baranyi, 2001). The fact that Dobák–Antal (2010) use the contingency approach (with

[2] Contingency theory was sometimes identified by a different term in Hungarian literature: e.g., situation theory (Dr. Cserny, 2000) or chance theory (András, 2003). However, according to my research, the most frequent term in Hungarian corresponds with contingency theory in English.

the opportunity for strategic choice) also highlights the theory's relevance. The term 'contingency theory' was first mentioned in the literature by Lawrence and Lorsch in 1967, in the context of organisational structure. Unfortunately, the exact date of the concept's origination is unknown (Donaldson, 2001).

Contingency theory played a leading role in the organisational practice of the 1970s. It typically examined the relationship between organisational structure and the operating conditions (in other words, the contextual totality of contingency factors), using the method of empirical comparative analysis. This analytic approach emphasises the interaction between the organisation and the environment and the importance of adaptation to the environment. The hypotheses are as follows:

- the formal organisational structure has a significant effect on an organisation's effectiveness;
- there is no universally effective organisational structure; and
- the effectiveness of different structures are empirically analysable.

Using these hypotheses as starting points, contingency theory was supposed to 1) explain the differences between organisational structures; 2) identify necessary organisational changes in accordance with changing situations; 3) narrow down the set of optional organisational models (Dobák-Antal, 2010).

Contingency theories dealing with organisational structure (so-called 'structural contingency theories') consider the environment, the organisational size and the strategy of the organisation as contingency factors. These are the factors that an organisational structure must be adapted to. Of course, there are other contingency factors as well; however, only these three are significant from this perspective. Beyond structural contingency theories, there are additional theories that focus on organisational characteristics such as management, human resources and strategic decision making (Donaldson, 2001). The schools of structural contingency theory can be divided into three groups:

- harmonisation of organisational structures and environmental conditions (variability, complexity);

- the modifying effect of the applied technology on the organisation; and
- the relationship between organisational size and structure.

These theories only address a single factor at a time; however, other multi-factor theories were developed that describe structural changes as the joint effect of two or more factors (e.g., environment and size), creating an integrated concept (Baranyi, 2001; Dobák, 2006; Dobák-Antal, 2010).

The most significant contemporary research fields of contingency theory are the following (Donaldson, 2001):

- comparing the final effectiveness to the expected performance relative to the contingency factors; i.e., to what degree was the performance realised, as forecast by a theory based on contingency factors;
- research of organisational elements affected by contingency factors; and
- inclusion of contingency theory into other disciplines.

Certain elements of contingency theory are also represented in this research; therefore, this research fits into the contemporary research fields, especially into the third one of the abovementioned.

The most influential researchers of contingency theory

The most influential researchers and the background of their works will now be introduced. The results of their studies will be detailed later, along with an examination of the different contingency factors.

The Aston studies, cornerstones of contingency theory literature, were published in three different waves as the research progressed. Because the literature lacked a systematic analysis of the correlation between contingency factors, administrative systems and individual behaviour, the first study (Pugh et al., 1963) examined labour organisation and behaviour. Moreover, the existing studies were incomparable because the results were generalised from single case studies. The first study was highly theoretical and provided an overview of the bureaucracy literature, recommending possible new methods of improvement. Pugh et al. (1968) studied these recommendations empirically, with a sample of 52 large organisations (employing more than 250 people) with different environmental and ownership backgrounds from the Birmingham area. The study found that organisational bureaucracy systems were not standardised and that the different organisations were structured in different ways. Consequently, Weber's term of the bureaucratic ideal was not adequate any more. Pugh et al. (1969a) continued the same research one year later by classifying the previously examined 52 organisations into clusters, according to their bureaucracy systems. Four pure and three transitional clusters were created, and a possible method of development was also included among the different bureaucratic solutions. The subsequent study of Pugh et al. (1969b) completed the research with previously identified contingency factors.

Woodward (1965) examined 203 manufacturing companies from South Essex in her research. 46% of the companies in the sample employed 100 or less people, 24% employed 101-250 people and the other 30% of the companies employed more than 250 people. Finally, 100 companies took part in the survey, analysing the dimensions of organisational differences by filling out questionnaires. The primary questions of the survey were the following: why and how does the structure of industrial organisations differ from each other, and why are certain structures more successful than others?

Lawrence–Lorsch (1967) compared six different organisations operating in the same industrial environment. According to their starting point, an organisation consists of several significant sub-systems, and they investigated the integration and differentiation of these sub-systems. Integration was defined as the process of achieving unity of effort among the subsystems in the accomplishment of the organisation's task. Differentiation was defined as the state of segmentation of the system into subsystems.

The organisations were all operating in the chemical processing industry, which was characterised by relatively rapid technological change, innovation and product modification. The source of competitive advantage was the development of new and improved products and processes. The reason for the examination of this industry was the high level of organisational integration and difference required by the environment. The results supported the hypothesis, suggesting that highly differentiated subsystems have more difficulties in achieving integration than less highly differentiated ones. Correlation was found between the performance of subsystems and sub-environments, through the measurement of change in profit, sales volume and sales volume of currently developed products. In conclusion, highly performing organisations' subsystems differed from each other significantly, showing higher consistence with their sub-environmental demands than in the cases of organisations with lower performance. Moreover, effective organisational operations also required the sub-systems' integrational level to meet the environmental requirements.

Perrow (1967) investigated technology as a contingency factor and based his research on four basic assumptions:

- technology is a defining parameter of organisations;
- technology is an independent factor that the company depends on;
- examine a company as a whole;
- the technological aspect is the best way to compare organisations to each other.

The conclusions drawn by Perrow will be introduced later; however, his concepts were not empirically supported.

According to Thompson (1967), the significant challenges for complex organisations are posed by uncertainties. Companies handle uncertainty by instructing certain parts to specifically address it, while other parts are operating under (more or less) certain conditions. The two basic sources of uncertainty are technology and environment, and the differences between these dimensions result in extra-organisational differences. Similarly to Perrow (1967), the results of the research are not empirically supported.

Child (1972) introduced the term 'strategic choice' to contingency theory, and criticised the results of Pugh et al. (1969b) in his paper.

Duncan (1972) emphasised that the relevant dimensions and elements of the environmental concept had not been defined in previous studies. He tried to do this based on the perceptions of organisational members in 22 decision-making units in three manufacturing and three R&D organisations.

Table 1 provides a short summary of the most influential research on contingency theory, extending the already known facts with new perspectives. If a researcher has studied a certain issue or factor in his/her work, the issue/factor is marked with 'X'. Although the results will be detailed later, a few significant conclusions can already be drawn. It is obvious that the most often researched contingency factors are size, technology and environment. It is also significant that the majority of the research examined organisations as a whole, while the Aston studies and Child (1972) focused on smaller units (work organisations). All of the studies mention only three contingency factors (size, technology and environment); additional factors are mentioned only in the Aston studies. The organisation appears in almost every study as the dependent variable, influenced by the contingency factors. It should also be mentioned that half of the authors did not do any empirical research, so empirical verification was not necessarily included, even in classical contingency theory studies. This fact increases the value of all the studies (including this thesis) that combine theoretical and empirical support.

	Unit of analysis	**Size**	**Techno-logy**	**Environ-ment**	**Other contingency factors**	**Organi-sation**	**Empirically supported**
Aston studies	work organisation	X	X		X	X	X
Woodward	company	X	X			X	X
Lawrence – Lorsch	organisation			X		X	X
Perrow	organisation		X			X	
Thompson	organisation	(X)	X	X		X	
Child	work organisation	X	X	X		X	
Duncan	decision group			X			X

Table 1: The most influential researchers of contingency theory

Critical review of contingency theory

A critical review of contingency theory must also be mentioned in an objective research, particularly because the theory was criticised several times. Kieser (1995a) divided the most significant arguments into two groups. An argument is endogeneous if it emphasises the methodical imperfection of a theory without arguing the validity of it. However, exogeneous arguments always question the theoretical basis of a theory as well.

Kieser (1995a) mentions the following endogeneous arguments:

(1) significant, new situational and structural characteristics are not taken into consideration;

(2) the applied measurement methods are unreliable and incomparable in the case of structural differences;

(3) the applied statistic methods are inappropriate;

(4) the sample-drawing studies are unrepresentative and unreliable;

(5) the empirically proved results are uninformative.

The exogeneous arguments are the following:

(1) situation does not determine organisational structure;

(2) coherence between situation and organisational structure may differ in line with cultural differences (I suggest that this argument should be mentioned among the endogeneous arguments because it only introduces culture as a new contingency factor).

(3) other organisation theory-related arguments (e.g., the problem of power and the perception of stakeholders) are not discussed, and it has no effect on the environment. I think that many of these arguments are similar to the previous culture-related one, introducing a new factor or changing the approach of studying the organisation (similarly to the many different schools of strategic management).

Dobák (2006) suggests a different classification and names the following imperfections of contingency theory:

- it studies the relationship of structure and influencing factors too mechanically, and does not bother with the possible choice opportunities of the organisations;
- the process of change is usually not emphasised enough;
- it does not correctly handle inter-organisational interests, power mechanics and conflicts;
- it does not examine organisational actions and processes; and
- the measurement of organisational characteristics, the causal relationship is only analysed with quantitative methods.

Curiously, after presenting the critical arguments Kieser (1995a) did not respond to the arguments of the supporters of contingency theory (he only, e.g., refers to Donaldson briefly). He does not find thinking in structure types adequate (e.g., the typology of Mintzberg (1979)). On the whole, Kieser does not seem to sympathise with contingency theory.

What answers were given to these critical arguments? On the one hand, the majority of contingency researchers accepted the necessity to reconsider the deterministic stance of contingency theory. The theory did not allow any deviance from the only reasonable organisational structure in the long-term, and it denied the existence of different organisational structures. However, according to improved contingency theory, contingency factors may change and are also changeable in the long term. In addition, companies are not determined by their organisational contexts, these only create tendencies for them. Nevertheless, the assumption that different contingency factors are modifiable to different extents remains unchanged. (Baranyi, 2001)

Donaldson (1985), one of the primary supporters of contingency theory, gave detailed answers to all of the criticisms to protect the theory. At the end of his book, he introduced a decision tree, starting from the diversity of organisational activities through the product range, suggesting that the relationship between products and the requirement of innovation leads to optimal organisational structures, representing a deterministic point of view. Donaldson (1996) strongly supported the positivist organisation theory in his book again, specifically the deterministic contingency theory. According to this, he strictly rejected the concept of strategic choice, emphasising that, ultimately, everything (even the career and the personality of the manager) is affected by contingency factors. He also rejected configurational theories and typologies (e.g., Mintzberg, 1979; Mintzberg, 1998) because in his opinion these do not represent all of the possible cases. The importance of organisational size was discussed in details too.
I personally think that Donaldson properly notes the weaknesses of certain arguments. On the other hand, his radically deterministic point of view (e.g., rejecting the possibility of strategic choice) makes his theory unrealistic and hardly acceptable in many ways. In my research, the possibility of strategic choice and the existence of certain configurations are not rejected; on the contrary, I will try to support them in my thesis.

1.2.2. Strategic management

As it was previously mentioned, the study of contingency factors (especially the environment) became a popular research field of the strategic management discipline in the 70s and 80s. I find it useful to give a brief overview of this field after presenting the most significant contingency theory authors, with a similar approach to the previous sub-chapter; i.e., I will only show the primary guideline, and the results concerning the different contingency factors will be presented later in this chapter.

Miles et al. (1978) developed a general model of the adaptive process which they called 'the adaptive cycle'. It is consistent with the strategic choice approach formulated by Child (1972). Miles et al. (1978) identify three broad problems of organisation adaptation:

(1) The Entrepreneurial Problem: the entrepreneurial insight must be developed into a concrete definition of an organisational domain, like a specific good or service and a target market or market segment.

(2) The Engineering Problem: the organisational system must be developed to solve the entrepreneurial problem. Such a system requires the successful management of product or service distribution.

(3) The Administrative Problem: the problem of reducing uncertainty within the organisational system. The reduction of both factors can be reached by the rationalisation and stabilisation of those activities which successfully solved the problems faced by the organisation during the entrepreneurial and engineering phases.

To solve the three above-mentioned problems, organisations may apply four different types of strategies: Defenders, Analysers, Prospectors and Reactors. The first two types are more adaptable to the environment's low dynamic level than the third one. The fourth form is considered a residual strategy referring to organisational problems in developing and communicating a strategy articulation and in adapting to the environment.

Mintzberg (1979) names several contingency factors: age and size of the organisation; technical system regulation and sophistication; stability, complexity, diversity and hostility of the environment; ownership; needs of the members of the organisation; and fashion. He also mentions the debate about the most influential contingency factors in the literature (Mintzberg considers size, technology and environment as the most influential contingency factors).

Bourgeois (1980) was the first to use the three-level classification of the environment in the field of strategic management. Afterwards, several studies were published concerning the environmental factors in this field, naming a wide range of factors, depending on the particular researcher's approach.

1.3. Description of the most significant contingency factors

In the overview of contingency theory and strategic management literature, the most significant contingency factors could already be seen: environment, size and structure. Environment is the least changeable factor in the short-term. Size and technology are also less changeable in the short term too but even more on the medium term (Dobák, 2006; Dobák-Antal, 2010). Next, these contingency factors will be detailed, going from the exterior to the interior, i.e., I start with the environment and proceed with size and technology.

1.3.1. Environment

Environment as a contingency factor was first mentioned in the publication of Lawrence-Lorsch (1967). The authors did not treat environment as a single entity, and divided it into three sub-environments: the market sub-environment, the scientific sub-environment and the technical-economic sub-environment. Each of the sub-environments can be measured on a scale from highly dynamic to extremely stable. The following three indicators of sub-environmental certainty were used:

(1) the rate of change of conditions over time in the sub-environment;

(2) the certainty of information about conditions in the sub-environment at any particular time;

(3) the modal time span of definitive feedback from the sub-environment on the results of subsystem behaviour.

Thompson (1967) examined the environment in connection with the applied technologies of the organisation. Organisations intend to seal off their technical cores from environmental effects as much as possible to make them operate adequately. If a company fails to protect the technical core, the environment will have a greater influence on it. Homogeneity and stability are considered the most useful dimensions to describe the environment.

Child (1972) emphasised three environmental conditions as the most significant ones:

(1) *Variability* refers to the degree of change that characterises environmental activities in an organisation's operations. The degree of the change can be described by three variables: (a) the frequency of changes in relevant environmental activities, (b) the degree of difference involved at each change and (c) the degree of irregularity in the overall pattern of change (variability of change). The higher that the environmental variability is, the more adaptive the company should be.

(2) *Complexity* refers to the heterogeneity and range of environmental activities which are relevant to an organisation's operation.

(3) *Illiberality* refers to the degree of threat faced by organisational decision-makers in the achievement of their goals from external competition, hostility or even indifference.

Most companies have the opportunity to choose their operational environment. Moreover, large companies are also able to manipulate it to an extent. The term 'strategic choice' is also used by Child to refute the determinism of the environment.

In connection with the organisation's relation to the environment, Child states that the organisational environment cannot be defined correctly without any reference to the organisation's domain. The domain refers to the organisational goals and the activities performed to reach these goals. Consequently, (1) the environment can be divided into different segments according to its influence on organisational goals and activities, and (2) there is no clear boundary between an organisation and its environment; they both depend on the goals and the activities.

Duncan (1972) identified two dimensions of the environment: the simple–complex and the static–dynamic dimensions.

1) The decision unit's environment is simple, if the significant environmental factors are only a few in numbers and are similar to each other. The complexity of the environment refers to the high number of influential environmental factors. Duncan integrated the possible factors into one formula to measure the complexity of the environment, based on the similarity and number of the relevant factors.

2) The static-dynamic dimension refers to the stability of the internal and external environmental factors. Duncan divided this dimension into two more sub-dimensions. The first sub-dimension examines the temporal stability of the environmental factors

perceived as relevant by the organisational members. The second sub-dimension examines the frequency of updates and extension of these factors by the members. Duncan also developed a method of measuring the sub-dimensions.

In addition, Duncan developed a four-level scale to measure perceived environmental uncertainty, taking the two environmental dimensions also into consideration. The level of uncertainty is low in the case of the simple-static environment, gets higher in the case of complex-static and simple-dynamic environment and it is the highest if the environment is complex-dynamic. This hypothesis was empirically tested, and its results also support the notion that the perceived uncertainty of the simple-static environment is the lowest, and the perceived uncertainty of the complex-dynamic environment is the highest. The difference between the perceived uncertainties of the two environment types was not significant.

Miles–Snow (1978) extended Child's (1972) study and gave a historical review of the literature related to the conceptualisation of the environment:

> (1) The first widely accepted typology differentiated between four types of environment, based on the degree of interconnectedness and the extent of change in the environment. Different organisational structures were also recommended for the different types.
>
> (2) The terms 'general' and 'specific' environment are introduced. The first term affects all organisations; the second term affects only the focus organisation.
>
> (3) The difference between the rate of change and uncertainty (unpredictable change) was not recognised every time.
>
> (4) The terms 'heterogenic' and 'homogeneous' environment first appear, without a clear definition of the terms' meanings.
>
> (5) The recognition of the organisations' ability to manipulate the environment.

Mintzberg (1979) stressed the fact that the literature focuses on certain characteristics of organisational environment instead of providing definitions. The characteristics and the associated intermediate variables are as follows:

> (i) Stability: stable–dynamic;
>
> (ii) Complexity: simple–complex;
>
> (iii) Market diversity: integrated–diversified;
>
> (iv) Hostility: munificent–hostile.

Bourgeois (1980) introduced the three categories to describe an environment. Based on this, an environment can be defined by its (1) objects (consumers, the suppliers, the governmental organisations, etc.), (2) attributes or (3) perceptions about it. Although this concept can be useful, it requires deep knowledge of the company's environment. From the viewpoint of my thesis, the second and the third categories are more relevant. According to Bourgeois, the two primary attributes of the environment are complexity and dynamism. Complexity refers to the number and versatility of extra-organisational factors, and dynamism shows the factors' rate of change. Similar measurement methods were used in the business policy literature of the 1950s, measuring the environment with different types of trends, rates, forces and other types of aggregates.

In the empirical studies, Bourgeois generally used the manager's perception to describe environmental uncertainty. The perception represents the environment through human thoughts and emotions, from an individual's point of view. Bourgeois' (1980) most significant innovation was the separation of objective and subjective perceived factors, emphasising that most of the empirical studies used subjective factors. Most of the subjective data about environmental uncertainty were based on the managers' perceptions (Bourgeois, 1980). After the separation of the factors, he also noted that the more the manager's perception harmonises with the environment, the higher the company's performance is (Bourgeois, 1985). Kim–Lim (1988) stressed even more the difference between the two factors. Although their research supposed a homogeneous environment in a particular industry, the simultaneous existence of several industrial environments was empirically supported when environment was described by subjective perceived factors.

Numerous studies on the environment were published in the field of strategic management. There are three environmental factors that are used by most of the research: complexity, dynamism and competitive threat. In this sense, complexity refers to the number of influential environmental factors, and dynamism refers to the speed and measure of the environmental changes. Sharfman–Dean, Jr. (1991) found that by measuring the previous factors with objective indicators, managers find it harder to reach expected profitability when there is strong competition; they perceive that their market is more unstable in a dynamic environment, and they feel that their decisions are more uncertain in complex environments.

The problems with measuring the environment became, once again, clear when Buchko (1994) retested the Miles-Snow perceived environmental uncertainty scale. According to his conclusion, we cannot obtain perfectly precise descriptions about the environment through perceptions, because perceptions about uncertainty are inherently unstable thanks to environmental complexity and dynamism.

Dobák (2006) divides the environment into four segments: market environment, scientific-technological environment, inter-organisational relations and cultural environment.

The market environment is the only segment that is closely related to my thesis. The dimensions of the market environment are as follows:

- Variability: the frequency of change of business partners and the intensity and irregularity of the changes. This is a static-dynamic dimension of the environment.
- Complexity: the number and diversity of the decision-making-related external factors and the relationship of the different environmental segments. This is a simple-complex dimension of the environment. Variability and complexity jointly represent uncertainty for an organisation.
- The restrictive effect of the market: it can be based on administrative power (e.g., governmental restrictions) and on market power (e.g., the monopolistic situation of business partners and the unbalance of demand and supply) (Antal-Mokos et al., 2000).

In Table 2, a summary of the literature review of the environment as a contingency factor, showing the diversity of how environment was handled, is provided.

	(Sub)environments	Dimensions	Indicators	Others
Lawrence-Lorsch (1967)	1. Market 2. Technical-economic 3. Scientific	Dynamical - stable	1. Rate of change 2. Certainty of information 3. Modal time on definitive feedback	
Thompson (1967)		1. Homogeneity 2. Stability		Protection of the technical core from the environmental influences
Child (1972)		1. Variability 2. Complexity 3. Illiberality	The frequency, degree and variability of change	Manipulation of the environment Strategic choice Domain
Duncan (1972)	1. Internal 2. External	1. Simple – Complex 2. Static - Dynamic	1. Formulas to measure dimensions 2. Perceived uncertainty	The measure of perceived uncertainty in the case of different environmental types
Miles-Snow (1978)	1. General 2. Specific	1. Degree of interconnectedness 2. Extent of change 3. Heterogenic-Homogeneous		The ability to manipulate the environment
Mintzberg (1979)		1. Stability 2. Complexity 3. Market diversity 4. Hostility		Environment is not defined, but described with its characteristics
Bourgeois (1980) **Kim – Lim (1988)** **Sharfman – Dean, Jr. (1991)** **Buchko (1994)**	More parallel subenvironments in one industry	1. Complexity 2. Dynamism 3. Competition	1. Number of influential environmental factors 2. The measure and dynamism of change	Objects Attributes Perceptions
Dobák (2006)	1. Market 2. Technical-scientific 3. Inter-organizational connections 4. Cultural	1. Variability 2. Complexity 3. Restrictive effect of market	The intensity and frequency of changing the partners; the number and diversity of external factors etc.	

Table 2: Environment as a contingency factor

1.3.2. Size

In the Aston studies, Pugh et al. (1963) examined two dimensions of work organisation size: the number of employees and asset value. The studies proved that size is one of the most critical contingency factors that affect organisational structure. It should also be mentioned that the definition of size partly changed during the operationalisation: it was not measured only with organisational size but also with the size of the mother (Pugh et al., 1969b).

In Woodward's (1965) study, the examined companies had only a few structural characteristics in common. Organisational size had a less significant effect than was previously expected. Neither the length of the chain of command, nor the quality of the companies' industrial relations correlated with the size of the company. Moreover, no significant difference was measured in the applied technologies between the companies (the groups, based on size, were as follows: 100-250 employees, 251-1000 employees and over 1000 employees).

According to Thompson (1967), there is no relationship between the size and the complexity of the organisation, and the more contingency factors an organisation is faced with, the greater control it has over the controllable factors. It is important to emphasise that his propositions were not tested empirically.

Child (1972) does not treat size as a deterministic factor because increasing size causes greater structural differentiation.

Miles–Snow (1978) found that organisational size may determine strategy even more than technology. Although, technology and size are accountable only for a low percentage of variance in organisational structure, so it must be influenced by other factors as well.

Donaldson (1996) discussed the question of organisational size in detail. Organisational size was previously measured using different indicators (number of employees, revenue, asset value). It is questionable whether these indicators measure the same thing (i.e., size is unidimensional) or if the measurement methods are incomparable. Finally, Donaldson concludes that the different forms of organisational size empirically move together, and though the correlation between them is not perfect, it is strongly positive. He also provides statistical support for his arguments that can be used on other statistic samples.

Dobák (2006) mentioned employee number, asset value and revenue as the most widely used instruments of measuring organisational size.

The different authors' concepts of size as a contingency factor are summarised in Table 3. It is also demonstrated that size can be measured with employee number, asset value and revenue.

	Number of employees	**Asset value**	**Revenue**	**Others**
Aston studies	X	X		The organisation and mother organisation are considered together
Woodward (1965)	X			Size has only a low effect on the organisation and the technology
Thompson (1967)				There is no relationship between organisational size and complexity
Child (1972)				Size is not regarded as a deterministic factor
Miles – Snow (1978)				It determines the organisational structure even more than technology
Donaldson (1996)	X	X	X	Size is an unidimensional variable, with strong, positive relationship between its manifestations
Dobák (2006)	X	X	X	

Table 3: Size as a contingency factor

1.3.3. Technology

Technology was already discussed in the Aston studies. According to that definition, technology consists of the techniques that are used in workflow activities, providing goods and services directly (Pugh et al., 1963). As a result of the research, it turned out that technology is one of the most critical contingency factors. Just like the term ‘size’, technology was also modified during the process of operationalisation. Finally, it was measured by workflow integration and labour costs (Pugh et al., 1969b).

Woodward (1965) classified the technology of companies from two different aspects:

- companies making one-off, or standardised products, could also be sub-divided according to:
    - -- the size and complexity of the one-off products; and
    - -- the production continuity and the diversity of the standardised products.
- companies performing process production or producing discrete products.

Altogether, 92 companies were grouped into 11 categories in the study. Groups I to VII contained companies producing integral products, groups VIII to IX contained companies performing process production, groups X to XI contained companies with combined systems. Moreover, groups from I to XI represented a scale of technological complexity.

There was no significant difference between the applied technologies and the size of the companies. (The classification was based on the following ranges: 100-250 employees, 251-1000 employees, over 1000 employees.) This can be explained by the relatively small size of the companies, because in this case, all of the sub-systems of these organisations remain close to the technical core. (Dawson–Wedderburn, 1980)

Interestingly, although companies with similar production systems had similar organisational structure, Woodward did not conclude that technology is the only significant factor in the development of the organisational structure. The following organisational parameters were related to the level of technological development: the length of the line of command, the span of control of the chief executive, the percentage of total turnover allocated to the payment of wages and salaries, the ratio of managers to total personnel, the ratio of clerical and administrative staff to manual workers, the ratio of direct to indirect labour and the ratio of graduate to non-graduate supervision in production departments.

Moreover, the two ends of the technological scale are similar in many ways. Companies on the two ends of the scale were rather organic, while companies in the middle were rather mechanistic (In the sense of Burns–Stalker (1961)).

Perrow (1967) studied and classified technology as a contingency factor based on two dimensions:

1) the number of the exceptional cases encountered in the work (few exceptions–many exceptions), and

2) the search process, undertaken by the individual when an exception occurs (analysable problems–unanalysable problems).

Based on the two dimensions, Perrow put the different types of industries into a matrix. For example, craft industries are described as having unanalysable problems with a few exceptions; however, heavy machinery engineering must handle many exceptions and analysable problems. In accordance with technology and task structure, four different types of organisations are identified: (1) decentralised organisation, (2) formal, centralised organisation, (3) flexible, centralised organisation and (4) flexible, polycentralised organisation. Perrow's model is shown in Figure 2.

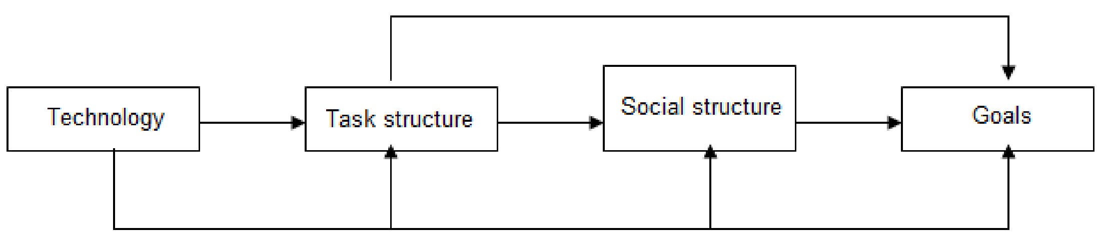

Figure 2: Perrow's model

Perrow made the following theory-based statements:

1) If we are not certain whether two organisations share the same type of technology, then finding the same relationships in them is unlikely.
2) Types of organisations will vary as much within each type as between types.
3) There is little point in testing the effect of a contingency factor, unless the effect of technology is controlled.
4) Certain organisational structures can be realised only with the right type of technology.

It is worth noting that Perrow made no empirical research to test his model or statements.

According to Thompson (1967), none of the existing technology typologies is general enough to cover the whole scale of technologies used by complex organisations. However, Thompson refers to Woodward (1965) in connection with manufacturing. Thompson defines three types of technology:

(1) Long-linked technology: the activities are ordered in a strict system (e.g., a production line in a mass production process).

(2) Mediating technology: connects partners and customers in a standardised and extensive way (e.g., the telephone company and the called customer).

(3) Intensive technology: a wide range of technologies are used to alter a certain object. Meanwhile, the selection, combination and application of the technologies are determined by the feedback received from the object (e.g., a hospital).

Organisations protect the technical core from environmental influences to operate at a higher level. If a company fails to protect the technical core; the environment will have greater influence as a consequence.

Dalton–Lawrence (1970) tried to answer the questions left behind by Woodward's (1965) methods. They mention two indices:

1) *The degree of variation in product range* provides an indication of which product lines are carried over from one year to the next. It is represented by the ratio of (1) the number of different products made in both of two successive years, and (2) the total number of different products made during the two-year period. The value of the indicator can be between 0 and 1. Empirical research found values ranging from 0.1 to approximately 0.8, and the different rates usually involved different management tasks at the different firms.
2) *The degree of interchangeability of components.* It is represented by the ratio of (1) the actual number of applications of different components to the firm's various products and (2) the theoretically possible number of applications. The value of the indicator can also be between 0 and 1. 1 means that all

components are used in each product, and a value of 0 indicates that components are not used in more than one product.

In addition to these, a third measure was also introduced: the degree of complexity of the product, which is simply the number of assembly stages in the manufacturing process, from materials to the final finished product.

Child (1972) also examined how technology impacts Woodward's (1965) and Perrow's (1967) definitions. Child's technology theory differs from the other two in certain ways: he did not regard technology as a deterministic factor; instead, he included the aspect of human resources into his theory. Referring to Thompson's (1967) theory about the technical core, he emphasises the importance of the company domain.

According to Miles et al. (1978), the function of manufacturing can be connected to the previously introduced 'Engineering Problem'. The strategic reactions may be the following:

- Defenders: how to seal off a portion of the total market to create a stable domain. This requires a narrow product-market and mechanistic organisation.
- Analysers: how to achieve and protect equilibrium between conflicting demands for technological flexibility and technological stability. It is caused by the organisation's constant demand for finding new products and markets, while keeping its position on the market at the same time. The problem can be best solved with a version of a matrix organisation structure.
- Prospectors: how can long-term commitment to a single technology be avoided? In this case, the prospector's structure-process mechanism must be organic, searching constantly for possible new products and markets.

Miles-Snow (1978) found that technology does not influence organisational structure directly, but through different operational and coordinating instruments of technology management. They also listed several technology-related problems from the literature:

- the definition and measurement of technology and structure are inconsistent, causing problems in comparison;
- between-industrial differences are not taken into consideration, although these may cause variance between structures instead of technology;

- one organisation may use several different technologies at the same time, so it is even more difficult to identify the effect of the dominant technology;
- organisational size may be a more of a determinating factor of structure than technology in several cases;
- technology and size cause only a low percentage of the variance of the organisational structure, so there must be other factors too;
- it is not always evident whether technology determines structure or organisational structure determines technology. The comparative analysis of technological effects on different levels of analysis was also performed by only a few researchers.

Dobák (2006) distinguishes information technology and core process technology, and defines technology as a set of techniques, methods and information used during the task solution. Core process technology is connected to production, defined as a set of instruments, methods and knowledge. There are two levels of interpretation:

- Technology from the organisation's point of view: development level of technical instruments, the level of automatisation, the fluency of activities, the degree of mass production, the method and frequency of supervisions, the uncertainty of the process, the degree of innovation and the characteristics of the used materials and the product.
- Technology from the individual's point of view: 1. In instances of more routinised task execution, employees are less involved in the decision-making process. 2. In instances of more complex tasks, employee empowerment is higher. 3. The uncertainty of the technological output results in more informal relationship and less written regulation.

In Table 4, the most significant results of the contingency researchers are summarised. The difference between the researchers' viewpoints can be clearly seen by comparing the dimensions and the measurement methods. It makes further research even more difficult that the differences are the biggest in this case compared to the other two previous contingency factors.

	Dimensions	Measurement	Other
Aston studies		1. The integration of workflow 2. Labour costs	It has a critical effect on structure
Woodward (1965)	1. One-off or standardized product 2. Process production or discrete product	Complexity, size (one-off products) Production continuity, product diversity (standardized products)	Companies with familiar production systems had familiar organisational structure
Perrow (1967)	1. Number of exceptional cases 2. Search processes		Different types of organisations according to task structure and technology
Thompson (1967)	1. Long-linked 2. Mediating 3. Intensive		The separation of technical core from the environment
Dalton-Lawrence (1970)		1. The degree of variation in product range 2. The degree of interchangeability of components 3. The degree of complexity of the product	
Child (1972)			Technology is not regarded as a deterministic factor The introduction of the aspect of human resources
Miles et. al (1978) **Miles – Snow (1978)**	The definition and measurement of technology are inconsistent in the previous literature		Engineering problem Different strategic decisions
Dobák (2006)	Core process and information technology	Different on organisational and individual level	

Table 4: Technology as a contingency factor

After the presentation of the relevant literature on contingency factors, the concept of fit and equifinality will be discussed. In this sub-chapter these are discussed only in general and will be adapted to the field of OM in Chapter 2.

1.4. The concept of fit and equifinality

Mintzberg (1979) calls attention to the problems and opportunities of the analysis of contingency factors. For example, the relationship between contingency factors can be better explained if groups of factors are examined instead of single factors. This idea was also mentioned by Drazin–Van de Ven (1985). Mintzberg (1979) also reminds that mostly cross-sectional analyses were used for the examination of the relationship between contingency factors and organisational parameters and that the existence of the relationship was tested with correlation analysis. This also means that the direction of causality cannot be examined. On the other hand, structure seems to be easier to modify (e.g., to decentralise the organisation instead of liquidating competition) than a contingency factor. Mintzberg (1979) also accepts this assumption.

Further methodological problems may be caused by (1) the simultaneous handling of more contingency factors, (2) the management's incorrect perception of contingency factors and (3) a non-linear relationship between a contingency factor and a dependent variable.

Although the term had already been used in the literature, it is Drazin–Van de Ven (1985) who introduced the three levels of fit (see also in Figure 3):

(1) *selection approach*: organisational context was related to organisational structure without examining whether this context–structure relationship affected performance;

(2) *interaction approach*: fit is an interaction effect of the context and the organisational structure on performance;

(3) *systems approach*: emphasises the need to adopt multivariate analysis to examine consistent patterns among dimensions of contingency factors, organisational context, structure and performance. Consequently, an organisational pattern of structure and process has to be selected that matches the set of contingency factors faced by the firm. In other words, the effect of sets of contingency factors and structural factors on performance is examined.

