

An empirical study on human resource planning in Belgian production companies

Jorne Van den Bergh
Jeroen Beliën
Brent Hoskens

FEB@HUBRUSSEL RESEARCH PAPER
NOVEMBER 2013
Nr. 2013/10

FACULTEIT ECONOMIE EN BEDRIJFSWETENSCHAPPEN
CAMPUS BRUSSEL (HUBRUSSEL)
Warmoesberg 26
1000 BRUSSEL, België
tel. + 32 2 210 12 11

An empirical study on human resource planning in Belgian production companies

Jorne Van den Bergh^{a,b,†}, Jeroen Beliën^{a,b}, Brent Hoskens^c

^a KU Leuven, campus Brussels (HUBrussel), Center for Informatics, Modeling and Simulation, Warmoesberg 26, 1000 Brussels (Belgium), jorne.vandenbergh@kuleuven.be, jeroen.belien@kuleuven.be

^b Affiliated researcher KU Leuven, Research Center for Operations Management, Naamsestraat 69, Leuven (Belgium)

^c KU Leuven, Research Center for Operations Management, Naamsestraat 69, Leuven (Belgium)

[†] Corresponding author at: Center for Informatics, Modeling and Simulation, Warmoesberg 26, 1000 Brussels (Belgium). Tel: +32 2-210 16 11; fax: +32 2 217 64 64.

This paper investigates human resource planning in Belgian production companies. First, a literature study is developed to serve as a basis for the results of the empirical research. The literature study is mainly based on papers in the field of operations research that provide interesting insights such as the research-application gap, which is the lack of implementation of models provided by literature. The most important part of this paper is the empirical research. The empirical research is mainly based on an online developed questionnaire on personnel planning, which is completed by 123 Belgian production companies. The goal of the survey is to investigate the planning tools that are used. Aspects that influence the complexity of the planning problem and the influence of company size on the use of the specific planning tools are examined. Furthermore, the future objectives and investment plans of Belgian production companies concerning human resource planning are also surveyed. Finally, some general remarks on the Belgian labor market are mentioned briefly.

Key words: Human resource planning, planning tools, empirical research, Belgian production companies.

1. Introduction

Human resource management is of key importance in almost all companies. Human resource management has the opportunity to enable organizations to survive, grow, be competitive and profitable (Werner, Jackson & Schuler, 2012). Many CEOs from the largest multinational firm to the smallest domestic firm claim that the management of people is vital to their success today and will continue to become more vital. A key area in human resource management is human resource planning, which has been widely studied. Mathematical formulations and algorithms to solve the personnel scheduling problem are numerous in literature, but the question is whether these algorithms are implemented in real-world

companies. Labor costs are one of the biggest cost factors of Belgian companies. With the availability of many planning software solutions, it could be cost-efficient for some companies to implement planning software. In health care, for instance, labor costs could amount to 70% of the total costs. Saving a few percent on this by implementing a planning system, will therefore be very beneficial.

The main goal of this paper is to provide a well-structured overview of the planning methods used in Belgian production companies. The scope is limited to manufacturing companies excluding service providers like, e.g., hospitals and call centers. To obtain these data an online questionnaire has been set up and 650 Belgian production companies have been invited to respond. The questionnaire has been completed by 123 companies resulting in a response rate of 18.9%. Based on the results of this survey the planning methods in Belgian companies will be analyzed profoundly from different points of view. Furthermore, other issues of the planning problem will be handled such as the main reasons for a specific planning tool and the aspects that influence the complexity of the planning problem. This complexity depends on a variety of factors including the preferences of employees and the cyclicity of the personnel rosters. Finally, to verify the conclusions of the survey, other sources are consulted. This paper is ordered according to the following sequence.

First, an examination of literature is necessary to serve as a benchmark for the empirical research. The focus in this literature review lies on operational human resource planning. Further, the research-application gap is addressed, which emphasizes the lack of implementation of models provided by literature. The second and most important section is the examination of human resource planning in Belgian companies, both multinationals and small and medium sized companies. These data are provided by an online developed survey. The analysis of these data highlights some continuities and discontinuities across different companies taking into account different points of view such as company size. At first sight, intuition suggests that bigger companies will be more automated. But is this also true in practice? The aspects that influence the complexity of the specific planning problems in real-world companies will also be investigated. Evidentially, the provision of the right data by the companies is essential to successfully extract interesting conclusions. Finally, an overview of the most important results is provided, which covers all the interesting and remarkable results subtracted from the data. The direct link with literature is also handled. Other studies concerning this research area are mentioned to find out whether the obtained data are consistent with other surveys.