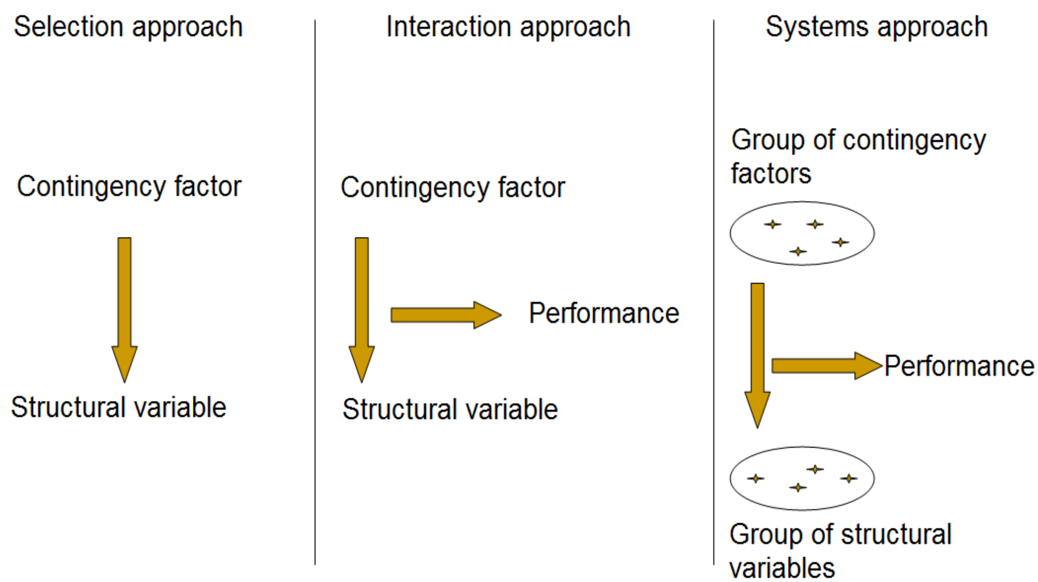

Figure 3: The interpretations of fit (Drazin–Van de Ven, 1985)

The work-unit, the smallest collective group in an organisation, was chosen as the unit of analysis. A work-unit consists of a supervisor and his staff working under his control. Drazin and Van de Ven proposed the following: highly performing units should improve their structure and processes in line with complexity and variability. To prove their proposition, 629 units of 60 offices in California and Wisconsin were queried between 1975–1978. The results supported the first and the third approaches.

As it was previously mentioned, contingency researchers support different theories about the determinism of the environment. Although Child (1972) had already mentioned the term ‘strategic choice’, it was not accepted by everyone. Many shared the opinion that fit is a deterministic process because under certain circumstances it is the only way to reach the prospected results. On the contrary, the term ‘equifinality’, defined by Gresov–Drazin (1997) refers to a steady state that can be reached from different initial conditions and in different ways.

Hence strategic choice and flexibility are available to organisation designers to achieve higher performance. Although the environment determines the *functions* that should be performed by the organisation, it does not determine the needed *structures*.

These last two terms can be defined in the following way. ‘Function’ is the way in which a component part of a subsystem (i.e., a structure) contributes to the maintenance of the system and its ability to be adaptive to its environment. ‘Structure’ is the pattern of relationships between individuals, and it modifies information and physical objects.

Equifinality occurs when, in a sample of organisations, different structural alternatives cause the same functional effect. To test the different types of equifinality, researchers have to prove that sub-samples in a certain sample of organisations provide the same level of performance. Consequently, the selection of the right aspect of evaluation is of critical importance. This idea already appeared in the OM literature (e.g., according to Hayes-Pisano (1994), both MRP and JIT systems are able to create similar capabilities in organisations and, through these capabilities, lead the organisations to the same result).

Following the presentation of the theoretical background of contingency theory and the concept of fit and equifinality in Chapter 2, these concepts will be adapted to the field of OM.

2. Contingency factors in the field of OM related to manufacturing practices and operations performance

In the previous chapter, the most important contingency theories and the related literature were reviewed, and the most important contingency factors were identified. In Chapter 2, I will study the role of the contingency factors in the field of OM, especially in manufacturing. I will highlight the differences between the concept of contingency theory and OM's contingency approach and introduce the OM literature related to the most important contingency factors. Then, the connection between manufacturing practices and the contingency factors will be described. At the end of the chapter, the third element of the model—the operational performance—will be examined, including its definition and relation to the contingency factors and manufacturing practices.

2.1. Contingency factors in the field of OM

The two fields of OM are manufacturing and services. However, in my thesis, I will study only the field of manufacturing in detail. Manufacturing can be defined as the partial utilisation of available resources to produce new goods through the permanent alteration of other resources (Chikán, 2008). In the later portions of this study, I will use terms such as manufacturing contingency factors, manufacturing practices, and operations performance, even if the original source uses the term OM. OM will only be used to refer to my discipline, similar to Tiwari et al. (2007), who use the term "OM" only in the context of a manufacturing industry.

The most influential article about manufacturing contingency factors is the study by Sousa – Voss (2008), which emphasised the lack of examination of contingency factors. The writers noted that many recently published studies referred to the lack of the overall efficiency of the manufacturing practices and made their arguments contingent on the context. Contingency theory has already been adapted to the field of OM (first in connection with manufacturing strategy) but not for manufacturing practices. The original contingency theory studies were introduced to the field of OM through Skinner's works and led to the manufacturing-strategy contingency paradigm, which tells us that if manufacturing strategy decisions are consistent both externally and internally, the firms' performance will improve (Skinner, 1969).

According to Sousa – Voss (2008), the contingency theory related to manufacturing practices consists of three groups of variables:

(1) use of the manufacturing practices;
(2) contingency factors; and
(3) performance.

Figure 4 represents the differences between the traditional contingency theory and the contingency approach of OM.

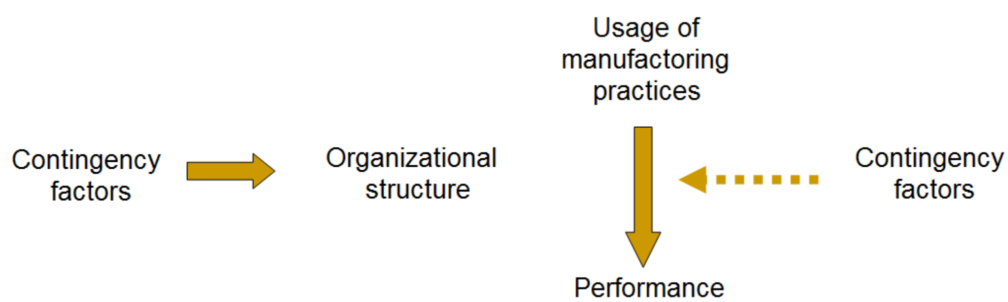

Figure 4: Traditional contingency theory and the contingency approach of OM

Traditional contingency theory examines the effect of contingency factors on organisational structure, as was explained in Chapter 1. This model may also be extended with performance measurements because of the differences between organisational structures. OM's contingency approach differs from the traditional approach because in its case, the basic relationship is between manufacturing practices and operations performance influenced by manufacturing contingency factors. Contingency factors can be classified as drivers, mediators, or moderators. The exact form may differ depending on the researcher's approach, and the empirical results determine the validity or invalidity of the research models. The possible relationships of contingency factors to manufacturing practices and performance are depicted in Figure 5.

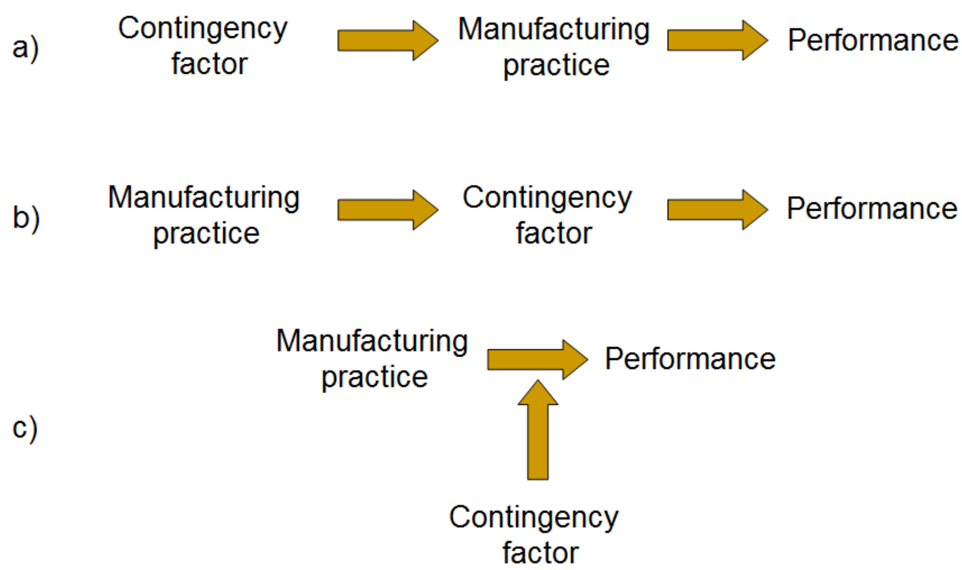

Figure 5: Contingency factors as (a) drivers, (b) mediators, and (c) moderators

As will be described in Chapter 3, my research model presents the same relational structure between contingency factors, operations performance and manufacturing practices.

Sousa – Voss (2008) reviewed those studies that analysed the influence of contingency factors on the implementation of manufacturing practices. Contingency factors were divided into four groups, as observed in Table 5. ('Number of studies' includes 35 different publications. A publication was mentioned more than once if it contained research about additional contingency factors).

Contingency factor	Number of studies	Most frequently used variable to measure the contingency factors	Most frequently studied manufacturing practice	Presence of performance variables	Existence of contingency effects
National context and culture	12	Country of operation (6 studies) Native country (4)	Quality management (6) General (manufacturing) best practices (4)	1 study	Exists with 1 exception
(Firm) size	9	Number of employees (8) Firm size (1)	Quality management (5)	2 studies	Depends on the examined manufacturing practice
Strategic context	14	Production system related variables (6)	Quality management (6) JIT / lean (4)	7 studies	Exists with 2 exceptions
Other	7	Industry (3)	Quality management (2)	Not used	Exists in all studies

Table 5: OM studies researching contingency factors (based on Sousa – Voss, 2008)

The studies were classified into three groups according to the research design:

(1) Interferential-aggregate studies: studies that are designed to investigate the existence of differences between the implementations of practices at an aggregate level. Typical format of the hypothesis: H0: There are differences in the use of a set of practices across different contexts. Six studies out of the 35 were classified as interferential-aggregate.

(2) Interferential-detailed studies: studies that are designed to investigate the existence of differences between the implementations of practices at a detailed level, specifying the effects of different contexts on individual practices. Typical format of the hypothesis: H0: Practice X is used to a greater extent in context Y than in context Z. Eighteen studies out of the 35 were classified as interferential-detailed.

(3) Explorative-comparative (non-inferential) studies: studies that tried to uncover differences between the implementations of practices in different contexts but that lacked precise, tested or testable hypotheses. Eleven studies out of the 35 were classified as explorative-comparative.

Form the aspect of Drazin – Van de Ven's (1985) typology (selection, interaction and system approach; see also in Chapter 1), the studies can be classified in the following way: the selection approach was used in 24 studies, but the interaction approach was used only 7 times. The system approach was applied in 4 studies: two times for the whole system and twice for only a part of it. The examination of equifinality was completely missing from these studies. In summary, it is clear that there are numerous possibilities for further research to explore the role of the contingency factors in connection with manufacturing practices and operations performance.

Based on these facts, Sousa – Voss (2008) suggested numerous further research possibilities for OM researchers:

- 1. The taxonomy of contingency factors must be developed.
- 2. It is important to identify those contingency factors that explain the greatest variance in performance. It would also be useful to integrate highly correlating contingency factors into one factor.
- 3. Researchers are supposed to combine different approaches that are not mutually exclusive. The selection approach can be used to detect the relationship between manufacturing practices and certain contingency factors. The interaction approach may be helpful to identify the most critical correlations between contingency factors and manufacturing practices. Finally, the results of the system approach are comparable with the results of the interaction approach. In addition, it can also help to explore the affecting contingency factors and to examine equifinality.
- 4. The system approach should be applied more frequently, e.g., using configurational research methods (Meyer et al., 1993) or profile deviation (Venkatraman, 1989; Venkatraman – Prescott, 1990). These methods are detailed in Chapter 3.
- 5. In connection with performance measurements, a greater emphasis should be placed on traditional operational performance dimensions because they have not been adequately studied. For example, it may be interesting to examine whether the relationship between manufacturing practices and contingency factors depends on the dimension of operations performance that is achieved (e.g., the relationship may be different if the focus is on cost rather than on flexibility).
- 6. The use of methodologies orientated towards theory building (e.g., case research) should increase.

Referring to Chapter 1, several contingency factors can be easily separated from the others. The most important and studied contingency factors are the environment, size and technology. However, in the field of OM, the importance of managerial choice should also be taken into consideration. The goals of business strategies are adapted to the field of manufacturing according to the manufacturing strategy, and the priorities of the manufacturing strategy will also influence the use of different manufacturing practices. These priorities (also called strategy foci) can be considered as contingency factors in the manufacturing practices. Sub-chapter 2.1.4 will demonstrate that these priorities were usually described with different competitive priorities.

Based on Chapters 1 and 2, **in my research model, I will examine the effect of four contingency factors (environment, size, technology and strategic focus) on the implementation of manufacturing practices and operations performance**. In the following part of this chapter, I will introduce the literature connected to these contingency factors' effects on the use of manufacturing practices and operations performance as well as on the relationship between manufacturing practices and operations performance. The studies will be introduced chronologically, describing the subject, the framework and the empirical research (if it exists) of each study. If a study examines more than one contingency factor, it will be detailed in the section dedicated to the first factor and mentioned in all of the other cases. All of the information about each discussed contingency factor will be summarised in a table at the end of each section.

2.1.1. Environment as a manufacturing contingency factor

The model of Swamidass – Newell (1987) examined the effect of environmental uncertainty on the flexibility of manufacturing strategies as well as the effect of manufacturing strategies on business performance. To analyse uncertainty, perceptual measures were used. (This is a widely applied method because organisations obtain information about environmental uncertainty only through managerial perceptions.) The operationalisation of the environment was based on Duncan's (1972) work. The 35 companies analysed operated in the machinery and machine tools industry. Path analysis was used to analyse the questionnaire data. Swamidass – Newell found a positive relationship between the degree of environmental uncertainty and the level of manufacturing strategy flexibility: 1) the increase in flexibility is a possible way to handle increasing uncertainty, and 2) the relationship between two contingency factors was examined.

Sitkin et al. (1994) investigated the effect of the environment in the field of Total Quality Management (TQM). They assumed that the adaptability of TQM-related rewards and incentives depends on the level of uncertainty, although this relationship was rarely studied in the TQM literature. For this study, they created a contingency model to examine the efficiency of TQM. In their interpretation, efficiency depends on uncertainty (task, product/process and organisational uncertainty) and on the fit of TQM principles and practices. However, the model was not tested empirically.

Dean – Snell (1996) examined the moderating effect of the industrial competitiveness level on the relationship between integrated manufacturing (the combined application of advanced manufacturing technology [AMT], total quality management [TQM], just-in-time [JIT]) and performance. They found that the AMT-performance relationship is likely to be stronger in the case of more concentrated industries but only at the 5% significance level. The JIT-performance relationship was stronger in industries with slower growth but barely at the 10% significance level, thus there was only a weak correlation between them. Through questionnaires, 92 companies were examined; each company operated in the SIC 33-37 industries. The data were analysed with a hierarchical multiple regression analysis.

In their model, Reed et al. (1996) identified dynamism, complexity and munificence as the three components of uncertainty. The first and the second components are consistent with classical contingency theory and with the studies of Burns – Stalker (1961), Thompson (1967) and Lawrence – Lorsch (1967). According to Reed et al., firm performance is determined by the fit of environmental uncertainty, TQM and firm orientation (a customer or operations orientation). To operationalise uncertainty, two methods are suggested:

1) Direct measures, e.g., the rate of technological change in products and processes, dynamism measured with sales growth and volatility, and complexity measured with industry concentration, and
2) Proxy or indirect measures, e.g., the perceived environmental uncertainty.

Reed et al. (1996), similarly to Sitkin et al. (1994), did not test their model.

Jonsson (2000) studied whether companies in dynamic environments (where flexibility is an important competitive resource) invest more heavily in advanced manufacturing technologies (AMTs) than companies in stable environments. In this study, 324 companies from the SIC 33-37 industries responded to the questionnaire. Environmental uncertainty was measured according to two variables: market uncertainty and political uncertainty.
The companies were classified using cluster analysis, and ANOVA was used to examine the differences between the clusters (high investigators, hard investigators and traditionalists). A significant difference was found between the environments of the three groups.

Ward – Duray (2000), similarly to Swamidass – Newell (1987), examined the relationship between two contingency factors. In their empirically tested model, the environment affects the manufacturing strategy directly and indirectly (through competitive strategy), and both of the strategies affect performance. The environment was measured with its dynamism, using the following factors: the rate at which products and services become obsolete, the rate of innovation, and the rate of change of customer preferences. In this study, 101 manufacturing companies (from the industries of fabricated metal products, electrical devices, and electronic controls) were questioned to estimate a path model using covariance structure analysis. The analysis did not support the hypothesis that environmental dynamism directly affects the manufacturing strategy.

González-Benito (2002) designed a general model for just-in-time (JIT) purchasing implementation. This approach integrated environmental factors such as the market structure, dynamism, position in the manufacturing channel, social system and internationalisation, but this section of the model is not used in the empirical testing.
The empirical research was based on the questionnaire responses of Spanish auto components manufacturers. The sample consisted of 397 companies (employing at least 50 workers) from the electronics, plastic and steel industries.

Koufteros et al. (2001) studied the effect of concurrent engineering practices (CE) on quality, product innovation and premium pricing. According to one of their hypotheses, firms in high change environments will adopt higher level of CE practices than firms in low change environments. The analysis (structural equation modelling/SEM method) verified the hypothesis. The sample consisted of 122 companies from the SIC 34-37 industries.

Koufteros et al. (2002) and Koufteros et al. (2005) described the changes in environmental uncertainty and environmental components. These components were regularly operationalised with the measure of change. According to one of the environment-related hypotheses, firms in uncertain environments will adopt higher levels of integrated product development practices than firms in more certain environments. Koufteros et al. (2002) names the following components of the uncertainty factor:

1. What best describes the percent of products in your industry whose performance has improved over the last 2 years due to technological change?
2. In this industry, what best describes the degree of improvement in product performance within the last two years?
3. In this industry, how quickly do new products capture market share from existing products?
4. In this industry, what best describes the frequency of product change within the last two years by you or your competition?
5. What best describes the percent of products in your industry whose quality has improved over the last 2 years due to technological change?
6. What best describes the percent of products in your industry whose manufacturing practices have been substantially improved over the last two years due to technological change?
7. In this industry, how extensive is the typical product change?

The empirical research was based on the questionnaire responses of 244 companies from the SIC 34-37 industries. Small companies (less than 500 employees) were represented to a greater extent than large companies (over 500 employees).

The previously introduced hypothesis was tested with SEM (structural equation modelling). Uncertainty appeared in the model as a moderating factor, which was handled in the following way: the sample was divided into two groups according to the high or low value of the moderating factor (e.g., uncertainty). This method proved to be better than handling uncertainty as a direct effect. Finally, there was no significant difference found between the two levels of uncertainty, thus the structural model seemed to be the same under both environmental circumstances.

Merino-Diaz De Cerio (2003) studied the questionnaire responses of 965 Spanish manufacturing companies, examining whether companies facing higher levels of competition use higher level of quality management (QM) practices. QM practices were defined in an extensive way, including practices connected to product development, manufacturing processes, customer and supplier relationships, and human resources management. Probit modelling and cluster analysis were used as methods of analysis. Three clusters were created according to the implementation level of the practices (high/intermediate/low). The level of competition failed to register any link with the level of QM practices.

Pagell – Krause (2004) examined the effect of the environment on manufacturing flexibility (hence examining two contingency factors). The environment was measured with three objective variables: munificence, instability and complexity. For this study, 252 companies responded to the questionnaire. Path analysis found no relationship between the levels of flexibility and environmental uncertainty, so they could not support the results of Swamidass – Newell (1987). The fact that companies in the two samples used different technologies to handle environmental challenges may also be a reason for the results.

Raymond (2005) analysed the questionnaire responses of 118 Canadian SMEs (20-250 employees), covering the whole manufacturing and construction industry. The model contained the following elements related to my research: 1) environmental uncertainty affects the assimilation of advanced manufacturing technologies (AMT) and 2) the level of the assimilation affects operational performance. The first hypothesis was not accepted, but a high level of significance was found for the second relationship (the highest in the model).
Environmental uncertainty was measured on a 5-point Likert scale. The respondents were asked to indicate on the scale the degree of change and unpredictability in the firm’s markets, competitors and production technology. The operations performance was measured in terms of productivity, quality and cost (using 9 different variables).

For the analysis, structural equation modelling was used, especially the partial least squares (PLS) method.

Ketokivi (2006) studied flexibility strategies. The complexity and dynamism of the environment were considered as important external contingency factors, which also partly determine the applicability of specific flexibility strategies. In his interpretation, this finding is consistent with the SCP (structure–conduct–performance) paradigm of industrial organisation (IO), saying that the company's strategy reflects the environment in which the company operates (see Appendix 2). Complexity was operationalised with the width of the product line and the ratio of mass customisation, while dynamism was operationalised with the uncertainty and variability of demand.
The question was investigated using survey and case studies, and the study examined 14 of a company's plants. The results showed that the choice of flexibility strategy is not completely determined by the environment; technology and strategy also seemed to be important contingency factors.

Hung (2007) analysed the case of a Taiwanese motherboard manufacturer and how it implemented TQM practices to increase its quality performance and innovation performance. According to Hung's assumption, the primary effect of TQM performance affects quality performance, and the secondary effect affects innovation performance. The way the business environment affects this relationship was also examined. Hung suggested that in a stable environment, TQM practices have a direct effect on quality. However, the secondary effect on innovation performance appears only after environmental changes, so the environment mediated the effect of TQM practices on the innovation performance. The business environment was not defined in further detail.

Hutchinson – Das (2007) examined a reorganised company using case study methodology. Of the company's three manufacturing groups, the researchers focused on the DPG (discrete products group) as producing multiple products at low volumes using batch manufacturing processes. They examined the model of Vokurka – O'Leary-Kelly (2000), formulating the following propositions:

- for firms facing a decrease in environmental munificence, the level of workforce experience will influence the adoption of appropriate manufacturing flexibility, leading to improved performance, and

- for firms facing a high level of environmental dynamism and uncertainty, along with a low level of munificence, the acquisition of suitable manufacturing technology will provide appropriate manufacturing flexibility, which leads to improved performance.

The performance was measured according to the dimensions of cost, quality and delivery. However, the results were not re-tested on a larger sample.

Matyusz – Demeter (2008) examined the effects of two environmental contingency factors, market dynamism and competition intensity, on manufacturing practices and operations performance. The research was based on the fourth wave of an international survey (International Manufacturing Strategy Survey—IMSS) in 2005 among the 'innovative' industries (ISIC 28-35) of 23 participating countries with a sample of more than 700 firms. The results showed that market dynamism has a direct effect on certain process-control practices (process focus) and on certain performance dimensions (quality, time). On the other hand, it has an indirect effect on a few manufacturing practices (technology and product development practices). Because the following two studies were based on the same questionnaire, I will not revisit the IMSS.

Matyusz et al. (2009) studied the effect of size and geographical focus on manufacturing practices and business performance. For my thesis, only the relationship between the geographical focus and the manufacturing practices is relevant. The results showed that companies with an international focus apply manufacturing practices to a greater extent than those companies, which only produce for the national market.

Matyusz et al. (2010) examined whether the companies' scope of operation (i.e., the company manufactures globally or in its native country) moderates the relationship between manufacturing practices and operations performance. The analysis did not support the hypothesis.

The study by Demeter – Matyusz (2010) was based on the preliminary data of IMSS-V (the fifth wave of the International Manufacturing Strategy Survey), which had 561 valid observations from 17 countries in 2009. All of the companies operated in the ISIC 28-35 industries. The effect of the rate of process and product technology changes on manufacturing practices and lead time was examined in this survey. The results showed that the higher rate of process technology change motivates companies to use manufacturing practices to a greater extent than the higher rate of product technology changes. The majority of the companies faced a high rate of technological changes.

Table 6 summarises the previously presented studies: the name of the source; the examined contingency factor; the type of contingency factor (D = driver; ME = mediator; MO = moderator[3]); the relationship it affects and the significance of the effect; the empirical research method; the investigated industries; the sample size; and the instrument of the analysis.

The moderating effects were examined ten times, whereas the driving effects and mediating effects were studied in only one case (Hung, 2007). The effects were significant and non-significant at approximately the same percentage rate. Although many different contingency factors were studied, the applied methodologies do not show a diverse picture. In most of the studies, the data were collected through the questionnaire responses and were analysed with regression analysis methods. However, the studies differed among the industries of the examined companies.

[3] If there is a moderating effect between two variables, the two variables are separated with 'and' in the 'What does it affect?' column in Table 6.

	Contingency factor	Type of the factor	What does it affect?	Significant?	Empirical research method	Industries	N	Analysis techniques
Swamidass – Newell (1987)	Environmental uncertainty	D	Flexibility	Yes	Questionnaire	Machinery, machine tools	35	Path analysis
Sitkin et al. (1994)	Uncertainty	MO	TQM principles, practices and efficiency	-	-	-	-	-
Dean – Snell (1996)	Intensity of the competition (concentration, industrial growth)	MO	Integrated manufacturing and performance	Partial and very weak	Questionnaire	SIC 33-37	92	Regression analysis
Reed et al. (1996)	Uncertainty (dynamism, complexity, munificence)	MO	TQM, company orientation and revenue growth, cost reduction	-	-	-	-	-
Jonsson (2000)	Dynamism, environmental uncertainty	D	Investment in AMT	No	Questionnaire	SIC 33-37	324	Cluster analysis, ANOVA
Ward – Duray (2000)	Dynamism	D	Manufacturing strategy	No	Questionnaire	Fabricated metal products, electronical devices, and electronic controls	101	Path analysis
González-Benito (2002)	Market structure, dynamism, manufacturing channel position, social system, internationality	MO	Product characteristics and the implementation of JIT purchasing practices	-	Questionnaire	Electronic, plastic, and steel industries	397	-
Koufteros et al. (2001)	High/low change	MO	Concurrent engineering practices	Yes	Questionnaire	SIC 34-37	122	SEM
Koufteros et al. (2002, 2005)	Uncertainty (measure of change)	MO	Integrated product development practices	No	Questionnaire	SIC 34-37	244	SEM
Merino-Diaz De Cerio (2003)	Competition	D	Quality management (TQM)	No	Questionnaire	Manufacturing industry	965	Cluster analysis, probit model
Pagell – Krause (2004)	Environment (munificence, instability, complexity)	D	Manufacturing flexibility	No	Questionnaire	Majority of the respondents from 6 different manufacturing industries	252	Path analysis

	Contingency factor	Type of the factor	What does it affect?	Significant?	Empirical research method	Industries	N	Analysis techniques
Raymond (2005)	Uncertainty (the rate and unpredictability of change)	D	AMT assimilation	No	Questionnaire	Manufacturing industry, construction	118	SEM PLS
Ketokivi (2006)	Complexity, dynamism	D	Flexibility	Weak	Case study	Metal fabrication	14	-
Hung (2007)	Stability of business environment	MO ME	TQM and quality TQM and innovation performance	Yes Yes	Case study	Motherboard manufacturing	1	-
Hutchinson – Das (2007)	Munificence Munificence, dynamism, uncertainty	MO MO	Workforce and flexibility Technology and flexibility	-	Case study	Electrotechnical and optical products	1	-
Matyusz – Demeter (2008)	Market dynamism, Competition intensity	D D	Process control Technology, product development, quality	Yes Yes	Questionnaire	ISIC 28-35	711	Path analysis
Matyusz et al. (2009)	Geographical focus	D	Manufacturing practices	Yes	Questionnaire	ISIC 28-35	683	ANOVA
Matyusz et al. (2010)	Scope of operation	MO	Manufacturing practices and operational uncertainty	No	Questionnaire	ISIC 28-35	251	SEM
Demeter – Matyusz (2010)	The rate of process and product technology change	D	Use of manufacturing practices	Partly	Questionnaire	ISIC 28-35	561	ANOVA

Table 6: Environment as a manufacturing contingency factor

2.1.2. Size as a manufacturing contingency factor

White (1993) conducted an extensive questionnaire-based study to examine companies that implement just-in-time (JIT) practices. The sample consisted of 1035 companies. The firm's size was categorised according to the number of employees: fewer than 250 employees, 250-499 employees, 500-999 employees, and more than 1000 employees. Most of the examined companies operated in the electronic/electric industries. The researcher found that larger companies implemented JIT practices to a lesser extent than smaller ones.

According to the classification of Ghobadian – Gallear (1996) and Ghobadian – Gallear (1997), micro companies employ fewer than 10 employees, small companies employ 10-99 employees, medium companies employ 100-499 employees, and large companies employ more than 500 employees. Their research, based on four case studies, did not study micro companies, and so they suggested further studies in this field. The validity of the TQM (total quality management) concept was examined at the SMEs through case studies. The results revealed that size is an important factor for certain TQM characteristics, but in other cases, no significant difference was found between the two smaller and two larger companies.

Cagliano (1998) found that larger companies usually implement manufacturing practices more intensively than smaller companies. Her analysis is a perfect example of the selection approach (the simultaneous analysis of one contingency factor and one practice, excluding its effect on performance). Size was operationalised according to the number of the employees and revenue. According to the number of the employees, the following groups were created: micro companies (fewer than 20 employees), small companies (20-200 employees), medium companies (200-500 employees), and large companies (more than 500 employees).

Swamidass – Kotha's (1998) questionnaire-based research examined 160 companies from SIC 34-39 industries using regression analysis. The unit of the analysis was the strategic business unit (SBU). Their first hypothesis assumed that the implementation level of advanced manufacturing technologies (AMT) grows linearly as size grows logarithmically. This hypothesis was confirmed in the case of most AMTs. The second hypothesis assumed that size moderates the relationship between AMT use and performance, but they found only a weak effect. The implementation level of AMT was measured on a five-point Likert scale, similar to performance. The AMT implementation level measurement contained mostly financial performance variables, but several variables also pertained to the operations performance.

Voss et al. (1998) and Cagliano et al. (2001) examined 285 SMEs from seven countries (Italy, UK, Belgium, Denmark, Sweden, Ireland) and 21 industries (the following industries represented more than 60% of the sample: fabricated metal products, industrial machinery and equipment, electronic and electric equipment, food, printing and publishing). The researchers established the following size categories: micro companies (5-20 employees), small companies (21-50 employees), and medium companies (51-200 employees). The following research questions pertain to my research:

- Which is the level of adaptation of world-class practices within SMEs? Is it homogeneous or does it vary between companies? The results showed that there are various levels of adaptation. The levels of adaptation differed more in the case of the micro and small-medium size companies than when comparing SMEs to large companies.
- Does SMEs' performance reach the world-class level? The results were varied, but the effect proved significant (i.e., performance improves as the size increases).

According to Jayaram et al. (1999), there are positive relationships between individual HRM practices and manufacturing performance. A review of the literature suggested that HR practices can exhibit a significant, positive relationship with more than one dimension of manufacturing performance; and HRM practices are usually discussed individually, rather than in bundles. Manufacturing performance was measured by four factors: cost, flexibility, time and quality. Size had only one significant effect as an explaining factor, in the case of quality performance, demonstrating that smaller companies reach a higher level of quality performance. The study sample consisted of 57 automobile suppliers from North America. The unit of analysis was the strategic business unit (SBU).

McKone et al. (1999) examined the effect of contexts on the total productive maintenance (TPM) practices. Three different contexts were defined:

1) Environmental context: the company's country and industry.
2) Organisational context: equipment age, type of equipment (standardised or customised), company size (number of employees instead of sales due to currency differences), plant age and unionisation.
3) Managerial context: the general level of employee involvement (EI), just-in-time (JIT) and total quality management (TQM) development.

The hypotheses assumed that environmental factors (country and industry) explain a significant portion of variation in TPM implementation levels. The data used for the analysis were collected as part of the World-Class Manufacturing (WCM) Study. Questionnaire data were collected from 107 manufacturing plants in three countries (Japan, USA, Russia) from the electronics (SIC32), machinery (SIC33) and automobile (SIC32) industries. The collected data were analysed using regression analysis, which found that organisational factors (such as organisational size) have only a small influence on the adaptation level of TPM practices.

Jonsson's (2000) cluster analysis showed that companies that invested more in advanced manufacturing technologies (AMT) have more employees than companies of the two other clusters that invested less.

Cua et al. (2001) studied the joint effect of just-in-time (JIT), total quality management (TQM) and total productive maintenance (TPM) on manufacturing performance. Size was one of the contextual factors of the analysis (operationalised using the number of employees). A better performance was expected from the larger manufacturing plants, but size did not prove to be significant. The data used for the analysis were collected as part of the World-Class Manufacturing (WCM) Study. Questionnaire data were collected from 163 companies of three industries (electronics, machinery, and transportation parts). Discriminant analysis was used to analyse the data.

Spencer – Loomba (2001) found with their questionnaire-based research that smaller manufacturing companies can implement total quality management (TQM) programs as successfully as large companies, resulting in competitive advantages in inventories, lead time, labour costs and operating expenses. The data were provided by 123 American manufacturing companies, and 39 of the respondents were small companies with fewer than 350 employees.

González-Benito (2002) mentioned organisational factors (e.g., the organisational size) in the above-mentioned general model for just-in-time (JIT) purchasing implementation in the case of the customer and the purchaser. This portion of the model was not tested empirically.

Koufteros et al. (2002) and Koufteros et al. (2005) classified companies in two size categories: small (fewer than 500 employees) and large companies (500 employees or more). The effect of size was not examined in their model.

McKone – Schroeder (2002) studied how company and plant size affect the application of specific technology practices (connected to process technology and product technology development). Plant size had only a weak influence on product technology development but no influence on process technology. The data used for the analysis were collected as part of the World-Class Manufacturing (WCM) Study. The questionnaire data were collected from 163 companies in three industries (electronics, machinery and transportation parts). The analytical tool was hierarchical regression analysis.

Merino-Diaz De Cerio (2003) found that larger companies use quality management techniques to a greater extent.

Shah – Ward (2003) established the following size categories for the companies under analysis: small (fewer than 250 employees), medium (250-999 employees), large (1000 or more employees). A significant relationship was found between the company's size and most of the implemented lean practices (in 20 of the 22 cases). This finding suggests that the larger a company is, the more likely it is to implement lean practices. The researchers collected data (via a questionnaire) from 1757 companies of certain manufacturing industries (SIC20-SIC39). Several statistical analysis methods were used, e.g., Spearman's rank correlation, factor analysis, chi squared test or hierarchical regression analysis.

According to the model developed by Ketokivi – Schroeder (2004), three different groups of factors may affect the organisation and the system of applied manufacturing practices: strategic goals, environmental contingency factors and institutional effects. However, only the first and the third factors moderate the relationship between performance and manufacturing practices. In their preliminary analysis, only the direct, practice-orientated effects were studied. Company size had a significant effect on design for manufacturability, the cross-training of the employees, and the implementation of just-in-time (JIT) practices as a result of one of their analytical approach. As another analytical approach showed, the company's size has a significant relationship with its design for manufacturability, cross-functional cooperation and the implementation of JIT practices.
During the preliminary empirical analysis, 164 medium and large companies (employing at least 100 employees) were studied from three different industries (automotive suppliers, machinery, and electronics) and five different countries (Germany, Italy, Japan, UK, USA), as part of the second wave of the WCM Project between 1994 and 1997. A multivariate general linear model was used for the analysis.

The study of Koh – Simpson (2005) examined the implementation of ERP systems at SMEs with ANOVA. The sample of this questionnaire-based study consisted of 64 British companies from the manufacturing industry. The applied categories were the following: micro (10 or fewer employees), small (10-49 employees), and medium-sized companies (50-250 employees).

Raymond (2005) examined 118 Canadian SMEs (20-250 employees) in his above-mentioned questionnaire-based research.

Zhang et al. (2006) examined the effect of advanced manufacturing technologies (AMT) and operations improvement practices on flexibility. The questionnaire results provided data pertaining to 273 companies from the SIC 34-38 industries. Size (measured by the number of employees) was one of the control variables of the analysis, but its effect did not prove to be significant after the regression analysis.

Crowe – Brennan (2007) based their survey on the third wave of the International Manufacturing Strategy Survey (IMSS) and on the questionnaire data concerning 558 companies. All of the companies operated in the manufacturing industry (ISIC 28-35). Size was measured according to revenue and the number of employees. However, size was not treated as a contingency factor; only its relationship with environmental-protection variables was examined using correlation analysis.

Sila (2007) focused on the question of whether quality management practices (TQM) are affected by contingency factors or whether they can be used universally. The original quality scholars (Crosby, Juran, and Deming) argued for the universalistic approach, but contemporary experts focus on context-dependency. Sila (2007) distinguished organisational factors and contingency factors (including company size). Size was measured according to the number of employees: small companies employed fewer than 100 employees, medium companies employed 101-500 people, and large companies had at least 500 employees.
As a result, no significant difference was found between the different size groups in the use of TQM practices. The data were collected through questionnaires from 286 companies in the manufacturing and service industries (SIC 28, 34-38, 50-51, 73, 87) and were analysed using SEM (structural equation modelling).

Small (2007) studied the advanced manufacturing technology (AMT) implementation and performance of 82 American companies from the SIC 35-37 industries by analysing their questionnaire responses. MANOVA and multivariate regression analysis were used for the analysis. Size was used as a control variable. The results indicated that companies with more employees apply more complex technologies.

Bayo-Moriones et al. (2008) examined the effect of plant size (as the logarithm of the number of workers) as an organisational factor on just-in-time (JIT) practice implementation. Questionnaire data were provided regarding 203 Spanish companies from all manufacturing industry sectors. The data were analysed using regression analysis. No relationship was found between plant size and JIT practice implementation.

Demeter – Matyusz (2008) studied the effect of company size on manufacturing practices. If a company employed fewer than 250 people, it was classified as an SME; otherwise, it was categorised as a large company. As a result, significant differences were found between the two groups in the relationship of used manufacturing practices and performance. In the case of SMEs, process control and product development had a significant effect on the company's quality performance. Large companies' quality performance was significantly affected by technology practices, and flexibility performance was affected by product development practices.

Jayaram et al. (2010) examined how company size affects the implementation of total quality management (TQM). Previous studies found different results, e.g., Sila (2007) did not find any relationship, but Shah – Ward (2003) found a strong relationship, as did the study by Jayaram et al. (2010) The questionnaire responses of 394 companies (from the SIC 20-39 industries) were analysed using the multi-group SEM LISREL method. Companies with fewer than 250 employees were classified as small; companies with more than 250 were classified as large.

Table 7 summarises the above data: the name of the source, the size categories, the type of contingency factor (D = driver; MO = moderator[4]), the relationship it affects and whether it is significant, the empirical research method, the investigated industries, the sample size, and finally, the instrument of analysis.

It can be clearly observed that different size categories were established in almost every study. This makes it difficult to compare results, e.g., ten different definitions are given for the group of 'small companies', and in these cases, they were not merged with medium-sized companies as SMEs. The question, 'What is typical for small companies?' can not be clearly answered because it depends on the study's categorisation of a small company. In some studies (marked with '*'), size was treated as a continuous variable without categories; or, there were categories, but without a size label attached to them. The number of employees was used as a measure in almost every case, whereas revenue was only used in a few articles.

The moderating effect was studied in only a few cases, whereas the focus was on the driving effect. The effect of the size was usually found to be significant, even if this effect was weak in some cases. A questionnaire was the most commonly used method of data collection. Using the environment as a contingency factor, different industries were examined from study to study. Regression and ANOVA analysis were the most commonly used analytical techniques in the studies.

[4] If there is a moderating effect between two variables, the two variables are separated with 'and' in the column 'What does it affect?' in Table 7.

	Micro	Small	Medium	Large	Type	What does it affect?	Significant?	Empirical research method	Industries	N	Analysis techniques
White (1993)*	(-249)	(250-499)	(500-999)	(1000-)	D	JIT practices	Yes	Questionnaire	Electronics	1035	Comparison of distributions
Ghobadian – Gallear (1996, 1997)	-9	10-99	100-499	500-	D	TQM practices	Partly	Case study	Mixed	4	-
Cagliano (1998)	-19	20-200	200-500	500-	D	Manufacturing practices	Yes	Questionnaire	ISIC 381-385	522	ANOVA
Swamidass – Kotha (1998)*					D MO	AMT implication AMT implication and performance	Yes Very weak	Questionnaire	SIC 34-39	160	Regression
Voss et al. (1998) **Cagliano et al. (2001)**	5-20	21-50	51-200	201-	D D	Implication of practices Performance	Yes	Questionnaire	21 different	285	More different techniques
Jayaram et al. (1999)*					D	Performance	Partly	Questionnaire	Automobile suppliers	57	Regression
McKone et al. (1999)*					D	TPM practices	Very weak	Questionnaire	SIC 32-33	107	Regression
Jonsson (2000)*					D	AMT	Yes	Questionnaire	SIC 33-37	324	Cluster analysis, ANOVA
Cua et al. (2001)*					D	Performance	No	Questionnaire	Transportation parts, machinery, electronics	163	Discriminant analysis
Spencer – Loomba (2001)		-349		350-	D	TQM practices	No	Questionnaire	Manufacturing industry	123	Comparison of means
González-Benito (2002)*					D	JIT purchasing practices	-	Questionnaire	Electronic, plastic, and steel industries	-	-
Koufteros et al. (2002, 2005)		-499		500-	-	-	-	Questionnaire	SIC 34-37	244	SEM
McKone – Schroeder (2002)*					D D	Product technology development Process technology	Weak No	Questionnaire	Transportation parts, machinery, electronics	163	Regression

	Micro	Small	Medium	Large	Type	What does it affect?	Significant?	Empirical research method	Industries	N	Analysis techniques
Merino-Diaz De Cerio (2003)*					D	Quality management	Yes	Questionnaire	Manufacturing industry	965	Cluster analysis, probit model
Shah – Ward (2003)		-249	250-999	1000-	D	Lean practices	Yes	Questionnaire	SIC 20-39	1757	Regression
Ketokivi – Schroeder (2004)			100-		D	Manufacturing practices	Partly	Questionnaire	Automotive suppliers, machinery, electronics	164	Multivariate general linear model
Koh – Simpson (2005)	-10	11-49	50-250	251-	-	-	-	Questionnaire	Manufacturing industry	64	ANOVA
Raymond (2005)		20-250			-	-	-	Questionnaire	Manufacturing industry, construction	118	SEM PLS
Zhang et al. (2006)*	(-99)	(100-499)	(500-999)	(1000-)	D	AMT, operations improvement practices	No	Questionnaire	SIC 34-38	273	Regression
Crowe – Brennan (2007)*					D	Environmental protection variables	No	Questionnaire	ISIC 28-35	558	Regression
Sila (2007)		-99	101-500	501-	MO	TQM practices	No	Questionnaire	SIC 28, 34-38, 50-51, 73, 87	286	SEM
Small (2007)*		(-199)	(200-)		D	Technological complexity	Yes	Questionnaire	SIC 35-37	82	MANOVA, regression
Bayo-Moriones et al. (2008)*					D	JIT practices	No	Questionnaire	Manufacturing industry	203	Regression
Demeter – Matyusz (2008)		-249		250-	D	Manufacturing practices	Partly	Questionnaire	ISIC 28-35	704	Path analysis
Jayaram et al. (2010)		-250		251-	MO	TQM implementation	Yes	Questionnaire	SIC 20-39	394	SEM

**In the marked studies companies were not classified as micro/small/medium/large size companies, but size was measured on a continuous scale without clear categories, or category titles. In these cases the micro/small/medium/large categories are not adequate.*

Table 7: Size as a manufacturing contingency factor

2.1.3. Technology as a manufacturing contingency factor

As will be observed in the following section, technology has numerous interpretations. According to a definition from the field of technology management, technology is the company's knowledge of describing a task and how it should be executed. Technology is manifested in the form of products, methods and processes. Technology also includes products, such that one can differentiate between a product technology and a manufacturing technology (or process technology) (Pataki, 1995). Drawing this distinction is important because it emphasises the fact that technology should not be approached from a process perspective only.

In the field of OM, the concept of a product-process matrix has a long history. The concept was first developed by Hayes – Wheelwright (1979) in linking the periods of product and process lifecycles. For the product, the periods were characterised by the produced quantity and the number of product types (from low-volume, one of a kind products to high-volume, highly standardised products). For the process, the scale ranged from job shops to continuous flow. A certain process cycle can be connected to each product lifecycle to manufacture the product most efficiently. Visually, the right product-process combinations are placed on the diagonal of the matrix. Several versions of the matrix were developed, which differed slightly from one another in the interpretation of the dimensions. For example, Demeter et al. (2008) emphasised the question of whether the applied process type is more affected by the requirements of technology or the product (instead of discussing the particular periods of the process lifecycle). Kemppainen et al. (2008) reviewed all of the studies in which the product-process matrix was empirically tested. These studies provided mixed results. On the on hand, the adaptability of the matrix was proved under certain circumstances. On the other hand, several defects and possible ways of improvement were found.

According to Lawler's (1987) perspective, technology is only partly driven by the services and products provided by the company (thus, there is partial flexibility in the applied technology). Moreover, technology does not entirely determine the nature of the tasks performed at the company. Lawler emphasised two aspects of the technology:

1) degree of interdependence, i.e., to two what extent do individuals need to cooperate to manufacture successfully, and

2) degree of complexity, i.e., to what extent is the job repetitive or based on complex knowledge.

White (1993) evaluated the companies according to the type of manufacturing process. The only criterion was the generation of at least 70% of the revenue from one of these manufacturing processes: job shop, batch, repetitive manufacturing or flow process. The results showed that companies using repetitive manufacturing or flow process implement JIT at a higher rate than companies using job shops.

Hobbs (1994) examined the adaptability of the just-in-time (JIT) manufacturing philosophy in two different manufacturing environments: repetitive manufacturing and job shop. In his opinion, JIT is the most adaptable in repetitive manufacturing environments, although many practices can also be successfully implemented in job shop environments.

Funk (1995) assumed in his article that the importance of JIT manufacturing implementation is related to the logistical complexity of the product. The logistical complexity was measured according to the number of manufacturing steps or by the number of the parts utilised in the plant. Logistically simple products consisted of few parts, or steps, although technologically they may have been complex (e.g., process industries). Logistically complex products consisted of numerous parts or manufacturing steps (e.g., discrete products).

Funk also compared the logistical complexity of the industries:

- Process industries—low complexity,
- Non-metallic fabrication and assembly—medium complexity,
- High-technology products—high complexity,
- Metal fabrication and assembly—high complexity.

Funk assumed that the best form of JIT manufacturing also depends on the logistical complexity of a product. According to his hypothesis, the higher the logistical complexity of a product, the more important it is to implement JIT manufacturing. However, the hypothesis was not proved empirically.

Hendry (1998) examined the make-to-order (MTO) industries, which produce highly diverse products in small quantities. She only analysed companies that were MTOs from their inception. The possible implementation of a world-class manufacturing (WCM) concept in this industry was also discussed, but the study lacked empirical support.

In their above-mentioned study, McKone et al. (1999) studied the effect of contexts consisting of different contingency factors on the total productive maintenance practices. The organisational context included the type of equipment used, which was operationalised by the rate of the standardised equipment compared to all the forms of equipment. The researchers found that organisational factors (such as the type of equipment) had only a minimal effect on the implementation level of TPM practices.

As already mentioned, Cua et al. (2001) examined the joint effect of just-in-time (JIT), total quality management (TQM) and total productive maintenance (TPM) on a company's manufacturing performance. The type of process was used as a contextual variable in the study. The authors expected a higher manufacturing performance from more process-oriented manufacturing plants. The analysis found that the process type had a significant effect on volume flexibility and, to a lesser extent, on a product's quality and on-time delivery.

Das – Narasimhan (2001) examined the issue of fit between the process environment (job shop, assembly lines) and advanced manufacturing technologies (AMT) and the impact of fit on the company's manufacturing performance. The questionnaire provided data pertaining to 226 companies from the SIC 34-38 industries. Manufacturing performance was measured using the four traditional dimensions (cost, quality, flexibility, delivery) and innovation (with new product introduction time). The results showed that quality is important in the case of assembly line environments, and cost reduction is important in both environments. Confirmatory factor analysis (CFA), profile deviation, and regression analysis were utilised.

As described above, González-Benito (2002) provided organisational variables for both the supplier and the purchaser sides for the implementation of just-in-time (JIT) purchasing in his general model. Technology is one of the variables, but this portion of the model was not used in the empirical tests. However, the study placed a great emphasis on the product variables:

- Volume: a variable that is directly related to the space needed for storage and the maintenance and transportation costs incurred in supply activities;
- Specificity: a component/product is said to specific when it is designed and manufactured to satisfy the requirements of a particular purchaser. This variable is the inverse of standardisation;
- Technological complexity: the degree of technical knowledge and experience required to design and manufacture technological components;
- Essentiality: a component is essential if a part or all of the manufacturing processes must halt when this component is not available;
- Fragility: the level of components' fragility affects warehousing costs;
- Variability: this variable measures the extent to which different versions of the component must be alternated when assembled into final products; and
- Economic value: the financial value of a product.

In the empirical analysis, only the effect of product variables was examined, but the effect of the other environmental and organisational variables was not. The relationship between product variables and JIT purchasing was measured with rank correlation. Most product variables correlated with the majority of JIT purchasing components, with the exception of volume and variability.

McKone – Schroeder (2002) examined how the type of process affects the implementation of certain technology practices (related to process technology and product technology development). The relationship between the type of the process and the implementation of both practices were positive and significant.

Youssef – Al-Ahmady (2002) examined how the use of flexible manufacturing systems (FMS) affects the implementation of quality management practices at manufacturing companies. The analysis revealed significant differences between FMS users and non-users in the implementation of quality management practices. FMS users also placed a greater emphasis on the human aspects of quality by employing human resource practices. Following the data collection (questionnaire), 102 U.S. companies from five industries (aerospace, electronics, industrial and farm equipment, metal products, motor vehicles and parts) were analysed using ANOVA.

The results of Merino-Diaz De Cerio (2003) proved that 1) plants with a high rate of automatisation use quality management practices to a great extent and 2) plants that have undergone the greatest technological change in recent years will also have introduced the most quality management practices. However, the hypothesis proposing that the more continuous the flow of the production process is, the more quality management practices will have been introduced was not proved.

According to the hypothesis of Koh – Simpson (2005), a product's late delivery is significantly affected by different underlying causes of uncertainty in different manufacturing environments. The analysed manufacturing environments included the following: made-to-stock (MTS), made-to-order (MTO) and mixed mode (MM). According to the results, companies working with fewer than 5000 parts are more likely to be influenced by the effects causing uncertainty than companies working with more than 5000 parts. Such effects are, for example, rejection because of quality, supplier delivery with a shortage, quality problems or late delivery, unexpected changes in demand, items missing in BOM, customer changes (lead time, quantity, quality) and inventory uncertainties.

Raymond – St-Pierre (2005) analysed 248 Canadian companies from 15 different industries using the SEM PLS method. The causes and effects of AMS sophistication (assimilation and integration, which is similar to technological complexity; see also Small (2007), below) were examined. The analysis found that AMS sophistication is influenced by the type of manufacturing: the more the company produces in small batches, the higher the level of AMS sophistication.

Ketokivi's (2006) results listed above showed that choosing a certain flexibility strategy is not completely determined by the environment; technology is also an important contingency factor.

Zhang et al. (2006) examined the effect of advanced manufacturing technology (AMT) and operations improvement practices on flexibility. The type of product was one of the control variables (in four categories, from 'one of a kind, low volume/low standard products' to 'high standardised, high-volume' products), but its effect did not prove to be significant.

Small (2007) concluded after his literature review that the advanced manufacturing technology (AMT) portfolios implemented by the companies can be distinguished according to their complexity (sophistication). According to Small's proposition, companies that adopt more complex technology will exert higher levels of effort on implementation than those with less complex technology. As for the implementation, several activities were examined and classified into the following groups: planning, HR, technological and investment activities. The proposition was proved for planning and investment activities. According to another proposition, companies that adopt more complex technologies will tend to achieve a higher level of performance improvement than those with less complex technologies. However, this hypothesis proved to be true only for certain elements of performance: delivery lead-times, inventory turnover rates, and the ability to change the production lot size.

Swink – Nair (2007) examined the assumed moderating effect of design-manufacturing integration (DMI) between advanced manufacturing process technology and manufacturing performance (cost efficiency, quality, delivery, new product flexibility and process flexibility). Process orientation was one of the control variables (engineer-to-order (ETO), assembly-to-order (ATO), manufacture-to-order (MTO), manufacture-to-stock (MTS)). After their questionnaire-based research, 224 North American companies from the SIC 25-26, 32-39 industries were analysed with hierarchical moderated regression analysis. The results indicated that in new product flexibility, there is a difference between the companies in process orientation; moreover, ETO environments are more flexible than the others.

Miltenburg (2008) used the terms manufacturing systems, production process types and manufacturing process types as synonyms and divided them into three categories:

1) craft production: job shop and batch flow;

2) mass production: operator-paced line flow, equipment-paced line flow and continuous flow; and

3) lean manufacturing: just-in-time and flexible manufacturing.

These process types can be arranged according to the following factors:

I) the production mix (number of products produced and the production volume of each product);

II) the layout and material flow, and

III) the manufacturing outputs (delivery, cost, quality, performance, flexibility, and innovativeness).

None of the manufacturing systems can guarantee the best performance for all of the outputs. According to the author, the manufacturing system determines improvement activities and implemented manufacturing practices. That is, the companies implement the manufacturing practices that best fit the manufacturing systems' requirements.

Demeter – Matyusz (2011) compared the inventory performance of lean and non-lean companies, measured according to the inventory turnover rate. The data were acquired from the fourth round of the International Manufacturing Strategy Survey (IMSS).

In the analysis, the following technology-related contingency factors were taken into consideration:

1) production system (job shop, cellular manufacturing, dedicated line)
2) order types (engineer-to-order (ETO), make-to-order (MTO), assemble-to-order (ATO) and make-to-stock (MTS)
3) product types (one of a kind, batch or mass).

Significant relationships were found between different inventory levels and the mentioned contingency factors only in a few cases. Companies with higher ratios of job shop production had higher levels of WIP inventories than companies with higher ratios of assembly line production, with cellular manufacturers falling in between. In the case of order types, there was a significant relationship between raw material inventory levels and MTO/ATO orientation (positive in the former and negative in the latter case). That is, companies that manufacture more to order usually have a higher raw materials inventory, while ATO producers have lower raw material levels. In the case of MTS manufacturers, the finished goods inventory level was significantly higher. There was no significant relationship between product types and inventory levels.

Table 8 summarises the above information: name of the source, name of the contingency factor (product, process), the type of the contingency factor (D = driver; ME = mediator; MO = moderator[5]), the relationship it affects and whether it is significant, the empirical research method, the investigated industries, the sample size, and the instruments of analysis.

[5] If there is a moderating effect between two variables, the two variables are separated with 'and' in the 'What does it affect?' column in Table 8.

It is clear that a wide range of technology factors are represented in the reviewed studies. The same name usually means different operationalisation, e.g., ETO, MTO, ATO, MTS in the case of Swink – Nair (2007) or Demeter – Matyusz (2011), or in the case of process types with the same name the separating boundaries between the categories were elsewhere.

I did not locate any studies that examined the moderating effects of technology; only the driving effect was investigated. The effects of technology contingencies were significant in almost every case. Survey research was the most dominant empirical method, and the examined industries were heterogeneous. Regression and ANOVA analysis were the most frequently used analytical methods.

	Product	Process	Type	What does it affect?	Significant?	Empirical research method	Industries	N	Analysis techniques
Hayes – Wheelwright (1979)	Produced quantity Number of product types	Continuity of flow	-	-	-	-	-	-	-
Lawler (1987)	-	Degree of interdependence Degree of complexity				-	-		
White (1993)	-	Job shop, batch, repetitive manufacturing, flow process	D	Implementation of JIT practices	Yes	Questionnaire	Electronics	334	Comparison of distributions
Hobbs (1994)	-	Job shop, repetitive manufacturing	-	-	-	-	-	-	-
Funk (1995)	Logistical complexity	Technological complexity	D	JIT	-	-	-	-	-
Hendry (1998)	Variability, produced quantity	MTO	-	-	-	-	-	-	-
McKone et al. (1999)	-	Ratio of the standardized equipments	D	TPM	Very weak	Questionnaire	SIC 32-33	107	Regression
Cua et al. (2001)	-	Process type	D	Volume flexibility, product quality, on-time-delivery	Yes	Questionnaire	Electronics, machinery, transportation parts	163	Discriminant analysis
Das – Narasimhan (2001)	-	Process environment (job shop, assembly lines)	D D	AMT Operational performance	Partly	Questionnaire	SIC 34-38	226	CFA, profile deviation, regression
González-Benito (2002)	Volume, specificity, technological complexity, essentiality, fragility, variability, economic value	-	D	JIT purchasing practices	-	-	-	-	-

	Product	Process	Type	What does it affect?	Significant?	Empirical research method	Industries	N	Analysis techniques
McKone – Schroeder (2002)	-	Process type	D D	Process technology Product technology development	Yes Yes	Questionnaire	Electronics, machinery, transportation parts	163	Regression
Youssef – Al-Ahmady (2002)	-	FMS	D D	Quality management HR practices	Yes Yes	Questionnaire	Several different industries	102	ANOVA
Merino-Diaz De Cerio (2003)	-	Level of automation Continuity of the flow	D D	Quality management	Yes No	Questionnaire	Manufacturing industry	965	Cluster analysis, probit model
Koh – Simpson (2005)	Number of parts	MTO, MTS, MM	D	Late delivery	Yes	Questionnaire	Manufacturing industry	64	ANOVA
Raymond – St-Pierre (2005)	-	Type of process	D	AMS	Yes	Questionnaire	15 different industries	248	SEM PLS
Ketokivi (2006)	-	Technology	D	Flexibility	Yes	Case study	Fémgyártás	14	-
Zhang et al. (2006)	Type of product	-	D	AMT, operations improvement practices Flexibility	No	Questionnaire	SIC 34-38	273	Regression
Small (2007)	-	Complexity	D	HR practices, technological practices Performance	No Partly	Questionnaire	SIC 35-37	82	MANOVA, regression
Swink – Nair (2007)	-	ETO, MTO, ATO, MTS	D	New product flexibility	Yes	Questionnaire	SIC 25-26, 32-39	224	Regression
Miltenburg (2008)	-	Craft, mass production, lean	D	Manufacturing practices	-	-	-	-	-
Demeter – Matyusz (2011)	One of a kind, batch, and mass products	Job shop, cellular manufacturing, dedicated line; ETO, MTO, ATO, MTS	D	Inventory level	Partly	Questionnaire	ISIC 28-35	610	ANOVA, correlation

Table 8: Technology as a manufacturing contingency factor

2.1.4. Strategic focus as a manufacturing contingency factor

Dangayach – Deshmukh (2001) reviewed the literature relating to manufacturing strategy using a total of 260 articles from 31 journals and international conferences that were published prior to January 2001. Out of the 260 articles, 89 studied competitive priorities (cost, quality, delivery speed, delivery dependability, flexibility), indicating the popularity of this approach in the field of OM and the basic competitive priorities of manufacturing. In my thesis, I consider these priorities as strategic foci. In the following part of this section, I will review the relevant literature in two different ways. I will present studies that researched manufacturing strategy from the approach of competitive priorities and that established categories (usually with cluster analysis) based on these priorities representing different manufacturing strategies, i.e., different strategic foci in the interpretation of my thesis. I will also present studies that examined the effects of the company's strategic focus (as a contingency factor).

Dean – Snell (1996) examined how the manufacturing strategy moderates the relationship between the implementation of integrated manufacturing (the joint use of AMT, TQM, and JIT) and performance. The results showed that the deployment of a quality strategy strengthens the AMT-performance relationship, but a cost strategy weakens it. To the researchers' surprise, the companies in the sample usually did not implement a combination of AMT and a quality strategy, i.e., quality orientation did not necessarily entail a higher level of AMT implementation. A possible reason is that companies see AMT as merely an extension of labour-saving mass production techniques. The manufacturing strategy was measured with 31 variables that operationalised the four traditional competitive priorities (cost, quality, flexibility, and delivery).

Cagliano (1998) studied manufacturing strategy configurations in detail using the data of the first and second waves of the International Manufacturing Strategy Survey (IMSS). Six different manufacturing strategy configurations were identified along the dimensions of price, flexibility, product mix, service and quality, which can be characterised as follows:

1) manufacturing innovators scored high in every dimension, although quality was the most important dimension;
2) for caretakers, price is most important, followed by quality;

3) technology exploiters prefer a broad product mix with low prices, and they are inflexible;
4) for cost minimising customisers, price and flexibility are the most important, while a broad product mix is not a priority;
5) high performance producers emphasise services and quality, neglecting price and flexibility; and finally,
6) for marketeers, flexibility, quality and services are equally important.

These configurations can be compared or identified with certain configurations described in prior studies (e.g., Miller – Roth, 1994).

Forza – Filippini (1998) proposed that a strong orientation towards quality leads to a higher level of process control by way of multifunctional employees and employee suggestions. After survey-based research, a total of 43 companies belonging to the electronics and mechanical sectors were analysed using SEM. Although a strong relationship was found between quality orientation and HR practices, HR practices were not directly connected to process control and did not mediate the effect of quality orientation.

Kathuria (2000) proposed that manufacturing units can be classified into different groups according to the emphasis placed on competitive priorities (cost, quality, flexibility, delivery). Kathuria examined the proposition with a sample of 98 companies from 14 industries using cluster analysis. The resulting clusters had the following characteristics: 1) low values in all dimensions, and quality was the highest among them; 2) quality and cost focus; 3) quality and delivery focus; and 4) each dimension is important, especially quality and flexibility.

Kathuria – Davis (2000) examined what workforce management practices are appropriate for quality management. The types of work force management practices were divided into three groups:

1) relationship-oriented practices, e.g., networking, team-building, supporting, and mentoring;
2) participative leadership and delegation practices, e.g., consulting and delegating;
3) work-oriented practices, e.g., planning, problem-solving, monitoring, and informing.

A total of 14 practices were analysed, including 70 variables. The results indicated that managers with a high emphasis on quality apply relationship-oriented practices more frequently than managers with a lower emphasis on quality. In the case of participative and work-oriented practices, no such difference was found. The unit of analysis was the manufacturing plant. After the survey research, 98 companies were analysed from 17 different industries with correlation and t-tests.

Kotha – Swamidass (2000) analysed 160 firms from the SIC 34-39 industries with factor analysis and regression analysis based on questionnaire data. The researchers defined several dimensions of advanced manufacturing technology (AMT) in the study. In connection with these dimensions, a positive relationship was not found between the implementation of cost-leadership strategy and high-volume automation technology, but the differentiating strategy was positively related to some other dimensions of AMT use.

Sousa – Voss (2001) and Sousa (2003) studied three manufacturing strategy configurations at five printed-circuit manufacturers with case study methodology from the electronics industry. The three configurations were the following:

1) niche differentiator,
2) broad differentiator, and
3) cost leader.

According to the hypothesis of Lewis – Boyer (2002), high-performing companies place a greater strategic emphasis on the four traditional competitive priorities than low-performing companies. Following the survey research, the hypothesis was tested on a sample of 110 companies (more than 60% from the SIC 34-39 industries) with ANOVA. The researchers controlled for the type of advanced manufacturing technology (AMT); based on this approach, all of the companies implemented the same type of AMT. The measured aspects of production performance were product quality, scrap minimisation, on-time delivery, equipment utilisation, and job lead time, which can be matched with the traditional quality dimensions (cost, quality, flexibility, and delivery). The analysis indicated that there was no difference between companies in terms of the cost focus. However, in the case of the other competitive priorities, the results supported the hypothesis.

Ahmad et al. (2003) studied why the same JIT practices are able to foster competitiveness in some plants but fail to do the same in other plants. Following the data collection (using a questionnaire), 110 plants from three industries (electronics, machinery, transportation) were analysed with muiltivariate regression analysis and profile deviation. The results showed that the manufacturing strategy does not moderate the relationship between JIT practices and plant competitiveness. Plant competitiveness was measured along the dimensions of cost, quality, delivery and flexibility.

Christiansen et al. (2003) divided 63 Danish companies (from the chemical, metal, machinery, electronics, telecom, medical devices industries) into four groups with cluster analysis. The companies had a minimum of 50 employees, and the groups represented different manufacturing strategies. Three important relationships were identified and examined: 1) manufacturing strategy–manufacturing practices, 2) manufacturing strategy–operations performance, and 3) manufacturing practices–operations performance. According to their literature review, no previous research had examined the three relationships simultaneously. The strategic foci of the clusters were the following: cost, quality, speed, and aesthetic design. The study examined the following bundles of manufacturing practices: JIT, TQM, total productive maintenance (TPM) and HRM. The dimensions of operations performance were cost, quality, delivery reliability and delivery speed. The results were the following.

1) The relationship of manufacturing strategy and manufacturing practices: low pricers placed an emphasis on all of the practices. For quality deliverers, the TPM was the most important; for speedy deliverers, the JIT practices were the most important. In the case of aesthetic designers, none of the practices was important, a finding that may reflect the different nature of their manufacturing practices.
2) The relationship of manufacturing strategy and operations performance: in the case of low pricers, quality deliverers, and speedy deliverers, the dimensions related to performance were the most important. There is no dominant dimension for aesthetic designers.

Sum et al. (2004) proposed that high-performing SMEs can be grouped into different strategic clusters based on their competitive priorities of cost, quality, delivery and flexibility. In the analysis, 43 companies were examined (not only from manufacturing industries) using cluster analysis. Three clusters were found: 1) all-arounders, who have a relatively low emphasis on all priorities; 2) efficient innovators, who placed an emphasis on cost, delivery and flexibility; and 3) differentiators, who placed the highest emphasis on quality and the lowest on cost.

Cagliano et al. (2005) classified the studies about manufacturing strategy configurations into two groups. The studies of the first group originated their theoretical basis from the field of OM, used surveys or case studies as empirical methods, and examined the data with cluster or factor analysis. The typical aim of these studies was to identify companies implementing similar manufacturing strategies (e.g., Miller – Roth, 1994).

The second group used the general manufacturing strategies of the first group for further research (usually with case studies and surveys) to generate new results (e.g., Cagliano, 1998).

Although the studies used slightly different dimensions and terms, the suggested manufacturing strategy configurations were quite similar. Cagliano et al. (2005) divided these configurations into four groups (for the characteristics of these clusters, see the portions of this section related to Cagliano (1998)):

1) market-based strategy: marketeer companies are found here (Miller – Roth, 1994; Cagliano, 1998).

2) product-based strategy: technology exploiters, high-performance producers (Cagliano, 1998), and innovators (Miller – Roth, 1994) are found here.

3) capability-based strategy: manufacturing innovators (Cagliano, 1998) are found here.

4) price-based strategy: caretakers (Miller – Roth, 1994; Cagliano, 1998) and cost minimisers (Cagliano, 1998) are found here.

Da Silveira (2005) examined 183 companies from three industries (fabricated metal products, machinery, equipment) based on the third wave of the IMSS with profile deviation and regression analysis. As a result, he created three groups of order-winner priorities: 1) delivery speed, 2) unique design capability, and 3) price.

Oltra et al. (2005) collected questionnaire responses from 130 Spanish companies with project production process. Three clusters were established based on their competitive priorities using cluster analysis: 1) cost, 2) production quality and delivery, and 3) innovation. Cost and delivery appear to be the most important factors among companies with project production process.

The results of Raymond – St-Pierre (2005) showed that advanced manufacturing systems (AMS) sophistication is positively affected by a more aggressive strategic orientation (in my interpretation, the use of more strategic foci at a given company).

Hutchinson – Das (2007) examined the model of Vokurka – O'Leary-Kelly (2000) in one case study. The company under analysis produced multiple products at low volumes using batch manufacturing processes. According to their proposition, for firms following a differentiation strategy (i.e., that do not focus on cost), the acquisition of suitable manufacturing technologies will provide an appropriate manufacturing flexibility leading to an improved performance. The researchers also indicated that the results were drawn from a single case and were not tested on a larger sample.

The literature review of Martin-Pena – Diaz-Garrido (2008) supports the notion that the four basic dimensions of manufacturing strategy are cost, quality, flexibility and delivery. They extended these with the dimensions of after-sales service and environmental protection. The researchers examined 353 Spanish companies using cluster analysis. The researchers studied whether companies may be classified into distinct groups representing different manufacturing strategies. The characteristics of the resulting clusters were the following: 1) each of the competitive priorities was equally important and had high values, but others 2) focused on quality and delivery. No manufacturing strategy focused on minimising costs was found.

Peng et al. (2011) asked the following research question: are there different forms of fit between competitive priorities and improvement or innovation capabilities related to the operations performance of the manufacturing plant?
Competitive priorities were measured along the same five dimensions as performance: cost, quality, delivery, flexibility and innovation. Improvement capability is the strength or level of a bundle of organisational practices to improve existing products or processes incrementally, while innovation capability refers to the strength or level of a bundle of organisational practices to develop new products or processes.

Two types of fit were examined at 238 companies from three industries (electronics, machinery, and transportation components) with regression analysis based on Venkatraman (1989):

1) improvement and innovation capabilities mediate the relationship between competitive priorities and operations performance, and
2) competitive priorities have moderating effects on the relationship between improvement and innovation capabilities and operations performance.