2. Human resource planning

In many manufacturing companies human resources are the most expensive, but also the most flexible factors. Therefore, the optimal utilization of human resources is an important success factor contributing to long-term competitiveness (Zülch, Rottinger & Vollstedt, 2004). A crucial step in the human resources

planning process is the translation of strategic goals and objectives into operational priorities, which is the goal of the operational human resources plan. This operational plan provides the link between the strategic plan and the detailed business plan of each team within a division. Literature is overwhelmed with papers that describe mathematical models that try to solve this operational personnel planning problem as efficient as possible. Van den Bergh, Beliën, De Bruecker, Demeulemeester and De Boeck (2013) classify a set of 291 articles started from 2004 onwards in the light of different perspectives concerning personnel or workforce scheduling. Examples of these perspectives are personnel characteristics, shifts definitions, constraints, performance measures, etc. An important conclusion in this paper is that although the mathematical models for personnel scheduling problems have a strong theoretical impact, they are barely used in practice. Especially the neglect of a number of characteristics of the real-world personnel scheduling problem puts a burden on the real-life applicability.

Kellogg and Walczak (2007) perform a comprehensive survey to investigate whether the numerous developed personnel scheduling algorithms are actually used and implemented in real-world hospitals. They conclude that only 38 percent of the systems that are discussed in research articles are eventually tested in real-world and there seems to be very little academic involvement in systems that third-party vendors offer. Approximately 30 percent of the hospitals do not use a specific software system to plan their personnel. The nurse scheduling problem is a specific planning problem but nevertheless the insights into this problem can be broadened to other planning problems with shift scheduling. Kellogg and Walczak (2007) point out that although the development of scheduling algorithms has used academic research for quite some time, the direct involvement of academics in the design and development of implemented scheduling solutions in the United States appears to be minimal to nonexistent. There appears to be an overwhelming reliance on self-scheduling methods. There are several explanations for this such as the narrow focus of many researchers, the lack of customer support that academics offer, the availability of commercial software and the lack of acceptance of innovation. The latter appears to be a general problem in many companies that plan to innovate. It is important to note that the survey they developed goes from 1985 to 2005, so no data after 2005 are incorporated in their conclusions. Another important remark is that the study of Kellogg and Walczak (2007) is based on American hospitals. European-based research seems to be more successful in closing the research-application gap with an overall implementation percentage of 58 percent in comparison to 16 percent of North America according to the data provided by Kellogg and Walczak (2007). Petrovic and Vanden Berghe (2012) address the odd relation between the very large number of novel approaches in nurse rostering and the struggle of the timetabling community to find their way to implementations. One of the reasons behind this behavior is the way in which academics introduce their state-of-the-art approaches. Mostly, only a few comparisons

have been carried out and these are mostly comparisons of two or more approaches developed by the same authors. Bridging the gap between the nurse rostering theory and practice is also being prevented by the lack of transferability of the methods to other problems. Therefore, Petrovic and Vanden Berghe (2012) propose seven criteria to provide a clear picture about the advantages and disadvantages of approaches. Expressive power, flexibility, algorithmic power, learning capabilities, maintenance, rescheduling capabilities, and parameter tuning may offer guidance to researchers and developers of systems for nurse rostering. In Vanden Berghe (2012) some research questions and opportunities are presented which should enable the researchers to implement their approaches into practical decision support systems. One of the major challenges is the (weak or very strong) connection with other problems (e.g., task scheduling, vehicle routing, etc.). While most researchers contribute by searching for faster or better optimization algorithms for a single decision or optimization problem, the focus should lie on the vertical and horizontal influences on personnel scheduling, since it never occurs as an isolated problem in real life. Similar findings are obtained by Van den Bergh et al. (2013). Another important challenge provided by the latter two papers is the integration of human factors and scheduling theory. Lodree Jr, Geiger and Jiang (2009) notice that the exhaustive scheduling literature has repeatedly demonstrated the significant impact of scheduling decisions on system performance, while the human factors literature suggests that task sequencing decisions have a profound impact on human performance and well-being. The combination of these two worlds, however, is almost non-existent. The authors establish a framework for scheduling human tasks that account for physical and/or cognitive human characteristics and behaviors (e.g., meeting employee preferences in shift pattern creation) and discuss some interdisciplinary research opportunities in scheduling and human factors.

An interesting analysis of real-world personnel scheduling problems is provided by De Causmaecker, Demeester, Vanden Berghe and Verbeke (2004). They classify real-world personnel scheduling problems in four different categories: permanence, mobility, fluctuation and project centered planning. The aim of their paper is to classify the encountered planning problems and to generate a basic structure in which different planning systems can be implemented. The results are based on a limited set of planning problems in eleven different real-world companies. It is worth to notice that this set is not comprehensive enough to make quantitative statements. Production companies, which are the focus of this paper, belong to the permanence centered classification group. This means that the demand for capacity or personnel is defined in advance and minimum personnel coverage is required at all times. The two companies that deal with permanence centered planning in De Causmaecker et al. (2004) use pen and paper and Excel to plan their personnel. It is remarkable that a hospital with 700 employees uses an Excel file for one month and one department to perform their personnel scheduling. The survey developed in this paper will show