The results provided partial support for mediation, and mediating effects dominated direct effects (seven versus two effects) with medium power. The significant mediating effects are the following:

1) cost priority –> improvement capability –> inventory turnover, (product) quality and delivery performance;
2) flexibility priority –> innovation capability –> delivery performance and innovation performance; and
3) innovation priority –> innovation capability –> delivery performance and innovation performance.

None of the moderating effects were significant.

Table 9 summarises the above information: the name of the source, the examined contingency factor, the type of contingency factor (D = driver; ME = mediator; MO = moderator[6]), the relationship it affects and whether it is significant, the empirical research method, the investigated industries, the sample size, and the instruments of analysis.

Moderating effects were only studied in a few cases; the examination of the driving effect prevailed. The effects of the strategic foci were mixed: there were numerous significant, partly significant and insignificant practices. The applied empirical method was survey research in almost every study, and the examined industries again varied. For analysis, regression-based and cluster analytical methods were the most frequently used.

After the literature review of manufacturing contingency factors, I will discuss manufacturing practices and operations performance.

[6] If there is a moderating effect between two variables, the two variables are separated with 'and' in the column 'What does it affect?' in Table 9.

	Strategic focus	Type	What does it affect?	Significant?	Empirical method	Industries	N	Analysis techniques
Dangayach – Deshmukh (2001)	-	-	-	-	-	-	-	-
Dean – Snell (1996)	Quality Cost	MO MO	AMT and performance	Yes Yes	Questionnaire	SIC 33-37	92	Regression
Cagliano (1998)	6 configurations	-	-	-	Questionnaire	ISIC 381-385	565	Cluster analysis
Forza – Filippini (1998)	Quality	D	HR practices	Yes	Questionnaire	Electronics, mechanical	43	SEM
Kathuria (2000)	4 configurations	-	-	-	Questionnaire	14 industries	98	Cluster analysis
Kathuria – Davis (2000)	Quality	D	HR practices	Partly	Questionnaire	17 industries	98	Correlation, t-test
Kotha – Swamidass (2000)	Cost Differentation	D	AMT AMT	No Yes	Questionnaire	SIC 34-39	160	Factor analysis, regression
Sousa – Voss (2001), Sousa (2003)	3 configurations	-	-	-	Case study	Electronics	5	-
Lewis – Boyer (2002)	Cost Other focus	D D	Performance	No Yes	Questionnaire	Mostly SIC 34-39	110	ANOVA
Ahmad et al. (2003)	Manufacturing strategy	MO	JIT and competitiveness	No	Questionnaire	Electronics, machinery, transportation	110	Regression, profile deviation
Christiansen et al. (2003)	Cost, quality, speed, innovation	D	Manufacturing practices Operations performance	Mostly yes	Questionnaire	6 industries	63	Cluster analysis
Sum et al. (2004)	3 configurations	-	-	-	Questionnaire	Manufacturing and services	43	Cluster analysis
Cagliano et al. (2005)	4 configurations	-	-	-	-	-	-	Cluster analysis
Da Silvera (2005)	3 configurations	-	-	-	Questionnaire	Fabricated metal products, machinery, equipment	183	Regression, profile deviation
Oltra et al. (2005)	3 configurations	-	-	-	Questionnaire	Project process	130	Cluster analysis

	Strategic focus	Type	What does it affect?	Significant?	Empirical method	Industries	N	Analysis techniques
Raymond – St-Pierre (2005)	More together	D	AMS	Yes	Questionnaire	15 different industries	248	SEM PLS
Hutchinson – Das (2007)	Differentiation	D	Manufacturing flexibility, performance	-	Case study	Manufacturing	1	-
Martin-Pena – Diaz-Garrido (2008)	2 configurations	-	-	-	Questionnaire	8 different industries	353	Cluster analysis
Peng et al. (2011)	4 + 1 traditional dimensions	D	Improvement, innovation practices and performance	Partly No	Questionnaire	Electronics, machinery, automobile industry	238	Regression

Table 9: Strategic focus as a manufacturing contingency factor

2.2. Manufacturing practices in the field of OM

In their literature review, Bolden et al. (1997) identified 87 different manufacturing practices from previous studies that are capable of managing and improving daily operations. They did not find any consensus between the researchers and indicated that the researchers' field of specialisation determines their manufacturing practices. Engineers support technology and process-related practices, while psychologists preferred human-related and organisational practices.

Manufacturing programs were classified according to two dimensions. The first dimension was the domain of the application of the practice:

1) design and production,
2) inventory and stock,
3) work organisation, or
4) broader organisation of manufacturing.

The second classification was made according to the goal:

i) improved quality,
ii) reduced cost,
iii) responsiveness to customers,
iv) improved technology, or
v) employee development.

The following OM studies will explicitly highlight the richness and chaotic nature of the research of manufacturing practices.

Miyake (1995) examined the joint implementation of just-in-time (JIT), total quality management (TQC) and total productive maintenance (TPM), to see whether these practices strengthen one another. A sample of 506 quality award winner companies were analysed. The results showed that 54 companies implemented certain combinations of the practices, and 12 companies implemented all of them simultaneously.

Voss et al. (1998) and Cagliano et al. (2001) created a different classification of manufacturing practices:

- Strategic orientation practices (quality and services strategy, customer orientation, TQM, performance measurement, manufacturing strategy, integration with customers and suppliers)
- Human resource management (shared vision with employees, employee involvement, training and education)
- Production planning (planning frequency, small batches, kanban)
- Equipment management and layout (flow layout, preventive maintenance, housekeeping)

McKone et al. (1999) placed an emphasis on the supporting practices of total productive maintenance (TPM), but they also found JIT and TQM to be factors that affect TPM practices. Their results confirmed that the implementation of TQM has a strong relationship with TPM practices, while the implementation of JIT practices had a significant effect in only a few cases.

Kathuria – Davis (2000) specified three groups of workforce management practices:

1) relationship-oriented practices, e.g., networking, team-building, supporting, mentoring;
2) participative leadership and delegation practices, e.g., consulting and delegating; and
3) work-oriented practices, e.g., planning, clarifying, monitoring, informing.

All of these workforce management practices correlated positively and significantly with one another.

Gordon – Sohal (2001) identified seven areas of manufacturing practices: 1) quality management, 2) time management, 3) workforce empowerment, 4) work teams, 5) product and process development, 6) employee training, and 7) manufacturing technology.

Christiansen et al. (2003) examined the following bundles of manufacturing practices: just-in-time (JIT), total quality management (TQM), total productive maintenance (TPM), and human resources management (HRM).

Dewhurst et al. (2003) studied the relationship of information technology and TQM as well as their effect on one another. They provide an extended definition for TQM, including human resources management, product design and process-flow management practices.

Laugen et al. (2005) based their research on the third wave of the IMSS, drawing upon the responses of 474 companies (ISIC 381-385 industries) from 14 countries. The longitudinal changes in the importance of more than a dozen manufacturing practices were examined. Based on the analysis, the 'best practices' were the following: process focus, pull production, equipment productivity and environmental compatibility; however, information and communications technology and quality management were no longer considered best practices. The researchers also noted that these best practices were often implemented jointly at numerous companies.

In the study by Swink et al. (2005), the effects of certain manufacturing practices (product-process improvement, supplier relationship management, labour force improvement, just-in-time (JIT) flow, and process quality management) were examined on certain manufacturing capabilities (cost efficiency, process flexibility, and new product flexibility). In their literature review, numerous earlier studies were presented pertaining to manufacturing practices and their interpretation. The researchers found that there are few studies that shared the same opinion about the exact content of any given practice. It is important to note that the interactions that occur between practices during their implementation had hardly been examined previously.

Tiwari et al. (2007) studied those manufacturing practices that they considered to be best practices: 5S, TPM (total productive maintenance), TQM, six sigma method, kanban, kaizen, business process reengineering (BPR) and benchmarking.

Bayo-Moriones et al. (2008) analysed the effect of advanced manufacturing technologies (AMT) and quality management on JIT practices' implementation. They found the effect to be significant and positive.

Peng et al. (2011) differentiated between improvement and innovation capability. Improvement capability is the strength or level of a bundle of organisational practices to improve existing products or processes incrementally, while innovation capability is the strength or level of a bundle of organisational practices to develop new products or processes.

The way in which manufacturing practices described by the International Manufacturing Strategy Survey (IMSS) appear in Laugen et al. (2005) is discussed above. It is also important to mention that manufacturing-practice related questions are grouped in the questionnaire, and these groups are distributed throughout the questionnaire. This fact increases the variety of how one may investigate manufacturing practices. The groups of manufacturing practices are the following (see the exact questions in Appendix 3):

1) practices related to the manufacturing organisation and HR practices,
2) process-control practices,
3) product-development practices,
4) quality practices, and
5) technology practices.

Following the overview of the different manufacturing practices, operations performance will be discussed.

2.3. Manufacturing practices and the operations performance

Miltenburg (2008) indicated that no manufacturing system is capable of providing the best performance in all performance dimensions simultaneously. Numerous classifications of operations performance dimensions exist; I mention several of them here.

- The traditional dimensions (cost, quality, delivery, and flexibility) are represented in every OM textbook (e.g., Waters, 2002; Chase et al., 2006; Demeter, 2010), sometimes (but not necessarily) also extended with one or two additional dimensions. The best examples from studies are Jayaram et al. (1999), McKone et al. (2001), Ahmad et al. (2003), Pagell – Krause (2004), Hutchinson – Das (2007), and Liu et al. (2011).
- Voss et al. (1998) and Cagliano et al. (2001) measured operations performance according to the following factors: rapid equipment changeover, production cycle time, frequency of priority orders, process capability, internal defects and inventory turns. In addition to these aspects, they also defined external aspects: delivery reliability, product reliability, and product cost.
- Crowe – Brennan (2007) added the dimension of innovation to the classical four dimensions, e.g., Das – Narasimhan (2001) and Peng et al. (2011).
- Raymond (2005) measured operations performance in the dimensions of productivity, quality and cost (with 9 variables). Small (2007) also used 9 variables, but all of these studies' variables can be classified into the four traditional dimensions. The same four factors were measured with more than four dimensions in, e.g., Lewis – Boyer (2002) and Swink – Nair (2007).
- Swink et al. (2005) defined cost efficiency, process flexibility and new product flexibility as manufacturing capabilities. Essentially, these capabilities are the renamed and aggregated versions of the manufacturing performance dimensions.
- Problems may also occur with the operationalisation and measurement of flexibility. In his study, Oke (2005) wrote about the problems of flexibility-related taxonomies (e.g., using different names for the same type of flexibility or drawing no distinction between flexibility and change capability (change capability means quick and easy permanent change)).

Gerwin (2005) defined seven dimensions of flexibility according to the source of uncertainty; Larso et al. (2009) defined 18 different flexibility dimensions based on previous literature. These flexibility dimensions can be ordered into a hierarchy: there are dimensions at the strategic level, shop-floor level, and operational level.

What causes these differences? On one hand, there are no generally accepted definitions for performance indicators (Corbett – Wassenhove, 1993; Miltenburg, 2008). Even the traditional four performance dimensions were operationalised in several different ways in the various studies (the definitions are the most chaotic in the case of flexibility, as I mentioned previously). However, different researchers had different concepts about the relationship between performance dimensions (if this topic was discussed at all). The three major concepts are the following (Miltenburg, 2008).

1) Rigid trade-off model: there is mutual trade-off between performance dimensions, where one dimension can be improved only at the expense of another. This model is based on the work of Skinner (1969).
2) Cumulative model: the performance dimensions have a type of hierarchy between them, e.g., the sandcone model (Ferdows – de Meyer, 1990). There are different opinions in the literature about this concept: there are supporters (e.g., Crowe – Brennan, 2005; Martin-Pena – Diaz-Garrido, 2008), detractors (e.g., Flynn – Flynn, 2004; Swink et al., 2005), and others who suggest different hierarchies on the same theoretical basis (e.g., Größler – Grübner, 2006; Hallgren et al., 2011).
3) Integrative model: this model draws upon several elements of the above two models. Trade-offs are technological boundaries that are always present, thus a company on the boundary can improve certain performance dimensions only by way of trade-offs. However, if a company has not yet reached the technological boundary, it has the opportunity to improve its performance according to the cumulative model (e.g., Vastag, 2000; Liu et al., 2011).

As can be clearly observed, the situation lacks simplicity and transparency. Moreover, the effect of manufacturing practices on operations performance was studied in only 10 of the 42 presented articles in Table 5. Even if the effect was studied, the usefulness of

the results was not guaranteed. Even if the implementation of the practice was successful, it is difficult to distinguish the effects of the different practices on operations performance (Cua et al., 2001). There may be some practices that improve performance only marginally compared to the efforts invested in them. Some practices had controversial effects on each other, e.g., TQM and the reorganisation of the company (Grant et al., 1994), while some practices are the prerequisites for the successful implementation of others, e.g., a high quality level must be reached before the implementation of JIT (just-in-time) systems. For this reason, Voss (2005) advised the examination of bundles of closely connected practices instead of the examination of single practices.
Moreover, the examination of the effect of contingency factors on the relationship between manufacturing practices and operations performance is an even more neglected field of research (Ketokivi – Schroeder, 2004), though these contingency factors may influence the effectiveness of practices on operations performance improvement to a great extent (Sousa – Voss, 2002).

In the following section, some important research results concerning the relationship between manufacturing practices and the operations performance will be chronologically presented.

Ghobadian – Gallear (1996) and Ghobadian – Gallear (1997) found that the TQM concept can be implemented successfully in the case of SMEs. The introduction of TQM increased the SMEs' growth and survival potential in the long term. However, the method and the details of the introduction differed from the process at larger companies.

The results of Forza – Filippini (1998) indicated that the implementation of process control leads to fewer defective products (i.e., to higher level of quality).

Swamidass – Kotha (1998) concluded that there is no direct relationship between the implementation level of advanced manufacturing technology (AMT) and the operations performance.

Voss et al. (1998) and Cagliano et al. (2001) found that the implementation level of world-class manufacturing practices were very heterogeneous at SMEs. The management of planning and HR was usually weak, while the quality and customer foci were popular. Under these circumstances, company performances were heterogeneous: some of them reached the world-class level, while others did not approach it.

According to the assumptions of Jayaram et al. (1999), there are positive relationships between single human resources management (HRM) practices and the manufacturing performance. The measured aspects of performance were cost, quality, flexibility, and time. Following the analysis of 22 single HRM practices, significant relationships were found between HRM practices and at least one performance dimension in 21 cases, between HRM practices and two performance dimensions in 12 cases, and between HRM practices and three performance dimensions in 3 cases. Single HRM practices correlated generally with the logically related performance aspects, e.g., HRM practices for cost reduction correlated with cost performance. When they examined the HRM practices in bundles, the same positive and significant effects were found.

Cua et al. (2001) examined the joint effect of a just-in-time (JIT), total quality management (TQM) and total productive maintenance (TPM) on the manufacturing performance. The results of the research supported the researchers' hypotheses that 1) better-performing companies implement these practices to greater extent; 2) better-performing companies implement practices from all three groups, not just from one; and 3) different configurations of practices affect specific performance dimensions, e.g., TQM practices have a stronger relationship with quality than other practices.

Fullerton – McWatters (2001) examined 91 companies based on questionnaire data from the SIC 20-39 industries with ANOVA. Nearly two-thirds of the companies operated in the SIC 35 and SIC 38 industries. The results showed that companies that use a wider range of JIT practices achieve better performance in 1) quality improvement, 2) time-based responses, 3) employee flexibility, and 4) inventory reduction.

As mentioned in the previous section, Gordon – Sohal (2001) divided the manufacturing practices into seven groups (quality management, time management, workforce empowerment, work teams, product and process development, employee training and manufacturing technology). The use of these practices was examined. Data were collected from 1299 companies and were analysed with a chi-squared test to compare the distribution of the use of practices. In the analysis, manufacturing practices were classified into four groups, but only two of these helped a plant to attain a higher level of performance. These groups included frequently used practices (connected to training and quality) and infrequently used practices (connected to technology and costs) that improved the plant's performance.

Koufteros et al. (2001) studied the effect of implementation of concurrent engineering practices on quality and product innovation. They found that concurrent engineering practices have a significant effect on product innovation but no significant effect on quality.

McKone et al. (2001) based their study on the World Class Manufacturing (WCM) project and examined 117 companies from three industries (electronics, machinery, automobile industry) with SEM method (with AMOS software). The traditional four dimensions of performance were measured. As a result, they could not reject the hypothesis that total productive maintenance (TPM) has a positive and direct relationship with manufacturing performance. Flexibility performance was the only performance dimension that was not affected by the implementation of TPM. Additional results showed that JIT practices mediate the effect between TPM and performance, but the implementation of TQM did not provide the same result.

Following the data collection (through survey research), Sohal – Gordon (2001) analysed a sample of 1299 Canadian and 165 Australian companies to examine the relationship between quality management practices and plant success. Success was measured with 22 performance variables (which can be matched to the traditional dimensions). Quality management practices consisted of 8 different practices. With one exception (acceptance sampling), all of the practices were used significantly more frequently by more successful companies.

Ahmad et al. (2003) studied why the same JIT practices are able to foster competitiveness in some plants but fail to do the same in other plants. The results showed that the implementation of JIT practices relates to plant competitiveness. Competitiveness was measured with the traditional competitive priorities of OM (quality, cost, delivery, flexibility), and a composite competitiveness measure was constructed from the underlying variables. Further manufacturing (called 'infrastructure' in this study) practices (quality management, product technology, work integration system, HRM policies) moderated the relationship between JIT practices and plant competitiveness.

Regarding the relationship of manufacturing practices and operations performance, Christiansen et al. (2003) found that companies that focus on low prices and speedy delivery achieve the same performance by implementing different combinations of manufacturing practices. For low pricers, JIT, TQM and TPM were equally important, but for speedy deliverers, JIT practices were essential.

Dewhurst et al. (2003) examined the effect and the interaction of information technology (IT) and TQM. They defined TQM extensively, including HR practices, product-design process and process flow management. In their proposed IT-TQM framework, both sets of practices directly affected the company's quality and operations performance, and IT indirectly affected performance through the dimensions of TQM.

Kaynak (2003) studied a complex model using the following relevant hypotheses:

1. Product design (as a TQM practice) is positively related to process management (which was also considered to be a TQM practice in the article).
2. Product design is positively related to process management.
3. Process management is positively related to quality performance.

After receiving the questionnaire responses, 382 firms from the SIC 20-39 industries and other service industries (manufacturing companies were dominant) were analysed using the SEM method (LISREL software). All hypotheses were significant in the model.

The following assumptions of Raymond's (2005) model relate to my thesis: environmental uncertainty affects the assimilation of advanced manufacturing technology (AMT) at a company, and the level of assimilation affects operations performance. The first hypothesis was not accepted, but the second one was strongly significant (the most significant in the entire model). As mentioned above, productivity, quality and cost were the measured aspects (with 9 variables) of operations performance.

Raymond – St-Pierre (2005) found that advanced manufacturing system (AMS) sophistication significantly impacts the operations performance of the SMEs, which was measured along the dimensions of quality, flexibility and cost.

Sila – Ebrahimpour (2005) analysed a highly complex model of TQM factors and examined their effect on the company's business results. The relevant parts of the model are the following:

According to one of the hypotheses, HRM affects business results. HRM consisted of addition elements, such as the 1) work system, 2) employee training, and 3) employee satisfaction. The business results also consisted of additional elements, such as 1) HR results (employee-turnover rate, employee absenteeism, number of employee suggestions received, and employee job performance), 2) organisational effectiveness (cost, quality, productivity, cycle times, number of errors or effects, and supplier performance), 3) customer results, and 4) financial and market results. During the analysis, no significant relationship was found between HRM and business results.

However, another hypothesis proposing that process management affects business results was accepted. Process management consisted of product and service design, process control, innovation and the continuous improvement of processes, products and services.

Data were collected with questionnaires, and 220 companies were examined from the SIC 28, 34-38 industries.

Swink et al. (2005) noted that the managers of the manufacturing plants were intent on implementing the best manufacturing practices (as introduced in the world-class manufacturing (WCM) literature) to improve their performance. However, the relationship between manufacturing practices and performance is only partly understood. According to Swink et al. (2005), despite the propositions of Skinner and his adherents, there is little documented evidence to prove the relationship between certain practices and performance. The study focused on the effect of strategic integration. Strategic integration represents the degree to which a manufacturing plant

cooperates with other inter-organisational divisions to harmonise its goals and manufacturing practices with the internal and external requirements.
The model examined the effect of certain manufacturing practices (product-process management, supplier relationship management, labour-force improvement, just-in-time flow, and process quality management) on manufacturing capabilities (cost efficiency, process flexibility, and new product flexibility) and the effect of manufacturing capabilities on market-based performance (with the elements of profitability, market share, and the increase in the number of sales). According to their hypothesis, these dimensions are affected in some way by strategic integration (the effect can be moderating, mediating or direct).
The results showed an ambivalent picture about the relationship between manufacturing practices and performance. The manufacturing practices had a significant effect only on the process flexibility through product-process improvement, labour force improvement and just-in-time flow. The other two performance dimensions are affected by certain practices only if strategic integration exists. Moreover, the researchers suggested the identification and examination of bundles of manufacturing practices.

The results of Tan – Vonderembse (2006) showed that concurrent engineering affects product development performance, and product development performance affects cost performance. The researchers analysed 240 companies from the SIC 30, 34-38 industries using the SEM LISREL method.

Zhang et al. (2006) examined the effect of advanced manufacturing technology (AMT) and operations improvement practices on flexibility. The results most supported the moderating model; consequently, the relationship between the implementation of ATM and manufacturing flexibility is moderated by operations improvement practices. The additive model was also significant but not as significant as the moderating model (in this case, the implementation of AMT and operations-improvement practices jointly affected manufacturing flexibility).

Sila (2007) found that the implementation of TQM and HRM practices has a direct and positive effect on organisational effectiveness.

Swink – Nair (2007) examined the effect of design-manufacturing integration (DMI), assuming a moderating effect on the relationship between advanced manufacturing process technology and manufacturing performance (cost efficiency, quality, delivery, new product flexibility and process flexibility). The results showed that the implementation of advanced manufacturing technology (AMT) was positively associated with new product flexibility and process flexibility. However, AMT use was negatively associated with cost efficiency and positively associated with quality, delivery and process flexibility when high levels of DMI were present (i.e., the moderating effect was revealed).

Tiwari et al. (2007) stated that companies generally believe that the implementation of best manufacturing practices is usually motivated by the company's poor performance and that the implementation and application of the practices will be easy. In contrast, the authors emphasised that a single manufacturing practice is not sufficient to reach a proper level of operations performance, thus they also support the use of practice bundles.

Boyle – Scherrer-Rathje (2009) emphasised that different studies (in different industries) found that several efforts to improve flexibility were unsuccessful or disappointing. The main reasons for their finding are the multidimensional nature of flexibility and the lack of robust, widely accepted measures. Moreover, the authors found a lack of examination of the relationship between leanness and flexibility. They discussed three types of flexibility in detail, which were the most discussed in previous studies and the most easily distinguishable by experts: product flexibility, process flexibility and volume flexibility. The empirical analysis found no industrial difference in the use of flexibility types but supported the relationship between leanness and flexibility.

In the study by Furlan et al. (2011), the complementarity of two lean bundles (JIT and TQM) and the role of HRM in this relationship were examined. The questionnaire-based study was accomplished as a part of the High Performance Manufacturing Research; 266 companies from three industries (electronics, machinery, and transportation) were analysed using regression analysis. The results showed that JIT and TQM complement one another. The implementation of JIT increases the efficiency of

TQM and vice versa, while the joint implementation leads to higher performance. Moreover, the HRM bundle helps the complementarity of JIT and TQM, the higher implementation of HRM is related to the complementarity of JIT and TQM. The company's performance was measured with six variables, which can also be classified according to the traditional dimensions.

The presented data are summarised in Table 10 per usual. Following the literature review of manufacturing contingency factors, manufacturing practices and operations performance, I will introduce the elaborated model and the hypotheses of my research in Chapter 3.

	Manufacturing practice	Performance dimension	Significant?	Empirical research method	Industry	N	Analysis technique
Ghobadian – Gallear (1996, 1997)	TQM	Survival and growth	Yes	Case study	Mixed	4	-
Forza – Filippini (1998)	Process control	Quality	Yes	Questionnaire	Electronics, mechanical	43	SEM
Swamidass – Kotha (1998)	AMT	Operational performance	No	Questionnaire	SIC 34-39	160	Regression
Voss et al. (1998), Cagliano et al. (2001)	Manufacturing practices	Performance	Mixed	Questionnaire	21 different	285	More techniques
Jayaram et al. (1999)	HR practices	Manufacturing performance	Yes	Questionnaire	Automobile industry	57	Regression
Cua et al. (2001)	JIT, TQM, TPM	Production performance	Yes	Questionnaire	Electronics, machinery, transportation part suppliers	163	Discriminance analysis
Fullerton – McWatters (2001)	JIT	4 dimensions	Yes	Questionnaire	SIC 20-39	91	ANOVA
Gordon – Sohal (2001)	Manufacturing practices	Plant performance	Partly	Questionnaire	Manufacturing industry	1299	Chi-square test
Koufteros et al. (2001)	Concurrent engineering on product innovation	Quality, product innovation	Indirectly yes	Questionnaire	SIC 34-37	122	SEM
McKone et al. (2001)	JIT, TPM	Manufacturing performance	Yes	Questionnaire	Electronics, machinery, transportation part suppliers	117	SEM
Sohal – Gordon (2001)	Quality management	Path success	Yes	Questionnaire	Manufacturing industry	1464	Chi-square test
Ahmad et al. (2003)	JIT	Competitiveness	Yes	Questionnaire	Electronics, machinery, transportation	110	Regression, profile deviation
Christiansen et al. (2003)	JIT, TQM, TPM, HRM	4 dimensions	Partly	Questionnaire	6 industries	63	Cluster analysis

	Manufacturing practice	Performance dimension	Significant?	Empirical research method	Industry	N	Analysis technique
Dewhurst et al. (2003)	IT, TQM	Quality, operations performance	-	Case study	13 industries	14	-
Kaynak (2003)	Product design Process management	Quality	Yes	Questionnaire	SIC 20-39	382	SEM
Raymond (2005)	AMT	Operations performance	Yes	Questionnaire	Manufacturing industry, construction	118	SEM PLS
Raymond – St-Pierre (2005)	AMS	Operations performance	Yes	Questionnaire	15 different industries	248	SEM PLS
Sila – Ebrahimpour (2005)	HR management Process management	Business results	No Yes	Questionnaire	SIC 28, 34-38	220	SEM
Swink et al. (2005)	Manufacturing practices	Process flexibility	Partly				
Tan – Vonderembse (2006)	Concurrent engineering	Product development Cost	Yes	Questionnaire	SIC 30, 34-38	240	SEM
Zhang et al. (2006)	AMT Operations improvement practices	Flexibility	Yes	Questionnaire	SIC 34-38	273	Regression
Sila (2007)	TQM HR practices	Organizational effectiveness	Yes	Questionnaire	SIC 28, 34-38, 50-51, 73, 87	286	SEM
Swink – Nair (2007)	AMT	5 dimensions	Mostly yes	Questionnaire	SIC 25-26, 32-39	224	Regression
Tiwari et al. (2007)	-	-	-	-	-	-	-
Boyle – Scherrer-Rathje (2009)	Lean	Flexibility	Yes	Questionnaire	NAICS 314, 316, 326, 327, 332, 333, 337	168	MANOVA
Furlan et al. (2011)	JIT, TQM, HRM	6 variables	Yes	Questionnaire	Electronics, machinery, transportation	266	Regression

Table 10: The relationship between manufacturing practices and operations performance

3. The elaborated research model and the hypotheses

This chapter builds on the first two chapters and presents the elaborated research model of the thesis and the hypotheses based on this model. These hypotheses are linked to analytical methods and approaches that can be applied in the field of OM to better depict the relationships among the hypotheses.

Figure 6 shows the elaborated research model, which consists of three major blocks. The first block is the configuration of the manufacturing practices, which affects the second block, operations performance. The third block is the block of contingency factors, which have a dual role. On one hand, they are drivers of the use of manufacturing practices, while on the other hand, they moderate the relationship between manufacturing practices and operations performance. As mentioned previously, I selected four important contingency factors whose effects are analysed in the model: environment, size, technology and strategic focus. Similar to Mintzberg (1979), I also accept the assumption that the direction of causation is from contingency factors towards manufacturing practices.

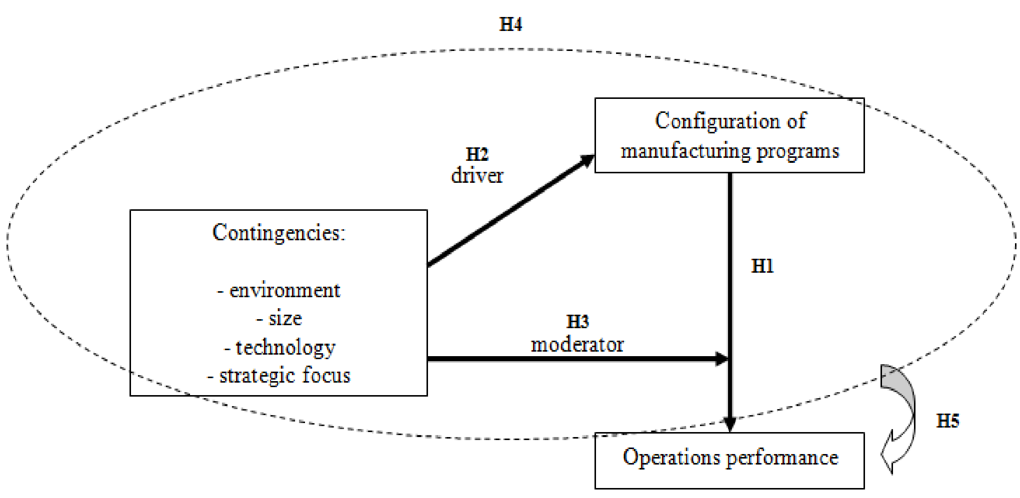

Figure 6: The elaborated research model

The model is simpler than what is theoretically possible to be manageable; accordingly, it does not contain certain other factors. Several contingency factors that could have been included in the model were omitted (e.g., culture, the company's country of origin, and industry).

The case against including culture as a contingency factor is simple: the IMSS (International Manufacturing Strategy Survey) questionnaire and its database are unable to grasp cultural effects.

Country effects are present in the IMSS survey. Among others, Matyusz – Demeter (2011a) also discovered important differences between Hungarian and international companies based on the newest database of IMSS. However, as observed in Chapter 4, the sample is uneven in terms of the number of respondents by country. Partly because of this fact, the proper treatment of the country effects surpasses the scope of this thesis.

Based on the results of the literature review, I did not feel it necessary to analyse industry effects in the current phase of the research. Most studies concerned with industry effects did not find significant effects, e.g., Swamidass – Kotha (1998) in SIC 34-39 industries; McKone – Schroeder (2002) and McKone et al. (1999) in the electronics, machinery and automobile industries; Jonsson (2000) in SIC 33-37 industries; Kathuria (2000) in 14 different industries; Koh – Simpson (2005) in the manufacturing industry; and Boyle – Scherrer-Rathje (2009) in NAICS 314, 316, 326, 327, 332, 333, 337 industries. There may be several reasons for this result: Swamidass – Kotha (2000) write about SIC 34-39 industries that 1) these industries use technologies that are crucial to them; 2) these industries provide the backbone of manufacturing in terms of, e.g., sales revenue; and 3) these companies, which produce discrete products, are rather homogeneous in their production processes and differ entirely from process flow companies. McKone – Schroeder (2002) and McKone et al. (1999) note that earlier results indicated that within-industry variance is significantly higher than between-industry variance and that the industries they examined are not very different in terms of practices. An earlier study based on the fourth round of IMSS also showed that industry effects are significantly smaller than country effects (Demeter et al., 2011).

Moreover, I do not analyse the relationship between operations performance and business performance. The factors mentioned above exceed the scope of the present thesis and would unnecessary dilute its focus. Of course, these factors could be analysed in further research.

In testing the model, I use both the interaction and system approach (Drazin – Van de Ven, 1985), which are two different levels of analysis. With the interaction approach, I examine the relationship of single manufacturing practices and contingency factors as well as their effect on operations performance. With the system approach, I analyse the configurations of contingency factors and manufacturing practices, and I examine the effects of these configurations on the operations performance. The possible analytical methods are described later in this chapter.

With the interaction approach, I test the relationships of the model marked with thick black lines in Figure 6. I reveal the nature of the relationships between manufacturing practices and operations practices if the effects of the contingency factors were omitted. This analysis is followed by an increasing inclusion of contingency factors in the empirical analysis. I examine the extent to which certain contingency factors are drivers of certain manufacturing practices. Then, I explore the moderating effects of certain contingency factors on the relationship between manufacturing practices and operations performance. To test these relationships, I formulate three hypotheses:

H1: The manufacturing practices examined in the model have a significant effect on the operations performance.
H2: The contingency factors examined in the model have a significant effect on the extent of the use of manufacturing practices.
H3: The contingency factors examined in the model moderate the relationship between manufacturing practices and the operations performance.

Hypotheses H1-H3 will be tested using SEM (structural equation modelling), more precisely with the PLS (partial least squares) approach, during which I accept or reject the hypotheses using regression equations. The PLS method has several advantages (Henseler et al., 2009):

i) it requires no distributional assumptions concerning the data,
ii) it is robust with different scale types,
iii) it can address complex models,
iv) a small sample size is not problematic, and
v) it is an appropriate method for exploratory research such as mine.

The system approach refers to the simultaneous examination of the effect of several contingency factors and manufacturing practices on operations performance, and the appearing configurations may be analysed (Hypotheses H4, H5). This configurational view is the natural extension of the contingency view (Ahmad et al., 2003), and its importance is also noted by Boyer et al. (2000). This portion of my research will be aggregated in terms of Sousa – Voss (2008), a less common approach compared to detailed studies in the existing literature, hence improving the value added of my research. In the OM literature, configurational research methods appeared earlier; thus, before formulating the hypotheses, I describe the most important features of these methods. At the same time, I must note that the existing models are limited to the field of manufacturing strategy. I have not found any studies during my literature review that would have applied configurational methods to manufacturing practices and contingency factors.

Bozarth – McDermott (1998) see the distinctive feature of configuration models in the application of multidimensional profiles to describe organisational, strategy and process types. They note that when a theory is described by multidimensional profiles, traditional models (working with mediation and moderation) may be entirely useless because of their linearity constraints and because only few variables may be investigated simultaneously. Configurational models were developed to address these disadvantages. The researchers argue that, in every situation, there are some viable strategies, organisational types, etc., that can be implemented by companies. By accepting the fact that there are multiple ways to be successful in any given environment, the configurational approach explicitly supports the notion of equifinality (Meyer et al., 1993).

Configurations can be especially apt when the research aim is to determine the dominant organisational patterns or when relationships between single variables cannot be easily interpreted, or perhaps they are too complex for traditional modelling processes.

The authors differentiate two major types of configurations, namely taxonomies and typologies. Only a segment of the theoretically possible configurations is viable and empirically watchable. Therefore, the aim is to create such typologies and taxonomies that account for the majority of the examined population.

Typologies describe ideal types that represent unique combinations of organisational attributes. If an organisation is closer to an ideal type, it will achieve a higher organisational effectiveness. Typologies have three additional characteristics.

1) They provide generalisable theories that are applicable to individual types (e.g., Hill (1993) on process types).

2) They specify the unidimensional constructs that are the building blocks of theoretical statements. These factors have some value that differs across the ideal types.

3) They are empirically testable.

An example of typologies includes Hayes – Wheelwright (1979), who derived the four process types (job shop, batch, assembly line, continuous flow) from some important factors (process flow, production volume, degree of standardisation) using case studies (Bozarth – McDermott, 1998).

Other typologies from contingency theory include Burns – Stalker (1961), Woodward (1965), Perrow (1967), Thompson (1967), Mintzberg (1979), and Miles – Snow (1978) (Meyer et al., 1993).

Taxonomies, unlike typologies, do not define ideal types; rather, they attempt to classify organisations into mutually exclusive and exhaustive groups through some kind of empirical method. The most important question in the case of taxonomies is the preliminary choice of variables used for the classification to avoid the accusation of data mining. Good taxonomies are insensitive to the techniques that created them and to the sample data.

An example of taxonomies includes Miller – Roth (1994), who performed empirical analysis on 164 American manufacturers. They selected 11 competitive priorities to investigate the fit between manufacturing tasks and the market environment, and they identified three strategy types: caretakers, marketeers and innovators.

From contingency theory studies, the Aston studies are examples of taxonomies (Pugh et al., 1963; Pugh et al., 1968; Pugh et al., 1969a; Pugh et al., 1969b).

After presenting the two approaches, it bears mentioning that there is some misunderstanding in the literature of the proper use of the terms typology and taxonomy, and there is also a debate concerning the advantages of these approaches.

Meyer et al. (1993) believe that the typology-taxonomy distinction is artificially created in many aspects because

1) in every typology, the configurations consist of several attributes, and the created types are based on empirical experiences; and

2) taxonomies are created with quantitative analytical tools from a database, but each useful taxonomy is theoretically supported, and the classifying organisational variables are carefully chosen by the researchers.

After presenting the configurations examined in the field of OM and their theoretical background, I propose a fourth hypothesis:

H4: There are different stable contingency-manufacturing practice configurations that coexist simultaneously.

The configurational approach accepts the fact that there are multiple ways to be successful in any given environment; thus, it explicitly supports the notion of equifinality (Meyer et al., 1993). The system approach of configurations in this thesis makes it possible to investigate the existence of equifinality in the case of certain configurations and to examine the performance indications of the various configurations. Based on these configurations, I propose a fifth hypothesis:

H5: The state of equifinality can be shown, i.e., different and stable contingency-manufacturing practice configurations exist that lead to the same high level of operations performance.

To test **Hypotheses H4 and H5,** one requires configurational methods, which are described in great detail by Venkatraman (1989) and Venkatraman – Prescott (1990). The main problem at the time of the writing of the articles was that no deeply elaborated method existed to test fit theories mathematically. This gap was caused by the several possible ways to interpret fit, as shown in Table 11.

The first dimension to evaluate fit is the degree of specificity. This measure indicates the level of precision in the functional form of fit. It has a strong relationship with the number of examined variables. With few variables, we are able to define a more precise function of fit than with numerous variables. This relationship is shown by the right-side column displaying the number of variables.

The values of the other dimension differ in terms of whether the fit and its testing are linked to some concrete criterion (e.g.. an efficiency or performance variable) or whether the fit does not require this approach.

Using these two dimensions, one arrives at six different approaches of fit.

Low	Profiledeviation (5)	Gestalts (4)	*Many*
Degree of specificity	Mediation (2)	Covariation (6)	**Number of variables in fit equation**
High	Moderation (1)	Matching (3)	*Few*
	Criterion-specific	**Criterion-free**	

Table 11: Different forms of fit (Venkatraman, 1989)

To examine the different forms of fit observed in the cells marked (1)-(6), different methods are appropriate. These forms of fit can be directly matched with the classification of Drazin – van de Ven (1985) concerning the interpretation levels of fit:

1) selection approach–matching (3);

2) interaction approach–moderation (1), mediation (2);

3) system approach–gestalts (4), profile deviation (5), covariation (6). (Sousa – Voss, 2008)

To test Hypotheses H4 and H5, three approaches are possible *(gestalts, profile deviation and covariation)*. I will now describe these approaches in further detail. The numbers that appear before the approaches are consistent with the numbers in Table 11.

(4) Gestalts: In this case, we examine the degree of internal coherence among a set of theoretical attributes. It is important to examine these theoretical attributes jointly because at the level of single pairwise attributes, we may find internal inconsistencies. This approach basically intends to create archetypes. The important analytical issues are the following:

i) Descriptive validity: it is necessary to develop a set of formal criteria to evaluate the descriptive validity of the gestalts, e.g.,

1) testing the number of gestalts,

2) presenting the stability of the clusters, and

3) characterising the gestalts based on the theory that guided the selection of input variables for the analysis. This final step means the difference

between gestalts and strategic taxonomies. In the latter case, we empirically identify the naturally occurring strategy types. The main criterion during the selection of the variables is to cover the possibilities exclusively. (For me, this approach suggests that by creating gestalts, we also create a typology, but this conclusion is not explicitly stated in Venkatraman (1989), and the opinion of the author is unclear concerning this issue).

ii) Predictive validity: the performance implications need to be established, and the existence of generic strategy types or multiple configurations of equal success should be demonstrated.

(5) Profile deviation: In this case, fit is the degree of adherence to an externally specified profile, and it is similar to the pattern analysis of Van de Ven – Drazin (1985). The approach differs from the gestalts because here the profile is attached to a dependent variable. This approach makes it possible for the researcher to create ideal types, and it is helpful in investigating environment-strategy relationships because the deviation from the profile can be linked to the decrease of performance. The analytical issues of profile deviation are the following:

1) developing a profile;

2) in the case of a multidimensional profile, the equal or different weighting of the dimensions;

3) during the examination of fit, the power of the test, which requires the researcher to create a baseline model.

This approach was used, e.g., by Ahmad et al. (2003) and Da Silveira (2005).

(6) Covariation: Here, fit is a pattern of covariation or internal consistency among a set of underlying theoretically related variables. The main difference between covariation and gestalts lies in the methodology. For gestalts, we apply cluster analysis, while for covariation, we use factor analysis. The analytical issues are the following:

i) explorative or confirmative approach; Venkatraman (1989) recommends the latter; and

ii) testing the impact of performance on fit.

In my research, I selected the gestalts approach from among the three possibilities. I will use cluster analysis as an analytical tool, which is a frequently used configuration method in the field of OM, primarily in the field of manufacturing strategy (see, e.g., Miller – Roth, 1994; Bozarth – McDermott, 1998; Cagliano, 1998; Jonsson, 2000; Kathuria, 2000; Sousa – Voss, 2001; Christiansen et al., 2003; Sousa, 2003; Sum et al., 2004; Cagliano et al., 2005; Oltra et al., 2005; Zhao et al., 2006; Martin-Pena – Diaz-Garrido, 2008).

4. Presenting the sources of data used in the analysis

This chapter describes the questionnaire used for the empirical analysis in further detail. I write about the questionnaire in general, the questions from the questionnaire that were used for the analysis and the interviews I conducted and used in discussing the results.

As mentioned previously, the data used in the empirical analysis are provided by a questionnaire survey. Using surveys is very popular in OM (see, e.g., Filippini, 1997; Scudder – Hill, 1998; Pannirselvam et al., 1999; Forza, 2002; Rungtusanatham et al., 2003), and in Chapter 2, it can be observed that mostly surveys were used for data gathering in the studies that investigated manufacturing contingency factors.
In this study, I utilise the International Manufacturing Strategy Survey (IMSS) database. IMSS is an international network of researchers who aim to study manufacturing strategy, its implementation, and its results for manufacturing and other adjacent areas (e.g., supply-chain management and new product development). IMSS was launched by Chris Voss (London Business School, UK) and Per Lindberg (Chalmers University of Technology, Sweden) in 1992. Since then, five waves have been executed. Important data concerning these waves are shown in Table 12.

Waves	**Date of data gathering**	**Number of participating countries**	**Number of companies responded**	**Average respondent rate**
IMSS - I	1992	20	600	33%
IMSS – II	1996	20	591	21%
IMSS – III	2001	17	558	33%
IMSS – IV	2005	23	711	13%
IMSS – V	2009	21	725	16%

Table 12: Summary data of the different IMSS waves

In my analysis, I will use the data from the fifth survey wave. These data were gathered by national research teams by asking the respondents to complete a standard questionnaire, which had been assembled by an expert panel, integrating the experience from the previous waves. If necessary, the questionnaire is translated into the local language by the local OM professors. Although there is a recommended process for the data collection (focusing on better-performing companies, contacting companies via letter and/or phone, mailing a printed questionnaire to a contact person at each company (usually the plant manager or operations manager), and tracing and assisting the contact person throughout the response phase), the final decision about the process is made by the national research teams. At the same time, the research teams are obliged to inform the global network about the sampling process. The centre coordinating the research executes a preliminary quality check before disseminating the data to the participants.

For further details, see, e.g., the summary book of the first wave of IMSS (Lindberg et al., 1998), the IMSS website[7], or articles that used data from previous waves of the IMSS (e.g., Cagliano, 1998; Frohlich – Westbrook, 2001; Acur et al., 2003; Husseini and O'Brian, 2004; Cagliano et al., 2005; Crowe – Brennan, 2005; Laugen et al., 2005; Cagliano et al., 2006; Demeter – Matyusz, 2008; Matyusz – Demeter, 2008; Matyusz et al., 2009; Demeter – Matyusz, 2010; Dukovska-Popvska et al., 2010; Farooq et al., 2010; Matyusz et al., 2010).

The fifth wave of the IMSS contains 725 valid observations from 21 countries (primarily from Europe, but apart from Africa, all other continents are represented) from the second half of 2009. The survey focuses on the ISIC 28-35 industries. The industry and country distributions are shown in Tables 13 and 14.

Manufacturing activity	Observations
Fabricated metal products, except machinery and equipment	242
Machinery and equipment not elsewhere classified	185
Office, accounting and computing machinery	12
Electrical machinery and apparatus not elsewhere classified	92
Radio, television and communication equipment and apparatus	42
Medical, precision and optical instruments, watches and clocks	42
Motor vehicles, trailers and semi-trailers	52
Other transport equipment	34
Missing	24

Table 13: Number of observations in different industries

[7] http://www.manufacturingstrategy.net

Country	Observations	Country	Observations	Country	Observations
Belgium	36	Hungary	71	Portugal	10
Brazil	37	Ireland	6	Romania	31
Canada	19	Italy	56	Spain	40
China	59	Japan	28	Switzerland	31
Denmark	18	Korea	41	Taiwan	31
Estonia	27	Mexico	17	United Kingdom	30
Germany	38	Netherlands	51	USA	48

Table 14: Number of observations in different countries

The blocks of the research model presented in Chapter 3 can be operationalised by the proper questions of the IMSS questionnaire. In the following section, I review each block and list those questions that can be linked to the blocks. The questions here are marked only by their number on the questionnaire. The questions themselves can be found in Appendix 3. During the operationalisation in Chapter 5, the questions will be presented in detail.

(1) Questions related to contingency factors in the questionnaire

Environment: A2, A3

Size of the business unit: A1c (number of employees)

Technology: B2, B8, B9, PC2, T1

Strategic focus: A4

(2) Questions related to manufacturing practices in the questionnaire

O11 (human relationship practices)

PC4 (process control practices)

PD3 (product development practices)

Q2 (quality management practices)

T2 (technology practices)

(3) Questions related to operations performance in the questionnaire

B4 (cost structure)

B10 (change in operations performance)

B11 (current performance)

PC3 (inventory levels)

Q1 (quality costs)

The interviews were conducted between December 2011 and January 2012. The exact dates can be found in the References chapter under the reference “Interviewees”. In total, I conducted interviews with 4 people at 3 companies. I prepared a draft interview that provided the framework for the conversation, but deviations from this draft were permitted. The aim of the interviews was not to “test” my research hypotheses through the interviewees but to learn the interviewees’ opinions concerning certain topics that are crucial for the study. I was curious as to how the interviewees describe certain concepts, what the concepts mean to them, and how they grasp and characterise the concepts, while I oriented the interviewees with appropriate questions if necessary. To summarise the results, the interviewees provided valuable insights for the analysis, as will be evident in Chapter 5.

The interviewees all asked to remain anonymous because the strict corporate policies did not allow them to offer named interviews without a long preliminary negotiation. All of the interviewees work for Hungarian subsidiaries of multinational companies. These companies operate in the manufacturing sector, more precisely in the ISIC 28-35 industries (the same industries as on the IMSS survey), and they have a good performance ranking among Hungarian companies. Interviewees “A” and “C1” are middle managers in manufacturing. Interviewee “B” is a top manager at a Hungarian subsidiary, similar to interviewee “C2”. It was especially interesting to compare the interviews of “C1” and “C2”, who work for the same company. I attempted to integrate these supplementary data in a useful way during the discussion.

5. Analysis and discussion

I apply several different statistical methods to examine the hypotheses previously shown and for which I have used different sources, which will be duly cited. Statistical analyses were performed using SPSS 15.0, while the PLS method was applied by using SmartPLS 2.0 (Ringle et al., 2005). Table 15 summarises the main steps of the analysis.

5.1. Cleaning the database	Cleaning, examination of missing data and outliers
5.2. Creating variables for the PLS model	Variables measuring contingency factors, manufacturing practices and performance
5.3. The elaborated PLS model	Testing hypotheses H1-H3
5.3.1. Evaluating the measurement models	Internal consistency of latent variables Reliability of manifest variables Convergence validity Discriminant validity
5.3.2. Validity of the structural model	Explaining power of endogeneous latent variables Analysis of path coefficients Effect size
5.3.3. Evaluating results	By contingency factors and manufacturing practices
5.4. Examination of contingency factor – manufacturing practices configurations	Cluster analysis (Hypothesis H4)
5.5. Examination of equifinality	ANOVA (Hypothesis H5)

Table 15: Main steps of the analysis

5.1. Cleaning the database

For this step, I was guided by the work of Sajtos – Mitev (s.a.), Tabachnick – Fidell (2007), and Tsikriktsis (2005). First, I checked the accuracy of the database, which showed that the data input was mostly correct and that there were no incorrect variable values (e.g., a value of 6 on the 1-5 scales). Instances in which only values of ‘1’ were present and values of ‘0’ were missing for categorical binary variables were interpreted as missing values in SPSS. These errors were corrected. This formal inspection was followed by content analysis.

Neither inflated nor deflated correlations pose problems. Inflated correlations do not appear during the analysis because I use particular variables only once. Deflated correlations are not problematic because the values of variables do not occur around one or two possible values but take almost all possible options. Moreover (as can be seen below), during aggregation of the variables, I expand the aggregated variable space with an extra step, allowing aggregated variables, which were constructed from variables measured on a 1-5 scale, to have values on a 1-100 scale.

Missing data analysis

This step is essential before proceeding with the analysis. First, an excess of missing data is problematic for the reliability and validity of the analysis if major data imputation is necessary. Second, the SmartPLS 2.0 software used for the PLS method is unable to handle missing data. I performed the analysis block-by-block, first on contingency factors, then on manufacturing practices, and finally on performance variables.

(1) First, I examined the contingency factor variables. A good rule of thumb states that in cases with 5-10% missing data, the missing values can be substituted by the variable mean, but for more than 15% missing data, the variable should be eliminated. Fortunately, this step was not required. After, I calculated Little's MCAR test, which indicated that the missing data are entirely random; they do not follow any patterns, which is the best possible scenario (chi-squared = 412.595; df = 5803; sign. = 1.000).
I also checked the ratio of missing data for the individual companies in the database. Companies with a ratio over 15% were deleted from the database (total of 36 companies). The remaining missing data were then substituted with the mean.

(2) The situation was different for the manufacturing practice variables. The maximal ratio of missing data was 4.5%, but these missing data followed a pattern (based on Little's MCAR test chi-squared = 848.817; df = 764; sign. = 0.017). This result was mainly caused by the fact that data were missing in small blocks, according to the groups of manufacturing practice variables (i.e., respondents answered all questions concerning quality management practices or answered none). Therefore, I examined the companies themselves and deleted those whose ratios of missing data were above 15%, meaning that a company was deleted if it had missing data in 2 out of the 5 groups of

manufacturing performance variables. A total of 41 companies were affected by this step. The remaining missing data were substituted by the mean.

(3) The situation was mixed for the performance variables; there were either hardly any missing data or the ratio was approximately 14-15%, though no pattern was discovered (based on Little's MCAR test chi-squared = 4698.569; df = 4912; sign. = 0.965). Because the existence of performance variables is critical for Hypothesis H5, once again, I turned to the companies to tackle the problems. There were 122 such companies where the ratio of missing data exceeded 15%. These companies were deleted from the database, and I substituted the remaining missing data with the mean. At that point, the critical ratios of 14-15% became much lower and acceptable, because of the deletion of the companies.

Examining outliers

The majority of variables was measured on a 1-5 scale or on a percentage scale, so outliers could cause only small problems, such as in the case of

- the size of the business unit (no. of employees) (A1c) and
- the amount of inventories given in days (PC3a-c).

After analysing the values of the variables, I deleted 3 companies because of unrealistic size figures. A total of 523 companies remained in the final sample.

5.2. Creating variables for the PLS model

The PLS model (Henseler et al., 2009; Henseler, 2010; Tabachnick – Fidell, 2007) tests Hypotheses H1-H3, but for this testing to occur, it is necessary to create appropriate variables.

5.2.1. Variables measuring contingency factors

I examine the effect of four contingency factors in the model: environment, size, technology and strategic focus. In many cases, I aggregated individual variables to create new variables, whose unidimensionality and reliability were assessed by Cronbach's alpha. The alpha value should be at least 0.6 (Henseler, 2010).

(1) As we have seen in Table 2 in Chapter 1, environment was most frequently characterised by 3 major dimensions (sometimes using different names but with similar meaning).

i) The first of these dimensions attempts to capture environmental dynamism (Lawrence – Lorsch, 1967; Thompson, 1967; Child, 1972; Duncan, 1972; Miles – Snow, 1978; Mintzberg, 1979; Bourgeois, 1980; Dobák, 2006). In addition to dynamism, this dimension has been called stability, variability, or rate of change.

To operationalize dynamism, I used Question A3 from the questionnaire ("Please indicate what characterises technological change in your business"), which used a 5-point Likert-scale to assess change and its degree (1 - slowly/hardly ever; 5 - rapidly/frequently) for the following aspects:

- logistic processes change, core production processes change, products become obsolete, and new products are introduced.

The four variables are unidimensional, and Cronbach's alpha has a value of 0.628, which exceeds the desired threshold.

ii) The second environmental dimension is complexity (Child, 1972; Duncan, 1972; Mintzberg, 1979; Bourgeois, 1980; Dobák, 2006). The questionnaire does not contain questions related to this dimension, so I created a variable based on Duncan (1972) with similar principles. A total of 11 variables can be related to environment (Questions A2-A3), which were all measured on 5-point Likert-scales, with the higher value of the variable indicating that the environmental effect in question is stronger.

For all companies, I counted the values of 4 or 5 of these variables, and I divided this number by 11 and transformed it into a percentage value. In this way, I obtained a new variable with a value between 0 and 100 (value is 0 if the company gave to all variables a value of 3 or less; value is 100 if the company gave a value of 4 or 5 to all 11 variables). A higher value indicated a more complex environment, as more environmental factors had a stronger effect.

iii) The third major dimension is competition (Bourgeois, 1980), which has also been termed illiberality (Child, 1972) or hostility (Mintzberg, 1979). To operationalize competition, I used three variables in Question A2, which asked the following question on a 5-point Likert-scale: "How do you perceive the following characteristics?":

- competition intensity (A2e): 1 – low intensity, 5 – high intensity

- market concentration (A2f): 1 – few competitors, 5 – many competitors
- market entry (A2g): 1 – closed to new players, 5 – open to new players

During the evaluation of unidimensionality, market entry had to be omitted; hence, the variable characterising competition consisted of two parts: competition intensity and market concentration (Cronbach's alpha = 0,623).

(2) Size is measured by the number of employees of the business unit (variable A1c).

(3) Technology is measured along four dimensions:

i) Question B2 shows product complexity ('How would you describe the complexity of the dominant activity?' on a 5-point Likert-scale through the following variables:

- product design (B2a): 1 – modular, 5 – integrated;
- product (B2b): 1 – single manufactured components, 5 – finished assembled products;
- bill of material (B2c): 1 – very few parts/materials, one-line bill of material, 5 – many parts/materials, complex bill of material;
- steps/operations (B2d): 1 – Very few steps/operations required, 5 – many steps/operations required.

The aggregated product complexity variable has a Cronbach's alpha of 0.732, i.e. it is reliable.

ii) Question T1 shows technology level ('How advanced is the core process technology of your dominant activity?') on a 5-point Likert-scale through the following variables:

- machines (T1a): 1 – mostly manual operations, using hand tools and/or manually operated general purpose machine tools and handling/ transportation equipment, 5 – most operations are done by highly automated machine tools and handling/transportation equipment (computer-controlled machines, robots, automated guided vehicles);
- integration (T1b): 1 – mostly stand alone machines, 5 – fully integrated systems;
- monitoring (T1c): 1 – no information system supporting process monitoring and control, 5 – The overall process is monitored and controlled in real time by a dedicated information system.

The aggregated technology level variable has a Cronbach's alpha value of 0.751, i.e. it is reliable.

iii) Question B8 asks about the process type implemented at the company ('To what extent do you use the following process types (% of volume)?'). The three possibilities are one of a kind production, batch production and mass production. Following McKone – Schroeder (2002) I weighted the possibilties (the lowest weight went to one of a kind manufacturing, the highest weight went to mass production), then I transformed this value to a percentage scale. The lower the value of the variable, the more dominant one of a kind manufacturing is at the company (at a value of 0 there is only one of a kind manufacturing), the higher the value, the more dominant mass production is (at a value of 100 there is only mass production). If there is only batch production, the variable has a value of 50. In case of mixed processes the value moves in the range according to the ratio of the different processes.

iv) Question B9 asks about customer orders (which affects the implemented technology) ('What proportion of your customer orders are designed/engineered to order, manufactured to order, assembled to order, produced to stock?'). I operationalized this variable similarly to process type (weighting and transformation). In case of design/engineer to order only the value of the variable is 0, in case of manufacture to order only it is 33, in case of assemble to order oly it is 66, while in case of produce to stock only it is 100. In case of mixed customer orders the actual value reflects the ratio of the different orders and moves between 0-100 között.

(4) I measure strategic focus through Question A4 about competitive priorities ('Consider the importance of the following attributes to win orders from your major customers.'), whose variables were measured on a 5-point Likert-scale (1 – not important, 5 – very important). I use the traditional four dimensions of OM (cost, quality, flexibility, dependability). The 12 variables were first divided into 4 factors by factor analysis, then I performed the analysis of unidimensionality based on this grouping. The dimensions consist of the following variables:

i) cost focus: lower selling prices (A4a);

ii) quality focus: superior product design and quality (A4b), superior conformance to customer specifications (A4c). Cronbach's alpha for quality focus is only 0.556. This value is below the expected threshold, but for now I left it in the analysis (later on I will give my reason for it).

iii) flexibility focus: wider product range (A4g), offer new products more frequently (A4h), and offer products that are more innovative (A4i). I.e. this focus is about product and mix flexibility. Cronbach's alpha for flexibility focus is 0.768. By omitting variable A4g (wider product range) value of alpha would increase to 0.799, but since alpha is high enough in case of the three variables as well, I kept all variables.

iv) sustainability focus (originally dependability focus): more dependable deliveries (A4d), faster deliveries (A4e), greater order size flexibility (A4j), environmentally sound products and processes (A4k) and committed social responsibility (A4l). Cronbach's alpha for dependability focus is 0.761. I have to add that this variable measures not only dependability, because it consists of greater order size flexibility (though this can be related to dependability) and aspects of social responsibility as well. Because of this the variable will require careful attention later, and during the analysis I will also write about why it was renamed finally to sustainability focus.

5.2.2. Variables measuring manufacturing practices

I investigate the effect of 5 sets of manufacturing practices in my model: HR practices, process control practices, technology practices, quality management practices and product development practices. The question was the same for all sets of manufacturing practices: 'Indicate the effort put into implementing the following action programs in the last three years.' (the questionnaire calls manufacturing practices as action programs). In case of all manufacturing practices the extent of use was measured on a 5-point Likert-scale (1 – none, 5 – high). The sets of practices consisted of the following manufacturing practices (manufacturing practices could consist of several more precisely defined programs, for these examples see Appendix 3 that contains the full questions):

(1) HR practices:

- increasing the level of delegation and knowledge of your workforce (O11a),
- implementing the lean organization model (O11b),
- implementing continuous improvement programs (O11c),
- increasing the level of workforce flexibility (O11d), and
- enhancing corporate reputation (O11e).

Cronbach's alpha for HR practices is 0.745.

(2) Process control practices:

- restructuring manufacturing processes and layout to obtain process focus and streamlining (PC4b), and
- undertaking actions to implement pull production (PC4c).

Cronbach's alpha for process control practices is 0.700.

(3) Technology practices:

- engaging in process automation programs (T2a),
- engaging in flexible manufacturing/assembly systems – cells programs (T2b),
- engaging in product/part tracking and tracing programs (T2c), and
- implementing ICT supporting information sharing and process control in production (T2d).

Cronbach's alpha for technology practices is 0.799.

(4) Quality management practices:

- quality improvement and control (Q2a),
- improving equipment productivity (Q2b),
- utilizing better measurement systems (Q2c),
- improving the environmental performance of processes and products (Q2d),
- increasing the control of product quality along the supply chain (Q2e), and
- monitoring corporate social responsibility of partners along the supply chain (Q2f).

Cronbach's alpha for quality management practices is 0.860.

(5) Product development practices:

- increasing design integration between product development and manufacturing (PD3a),
- increasing the organizational integration between product development and manufacturing (PD3b),
- increasing the technological integration between product development and manufacturing (PD3c), and
- improving the environmental impact of products (PD3d).

Cronbach's alpha for product development practices is 0.790.

It can be seen that from the individual manufacturing practices we can create 5 aggregate variables which are unidimensional.

5.2.3. Variables measuring performance

Variables related to performance are examined in two steps. For the PLS model I only use the variables of Question B10 ('How has your operational performance changed over the last three years?'), which were measured on a 5-point Likert-scale with the following values: 1 – deteriorated more than 5%, 2 – stayed about the same (-5%/+5%), 3 – improved 5-15%, 4 – improved 15-25%, 5 – improved more than 25%. The other performance variables (cost structure [Question B4], other process indicators [Question B11], quality costs [Question Q1], inventory level [Question PC3]) will be used later to thest Hypothesis H5. In order to aggregate variables I proceed along the widely accepted four dimensions of operations performance (cost, quality, flexibility, dependability), similarly than in the case of strategic focus. This is fortunate, because the relationship of strategic focus and performance can be better examined thanks to the shared dimensions. First I divided 22 variables with factor analysis into 4 factors, then I checked unidimensionality. The variables of the performance dimensions and the results of the unidimensionality checks are the following:

(1) Cost: unit manufacturing cost (B10k), procurement costs (B10l), labor productivity (B10o), inventory turnover (B10p), capacity utilization (B10q), and manufacturing overhead costs (B10r). Cronbach's alpha for cost performance is 0.830.

(2) Quality: manufacturing conformance (B10a), product quality and reliability (B10b), employee satisfaction (B10s), employee knowledge (B10t), environmental performance (B10u), and social reputation (B10v). Cronbach's alpha for quality performance is 0.854. By adding the last four variables (B10s-v) value of alpha increased significantly (from 0.789 to 0.854), and these show important aspects (employee satisfaction and knowledge, environmental performance and social reputation), but obviously this alters the meaning of this dimension, which should be taken into consideration later, during the analysis.

(3) Flexibility: product customization ability (B10c), volume flexibility (B10d), mix flexibility (B10e), time to market (B10f), product innovativeness (B10g), and customer service and support (B10h). Cronbach's alpha for flexibility performance is 0.826.

(4) Dependability: delivery speed (B10i), delivery reliability (B10j), manufacturing lead time (B10m), and procurement lead time (B10n). Cronbach's alpha for dependability performance is 0.813.

After operationalizing the variables I define the PLS model.

5.3. The elaborated PLS model

Figure 7 shows the elaborated model (based on Henseler et al., 2009; Henseler, 2010). As with all SEM models, this model consists of two major parts (measurement and structural model) and manifest and latent variables. The structural model shows the relationships between the latent variables (marked with ellipses, abbreviated with LV). The measurement model shows the relationships between LVs and their respective manifest variables (marked with rectangles). Manifest variables are measured variables, which define the LVs behind them (LVs cannot be measured directly). That is, we are not able to measure product complexity as an LV directly but only through its manifest variables [variables B2a-d]).

Each measurement model can be either reflective or formative. In a reflective measurement model, the direction of causality goes from the LV towards the manifest variables (marked by the arrowheads). Therefore, we expect manifest variables to correlate with one another because they share a common cause. Similarly, the omission of a manifest variable does not change the meaning of the LV. Measurement error is considered at the level of the manifest variables.

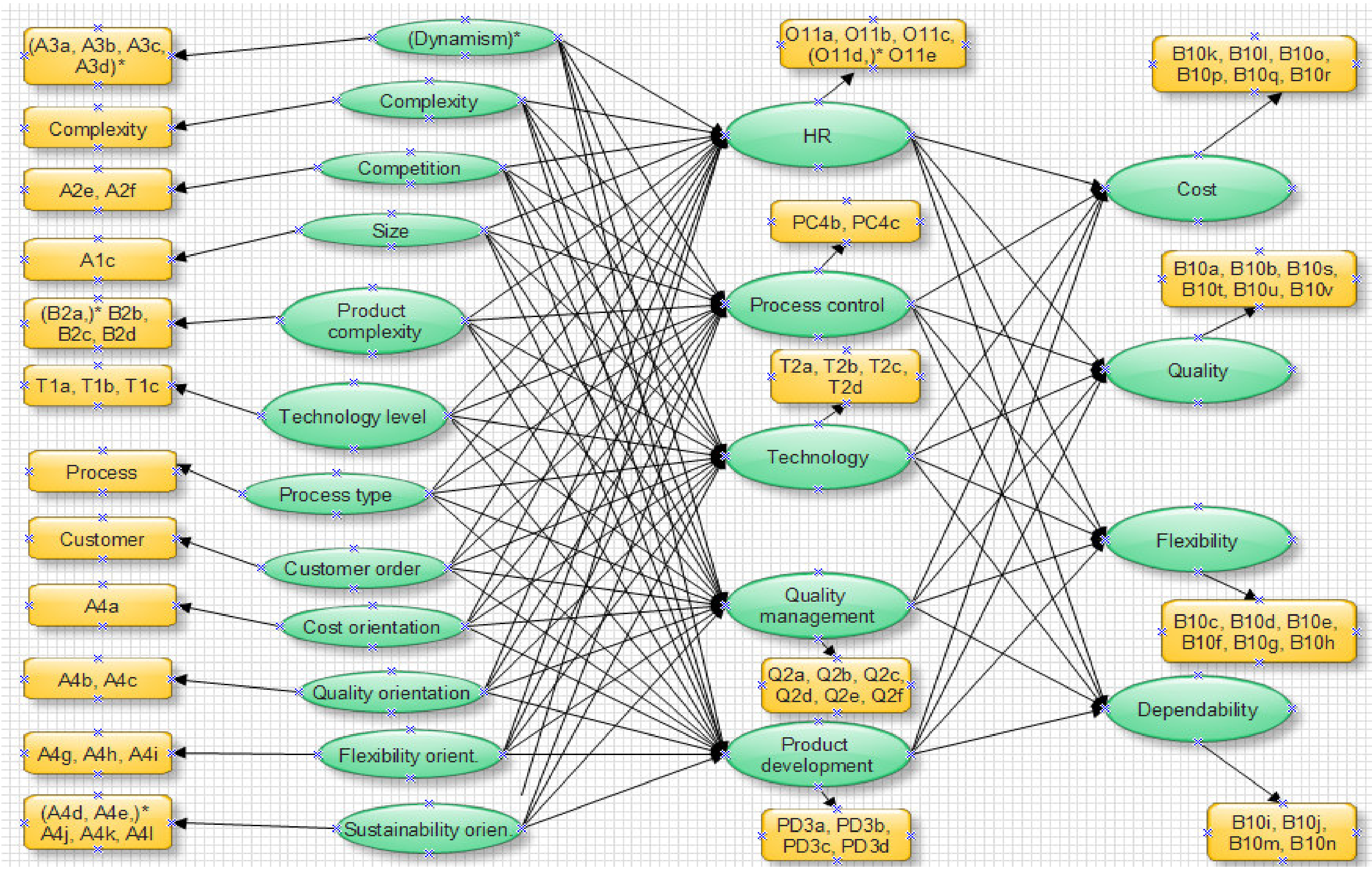

Figure 7: The PLS model

In formative measurement models, the direction of causality goes from the manifest variables towards the LV, and we do not expect manifest variables to correlate with one another. Therefore, the omission of a variable may change the meaning of the LV. Based on these factors, my PLS model contains a reflective measurement model.

I would like to add a few remarks to Figure 7. First, to have a clearer view of the model, I put all manifest variables of a certain LV into one rectangle, instead of drawing as many rectangles and arrows pointing towards them as the number of the variables, as that approach would have made a complex model more chaotic. For the same reason, I did not include the error terms in Figure 7. Some variables in the model are in brackets with an asterisk (i.e., LV Dynamism and its manifest variables and manifest variables A4d, A4e, B2a and O11d) because they did not meet the reliability and validity criteria that were performed later on (as we will see in the next section); hence, they were not included in the empirically tested model.

After preparation of the model, the first test run was performed (using the path weighting scheme and standardising the variables).

5.3.1. Evaluating the PLS model results

It is important to note that contrary to confirmative SEM models (e.g., LISREL), explorative PLS models still do not have such global indicators that would assess the overall goodness of the model. Hence, the measurement and structural models must be evaluated separately. The prerequisite for structural model evaluation is that the measurement models are reliable and valid; therefore, I continue the analysis by examining these models.

5.3.1.1. Evaluating the measurement models

The reliability and validity of the reflective measurement models can be evaluated in four different ways: internal consistency of LV, reliability of manifest variables, convergence validity and discriminant validity.

(1) Internal consistency of LVs

For this evaluation, we can use two indicators, Cronbach's alpha and Dillon-Goldstein's rho. Both indicators measure the reliability of a set of variables, and their value can be between 0 and 1. Depending on the source, the minimum required value may be between 0.6 and 0.7 or between 0.8 and 0.9. The exact threshold depends on the actual research phase (Nunnaly, 1994). An important difference between the two indicators is that alpha assumes a so-called tau-equivalent model, i.e., it treats all variables as equally important and assigns the same weight to them. Rho does not have this condition; weights differ from one another according to the reliability of the variables. The PLS method also assigns greater weight to more reliable variables; hence, the real reliability of the set of variables is somewhere between the values of alpha and rho. Table 16 shows the alpha and rho values for the model.

Latent variable (LV)	**Alpha**	**Rho**	**Latent variable (LV)**	**Alpha**	**Rho**
Dynamism	0.628	0.771	Sustainability orientation	0.761 / 0.750	0.828 / 0.858
Complexity	1	1	HR practices	0.745 / 0.761	0.832 / 0.848
Competition	0.632	0.845	Process control practices	0.700	0.870
Size	1	1	Technology practices	0.799	0.869
Product complexity	0.732 / 0.757	0.835 / 0.858	Quality management practices	0.860	0.895
Technology level	0.751	0.857	Product development practices	0.790	0.864
Process type	1	1	Cost	0.830	0.878
Customer order	1	1	Quality	0.854	0.891
Cost orientation	1	1	Flexibility	0.826	0.873
Quality orientation	0.556	0.815	Dependability	0.813	0.877
Flexibility orientation	0.768	0.866			

Table 16: Internal consistency of latent variables

The alpha and rho value of an LV that has only one manifest variable is naturally 1. It can be observed that rho values are always higher than alpha values. In the previously mentioned case of Quality focus, its alpha value was only 0.556, but the rho value was 0.815, which is a strong value. Because the real reliability of the LV is somewhere between 0.556 and 0.815, I kept it for further analysis because of the high rho value. In the following three cases, two alphas and rhos are given because for these LVs, not all manifest variables passed the reliability test (see Section (2) below):

- For Sustainability focus, ‘more dependable deliveries’ (A4d) and ‘faster deliveries’ (A4e)
- For Product complexity, ‘product design’ (B2a)
- For HR practices, ‘increasing the level of workforce flexibility’ (O11d).

Therefore, these variables had to be omitted from the model, and the values of alpha and rho had to be recalculated. It is important to add that LV Sustainability focus lost those two variables, which were most closely connected to the dimension of dependability. The remaining LV reflects an attitude much closer to sustainability; hence, later on, the LV will be evaluated accordingly, which was the reason for the LV's earlier name.

(2) Reliability of the manifest variables

Variable reliability shows how much variable variance is explained by the LV of the variable. Its value can be between 0 and 1, and regarding standardisation of the variables, this value equals the squared loading of the variable. The minimum acceptable value is 0.4 or above. Appendix 4 shows the squared loading values. This criterion was not met in the case of the variables mentioned in the previous section (O11d, A4d-e and B2a), which were then omitted from the model.

(3) Convergence validity

Convergence validity can be evaluated by the AVE (average variance extracted) value. Interpretation of AVE is similar to the variance explained value in factor analysis. AVE shows to what extent the LV explains the variance of its own manifest variables (practically, it shows an average variable reliability). Its value can be between 0 and 1, and the minimum accepted value is 0.5. A lower value indicates that another LV explains the variance of the manifest variables rather than their own LV. Table 17 shows the AVE values of the LVs in the model.

Latent variable (LV)	AVE	Latent variable (LV)	AVE
Dynamism	0.4661	Sustainability orientation	0.500 / 0.672
Complexity	1	HR practices	0.502 / 0.583
Competition	0.731	Process control practices	0.770
Size	1	Technology practices	0.624
Product complexity	0.563 / 0.671	Quality management practices	0.588
Technology level	0.666	Product development practices	0.614
Process type	1	Cost	0.545
Customer order	1	Quality	0.578
Cost orientation	1	Flexibility	0.534
Quality orientation	0.689	Dependability	0.641
Flexibility orientation	0.685		

Table 17: AVE values of the latent variables

From the table, we can see that the AVE of LV Dynamism is below 0.5; therefore, it is omitted from the model. In the case of three other LVs, there are two AVE values as well (similar to the two alphas and rhos). The first AVE value is the original, and the second AVE value is after the omission of the variables mentioned in Sections (1)-(2) (O11d, A4d-e, B2a). It can be clearly seen that after omission of these weak variables, the validity of the LVs improved significantly, which justifies this step.

(4) Discriminant validity

Discriminant validity can be examined in two ways, using either the Fornell-Larcker-criterion or cross loadings.

- Fornell-Larcker-criterion (Fornell – Larcker, 1981): The expectation of the criterion is that an LV should explain the variance of its own manifest variables rather than the variance of other LV's manifest variables. Therefore, it is necessary that the AVE value of the LV be higher than the squared correlation of the LV with all other LVs. Appendix 5 shows this relationship. The table in Appendix 5 shows the correlations between LVs with one exception: the diagonal values of the correlation matrix (which should have been 1) were exchanged to the squared root values of AVEs. The criterion is fulfilled if for every row and column, the value on the diagonal is the highest. The table does not contain the previously omitted LV Dynamism and variables. It can be seen that the criterion was fulfilled.

- Cross loadings: This condition states that the weight of a variable related to its own LV should be higher than its weights to all other LVs. This condition is shown in Appendix 6, from which we can see that the condition is also met, i.e., the measurement models are reliable and valid after the necessary modifications.

We can then begin to evaluate the structural model.

5.3.1.2. Evaluating the structural model

The structural model can be evaluated with three methods, by analysing 1) the explaining power of endogeneous LVs, 2) the path coefficients, and 3) the strength of the effect.

(1) Explaining power of endogeneous LVs (R^2)

Endogeneous LVs are those LVs that have arrows pointing towards them from another LV in the model. LVs that have arrows pointing towards them only from their manifest variables are exogeneous LVs, and the explaining power of these LVs is 0 because they are not determined by other LVs. Table 18 shows the explaining power of the endogeneous LVs in the model.

Endogeneous LV	**Explaining power (R^2)**	**Endogeneous LV**	**Explaining power (R^2)**
HR practices	0.266	Cost	0.195
Process control practices	0.255	Quality	0.300
Technology practices	0.511	Flexibility	0.194
Quality management practices	0.454	Dependability	0.174
Product development practices	0.363		

Table 18: Explaining power of endogeneous latent variables

R^2 values move on a quite broad range. In the case of manufacturing practice LVs, we can observe values between 0.255 and 0.511, i.e., contingency factors explain the variance of these LVs between 25.5 and 51.1%. Explaining power is weak at the level of 0.19, medium at the level of 0.33, and strong at the level of 0.67 (Chin, 1998, p. 323). The most explained LV is LV Technology practices followed by LV Quality management practices and LV Product development practices. In these cases, the amount of variance explained is stronger than medium. LV HR practices and LV Process control then follow, whose explaining power is a bit weaker than medium. To see exactly which contingency factors and to what extent they contribute to explaining power, we must analyse the path coefficients (see below in Section (2)). In the case of performance variables, the explained variance is weaker. Variance of LV Quality is explained by 30% for certain manufacturing practices, while the ratio of the other performance LVs is rather weak, between 17 and 19%.

(2)-(3) Analysis of path coefficients and effect size

Path coefficients can be interpreted as standardised regression coefficients. The sign and value of the coefficient are important, just as the significance of the relationship is. The problem of multicollinearity normally does not occur if discriminant validity is fulfilled (Henseler, 2010, p. 89).

Unfortunately, the examination of path significance is a bit odd. One primary advantage of the PLS method is that it does not require normal distribution from the variables. The consequence is that we cannot apply those statistical tests that are related to the normality assumption (e.g., t-tests and F-tests). Therefore, we must bootstrap the original sample to calculate an empirical t-value and compare this t-value to the t-value table. Bootstrapping means that by randomly selecting (with replacement) cases from the original sample, we create new samples and run the model on each new sample, calculate the path coefficients, and on the basis of these coefficients, we compute an empirical t-value that tells us whether the average path coefficients of the samples are significant. The degree of freedom of the t-test depends on the number of generated new samples (df = m-1, where m is the number of generated new samples). I bootstrapped the model with 5,000 samples, and with df = 4999, the t-values are as follows:

- 1.65 (at 10% significance level)
- 1.96 (at 5% significance level)
- 2.58 (at 1% significance level)

The value of the path coefficients does not tell us anything about the effect size. We can, however, use Cohen's f^2 value. This indicator examines if, and to what extent, the existence of the examined path changes the explaining power of the endogeneous LV. Based on f^2, the effect size of the path is weak if f^2 is higher than 0.02, moderate if f^2 is higher than 0.15, and strong if f^2 exceeds 0.35 (Cohen, 1988).

Table 19 shows the path coefficients significant at a p = 0.01 level together with effect size.

Relationship	Path coefficient	Standard error	t-value	f^2
Complexity -> HR practices	0.2071	0.0524	4.205	0.032
Complexity -> Technology practices	0.1233	0.0405	3.102	0.016
Complexity -> Quality management practices	0.1609	0.0437	3.628	0.026
Complexity -> Product development practices	0.1308	0.0469	2.886	0.014
Size -> Technology practices	0.0672	0.0247	2.7465	0.008
Product complexity -> HR practices	0.1311	0.0432	3.0781	0.022
Product complexity -> Technology practices	0.1172	0.0399	2.8889	0.016
Product complexity -> Product development practices	0.1881	0.0397	4.885	0.014
Technology level -> HR practices	0.256	0.0441	5.9324	0.067
Technology level -> Process control practices	0.2784	0.0453	6.1459	0.078
Technology level -> Technology practices	0.5501	0.0367	15.997	0.474
Technology level -> Quality management practices	0.3034	0.0362	8.3837	0.126
Technology level -> Product development practices	0.2681	0.0394	6.9538	0.083
Customer order -> Process control practices	0.1721	0.039	4.3606	0.033
Quality focus -> Quality management practices	0.1124	0.0355	3.1963	0.020
Flexibility focus -> Product development practices	0.1888	0.047	4.2842	0.034
Sustainability focus-> HR practices	0.1497	0.0476	3.1631	0.023
Sustainability focus -> Quality management practices	0.3247	0.0386	8.6139	0.139
Sustainability focus -> Product development practices	0.1742	0.046	3.8896	0.036
HR practices -> Quality	0.1411	0.0459	3.0725	0.014
Process control practices -> Cost	0.177	0.0507	3.4694	0.023
Process control practices -> Quality	0.1651	0.0466	3.4063	0.024
Process control practices -> Flexibility	0.2237	0.0492	4.5663	0.037
Process control practices -> Dependability	0.1936	0.0558	3.4539	0.024
Quality management practices -> Quality	0.296	0.0595	5.2517	0.053
Quality management practices -> Dependability	0.1927	0.0624	3.0387	0.020
Product development practices -> Flexibility	0.1803	0.0592	3.0208	0.020

Table 19: Relationships of the model that are significant at a p = 0.01 level

It can be seen that at a p = 0.01 level, 27 significant relationships exist. The following contingency factors have significant effects at this level on manufacturing practices (with the number of significant relationships in parentheses): Complexity (4), Size (1), Product complexity (3), Technology level (5), Customer order (1), Quality focus (1), Flexibility focus (1) and Sustainability focus (3). There were no significant relationships between Competition, Process type, Cost focus and manufacturing practices. If we examine manufacturing practices, the following have significant relationships with certain performance dimensions (with the number of significant relationships in parentheses): HR practices (1), Process control practices (4), Quality management practices (2) and Product development practices (1).

Table 20 shows the path coefficients significant at a p = 0.05 level together with effect size.

Relationship	Path coefficient	Standard error	t-value	f^2
Complexity -> Process control practices	0.1157	0.0515	2.2564	0.009
Process type -> Technology practices	0.0832	0.0376	2.3003	0.010
Process type -> Quality management practices	0.0926	0.0399	2.3141	0.013
Customer order -> Technology practices	0.067	0.0326	2.0558	0.008
Flexibility focus -> Process control practices	0.1175	0.0517	2.2813	0.012
Flexibility focus -> Technology practices	0.0813	0.0406	1.9914	0.008
Sustainability focus -> Technology practices	0.0815	0.0389	2.0973	0.010
Quality management practices -> Cost	0.1621	0.0639	2.5921	0.015
Product development practices -> Quality	0.1279	0.0519	2.4483	0.011

Table 20: Relationships of the model that are significant at a p = 0.05 level

At a p = 0.05 level, fewer (only 9) relationships were significant. The following contingency factors have significant effects at this level on manufacturing practices (with the number of significant relationships in parentheses): Complexity (1), Process type (2), Customer order (1), Flexibility focus (2) and Sustainability focus (1). If we examine manufacturing practices, the following have significant relationships with certain performance dimensions (with the number of significant relationships in parentheses): Quality management practices (1) and Product development practices (1).

Table 21 summarises these results, showing that 1) a certain contingency factor significantly affects the number of manufacturing practices, 2) manufacturing practices are affected by the number of contingency factors, and these manufacturing practices affect the number of performance dimensions, and 3) performance dimensions are significantly affected by the number of manufacturing practices. In this way, we can see the major factors in a quantified way.

Contingency	It affects how many manufacturing practices?	Manufacturing practice	Affected by how many contingency factors?	It affects how many performance dimensions?	Performance dimension	Affected by how many manufacturing practice?
Complexity	5	HR	4	1	Cost	2
Competition	-	Process control	4	4	Quality	4
Size	1	Technology	8	-	Flexibility	2
Product complexity	3	Quality management	5	3	Dependability	2
Technology level	5	Product development	5	2		
Process type	2					
Customer order	2					
Cost focus	-					
Quality focus	1					
Flexibility focus	3					
Sustainability focus	4					

Table 21: Summary of the results

5.3.1.3. Evaluating the results

In the following section, I discuss the results, beginning with the relationships between contingency factors and manufacturing practices.

The effect of complexity on manufacturing practices

Environmental complexity is one of the most influential contingency factors in the model because it significantly affects all manufacturing practices. However, I must also add that in 3 cases out of 5, this effect is very weak (f^2 value does not exceed the 0.02 threshold), and in the remaining cases, it is not much stronger (value of 0.032 with HR practices and value of 0.026 with Quality management practices).

As a reminder, I created the Complexity variable from 11 single variables, which were related to certain environmental aspects (e.g., environmental dynamism, competition, market conditions). Value of complexity depended on the number of variables that were given a value of 4 or 5 on a 5-point scale by the respondents, i.e., indicating how many environmental variables have a strong effect. Duncan (1972) showed that complex environments are more uncertain. My variable measuring complexity also shows this relationship, as for a high value, several different environmental variables affect the company strongly, increasing the uncertainty of company operations. Therefore, in the discussion section, I also mention literature on environmental uncertainty and environmental dynamism. As we have seen in the analysis, environmental dynamism did not appear as an individual LV in the model because it did not meet the reliability and validity requirements, though its effect may appear through the variable measuring complexity. Therefore, relevant results related to dynamism will also be mentioned here.

Jonsson (2000) did not find any relationship between the level of environmental uncertainty and investment in advanced manufacturing technology (AMT). Raymond (2005) also did not find a relationship between uncertainty and AMT assimilation.

Demeter – Matyusz (2010) found that the rate of change of product and process technology is related to several manufacturing practices, but the influence of process technology is stronger. Rate of change of product technology is related to quality management and HR practices, while rate of change of process technology is also related to product development and process control practices and to certain technology practices.

In my investigated model, the detected stronger effect in the case of HR practices, and quality management practices indicates that for companies, the important tools to tackle complexity are investment in human resources, improvement of employee capabilities and greater emphasis on quality management, which can help reduce (or, for more complex environments, at least prevent increases in) occurring quality costs. My interviewees also remarked on complexity. One individual highlighted the importance of competence building and the essential role of quality. His company manufactures such specialised products that even a temporary error can cause significant embarrassment to the (mainly industrial) customers, meaning that it is vital to ensure excellent quality (Interviewee "B", 2012). Another interviewee told me that the company's business environment had become much more dynamic and changing. Compared to the relatively stable situation three years earlier, demand had become highly unpredictable. This change very strongly affects managerial decisions, and the company requires more resources and a more flexible work force who can learn more complex processes and react better to emerging problems (Interviewee "A", 2011). Other important aspects were the acceleration of innovation speed and the shortening of product development time. For all of the company's products, the life cycle was drastically shortened. While earlier this phenomenon was characteristic of only specialised products, it is now an observable trend in high volume products. Ten to fifteen years ago, a product lived for 6 to 7 years, which has now decreased to 2 to 3 years. The basics of organising production have remained the same, but this acceleration requires much extra work for employees, as the same tasks occur much more frequently and the work force must cope by increasing its efficiency. The competitive environment of the company does not make the situation any easier. First, products are placed in the premium category; second, a number of regulations concerning the environmental performance of the product exist, causing the company's social responsibility to be in the limelight (Interviewee "C1", 2012).

The effect of competition on manufacturing practices

It is worth mentioning that competition in itself does not significantly affect manufacturing practices. Its effect likely influences manufacturing practices through environmental complexity but only by examining it jointly with other environmental variables (the variable measuring environmental complexity consists of partly single variables measuring competition, i.e., in the case of stronger competition, environmental complexity is also higher).

Merino-Diaz De Cerio (2003) did not find any relationship between competition and quality management. He defined quality management very broadly, and all of the manufacturing practices in my model appeared in his study as components of quality management. However, Matyusz – Demeter (2008) found a relationship between several manufacturing practices (i.e., quality management, technology, product development) and competition intensity. I must add that this study also used the IMSS database, but the operationalization of the variables was not the same as in my thesis, the authors worked with a previous version of the database, and the analytical method was different.

It is interesting that in the reviewed literature, there are very few studies that specifically examine the effect of competition on manufacturing practices. Similarly, my interviewees did not emphasise the role of this factor; for them, environmental complexity and uncertainty were far more influential.

The effect of size on manufacturing practices

Size has a significant relationship with only one type of manufacturing practice, namely, technology practices (according to which larger companies used technology practices to a greater extent). Its effect was very weak (0.008), however.

Based on the literature, the role of size is unclear. According to Table 7, we can see that approximately half of the studies found significant relationships, while the other half did not. Even in cases of similar manufacturing practices, the picture is mixed. For example, in the case of practices related to quality management, Spencer – Loomba (2001) and Sila (2007) did not find any size effect, while Shah – Ward (2003) and Jayaram et al. (2010) found particularly strong effects. McKone et al. (1999) found only a very weak size effect related to TPM practices. Sila (2007) and Jayaram et al. (2010) used the SEM method for analysis, but the investigated industries and operationalization were different, which could contribute to the difference in results. Another obvious problem is the use of different size categories. Hence, the fact that I did not find any relationship between size and quality management practices in my thesis does not contradict the existing knowledge.

The topic of size and technology practices is also interesting. Cagliano (1998), Swamidass – Kotha (1998), Jonsson (2000), Demeter – Matyusz (2008) found a relationship between size and the use of technology practices/advanced manufacturing technology (AMT), while Zhang et al. (2008) did not. The role of size in process control is also mixed. Some authors have found a relationship between the two (e.g., White, 1993; Shah – Ward, 2003), while others have not (e.g., McKone – Schroeder, 2002; Bayo-Moriones et al., 2008). Just as I assumed for quality management practices, operationalization and different size categories certainly also play a role in these differences.

My interviewees judged the role of size ambiguously. They highlighted the importance of size for availability of resources and experience, where larger companies that have greater possibilities are able to better optimise processes (e.g., by changing plant layout) because they have the necessary work force, knowledge and money to do so, though decision making is slower and more complicated. It is an advantage and a disadvantage that companies of different sizes employ people with different skills. In smaller companies, employees are considered generalists, while in larger companies, there are many specialists. In the case of technology, a small company is not normally able to compete with large companies (Interviewee "A", 2011). Another interviewee emphasised the difficulty of implementing changes, as larger companies have larger inertias (Interviewee "B", 2012). Organisational inertia was mentioned by another interviewee as well, although he called it inflexibility. According to him, the threshold is approximately 2,000 people, which is a much larger value than the usual category borders in OM. Unsurprisingly, this interviewee believed that not organisational size but organisational flexibility and openness to new things are the important factors. From a process planning point of view, the different sizes of manufacturing segments (workers producing certain types of products in a plant) do not cause problems for the company (Interviewee "C2", 2012). This last statement was supported by one of the segment managers who worked at the same company. According to him, the goal is to become more efficient regardless of size, though he admitted that a company's possibilities may differ from its exact size (Interviewee "C1", 2012).

The effect of product complexity on manufacturing practices

As a reminder, product complexity consists of variables measuring product sophistication, bill of material complexity, and number of steps/operations required. Product complexity did not have a significant effect on only process control and quality management practices. It is, however, interesting that the effect size is weak, even for the significant relationships. The strongest effect is found between product complexity and HR practices (0.022), but in the two other cases, f^2 is even lower (0.016 for technology and 0.014 for product development practices). Nonetheless, these relationships seem logical. For more complex products, appropriate training of employees may be necessary to handle this more difficult situation. Moreover, technological improvements may be needed if the company manufactures more complex products, which may also affect product development practices because higher product complexity makes the lives of the employees more difficult, not only during the manufacturing phases, but also during product development, where they must consider many more factors. This situation requires significantly better coordination between manufacturing and product development. The result that product complexity does not have a significant relationship with process control and quality management practices may indicate that these practices are more closely related to the manufacturing process itself, and product complexity requirements indirectly influence these practices through processes and applied technologies, which consequently create the products.

Examining the previous literature, very few studies have investigated product complexity, and many studies did not have empirical underpinnings (e.g., Funk, 1995; Hendry, 1998; González-Benito, 2002). According to Funk's (1995) hypothesis, the logistical complexity of the product affects the implementation of JIT practices; the more complex the product is, the more important it is to use JIT practices. He does not, however, test his hypothesis empirically. My analysis did not find a relationship between product complexity and process control practices, so this result does not support the assumption of Funk (1995).

My interviewees made several interesting comments about product complexity, which, on the whole, support the results of the analysis. At one company, technology is created with the product. If the appropriate technology does not exist, then the company invests and improves (Interviewee "A", 2011). The effect of products becoming more complex on processes was also highlighted in another interview in which the interviewee told me that it is expected that the shop-floor level give recommendations to modify the existing processes to make them more robust. These statements also indicate the close relationship between product and process. At this interviewee's company, the product mix consists of more than 35,000 products. Two-thirds of these products are quite unique, and only a few pieces must be manufactured each day, which requires from the workers the necessary competence, as they should understand what they manufacture and what materials are required on the assembly line at the right time and in the appropriate quantity. In the case of more complex products, tracing material may become problematic because if the same material is used at more than one location on the assembly line, it is virtually impossible to trace the exact path of these components. This phenomenon also signals competence building of workers. My interviewee interpreted competence as professional expertise, not practical/manual knowledge, because the two do not necessarily occur together (Interviewee "B", 2012). My third interviewee agreed, and he provided the example of driving: if someone can drive a car, he/she does not necessarily have knowledge about the car (Interviewee "C2", 2012). The important task is to place the worker of a particular competence level at a given location, and at critical points, the appointed worker must understand the product and the process, i.e., what he/she is doing and why. To improve this process, the company created a new database that stores the competence levels of each worker, and with the help of this database, they are able to distribute the workers more efficiently (Interviewee "B", 2012). To summarise, it can be said that human factors are important in product complexity; similarly, according to the results of the model, product complexity affects HR practices strongest. However, needs that arise from complexity often do not appear directly in manufacturing but through the process's influence.

The effect of technology level on manufacturing practices

In my thesis, technology level is measured by equipment automatisation level, integration of machines, and process monitoring level. Table 21 shows that in addition to environmental complexity, the contingency factor of technology level significantly affected all manufacturing practices. Moreover, effect sizes are among the strongest in the entire model. Technology level affects HR practices the least (0.067), but even this value is well above the 0.02 threshold of weak effect size. The effects on process control and product development practices are a bit higher (0.078 and 0.083, respectively). Very strong effects can be found in the case of quality management and technology practices. The first effect size is moderate (0.126), while the effect size on technology practices is very strong (0.474). I believe that these results are in line with the expectations. Technology level affects human resources from two sides. First, in the case of manufacturing certain unique products, the company requires a more skilled work force, indicating investment in human resources. Second, companies that mass-produce standardised products do not expect very sophisticated activities from most workers because of the increase in the level of automatisation. Here, HR practices play a very important role in reducing the disadvantages of performing monotonous tasks required from the workers and simultaneously increasing worker flexibility. More improved technology enables a higher level of process control and product development because of the broader range of technological possibilities; therefore, the significance of these relationships is also understandable. These same possibilities make highly efficient quality management possible (e.g., with different measurement systems, analyses, quality improvement and productivity programs), along with technology practices that are able to exploit high technology levels in practice (e.g., automatisation, tracing/tracking, marking, information sharing, process control).

Few studies have examined technology level, as most have approached technology from the perspective of process types and customer orders (see below). Youssef – Al-Ahmady (2002) found that companies using flexible manufacturing systems use quality management and HR practices to a greater extent. According to Merino-Diaz De Cerio (2003), plants with a high level of automatisation implement quality management practices to a great extent. McKone et al. (1999) also found a relationship between the degree of equipment standardisation in the plant and the use of TPM practices, though this relationship was very weak. On the contrary, Small (2007) did not find a relationship between technology sophistication and HR and technology practices.

My interviewees did not normally discuss this matter, and if they did, they connected it to human resources. Every visited company uses highly advanced technologies. One of my interviewees stated that improvements in these technologies are continuous and that the rate of technological change is rapid, with a major leap every 5 years. It is also important that technology improvement be made according to already existing skills, capabilities and experience and not because, for example, a competitor has introduced a new solution. In the case of new technology and assembly lines, employees visit the supplier and build the line together, learning the new features while on the job. If the technology is entirely new, they create the solution first as a pilot project and then extend it to the entire organisation based on the results. If the worker would like to change his/her rotation to vary the work, he/she may do so (Interviewee "C2", 2012).

The effect of process type and customer order on manufacturing practices

I discuss these contingency factors jointly because they are closely related to one another. Process type indicates the degree of standardisation of manufacturing (from one-off to mass production), while customer order indicates the uniqueness of the product (from engineer-to-order to make-to-stock). Both contingency factors significantly affected two manufacturing practices. Process type affects technology and quality management practices, while customer order affects process control and technology practices. However, effect sizes were very weak (under 0.02), with one exception. This one exception was the relationship between customer order and process control practices, i.e., the more standardised the customer order is (emphasis is on make-to-stock or assemble-to-order products), the more process control practices are used, which is a logical result. The weakness or non-existence of other effects may be explained by the following: the process type and customer order themselves lay the framework for how the manufacturing operates, but for the actual implementation, the main role is played by applied technology and its level; hence, effects of process type and customer order appear to be only indirect.

Das – Narasimhan (2001) found a partial relationship between process environment type (job shop, assembly lines) and advanced manufacturing technology. The results of McKone – Schroeder (2002) indicate a positive relationship between process type and technology practices (process technology and product technology development). According to Merino-Diaz De Cerio (2003), the continuous flow of the process is not related to the use of quality management practices. With the exception of this study, my results do not contradict those of other studies.

My interviewees also indicated that the effects of the manufacturing process determined by customer order appear indirectly through applied technology and solutions. One interviewee highlighted that the stability and volume of customer order is very important because they assign resources and projects based on these factors to customer needs. The company even has separate ramp-up plants, and after they bring the intended results, it is possible to move production elsewhere (Interviewee "A", 2011). Another interviewee stated that it is easier to balance the process with their high volume products because manufacturing steps can be divided more easily. The volume of the product is directly related to product complexity, as more complex products are normally manufactured in smaller volumes. This fact causes problems because it is not possible to create separate assembly lines for each product (due to huge investment costs), even if the assembly line could be utilised adequately. Consequently, an assembly line may be divided between 5 and 6 different products, which makes balancing more difficult (Interviewee "C1", 2012).

The effect of strategic focus on manufacturing practices

Of the four possible strategic foci, cost focus does not significantly affect any manufacturing practices, quality focus affects one practice, flexibility focus affects three, and sustainability focus affects four.

Unsurprisingly, quality focus significantly affects the use of quality management practices, though the effect is weak (0.020). The effect of flexibility focus is the strongest in the case of product development practices (0.034) and its relationships with technology, and process control practices are rather weak. Nonetheless, these practices are aligned with the variables that flexibility focus consists of (offering a wider product range, offering new products more frequently, offering products that are more innovative) and emphasis on innovation. Sustainability focus has a very weak effect on technology practices (0.010) and a somewhat stronger effect on HR practices (0.023) and product development practices (0.036), while its true strength appears in the case of quality management practices (0.139), which has a moderate effect size. This relationship can be interpreted well if we examine the single underlying variables. Two out of three variables of sustainability focus are related to environmental friendly products and processes and to dedicated social responsibility. Among quality management problems, we can find practices that focus on the improvement of environmental performance and corporate social responsibility monitoring.

The non-significant nature of cost focus is supported by several sources. Kotha – Swamidass (2000) did not find a relationship between cost-leadership strategy and the use of high-volume automation technology. The results of Lewis – Boyer (2002) indicate no difference in cost focus between companies performing better or worse. According to a proposition put forth by Hutchinson – Das (2007), which was derived from case study research, in companies following differentiating strategies (i.e., not cost focus), the purchase of appropriate manufacturing technologies increases company performance through improved levels of flexibility. However, other studies have arrived at different results. Christiansen et al. (2003) identified four clusters. Companies in the cost-focused strategy cluster placed great emphasis on all practices, though the degree was not significantly different among the practices (i.e., no single practice was used to a greater extent than the others). Peng et al. (2011) also found some partial effects and indicated that cost focus significantly affects improvement practices, which in turn affects certain performance dimensions.

Studies examining quality focus have found several results for its role. According to Forza – Filippini (1998), quality orientation leads to a higher level of process control through multifunctional employees and employee suggestions. Kathuria – Davis (2000) found that managers who emphasise quality to a greater extent use relationship-oriented HR practices to a greater extent, but this relationship was nonexistent for other types of HR practices. Kotha – Swamidass (2000) found a significant relationship between differentiating strategies and the use of certain types of advanced manufacturing technologies (AMT). The results of Lewis – Boyer (2002) showed that better performing companies placed a greater emphasis on quality than companies performing worse. In their previously mentioned study, Christiansen et al. (2003) found that companies using quality-focused strategies implement total productive maintenance (TPM) practices most frequently.

For flexibility focus, factors previously mentioned in connection with Kotha – Swamidass (2000) and Lewis – Boyer (2002) remain true here as well. According to Christiansen et al. (2003), the cluster focused on aesthetic/innovation did not implement manufacturing practices to any great extent. However, these practices (JIT, TQM, TPM, HRM) were not actually innovation oriented. This finding is in line with the results of my model, where flexibility focus exhibits its strongest relationship with product development practices.

Concerning sustainability focus, I have, unfortunately, not found any literature discussing this topic.

My interviewees perceived many factors related to strategic foci in similar ways. One highlighted the necessity of quality, with flexibility becoming increasingly more important, while cost and dependability are dimensions that the company must perform well (Interviewee “A”, 2011). My other interviewee also mentioned the importance of quality first. The reputation of cost/price is ambiguous. In certain markets, it is very important because it is the only way to cope with competitors who produce copied, poor quality products (which sometimes exist for only a very short period of time). In more developed markets, the requirement is the shortest possible lead time, which is a certain type of flexibility requirement. On-time dependability had been an interesting question in previous months/years, but it has become a bit less important in a sense. The key is not to deliver the product in 6 days with 100% probability. The company should take the customer order with a 6-day deadline if the probability of on-time delivery is only 94%, but the product will certainly arrive to the customer in 7-8 days. In my interpretation, this means that there was a customer expectation of drastically decreasing lead times compared to previous levels, and if this reduction was generally successful, then smaller deviations from this reduced level are not a significant problem (Interviewee “B”, 2012). My third interviewee also mentioned high quality as essential. In addition, it is important that the product is innovative, has a high technology level and provides a certain lifestyle feeling (Interviewee “C1”, 2012).

<u>The effect of manufacturing practices on operations performance</u>

With the exception of technology practices, it is very interesting that all manufacturing practices affect at least one operations performance dimension, though technology practices were significantly affected by the most contingency factors (8 in total). This result can be explained by several factors. First, it is possible that the positive effects of implementation of technology practices only appear with a time lag. Often, the introduction of a new technology initially causes more problems than it solves, until it is adopted well, and the workers and system are accustomed to the innovation. If this process occurs successfully, positive effects of the technology may then appear. Another explanation may be that technology practices are much more supportive in nature, i.e., they do not work by themselves but jointly with other practices. One example of this phenomenon is the process of automatisation, where this development makes higher level uses of process control practices easier and, thereby, affects performance dimensions. A great example for the ambiguous view of technology practices is the relationship between advanced manufacturing technology (AMT) and performance or, more precisely, flexibility, to which Vokurka – O'Leary-Kelly (2000) have also called attention. Jaikumar (1986) found very little relationship between AMT use and flexibility in American plants. Upton (1995, 1997) even draws the consequence that increases in AMT use decrease product and production flexibility. According to Suarez et al. (1996), AMT use affects certain dimensions of flexibility positively and others negatively. Boyer et al. (1997) found no effect of AMT use on flexibility. Swamidass – Kotha (1998) also concluded that the degree of AMT use is not related to operations performance. Raymond (2005) and Raymond – St-Pierre (2005) found that AMT sophistication has a beneficial effect on operations performance among Canadian SMEs. Swink – Nair (2007) found a positive relationship between AMT use and new product and process flexibility. Zhang et al. (2006) highlighted the supportive role of AMT and investigated the effect of AMT and operations improvement practices on flexibility. The best model was that in which operations improvement practices moderated the relationship between AMT use and flexibility. Swink – Nair (2007) also found proof for the supportive role of AMT. AMT use was negatively related to cost efficiency and positively related to quality, delivery and process flexibility only in the case of high level design-manufacturing integration. Unfortunately, the very diverse interpretations, definitions and operationalizations of AMT and flexibility make it very difficult to see this picture clearly.

HR practices significantly affect one particular performance dimension, albeit weakly (0.014): quality. This result meets expectations, as two variables of quality performance can be linked to employees (i.e., employee satisfaction and employee knowledge). Jayaram et al. (1999) found a significant relationship between HR practices and operations performance, more precisely between those practices and performance dimensions that are logically related to one another (e.g., HR practices directed towards cost reduction influenced cost performance). According to Gordon – Sohal (2001), oft-used practices related to employee training enhance business performance. Sila – Ebrahimpour (2005) did not find a relationship between the effect of HR management and business results, the reason for which may be that the indicator measuring business results was very heterogeneous; in addition to HR results, it consisted of variables measuring organisational effectiveness, customer results, and financial and market results. This result is supported by Sila (2007), who found a direct and positive relationship between HR practices and organisational effectiveness. Furlan et al. (2011) stated that the more often implementation of HR practices is related to JIT and TQM complementarity, the further it enhances that complementarity and, hence, contributes to better performance. This result may indicate that HR practices, similar to technology practices, are much more supportive in nature, i.e., they do not affect performance by themselves but help other practices to operate more efficiently. This notion is supported by the results of my model, where only one significant relationship between HR practices and performance dimensions existed.

Product development practices are significantly related to two performance dimensions, namely, flexibility (0.020) and quality (0.011), but the latter effect is very weak. The relationship with flexibility is not surprising, as flexibility contains many variables that can be connected to innovation (e.g., product customisation ability, time to market, product innovativeness). Aspects related to product development also appear in quality dimensions (e.g., product quality and reliability, environmental performance). The reason for the weak effect sizes may be similar to the case of technology and HR practices: from the manufacturing process point of view, product development can be considered a supporting activity. Koufteros et al. (2001) and Koufteros – Marcoulides (2006) examined the effect of concurrent engineering practices on quality and product innovation. They found a direct significant relationship with product innovation but only an indirect relationship with quality through product innovation, i.e., the effect on quality was weaker and indirect. Kaynak (2003) found proof of the positive relationship between product design and quality performance. Based on Swink et al. (2005), product-process improvement significantly affects process flexibility. Tan – Vonderembse (2006) showed a direct effect of concurrent engineering on product development performance (and, consequently, on cost performance).

The use of quality management practices significantly affected all performance dimensions, with the exception of flexibility; the weakest effect was on cost (0.015), followed by dependability (0.020), and finally quality (0.053). Though the model did not investigate this relationship and it may be a coincidence, it is worth observing that the order of effect sizes is the same as the order of the hybrid concept of cumulative performances (quality – delivery – cost; see Größler – Grübner, 2006; Hallgren et al., 2011). The previous literature fully supports the relationship between quality management practices and quality performance or performance interpreted in another way (Ghobadian – Gallear, 1996, 1997; Cua et al., 2001; Gordon – Sohal, 2001; McKone et al., 2001; Sohal – Gordon, 2001; Christiansen et al., 2003; Sila, 2007; Furlan et al., 2011).

Finally, process control practices have significant positive relationships with all performance dimensions, and effect size is always above 0.02. The strongest relationship is with flexibility (0.037). As previously mentioned, in the short term, the effects of several other manufacturing practices may appear indirectly through process control solutions, which is the reason for the great influence of these practices. The reviewed literature supports the significant effect of process control-related practices on performance (e.g., Cua et al., 2001, Fullerton – McWatters, 2001; McKone et al., 2001; Ahmad et al., 2003; Boyle – Scherrer-Rathje, 2009; Furlan et al., 2011). Demeter et al. (2011b) mentions at least another half-dozen studies from the 1990s that found positive effects of lean manufacturing on operations performance.

5.3.1.4. Mapping the moderating effects (Hypothesis H3)

Compared to the literature on contingency factors as drivers, there are relatively few studies on the moderating effects of contingency factors.

The most important theoretical underpinnings of moderation can be found in Baron – Kenny (1986) and Venkatraman (1989), while Henseler (2010) presents the applicability of moderation to PLS modelling. A moderator is a qualitative or quantitative variable that affects the direction and/or strength of a relationship between an independent and dependent variable (Henseler, 2010, p. 164). In my research, the complexity of the model offers several opportunities for testing a large amount of possible moderating effects, but because of the enormous capacity requirements of the computer test runs, I was required to narrow down the focus and concentrate on certain effects. Moderating effect size can be evaluated similarly to the strength of path coefficients with the f^2 value. Therefore, I focused on those moderating effects that had a minimum effect size of 0.02 (weak effect) on significant manufacturing practice–performance relationships in the model, and I tested the significance of these moderating effects (at $p = 0.05$ level) with bootstrapping, using 1,000 samples in each case. I centred the moderating variables; hence, the value of '0' represented the mean value of the moderator. The coefficient of the moderation showed the moderating effect size at the mean value of the moderator (this is the so-called ‘single effect’ value). Table 22 shows 1) the strongest significant moderating effects with the name of the moderator; 2) the manufacturing practice–performance relationship it moderates; 3) the path coefficient of the manufacturing practice–performance relationship without the moderating effect (b0) and with the moderating effect (b1); 4) the path coefficient of the moderating effect (b2); and 4) the moderating effect size (f^2).

Moderator	Relationship	b0	b1	b2	f^2
Sustainability focus	Process control practices -> Cost	0.177	0.192	0.147	0.036
Sustainability focus	Process control practices -> Quality	0.165	0.178	0.134	0.034
Sustainability focus	Process control practices -> Flexibility	0.223	0.238	0.125	0.023
Sustainability focus	Process control practices -> Dependability	0.194	0.212	0.167	0.064

Table 22: The strongest significant moderating effects

Value ‘b0’ shows the path coefficient of the relationship without moderation. Its interpretation is the same as the interpretation of the regression coefficient beta, i.e., the increase in the value of the independent variable causes an increase in the value of the dependent variable. For example, if the extent of use of process control practices increases, then performance will also increase to some extent (main effect). Value ‘b1’ has a different meaning and is the so-called single effect. It shows the degree of increase at the dependent variable if the value of the moderator variable is 0 (Henseler, 2010).
As a reminder, the moderator variable was centred with the mean, i.e., the value of ‘0’ represents the mean value of the moderator variable. Consequently, value ‘b1’ shows the degree of increase at the dependent variable, at the mean value of the moderator variable.

As shown in Table 22, there are very few significant effects, and these effects are not very diverse, as all are connected to sustainability focus and positively moderate manufacturing practice–performance relationships. However, other interesting points are worth noting. Tables 19-21 show that sustainability focus is a major contingency factor, as it has a significant relationship with four manufacturing practices as a driver. Only process control practices are not affected by sustainability focus, but it has moderating effects on the relationships between process control practices and performance dimensions, which are not negligible (effect sizes range between 0.023 and 0.064, above the 0.02 threshold of weak effect size). How can we interpret this result? Based on the moderating effect, the level of sustainability focus at the company has a positive moderating effect on the relationship between process control practices and performance dimensions, i.e., companies with the same degree of process control practices and those that better focus on sustainability will realise higher performance improvement than those with a more limited focus on sustainability. This difference in performance improvement can be arrived at in different ways, such as using more energy efficient equipment (cost), a design for the environment, less scrap (cost, quality), innovations with sustainability aspects (flexibility), more efficient supplier management and process control (dependability).

As mentioned above, moderating effects related to contingency factors had only been tested a few times in the existing literature, and the results are mixed.

In the case of environmental contingency factors, Dean – Snell (1996) found only a partial and very weak moderating effect of competition intensity on the relationship between integrated manufacturing and performance. The results of Koufteros et al. (2001) indicate that for product development, companies that operate in a changing environment are forced to use concurrent engineering practices to a greater extent. However, Koufteros et al. (2002, 2005) did not find support for the moderating effect of uncertainty on integrated product development practices. At different levels of uncertainty, the degree to which these practices are used did not change significantly; therefore, in their current state, these results do not provide a strong direction for product development practices. Based on his case study, Hung (2007) believes that the business environment moderates the relationship between TQM and quality; that is, in stable business environments, TQM practices have a direct effect on quality. This proposition was tested on a larger sample. Matyusz et al. (2010) did not find a moderating effect of company operations on the relationship between manufacturing practices and operations performance.

The picture is not less diverse in the case of the moderating effect of size. Swamidass – Kotha (1998) found only a very weak effect on the relationship between advanced manufacturing technology and performance. In the case of TQM practice use, Sila (2007) did not find moderating effects, while Jayaram et al. (2010) did.

Results are also inconsistent for strategic focus. Dean – Snell (1996) found moderating effects for quality focus and cost focus on the relationship between AMT use and performance. According to Ahmad et al. (2003), manufacturing strategy does not moderate the relationship between the use of JIT practices and plant competitiveness. Additionally, Peng et al. (2011) did not find a moderating effect of strategic focus on the relationship between improvement and innovation practices and performance.

Based on these results, it seems that contingency factors moderate the manufacturing practice – performance relationship only in very limited ways. Hence, hypothesis H3 gains marginal support compared to hypotheses H1 and H2, which had significant support. While it is beyond the scope of this thesis, it can be concluded with certainty that there are great possibilities for mapping moderating effects in future research.

5.4. Examination of contingency factor – manufacturing practice configurations (Hypothesis H4)

With testing Hypothesis H4 my aim is to identify stable, coexisting configurations. The relationship between these configurations and performance is analyzed later on, when I test Hypothesis H5. I performed the analysis under the guidance of Kovács (2006), Sajtos – Mitev (s.a.) and Tabachnick – Fidell (2007). I applied cluster analysis to uncover configurations, which is appropriate for this aim, and it has a history in the field of OM, mainly in relation with manufacturing strategy, as I mentioned that previously (see Chapter 3).

The first step again is the aggregation of variables. During the PLS modeling there were preliminary examinations of unidimensionality and reliability of sets of variables, but back then it was not necessary to really create those aggregated variables. The software SmartPLS 2.0 calculated LVs from the manifest variables and worked with the new ones computed by itself. For the cluster analysis I had to make this aggregation myself, but content-wise it does not mean anything new.

- The measurement of complexity is solved on the 0-100 scale.
- Size is measured by the number of employees of the business unit.
- In case of the remaining contingency factors I performed the operationalization for the PLS model, but now I created these aggregated variables in SPSS as well. In order to do this I averaged the single variables that make the contingency factors (e.g. in case of competition the two variables A2e-f), then I transformed this mean value onto a 1-100 scale to expand variable space and therefore the evaluation can be more subtle. Hence all remaining contingency factors are measured on a 1-100 scale with the exception of cost focus, which consists of only one variable. In that case I obviously stuck with the original 1-5 scale.
- I followed these same steps in case of the manufacturing practices, and consequently I got five aggregated variable on a 1-100 scale.

The next step is the investigation of variable normality. This is necessary because for cluster comparison I intend to use ANOVA, which requires normality for the F-test used (or at least a distribution not too much deviated from normality). In order to do this I created the histograms of the examined variables, and I checked values of skewness and kurtosis. The main point for the latter was that the absolute values of these indicators should not exceed 1. Then the distribution of the variable is not too different from the normal distribution (Sajtos – Mitev, s.a., p. 95.). Only size was problematic because of its enormous skewness and kurtosis. This was solved by computing the logarithm of the variable (Tabachnick – Fidell, 2007).

The next step on the checklist is the matter of outliers, which did not cause any problems. Because the measurement scales of the variables are not entirely the same, I standardized the variables to avoid possible bias coming from the different scales. Finally I checked whether there are too high correlations (above 0.9) between the variables, and I found none (Sajtos – Mitev, s.a.., p. 289.).

During the cluster analysis first I performed hierarchical analysis in order to map the optimal cluster number. As a clustering method I chose the Ward-method, because in case of hierarchical clustering ot is more benefical compared to the other methods, and the chosen metric obviously was the Eucledian distance. Based on the agglomeration schedule I prepared Figure 8 that represents the coefficients of the last few steps, and by using the „elbow criterion" I was able to find the optimal cluster number (Sajtos – Mitev, s.a., p. 307.).

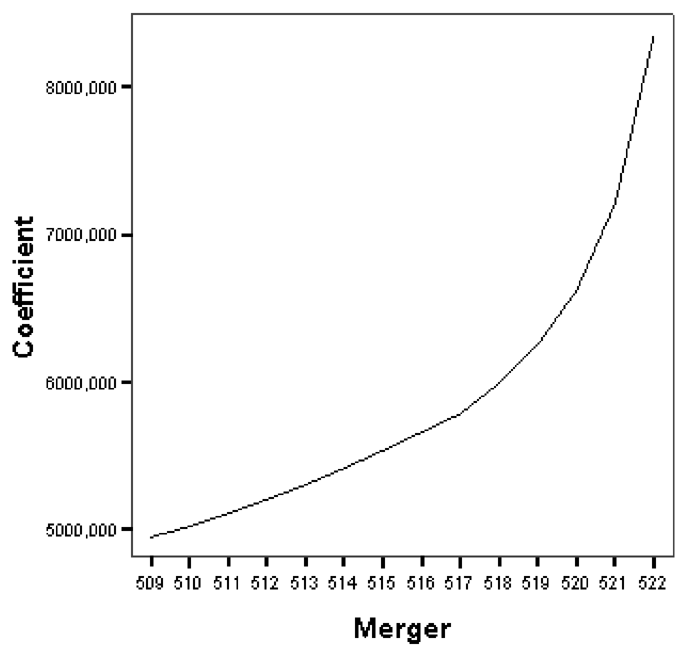

Figure 8: The increase of agglomeration schedule coefficients

Figure 8 shows that the value of the coefficient increases all the way. Axis X represents the number of the actual existing clusters in an inverted way. In case of 523 companies after 522 mergers there is only one cluster left. After 521 mergers there are two clusters left and so on. We can find the optimal cluster number where the increase of the coefficient starts to leap compared to previous mergers. Figure 8 shows that this leap occurs somewhere around 518-520th merger, i.e. optimal cluster number may be somewhere between 3-5 clusters. Following that I peformed k-means clustering for 3, 4 and 5 clusters as well. After comparing and interpreting the results I accepted the 4-cluster solution. This decision was further supported by the fact that I compared the resulted clusters of the hierarchical and k-means clustering for each of the three cases. I examined the overlap of the cluster membership between the different clustering methods. To assess the strength of the relationship I used Cramer's V, which was the highest at the 4-cluster solution. Hence in the following I present the 4-cluster solution and its results.

Table 23 shows the final cluster centers and the number of companies in each cluster, which indicates that the clusters are balanced.

	Cluster			
	1	2	3	4
Complexity	43.73	37.37	58.29	29.36
Competition	76.72	71.69	83.28	66.51
Size	2.48	2.42	2.80	2.23
Cost focus	3.8	3.9	3.9	3.8
Quality focus	86.59	78.48	91.02	80.00
Flexibility focus	67.16	60.97	78.66	54.86
Sustainability focus	63.50	57.81	78.44	50.75
Product complexity	84.84	64.18	82.31	68.56
Technology level	55.61	60.14	76.53	44.63
Process type	24.53	68.89	64.16	30.11
Customer order	33.03	58.94	57.79	38.92
HR practices	67.92	62.28	75.48	45.87
Process control practices	71.77	66.69	81.76	43.95
Technology practices	51.02	52.85	73.82	34.56
Quality management practices	60.77	57.25	78.29	42.89
Product development practices	60.88	52.12	76.01	41.23
Number of companies	**137**	**145**	**119**	**122**

Table 23: Characteristics of the final clusters

In order to map the configurations I compared final cluster centers with ANOVA. As I mentioned it previously, because of the F-test there is a normality prerequisite here, which was fulfilled. Another prerequisite is the homogeneity of variance, which means that the dependent variable should have the same amount of variance across the different values of the independent variable (which now is the cluster membership). This prerequisite can be checked by applying Levene's test (the results are shown in Appendix 7) (Sajtos – Mitev, s.a., p. 173.). Homogeneity of variance is not accepted in only 5 cases out of 16 (at $p = 0.05$ level). Fortunately the F-test is a very robust test, so this ratio probably will not cause any problems, and the test value will not be biased. According to the F-test the difference is significant in all cases except cost focus. Of course this does not mean that the clusters are significantly different from each other along all variables. In order to see which clusters are really different from each other, I performed post hoc comparisons with Scheffé- and Tukey-tests, which are among the most reliable test available (Sajtos – Mitev, s.a., p. 176.).

The two tests gave nearly identical results (out of 16 variables there were only 4 variables where there was mild difference in judging whether the two clusters are significantly different or not). Table 24 shows the result of post hoc analysis based on the Tukey-test. The meaning of the format (e.g. 3: 58,29) is the following: first the cluster number, then the cluster center value.

	Order			
	1	2	3	4
Complexity	3: 58.29	1: 43.73	2: 37.37	4: 29.36
Competition	3: 83.28	1: 76.72 2: 71.69	2: 71.69 4: 66.51	
Size	3: 2.80	1: 2.48 2: 2.42	2: 2.42 4: 2.23	
Cost focus	2: 3.9 3: 3.9 1: 3.8 4: 3.8			
Quality focus	3: 91.02	1: 86.59	4: 80.00 2: 78.48	
Flexibility focus	3: 78.66	1: 67.16	2: 60.97	4: 54.86
Sustainability focus	3: 78.44	1: 63.50	2: 57.81	4: 50.75
Product complexity	1: 84.84 3: 82.31	4: 68.56 2: 64.18		
Technology level	3: 76.53	2: 60.14 1: 55.61	4: 44.63	
Process type	2: 68.89 3: 64.16	4: 30.11 1: 24.53		
Customer order	2: 58.94 3: 57.79	4: 38.92 1: 33.03		
HR practices	3: 75.48	1: 67.92	2: 62.28	4: 45.87
Process control practices	3: 81.76	1: 71.77	2: 66.69	4: 43.95
Technology practices	3: 73.82	2: 52.85 1: 51.02	4: 34.56	
Quality management practices	3: 78.29	1: 60.77 2: 57.25	4: 42.89	
Product development practices	3: 76.01	1: 60.88	2: 52.12	4: 41.23

Table 24: Result of the post hoc analysis

By examining Table 24 we can observe some important things.

- In case of cost focus there is no significant difference among the clusters, everyone thinks that price as a major order winner is a bit more important than the average.

- Members of Cluster 3 have the highest values in case of all variables, mostly alone, not together with another cluster. Their environment is the most complex, they face the strongest competition. The value of complexity is above 58, which indicates that out of 11 environmental variables measuring complexity at least 5 have a strong or very strong effect (a value of 4 or 5 on the 5-point Likert-scale), and the variables measuring competition are probably between them. They are the largest companies, and with the exception of cost they treat all other foci as the most important to win orders. Their product is also fairly complex, technology level is high and they are more of a mass producer with more standardized customer orders. They put the greatest emphasis on the use of different manufacturing practices. Values between 73-81 mean an average value of 4 on the 5-point scale at the single manufacturing practice variable level. Based on these we can call them ’Large leaders’.

- Their opposite is Cluster 4, whose members use all manufacturing practices the least. In their case the product is also quite complex, but technology level is low (Value of 44 indicates an average value of 2 on the 5-point scale at the single variable level). They focus basically on quality and cost, the two other priorities are not important to them (in case of indifference the value would be around 60). Environmental complexity is low, and they face the least competition. Complexity value of 29 means that maximum only 2-3 environemtal variable can be considered strong or very strong. They are the smallest companies in terms of size. Process type is shifted towards one-off manufacturing with heterogeneous customer orders. The use of manufacturing practices is below average (values between 34-45 indicate an average value of around 2 on the 5-point scale at the single variable level). Later on I call this cluster as ’Small laggards’.
- The remaining two clusters are similar to each other in many aspects. There is no significant difference between them in size, perceived competition (which is above average), technology level (which is medium), and the use of technology and quality management practices (which are slightly below average, they stay under 60 points). In case of the remaining manufacturing practices their use is a bit more emphasized in case of members of Cluster 1, just as the focus on quality, flexibility and sustainability. This may be the consequence of a bit more complex environment and product. They use HR and process control practices to the greatest extent, at an above average level. Nonetheless there is a decisive difference between the two clusters: members of Cluster 1 usually get more unique customer orders and apply more one-off production, while members of Cluster 2 are the most standardized mass producers of all clusters. Because of this I call members of Cluster 1 as ’One-off manufacturers’, while members of Cluster 2 as ’Mass producers’.
- There is a clear distinction among the clusters along process type and customer order. Two clusters contain companies doing mass production, while two clusters contain companies that manufacture one-off products. Beyond this, however, cluster in the same category do not resemble each other in the other aspects. One-off manufacturers and Mass producers share many similarities, while Large leaders and Small laggards are mirror images of each other.
- It can be also concluded that environmental complexity moves together with strategic foci: companies operating in more complex environments find quality, flexibility and

sustainability more important to win orders than companies operating in a less complex environment. This can also be related to the less intense use of certain manufacturing practices at companies operating in a less complex environment.

- Looking at previous studies we can find clusters that can be compared to the clusters found in my thesis:

  - clusters similar to Large leaders were found by e.g. Kathuria (2000), Christiansen et al. (2003), Zhao et al. (2006), Martin-Pena – Diaz-Garrido (2008), where cluster members think all or most dimensions important and they have high values in these dimensions.
  - clusters similar to Small laggards were found by e.g. Kathuria (2000), Sum et al. (2004), Zhao et al. (2006), where low values are abundant everywhere.
  - in case of the remaining two 'not clear-cut' cluster it is difficult to decide whether previously found clusters can be matched to these, because the main difference between One-off manufacturers and Mass producers was in process type and customer order, but these factors were not used in the reviewed studies as clustering variables, therefore their analysis require further careful work.

Summarizingly it can be said that there are identifiable cluster patterns related to contingency factors and manufacturing practices, which supports Hypothesis H4. Though there are space for further research.

5.5. Examining equifinality (Hypothesis H5)

Finally I compared the performance of the clusters, first along the traditional performance dimensions (cost, quality, flexibility, dependability), then along different other indicators (cost structure, other performance indicators, quality costs and inventory level).

5.5.1. Cluster performance along the traditional performance dimensions

Variables used here were also operationalized for the PLS model, but now I created these aggregated variables in SPSS as well (similarly to contingency factors and manufacturing practices). In order to do these I averaged the single variables of the performance dimensions, then I transformed these values to a 1-100 scale to expand variable space and make the evaluation more subtle. Hence all performance dimensions are measured on a 1-100 scale. Normality and correlation requirements were met here as well. Table 25 shows cluster performance along these dimensions.

	One-off manufacturers (1)	**Mass producers (2)**	**Large leaders (3)**	**Small laggards (4)**
Cost	57	55	66	49
Quality	62	58	70	51
Flexibility	65	61	71	55
Dependability	62	60	69	54

Table 25: Cluster performance along traditional dimensions

Of the 4 clusters One-off manufacturers and Mass producers practically have the same level of performance improvement along all dimensions in the previous 3 years. The small differences between the two clusters are not significant. A performance of around 60 points means approximately 10% improvement on average at the single variable level compared to 3 years ago (see Question B10 in Appnedix 3). The performances of Large leaders and Small laggards clearly shine out, the former one upwards, while the latter one downwards. Values of Large leaders mean approximately 15% average improvement at the single variable level compared to 3 years ago, while in the case of Small laggards this means an improvement of around 5%. I find these results very interesting and they should be interpreted jointly with the cluster characteristics. As I mentioned it previously, there are two important separating factors among the clusters:

process type and customer order. One-off manufacturers and Mass producers are very similar to each other in many aspects, with the exception of these two factors. Despite the entirely different process type and customer order they were though able to reach the same amount of performance improvement in the previous years. Large leaders and Small laggards are once again the opposite of each other, not only in the effect of contingency factors and in the use of manufacturing practices. These results do not contradict Hypothesis H5, as the example of One-off manufacturers and Mass producers tells us, though it must be emphasized that here we are speaking about performance improvement over time, not about objective performance indicators.

5.5.2. Cluster performance along other dimensions

I examined four other types of performance indicators:

(1) Cost structure (Question B4:'Estimate the present cost structure in manufacturing (percentages should add up to 100%'): direct salaries/wages, manufacturing overheads, outsourced/contract work, direct materials/pats/components.

(2) Other performance variables (Question B11: 'What is the current performance level on the following dimensions?'), namely throughput time efficiency (as percentage of the total manufacturing lead time), late deliveries to customers (as percentage of orders delivered), scrap and rework costs (as percentage of sales), and customer complaints (as percentage of orders delivered).

(3) Inventory levels (Question PC3: 'How many days of production (on average) do you carry in the following inventories:'): raw material/components, work-in-process, finished goods.

(4) Quality costs (Question Q1: 'What is the approximate proportion of quality costs (the percentages should add up to 100 %)?): inspection/control costs, internal quality costs, preventive costs, external quality costs.

I used ANOVA for comparison and also implemented the post hoc tests that were mentioned in the cluster analysis to find significant differences, but there were only a handful of them.

i) in case of cost structure One-off manufacturers are significantly better than Small laggards in terms of manufacturing overheads (17.45% / 21.80%). This result is not surprising if we know the differences between the clusters, e.g. in the use of manufacturing practices. It also validates the difference between them in the cost performance dimension more strongly. Large leaders paid the least amount of direct salaries/wages: 17.9% versus 22.5-24.5% of the other clusters. This partly can be explained with the different use of manufacturing practices, and by process type, because the production of standardized goods usually does not require highly skilled workforce, hence salaries/wages can be kept at a lower level. Interestingly Small laggards spend significantly less on direct materials/parts/components than Large leaders and Mass producers (44.58% versus 53.36%, and 52.01%). This can be explained maybe with the different quality of the used materials, and with the process type again: standard products are cheaper, raw material costs less, but they are manufactured in such volumes that the absolute value spent on materials exceed the costs of one-off manufacturers who manufactures more expensive products but much less in volume.

ii) in case of other performance dimensions there was significant difference only in throughput time efficiency, in favour of Large leaders (65.72%) against One-off manufacturers (51.89%) and Small laggards (52.15%). Process type can be again an explaining factor. Large leaders using standardized mass production are able to increase throughput time efficiency much better by implementing process control practices, or eliminating waste than companies manufacturing more unique products.

iii) in case of inventory levels finished goods did not show significant differences among clusters (13.06-16.28 days). Looking at raw material/components Large leaders (22.71 days) have a huge advantage over Small laggards (35.02 days). Here beyond the proved difference in performance process type can play a part again: by organizing the standardized process more efficiently Large leaders are able to decrease the necessary amount of raw material/components significantly. Examining work-in-process One-off manufacturers (10.69 days) are way better than Mass producers (23.6 days). This difference is more interesting if we know that One-off manufacturers have smaller amount of raw material/components as well than Mass producers (25.63 days versus 31.49 days)! It is true though that this difference is not significant, but it also means that looking at the total inventory level One-off manufacturers are at least as good as Large leaders, though their process environment is totally different.

iv) in case of quality costs I found significant difference only in internal quality costs, in favour of Large leaders (19.97%) against One-off manufacturers (27.02%). This can be explained with the higher level of process control, quality focus and quality management, and the different process type at Large leaders, and in case of raw material/components this phenomenon probably worsened the performance of One-off manufacturers. There were no significant differences in the other types of quality costs among the clusters: inspection/control costs were between 33.34-37.36%, preventive costs were between 22.03-26.57%, while external quality costs were between 16.89%-19.71%, and there was no obvious ranking among the clusters in these dimensions.

All in all, these results support Hypothesis H5, although the deeper exploration and understanding of the relationships between different configurations and performance dimensions/indicators requires further research.

6. Summary

In my thesis I investigated the question: Among manufacturing companies, what is the effect of certain manufacturing contingency factors on the extent that certain manufacturing practices are used, and what are the implications of this effect on operations performance? To do this investigation, first I reviewed the existing literature in two steps. I went back for seminal studies to the fields of contingency theory and strategic management in order to identify the most significiant contingency factors, then based on these results I searched for published studies in the field of OM related to contingency factors. I identified a total of four contingency factors: the environment, the size, the technology and the strategic focus (which is special to the field of OM and shows the strategic orientation of the company). I also reviewed the relationship between manufacturing practices and operations performance. Based on this knowledge I elaborated my research model and created my five hypotheses, which are the following:

H1: The manufacturing practices examined in the model have a significant effect on the operations performance.
H2: The contingency factors examined in the model have a significant effect on the extent of the use of manufacturing practices.
H3: The contingency factors examined in the model moderate the relationship between manufacturing practices and the operations performance.
H4: There are different stable contingency-manufacturing practice configurations that coexist simultaneously.
H5: The state of equifinality can be shown, i.e., different and stable contingency-manufacturing practice configurations exist that lead to the same high level of operations performance.

Hypotheses H1-H3 were tested with the regression-based SEM method, using the explorative version of PLS modelling and focusing on individual relationships. The contingency factors that affected manufacturing practices the most significantly were the following: environmental complexity, product komplexity, technology level, flexibility focus and sustainability focus. Among manufacturing practices process control practices and quality management practices affected operations performance to the greatest extent These results supported Hypotheses H1-H2. During the testing of Hypothesis H3 very few significant relationships were found, i.e. this hypothesis was only very weakly supported.

To thest Hypothesis H4 I used cluster analysis in the space of contingency factors and manufacturing practices, and created 4 separated clusters. Large leaders had high values in all dimensions. Their mirror image was the cluster of the Small laggards. The other two clusters (One-off manufacturers and Mass producers) were very similar to each other in many aspects, but were totally different in process type and customer order. The characteristics of the clusters supported Hypothesis H4.

Finally I compared the 4 clusters along several performance dimensions (traditional performance dimensions, cost structure, inventory level, quality costs, other indicators). Hypothesis H5 was supported by 1) One-off manufacturers and Mass producers along the traditional performance dimensions, and by 2) the small differences among the clusters along the other performance indicators.

The research has several limitations. First, several contingency factors were left out in order to keep the model more simple. Based on the results it is possible the further extension of the model, e.g. by considering cultural, organisational aspects or country effects, although it would need other sources beyond the questionnaire as well.

Another constraint is the IMSS questionnaire which was not created to investigate contingency factors. This fact also limited my possibilities in operationalisation. It would be interesting to create a questionnaire specially designed to examine contingency factors (with keeping the questions related to manufacturing practices and operations performance), where the previously used variables can be built in (to help the aspects of comparison and interpretation). My thesis gave a deep review about the literature on contingency factors relevant to the model, so this review can be used as a starting point for further research.

Analysis techniques can be also improved. The currently used SEM PLS approach was appropriate because of the explorative nature of the research, but the computations were very time consuming because of the many investigated relationships. In order to improve this, a two-step analysis could be implemented. During the first step we create and examine a Bayesian network to analyse the relationship between the data, and the results of the first step can be used to propose and test a better specified SEM model

(Wu, 2010). Another necessary step would be the enumeration and deeper analysis of moderating effects. My thesis examined only those potentially moderating effects that (if significant) would have moderated the relationship between manufacturing practices and operations performance strongly. Unfortunately I got only very limited results among these potential effects. It is possible that there are other moderating effects which appear weak, but have a greater impact (i.e. the coefficient of the moderating relationship itself is small, but it could influence the coefficient of the original manufacturing practice – performance relationship significantly). It is also possible that moderating effect are present elsewhere. During the literature review I presented studies that examined the effect of several contingency factors on each other (pl. Swamidass – Newell, 1987; Ward – Duray, 2000; Pagell – Krause, 2004; Ketokivi, 2006). These potential effects were not examined in the thesis, but it is possible that these effects play a role in real processes, while other moderating effects can appear in the contingency factor – manufacturing practice relationship. An example for that: flexibility focus moderates the relationship between environmental complexity and product development practices – i.e. among companies operating in environments with the same complexity those that focus on flexibility more will use product development practices to a greater extent. This type of relationship was not examined by the model, but it is a possible extension of the model.

Steps that were made to uncover contingency factor – manufacturing practice configurations seem promising for further research. The comparison of cluster characteristics showed that contingency factors which were less significant on the level of individual relationships (e.g. process type, customer order) caused significant differences among clusters. There is a great potential in this field, because several aspects were not analysed (looking at country effects seems especially exciting). The deeper analysis and evaluation of equifinality also have a lot of opportunities. The results of the thesis support the concept of equifinality, but only the surface was scratched so far.

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Interviewees and the dates of the interviews:

Interviewee “A”: December 22, 2011, 1400-1500 hours

Interviewee “B”: January 24, 2012, 1100-1200 hours

Interviewee “C1”: January 25 2012, 1400-1500 hours

Interviewee “C2”: January 27, 2012, 1500-1600 hours

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Appendices

Appendix 1: Browsed journals and search characteristics

Journal title	Impact faktor (2010)	Browsed issues	Note
Journal of Operations Management	5.093	1998- (Vol. 17-29)	Browsing one by one (based on title and keywords I identified the potentially useful articles)
European Journal of Operations Research	2.158	Search for the term „manufacturing" gave 4250 hits, from these I checked the first 400 based on relevancy	-
Manufacturing and Service Operations Management	2.149 (2009-ben)	2009- (Vol. 11-13)	Articles with operations research focus (OR) which cannot be used in my research
International Journal of Production Economics	1.988	1998- (Vol. 54-135)	Browsing one by one
Production and Operations Management	1.851	2009- (Vol. 18-20)	OR focus
International Journal of Operations and Production Management	1.812	1998- (Vol. 18-32)	Browsing one by one
Computers and Industrial Engineering	1.543	2010	OR focus
International Journal of Production Research	1.033	No access at my university	Search for the term „manufacturing" gave 6232 hits, but because of no access I was not able to chech them
Journal of Engineering and Technology Management	0.737	1998- (Vol. 15-29)	Browsing one by one
Production Planning and Control	0.603	No access at my university	-
International Journal of Computer Integrated Manufacturing	0.553	No access at my university	-
International Journal of Technology Management	0.519	No access at my university	-
Total Quality Management and Business	0.387	Search for the term „manufacturing" gave 931 hits, from these I checked the first 200 based on relevancy	-
Journal of Manufacturing Technology Management	-	2004- (Vol. 15-22)	Browsing one by one
International Journal of Manufacturing Technology and Management	-	2010- (Vol. 20-23)	OR focus
Operations Management Research	-	2008- (Vol. 1-4)	Browsing one by one
Journal of Quality Management	-	1996-2001 (Vol. 1-6)	Browsing one by one

Appendix 2: Industrial organisation, population ecology approach, institutional approach

1. Industrial organisation (Porter, 1981)

Traditional industrial organisation was developed fully in the 1950-60s. According to the theory the performance of the company primarily depends on the industrial environment where the company competes. This is emphasized by the SCP-paradigm (structure-conduct-performance), which says the following: industrial structure determines the conduct or strategy of the companies, and then their joint effect determines the overall company performance on the market. Another important statement of the paradigm was the following: because industrial structure determines company strategy/conduct, which in turn determines performance, therefore it is enough to analyse the industrial structure, because company strategy/conduct is nothing else than a mere the reflection of the industrial environment. According to the theory the most significant industrial environmental factors were the following: barriers to entry, company number and size distribution, degree of product differentiation and the elasticity of demand.

This traditional industrial organisation approach had some severe constraints, e.g. the unit of analysis was not the company but the industry; industrial environment was treated as a static entity; this static industrial environment fully determined company performance.

Industrial organisation researchers later in the 1970s started to tackle these problems.For example, company also appeared as the unit of analysis; dynamic industrial models were developed, and there was a gradual shift from the deterministic point of view (i.e. company strategy could influence environment).

2. Population ecology approach (Hannan – Freeman, 1977; Hannan – Freeman, 1984; Dobák, 2006)

The population ecology approach is somewhat similar to the deterministic environmental view of contingency theory. Approaches examining the relationship of environment and organisations previously usually started from the companies' adaptation to environment, while this approach focuses on the natural selection of the environment. Natural selection is used to explain the appearance, survival and extinction of certain organisational structures. Selection consists of three steps: first new organisational structures appear, then the existing organisational types are being selected, finally the successful types survive and spread.

The unit of analysis in this approach is not the organisation itself, but the population of organisations. Because every organisation is different, external forces do not inflence them the same way and same extent. Despite that one can identify organisational groups that are quite homogeneous in terms of vulnerability against the environment. Inside these groups organisations with similar size usually compete with each other, not with smaller or larger organisations. In stable environments this usually leads to the extinction of medium-sized organisations because of the competition, while small and large organisations survive.

Summarizingly it can be said that the approach highlights some contingency factors: the environment (which can be characterized by stability and uncertainty), the organisational size and the age of the organisation. Nonetheless the empirical underpinning is missing. According to Kieser (1995b) one of the reasons can be the uncertainty in definitions, which appear throughout the approach. The unit of analysis is not the individual organisations, but the population, which is unfortunately not clearly defined, hence the separation of populations is very crude and difficult. Many other key terms are not defined or operationalised either, so the approach does not offer empirically relevant statements. Kieser (1995b) concludes that the analogy of biological evolution is not adequate, because biological processes cannot be transferred to organisations or to processes that happen between organisations. Kieser also adds that there are several competing evolutional theories in biology, and the representatives of the approach do not prove why their approach is better than the others. In my opinion it is not desirable to throw away the analogy of biological evolution itself, because population ecology is also just an approach, and this kind of group selectional view is not the most accepted in evolutionary biology. It seems that Kieser does not like approaches that emphasize a stronger role of the environment, which can also be observed when we assess contingency theory.

3. Institutional approach (Mintzberg, 1998)

Institutional approach perceives two resources in the environment: economic (e.g. money, land, machines) and symbolic (e.g. prestige, good reputation thanks to efficient operations, leaders celebrated by their past performance). The goal of the company is to seize economic resources and transform them into symbolic resources and vice versa, in order to protect itself from environmental uncertainty. Environment consists of relationships between key suppliers, customers, competitors, regulating and other government actors, which actors over time create very complex and powerful norms. Companies have to obey these norms in order to succeed. This obediance occurs through certain so called isomorphisms:

1) coercive isomorphism: pressure to behave in a conform way through different standards, rules etc. (e.g. strict safety rules for airlines).

2) mimetic isomorphism: occurs through the successful imitation of competitors, through the copy of their ideas.

3) normative isomorphism: professional norms, prescriptions advocated by company experts, which influence company decision making to a great extent (e.g. lawyers' point of view during contract negotiations).

Appendix 3: Questions from the IMSS survey

(1) IMSS questions related to contingency factors

A1.What are the name, origin and size of the corporation of which your business unit is a part?

Name Origin (headquarters' country)

Size of the business unit (# of employees): Total sales of the business unit – currency figure

A2. How do you perceive the following characteristics?

Market dynamics	Declining rapidly (1)	(5) Growing rapidly
Market span	Few segments (1)	(5) Many segments
Product focus	Physical attributes (1)	(5) Service emphasis
Geographical focus	National (1)	(5) International
Competition intensity	Low intensity (1)	(5) High intensity
Market concentration	Few competitors (1)	(5) Many competitors
Market entry	Closed to new players (1)	(5) Open to new players

A3. Please indicate what characterizes technological change in your business:

Logistic processes change	Slowly (1)	(5) Rapidly
Core production processes change	Slowly (1)	(5) Rapidly
Products become obsolete	Hardly ever (1)	(5) Frequently
New product are introduced	Hardly ever (1)	(5) Frequently

B2. How would you describe the complexity of the dominant activity?

Modular product design (1)	(5) Integrated product design
Single manufactured components (1)	(5) Finished assembled products
Very few parts/materials, one-line bill of material (1)	(5) Many parts/materials, complex bill of material
Very few steps/operations required (1)	(5) Many steps/operations required

B8. To what extent do you use the following process types (% of volume)? (percentages should add up to 100%):

One of a kind production	Batch production	Mass production	**Total**
%	%	%	0% **(100 %)**

B9. What proportion of your customer orders are (percentages should add up to 100 %):

Designed/engineered to order	Manufactured to order	Assembled to order	Producedto stock	**Total**
%	%	%	%	0% **(100 %)**

PC2. Production orders are planned through (tick one):

☐ Push systems (e.g. MRP) ☐ Pull systems (e.g. kanban, replenishment) ☐ Bottleneck (Theory of Constraints)

T1. How advanced is the core process technology of your dominant activity?

Mostly manual operations, using hand tools and/or manually operated general purpose machine tools and handling/ transportation equipment	(1)	(5)	Most operations are done by highly automated machine tools and handling/transportation equipment (computer-controlled machines, robots, automated guided vehicles)
Mostly stand alone machines	(1)	(5)	Fully integrated systems (e.g. flexible manufacturing cells/systems)
No information system supporting process monitoring and control	(1)	(5)	The overall process is monitored and controlled in real time by a dedicated information system

(2) IMSS questions related to manufacturing practices

O11. Indicate the effort put into implementing the following action programs in the last three years.

	Effort in the last three years	
	None (1)	**High (5)**
Increasing the level of delegation and knowledge of your workforce (e.g. empowerment, training, autonomous teams)		
Implementing the lean organization model by e.g. reducing the number of levels and broadening the span of control		
Implementing continuous improvement programs through systematic initiatives (e.g. kaizen, improvement teams)		
Increasing the level of workforce flexibility following your business unit's competitive strategy (e.g. temporary workers, part time, job sharing, variable working hours)		
Enhancing corporate reputation through firm's direct contribution and other campaigns (e.g., employment, safety, work conditions, corporate social activities, support community projects)		

PC4. Indicate degree of the following action programs undertaken in the last three years.

	Effort in the last three years	
	None (1)	**High (5)**
Expanding manufacturing capacity (e.g. buying new machines; hiring new people; building new facilities)		
Restructuring manufacturing processes and layout to obtain process focus and streamlining (e.g. reorganize plant-within -a-plant; cellular layout)		
Undertaking actions to implement pull production (e.g. reducing batches, setup time, using kanban systems)		

PD3. Indicate the effort put into implementing the following action programs in the last three years.

	Effort in the last three years	
	None (1)	**High (5)**
Increasing design integration between product development and manufacturing through e.g. platform design, standardization and modularization, design for manufacturing, design for assembly		
Increasing the organizational integration between product development and manufacturing through e.g. teamwork, job rotation and co-location		
Increasing the technological integration between product development and manufacturing through e.g. CAD-CAM, CAPP, CAE, Product Lifecycle Management		
Improving the environmental impact of products by appropriate design measures, e.g. design to recycle		

Q2. Indicate the effort put into implementing the following action programs in the last three years.

	Effort in the last three years	
	None (1)	**High (5)**
Quality improvement and control (e.g. TQM programs, six sigma projects, quality circles)		
Improving equipment productivity (e.g. Total Productive Maintenance programs)		
Utilizing better measurement systems for self-assessment and benchmarking purposes		
Improving the environmental performance of processes and products (e.g. environmental management system, Life-Cycle Analysis, Design for Environment, environmental certification)		
Increasing the control of product quality along the supply chain (raw materials and components certification, supplier audit, product integrity in distribution, etc.)		
Monitoring corporate social responsibility of partners along the supply chain (e.g. labor conditions)		

T2. Indicate the effort put into implementing the following action programs in the last three years.

	Effort in the last three years	
	None (1)	**High (5)**
Engaging in process automation programs (e.g. automated parts loading/unloading, automated guided vehicles, automated storage systems)		
Engaging in flexible manufacturing/assembly systems – cells programs (FMS/FAS/FMC)		
Engaging in product/part tracking and tracing programs (bar codes, RFID)		
Implementing ICT supporting information sharing and process control in production		

(3) IMSS questions related to operations performance

B4. Estimate the present cost structure in manufacturing (percentages should add up to 100 %).

Direct salaries/wages	Manufacturing overheads[1]	Outsourced/contract work[2]	Direct materials/parts/ components	**Total**
%	%	%	%	0% **(100 %)**

1 Manufacturing overheads include salaries within design, planning and maintenance, and of indirect personnel in production, but exclude costs such as administration and sales.
2 Outsourced/contract work is all work performed outside the company, but necessary for and incorporated into the final products.

B10. How has your operational performance changed over the last three years? How does your current performance compare with main competitor(s)[1]?

Compared to three years ago the indicator has						Relative to our main competitor, our performance is				
deteriorated more than 5%	stayed about the same -5%/+5%	improved 5%-15%	improved 15%-25%	improved more than 25%		much worse		equal		much better
1	2	3	4	5		1	2	3	4	5
					Manufacturing conformance					
					Product quality and reliability					
					Product customization ability					
					Volume flexibility					
					Mix flexibility					
					Time to market					
					Product innovativeness					
					Customer service and support					
					Delivery speed					
					Delivery reliability					
					Unit manufacturing cost					
					Procurement costs					
					Manufacturing lead time					
					Procurement lead time					
					Labor productivity					
					Inventory turnover					
					Capacity utilization					
					Manufacturing overhead costs					
					Employee satisfaction					
					Employee knowledge					
					Environmental performance					
					Social reputation					

1 Consider the average performance of the group of competitors that are the direct benchmark for the plant

B11. What is the current performance level on the following dimensions?

Throughput time efficiency (the time the products are worked on as a % of the total manufacturing lead time)? %

Late deliveries to customers (as percentage of orders delivered)? %

Scrap and rework costs (as percentage of sales) %

Customer complaints (as percentage of orders delivered) %

PC3. How many days of production (on average) do you carry in the following <u>inventories</u>:

Raw material/components Work-in-process Finished goods

Q1. What is the approximate proportion of <u>quality costs</u> (the percentages should add up to 100 %)?

Inspection/control costs (sampling, supervision, lab tests)	%
Internal quality costs (e.g. scrap, losses)	%
Preventive costs (training, documentation, preventive maintenance, etc.)	%
External quality costs (e.g. warranty costs, returns, etc.)	%
	0% (**100 %**)

Appendix 4: Squared loading values

Variable	**Squared loading value**	**Variable**	**Squared loading value**	**Variable**	**Squared loading value**
A2e	0,724371	*B10k*	0,583543	*O11e*	0,499001
A2f	0,737366	*B10l*	0,536996	*PC4b*	0,773168
A4a	1	*B10m*	0,653026	*PC4c*	0,767201
A4b	0,774576	*B10n*	0,618897	*PD3a*	0,68013
A4c	0,602952	*B10o*	0,587522	*PD3b*	0,611055
A4g	0,51653	*B10p*	0,492383	*PD3c*	0,583085
A4h	0,811441	*B10q*	0,513802	*PD3d*	0,580339
A4i	0,726074	*B10r*	0,554876	*Q2a*	0,584766
A4j	0,439834	*B10s*	0,624574	*Q2b*	0,629008
A4k	0,790143	*B10t*	0,622363	*Q2c*	0,605595
A4l	0,78606	*B10u*	0,5619	*Q2d*	0,578512
B10a	0,48972	*B10v*	0,61874	*Q2e*	0,52664
B10b	0,550564	*B2b*	0,473895	*Q2f*	0,604195
B10c	0,4761	*B2c*	0,794416	*T1a*	0,626789
B10d	0,544201	*B2d*	0,744942	*T1b*	0,730683
B10e	0,60918	*Process type*	1	*T1c*	0,63984
B10f	0,464715	*Complexitys*	1	*T2a*	0,589978
B10g	0,56355	*Size*	1	*T2b*	0,630436
B10h	0,544349	*O11a*	0,6241	*T2c*	0,656262
B10i	0,656748	*O11b*	0,590592	*T2d*	0,61811
B10j	0,636964	*O11c*	0,616853	*Customer order*	1

Appendix 5: Meeting the Fornell-Larcker criterion

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
(1)	**0,82**																			
(2)	0,36	**0,88**																		
(3)	0,35	0,13	**1,00**																	
(4)	0,38	0,51	0,14	**0,76**																
(5)	0,30	0,36	0,08	0,33	**0,74**															
(6)	0,10	-0,01	0,15	-0,04	-0,01	**1,00**														
(7)	0,28	0,31	0,11	0,33	0,31	0,08	**1,00**													
(8)	0,19	0,35	0,02	0,31	0,70	-0,03	0,28	**0,80**												
(9)	0,29	0,23	0,14	0,31	0,27	-0,02	0,29	0,31	**0,82**											
(10)	0,16	0,10	0,10	0,15	-0,02	-0,01	0,16	-0,06	0,05	**1,00**										
(11)	0,27	0,40	0,09	0,43	0,68	-0,02	0,32	0,66	0,32	-0,05	**0,76**									
(12)	0,14	0,15	0,04	0,18	0,10	-0,04	0,16	0,08	0,31	0,04	0,09	**0,83**								
(13)	0,50	0,49	0,27	0,60	0,38	0,07	0,37	0,36	0,52	0,14	0,49	0,30	**0,77**							
(14)	0,21	0,38	0,03	0,30	0,63	-0,05	0,31	0,67	0,23	-0,08	0,65	0,13	0,33	**0,73**						
(15)	0,19	0,30	0,11	0,24	0,23	-0,08	0,39	0,23	0,44	0,10	0,25	0,37	0,34	0,36	**0,83**					
(16)	0,06	0,20	-0,14	0,21	0,07	-0,13	0,19	0,07	0,13	0,09	0,15	0,13	0,16	0,16	0,21	**0,82**				
(17)	0,67	0,48	0,34	0,50	0,32	0,10	0,33	0,28	0,32	0,20	0,33	0,13	0,64	0,31	0,28	0,10	**0,79**			
(18)	0,42	0,48	0,15	0,52	0,34	0,02	0,36	0,31	0,39	0,16	0,42	0,19	0,64	0,37	0,40	0,28	0,56	**0,78**		
(19)	0,10	0,18	0,08	0,14	0,12	0,19	0,59	0,18	0,20	0,05	0,15	0,07	0,18	0,15	0,22	0,07	0,14	0,18	**0,85**	
(20)	0,11	0,22	0,34	0,11	0,09	-0,04	0,11	0,09	0,05	0,08	0,10	-0,04	0,10	0,08	0,18	0,00	0,19	0,07	0,04	**1,00**

(1) Technology level; (2) Process control practices; (3) Process type; (4) HR practices; (5) Cost; (6) Cost orientation; (7) Complexity; (8) Dependability; (9) Sustainability orientation; (10) Size; (11) Quality; (12) Quality orientation; (13) Quality management prctices; (14) Flexibility; (15) Flexibility orientation; (16) Product complexity; (17) Technology practices; (18) Product development practices; (19) Competition; (20) Customer order

Appendix 6: Cross loadings/1

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
A2e	0,09	0,16	0,07	0,12	0,08	0,24	0,50	0,11	0,09	0,08	0,07	0,06	0,11	0,09	0,17	0,09	0,15	0,15	**0,85**	0,07
A2f	0,08	0,14	0,07	0,11	0,12	0,10	0,52	0,20	0,26	0,00	0,18	0,06	0,19	0,16	0,21	0,03	0,08	0,16	**0,86**	0,00
A4a	0,10	-0,01	0,15	-0,04	-0,01	**1,00**	0,08	-0,03	-0,02	-0,01	-0,02	-0,04	0,07	-0,05	-0,08	-0,13	0,10	0,02	0,19	-0,04
A4b	0,15	0,12	0,10	0,16	0,09	-0,02	0,16	0,05	0,23	0,07	0,09	**0,88**	0,27	0,14	0,36	0,10	0,15	0,19	0,07	0,02
A4c	0,08	0,13	-0,06	0,13	0,07	-0,05	0,10	0,09	0,29	-0,01	0,06	**0,78**	0,22	0,07	0,24	0,11	0,06	0,11	0,05	-0,10
A4g	0,08	0,23	0,02	0,13	0,19	-0,07	0,25	0,21	0,33	0,04	0,16	0,21	0,23	0,27	**0,72**	0,12	0,15	0,28	0,20	0,11
A4h	0,19	0,23	0,15	0,20	0,21	-0,08	0,36	0,23	0,42	0,06	0,22	0,30	0,29	0,33	**0,90**	0,17	0,25	0,35	0,20	0,20
A4i	0,19	0,28	0,09	0,25	0,19	-0,06	0,34	0,15	0,35	0,13	0,22	0,38	0,31	0,30	**0,85**	0,23	0,28	0,35	0,15	0,13
A4j	0,25	0,17	0,12	0,16	0,22	0,04	0,27	0,26	**0,66**	-0,03	0,19	0,18	0,32	0,18	0,34	0,00	0,24	0,21	0,21	0,04
A4k	0,24	0,19	0,12	0,26	0,22	0,02	0,25	0,24	**0,89**	0,04	0,27	0,28	0,45	0,17	0,38	0,11	0,27	0,33	0,17	0,07
A4l	0,25	0,20	0,11	0,32	0,24	-0,09	0,22	0,28	**0,89**	0,08	0,31	0,28	0,48	0,23	0,38	0,18	0,28	0,40	0,14	0,02
B10a	0,23	0,34	0,09	0,32	0,49	0,00	0,25	0,47	0,14	-0,03	**0,70**	0,04	0,31	0,47	0,18	0,13	0,28	0,25	0,16	0,18
B10b	0,20	0,28	0,05	0,31	0,50	0,03	0,21	0,51	0,23	-0,04	**0,74**	0,06	0,33	0,52	0,20	0,12	0,23	0,31	0,09	0,13
B10c	0,09	0,18	-0,01	0,14	0,41	-0,07	0,25	0,45	0,13	-0,06	0,50	0,07	0,19	**0,69**	0,30	0,08	0,15	0,22	0,10	-0,02
B10d	0,16	0,33	0,02	0,20	0,49	-0,01	0,26	0,52	0,17	-0,09	0,45	0,07	0,21	**0,74**	0,22	0,04	0,23	0,21	0,19	0,09
B10e	0,18	0,33	0,00	0,22	0,54	-0,01	0,24	0,53	0,17	-0,06	0,48	0,03	0,22	**0,78**	0,28	0,14	0,26	0,27	0,13	0,11
B10f	0,17	0,25	0,05	0,18	0,45	0,03	0,17	0,53	0,18	-0,08	0,43	0,07	0,25	**0,68**	0,18	0,07	0,23	0,24	0,09	0,00
B10g	0,18	0,28	0,06	0,27	0,42	-0,07	0,26	0,42	0,17	-0,03	0,49	0,20	0,31	**0,75**	0,36	0,19	0,26	0,36	0,08	0,07
B10h	0,13	0,25	0,01	0,26	0,46	-0,07	0,17	0,49	0,20	-0,03	0,52	0,12	0,26	**0,74**	0,24	0,14	0,20	0,29	0,06	0,05
B10i	0,11	0,26	0,01	0,18	0,53	-0,01	0,22	**0,81**	0,25	-0,10	0,52	0,05	0,24	0,59	0,17	0,06	0,20	0,22	0,18	0,05
B10j	0,13	0,28	0,05	0,26	0,52	-0,02	0,23	**0,80**	0,29	-0,06	0,58	0,02	0,30	0,56	0,19	0,08	0,21	0,27	0,16	0,11

(1) Technology level; (2) Process control practices; (3) Process type; (4) HR practices; (5) Cost; (6) Cost orientation; (7) Complexity; (8) Dependability; (9) Sustainability orientation; (10) Size;

(11) Quality; (12) Quality orientation; (13) Quality management prctices; (14) Flexibility; (15) Flexibility orientation; (16) Product complexity; (17) Technology practices; (18) Product development practices;

(19) Competition; (20) Customer order

Appendix 6: Cross loadings/2

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
B10k	0,24	0,23	0,07	0,16	**0,76**	0,05	0,22	0,52	0,19	-0,04	0,50	0,03	0,25	0,43	0,13	0,00	0,27	0,22	0,05	0,11
B10l	0,21	0,26	0,07	0,26	**0,73**	-0,01	0,28	0,51	0,22	0,00	0,49	0,08	0,31	0,44	0,22	0,07	0,24	0,28	0,17	0,06
B10m	0,13	0,30	-0,01	0,23	0,60	-0,01	0,19	**0,81**	0,18	-0,04	0,49	0,05	0,24	0,51	0,14	0,04	0,20	0,19	0,10	0,09
B10n	0,21	0,27	0,00	0,29	0,59	-0,06	0,24	**0,79**	0,28	-0,01	0,52	0,12	0,36	0,50	0,22	0,04	0,28	0,30	0,14	0,03
B10o	0,27	0,30	0,11	0,32	**0,77**	0,04	0,28	0,60	0,17	-0,01	0,55	0,06	0,34	0,49	0,16	0,01	0,30	0,26	0,10	0,16
B10p	0,19	0,29	0,02	0,20	**0,70**	-0,02	0,21	0,52	0,17	0,01	0,46	0,06	0,22	0,47	0,14	0,04	0,18	0,23	0,11	0,03
B10q	0,16	0,24	0,00	0,27	**0,72**	-0,08	0,18	0,51	0,21	-0,03	0,53	0,09	0,25	0,53	0,17	0,09	0,20	0,23	-0,01	0,03
B10r	0,23	0,27	0,06	0,24	**0,74**	-0,02	0,18	0,44	0,25	-0,01	0,49	0,11	0,28	0,43	0,21	0,09	0,23	0,28	0,09	0,00
B10s	0,20	0,30	0,02	0,34	0,55	-0,05	0,20	0,49	0,22	-0,04	**0,79**	0,03	0,36	0,49	0,15	0,10	0,21	0,33	0,06	0,04
B10t	0,18	0,36	0,07	0,36	0,55	-0,03	0,24	0,57	0,19	-0,09	**0,79**	0,07	0,37	0,54	0,22	0,10	0,24	0,36	0,12	0,08
B10u	0,25	0,30	0,14	0,33	0,51	0,01	0,27	0,47	0,35	0,01	**0,75**	0,12	0,48	0,44	0,20	0,08	0,34	0,36	0,11	0,07
B10v	0,16	0,26	0,04	0,30	0,51	-0,07	0,28	0,50	0,31	-0,03	**0,79**	0,10	0,38	0,52	0,18	0,16	0,21	0,31	0,15	0,00
B2b	0,06	0,12	-0,14	0,14	0,00	-0,11	0,13	-0,01	0,05	0,04	0,05	0,05	0,05	0,06	0,18	**0,69**	0,01	0,17	0,07	0,13
B2c	0,01	0,19	-0,13	0,17	0,07	-0,12	0,16	0,07	0,11	0,03	0,14	0,11	0,13	0,16	0,22	**0,89**	0,08	0,26	0,06	0,00
B2d	0,08	0,17	-0,10	0,21	0,08	-0,10	0,17	0,08	0,14	0,13	0,16	0,14	0,18	0,14	0,14	**0,86**	0,12	0,25	0,06	-0,07
Folyamat	0,35	0,13	**1,00**	0,14	0,08	0,15	0,11	0,02	0,14	0,10	0,09	0,04	0,27	0,03	0,11	-0,14	0,34	0,15	0,08	0,34
Komplexitas	0,28	0,31	0,11	0,33	0,31	0,08	**1,00**	0,28	0,29	0,16	0,32	0,16	0,37	0,31	0,39	0,19	0,33	0,36	0,59	0,11
Meret	0,16	0,10	0,10	0,15	-0,02	-0,01	0,16	-0,06	0,05	**1,00**	-0,05	0,04	0,14	-0,08	0,10	0,09	0,20	0,16	0,05	0,08
O11a	0,27	0,36	0,06	**0,79**	0,30	0,04	0,28	0,26	0,18	0,09	0,38	0,13	0,42	0,30	0,13	0,16	0,36	0,37	0,15	0,08
O11b	0,24	0,51	0,09	**0,77**	0,23	-0,05	0,25	0,21	0,15	0,10	0,26	0,12	0,37	0,22	0,19	0,17	0,36	0,37	0,11	0,13
O11c	0,38	0,45	0,19	**0,79**	0,26	-0,02	0,24	0,23	0,23	0,17	0,29	0,14	0,50	0,20	0,21	0,11	0,46	0,40	0,07	0,09
O11e	0,26	0,25	0,09	**0,71**	0,22	-0,09	0,24	0,22	0,38	0,12	0,37	0,15	0,54	0,20	0,21	0,22	0,36	0,45	0,09	0,03

(1) Technology level; (2) Process control practices; (3) Process type; (4) HR practices; (5) Cost; (6) Cost orientation; (7) Complexity; (8) Dependability; (9) Sustainability orientation; (10) Size;

(11) Quality; (12) Quality orientation; (13) Quality management prctices; (14) Flexibility; (15) Flexibility orientation; (16) Product complexity; (17) Technology practices; (18) Product development practices;

(19) Competition; (20) Customer order

Appendix 6: Cross loadings/3

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
PC4b	0,31	**0,88**	0,09	0,45	0,32	0,03	0,28	0,30	0,22	0,12	0,37	0,16	0,43	0,33	0,26	0,17	0,41	0,47	0,13	0,20
PC4c	0,32	**0,88**	0,13	0,45	0,31	-0,05	0,26	0,31	0,18	0,05	0,34	0,11	0,43	0,33	0,26	0,18	0,43	0,38	0,18	0,19
PD3a	0,31	0,42	0,08	0,43	0,30	0,00	0,30	0,25	0,27	0,18	0,32	0,16	0,47	0,30	0,38	0,30	0,42	**0,82**	0,14	0,07
PD3b	0,35	0,39	0,11	0,43	0,27	0,05	0,27	0,24	0,24	0,07	0,32	0,12	0,49	0,31	0,23	0,18	0,44	**0,78**	0,16	0,05
PD3c	0,28	0,35	0,00	0,36	0,22	-0,04	0,27	0,21	0,20	0,14	0,30	0,11	0,40	0,26	0,28	0,22	0,39	**0,76**	0,11	-0,02
PD3d	0,36	0,35	0,26	0,42	0,28	0,06	0,28	0,26	0,50	0,11	0,38	0,19	0,62	0,28	0,34	0,19	0,50	**0,76**	0,17	0,09
Q2a	0,42	0,46	0,23	0,57	0,25	0,06	0,26	0,22	0,31	0,15	0,37	0,21	**0,76**	0,20	0,22	0,15	0,54	0,46	0,11	0,10
Q2b	0,51	0,43	0,29	0,49	0,36	0,12	0,29	0,33	0,36	0,05	0,40	0,17	**0,79**	0,28	0,20	0,03	0,56	0,46	0,13	0,09
Q2c	0,40	0,40	0,21	0,52	0,30	-0,02	0,29	0,28	0,34	0,20	0,40	0,21	**0,78**	0,27	0,28	0,09	0,52	0,49	0,13	0,11
Q2d	0,34	0,28	0,23	0,39	0,27	0,12	0,30	0,27	0,46	0,09	0,35	0,22	**0,76**	0,28	0,31	0,10	0,46	0,49	0,18	0,11
Q2e	0,31	0,35	0,12	0,38	0,27	0,03	0,26	0,24	0,35	0,07	0,34	0,26	**0,73**	0,24	0,22	0,19	0,42	0,50	0,10	0,07
Q2f	0,34	0,33	0,15	0,44	0,28	0,00	0,31	0,31	0,54	0,09	0,39	0,29	**0,78**	0,26	0,32	0,18	0,45	0,53	0,17	0,00
T1a	**0,79**	0,18	0,29	0,21	0,17	0,14	0,14	0,11	0,17	0,13	0,16	0,07	0,35	0,08	0,11	-0,07	0,50	0,25	0,05	0,04
T1b	**0,85**	0,36	0,31	0,36	0,30	0,11	0,24	0,18	0,29	0,16	0,24	0,11	0,45	0,21	0,19	0,10	0,59	0,40	0,10	0,11
T1c	**0,80**	0,31	0,25	0,33	0,25	-0,01	0,28	0,16	0,24	0,11	0,25	0,15	0,42	0,20	0,17	0,09	0,55	0,34	0,09	0,12
T2a	0,59	0,29	0,34	0,33	0,19	0,09	0,23	0,20	0,26	0,17	0,23	0,05	0,48	0,18	0,21	0,00	**0,77**	0,38	0,11	0,17
T2b	0,52	0,49	0,23	0,44	0,32	0,06	0,25	0,29	0,26	0,18	0,32	0,13	0,50	0,33	0,25	0,13	**0,79**	0,48	0,14	0,16
T2c	0,50	0,31	0,26	0,39	0,25	0,12	0,28	0,19	0,28	0,14	0,21	0,14	0,54	0,21	0,24	0,03	**0,81**	0,46	0,08	0,14
T2d	0,51	0,40	0,23	0,42	0,26	0,04	0,29	0,20	0,21	0,14	0,28	0,10	0,51	0,23	0,20	0,14	**0,79**	0,45	0,09	0,13
Vevo	0,11	0,22	0,34	0,11	0,09	-0,04	0,11	0,09	0,05	0,08	0,10	-0,04	0,10	0,08	0,18	0,00	0,19	0,07	0,04	**1,00**

(1) Technology level; (2) Process control practices; (3) Process type; (4) HR practices; (5) Cost; (6) Cost orientation; (7) Complexity; (8) Dependability; (9) Sustainability orientation; (10) Size; (11) Quality; (12) Quality orientation; (13) Quality management prctices; (14) Flexibility; (15) Flexibility orientation; (16) Product complexity; (17) Technology practices; (18) Product development practices; (19) Competition; (20) Customer order

Appendix 7: Result of the Levene-test

	Levene statistic	df1	df2	Sign.
Complexity	1.628	4	518	.166
Competition	1.321	4	518	.261
Size	3.303	4	518	.011
Cost focus	.869	4	518	.483
Quality focus	6.980	4	518	.000
Flexibility focus	1.369	4	518	.244
Sustainability focus	1.780	4	518	.131
Product complexity	4.265	4	518	.002
Technology level	.393	4	518	.814
Process type	30.654	4	518	.000
Customer order	8.004	4	518	.000
HR practices	.290	4	518	.884
Process control practices	1.400	4	518	.233
Technology practices	2.182	4	518	.070
Quality management practices	.389	4	518	.817
Product development practices	1.411	4	518	.229

Appendix 8: Connected own publications

PUBLICATIONS IN ENGLISH (BY YEAR)

Book chapter

1. Demeter, K. – Matyusz, Zs. (2010): The Impact of Technological Change and OIPs on Lead Time Reduction, in: Reiner, Gerald (ed.): Rapid Modelling and Quick Response. Intersection of Theory and Practice, Springer-Verlag London Limited, pp. 215-230.

2. Demeter, K. – Losonci, D. – Matyusz, Zs. – Jenei, I. (2009): The impact of lean on business level performance and competitiveness, in: Reiner, Gerald (szerk.): Rapid Modelling for Increasing Competitiveness; Tools and Mindset, Springer, 2009, pp. 177-198

Journal article

1. Matyusz, Zs. – Demeter, K. – Szigetvári, Cs. (2012): The impact of external market factors on the operational practices and performance of companies. Society and Economy, Vol. 34, No. 1, pp. 73-93. (megjelenés alatt)

2. Demeter, K. – Matyusz, Zs. (2011): The impact of lean practices on inventory turnover. International Journal of Production Economics, Vol. 133, pp. 154-163.

Full papers, conference presentations

1. Matyusz, Zs. – Demeter, K. (2012): The effect of contingencies on manufacturing practices and operations performance.
Seventeenth International Working Seminar on Production Economics, 20-24 February 2012, Innsbruck, Austria (megjelenés alatt a konferenciakötetben)

2. Matyusz, Zs. – Demeter, K. (2011): The effect of contingencies on manufacturing strategy and operations performance
Proceedings on the 18th International Annual EurOMA Conference
University of Cambridge, Cambridge, United Kingdom, 3-6 July 2011

3. Matyusz, Zs. –Demeter, K. – Boer, H. (2010): The effects of international operations on the relationship between manufacturing improvement programs and operational performance
Sixteenth International Working Seminar on Production Economics, Pre-Prints Volume 4, pp. 127-138. (eds. Robert W. Grubbström and Hans H. Hinterhuber)
Congress Innsbruck, Innsbruck, Austria

4. Demeter, K. – Matyusz, Zs. (2009): The impact of lean practices on inventory turnover
9th ISIR Summer School on „Changing Paradigm for Inventory Management in a Supply Chain Context", 25-29 August 2009, Katowice, Poland

5. Matyusz, Zs. – Demeter, K. – Boer, H. (2009): The effects of size and geographical focus on the relationships between manufacturing practices and performances
Proceedings on the 16th International Annual EurOMA Conference
Chalmers University, Gothenburg, Sweden, 14-17 June 2009

6. Demeter, K. – Matyusz, Zs. (2008): The impact of size on manufacturing practices and performance
Proceedings on the 15th International Annual EurOMA Conference
University of Groningen, The Netherlands, 15-18 June 2008

7. Matyusz, Zs. – Demeter, K. (2008): The impact of external market factors on operational practices and performance of companies
Fifteenth International Working Seminar on Production Economics, Pre-Prints Volume 1, pp. 311-322.
Congress Innsbruck, Innsbruck, Austria

8. Matyusz, Zs. – Demeter, K. (2008): The Impact of Lean Practices on Inventory Turnover. 15th International Symposium on Inventories. Budapest, Hungary, 22-26 August 2008

PUBLICATIONS IN HUNGARIAN (BY YEAR)

Journal article

1. Demeter, K. – Matyusz, Zs. (2010): Gyorsfénykép a magyar összeszerelő ipar reálfolyamatairól nemzetközi felmérés alapján. Logisztikai Híradó, XX. évf. 3. szám, pp. 16-17.

Working papers

1. Matyusz, Zs. – Demeter, K. (2012): A kontingeciatényezők hatása a vállalati termelési gyakorlatok és a működési teljesítmény kapcsolatára, különös tekintettel a válság szerepére. Budapesti Corvinus Egyetem, Vállalatgazdaságtan Intézet, Versenyképesség Kutató Központ (megjelenés alatt)

2. Matyusz, Zs. – Demeter, K. (2011): Adatelemző alaptanulmány: A termelési stratégia és termelési gyakorlat kutatás részletes eredményei, 2009-2010. 145. sz. Műhelytanulmány. Budapest, 2011. október
HU ISSN 1786-3031
http://edok.lib.uni-corvinus.hu/359/

3. Matyusz Zsolt – Demeter Krisztina (2010): A termelési stratégia és termelési gyakorlat kutatás eredményei 2009-2010 (Gyorsjelentés), 121. sz. Műhelytanulmány Budapest, 2010. február
HU ISSN 1786-3031
http://edok.lib.uni-corvinus.hu/319/

4. Demeter, K. – Matyusz, Zs. (2009): A „Külső tényezők és adottságok hatása a vállalatok teljesítményére az értékteremtés szűrőjén keresztül” projekt zárótanulmánya Versenyben a világgal 2007-2009 kutatás, 53. sz. műhelytanulmány
Budapest, 2009. január
http://edok.lib.uni-corvinus.hu/329/