whether these data are consistent with a much bigger set of 123 companies. De Causmaecker et al. (2004) also conclude that there exists a big research-application gap in reality. At present there is no support for automatic planning in real-life companies. However most of the planning problems outperform the capabilities of planning assistance programs as Excel. Some of the surveyed companies use their own scheduling software, but they lack in flexibly solving different problems. An interesting opportunity mentioned by De Causmaecker et al. (2004) is the distribution of personnel in multi-department companies. Planners are not aware of the possibilities this distribution can offer. Because there is a lack of performance measures, it is difficult to determine work overload in different departments, which is needed to obtain an efficient mutual exchange of personnel between departments. A final conclusion states that real-world companies do not wish a fully automated planning, but prefer evaluation tools that support the personnel planning instead. One can also take a look at the real-life scheduling process. Berglund and Karlton (2007) study the human, technological and organizational aspects that influence the production scheduling process. They conclude that the outcome of the scheduling process is influenced by the scheduler who adds human capabilities that cannot be automated. It is also affected by technical constraints in the scheduled production system and by the available scheduling software tools.

In 2004, Lourens and Brughmans questioned human resource managers of 54 medium sized and big companies from 14 different sectors (Lourens & Brughmans, 2006, p. 69, PA Consultancy Group). Although the available technology offers many solutions, information technology is not used in every human resource department. Not the technology but other factors hinder further distribution of information technology in the human resource department. One of these factors is the lack of a clear answer on the question how human resource management is best organized. For example, the discussion whether to use separated business units with own systems or cooperating business units with one central database. According to Lourens and Brughmans (2006), the main task of the human resource department is to make sure that at every moment the appropriate number of employees with the appropriate competences are present in the organization. The main reasons to implement human resource information systems include an increase in the quality of the human resource department and a cost reduction.

The research-practice gap in HR has already been discussed by Deadrick and Gibson (2007). They analyze the topics addressed by HR academics and professionals in articles published in both academic and practitioner journals during a 20-year time period (1986-2005). Their findings suggest that there are numerous interest area gaps between HR professionals and academics. Whereas the interests of professionals exceeds that of academics by far regarding “compensation and rewards” (14.34% and 1.98%, respectively), the opposite holds for “OB & motivation” (3.57% and 16.7%, respectively). The gap

for strategic HRM-related topics, which entails topics as strategic HR, HR planning, etc., is 6.75%, with a clear favor of interest of the professionals. In a more recent paper, Deadrick and Gibson (2009) extend their time-period to 30 years by also including 1976-1985 and try to address some trends over time: to what extent has the HR research-practice gap narrowed or widened over time? Their results indicate that HR Development and staffing were the two most popular HR issues throughout this time period. The issue of strategic HRM is not addressed in detail. The only conclusion we can derive from the tables is that its popularity by practitioners does not show a trend and remains stable at 9% over the time period. For the academics, there are no data given (i.e., which means that it is not one of the six most popular topics for this group). One of the reasons for this gap can be that most of the papers on this topic are not published in HRM journals. Our study will study the HR-planning gap in detail. However, instead of examining practitioner journals, we developed a survey, sent to Belgian production companies. Mayson and Barrett (2006) study the ‘science’ and ‘practice’ of HRM in small firms. They conclude that there is very little research in the area, although one recognizes the importance. They provide some examples in which HRM theory and practice can contribute to understanding issues faced by small, growing and entrepreneurial firms, such as recruitment, retention and deployment. Small firm owner-managers, however, are likely to opt for short term, cost effective solutions. One of the suggested solutions is to provide HRM training for these small firm owner-managers and entrepreneurs. This study will also focus on the policy of small (and large) firms in the field of personnel staffing and scheduling.

The review of Van den Bergh et al. (2013) starts from the available literature and addresses the variety of characteristics of the personnel scheduling problems as well as the real-life implementation. In this paper, we want to find out, by means of a survey, whether the same characteristics appear in personnel scheduling problems of Belgian production companies. Apart from the problem specifications, we are also interested in the current solution method and the presence of the aforementioned research-application gap.

3. Methodology

The previous part shows that there exists a research-application gap in personnel scheduling, although literature is overwhelmed with mathematical models that try to solve this problem. To check whether this research-application gap exists in Belgian companies, an online survey is developed. This survey tries to find out how Belgian production companies plan their personnel. The survey was limited to manufacturing companies, so no service companies such as hospitals and call centers were contacted. Note also that not all the companies in this survey deal with shift scheduling. Our final dataset includes responses of 123 companies consisting of 28 big companies, 47 medium sized companies and 48 small companies. This categorization is based on the economic regulation of the Flemish government, who classifies companies as small companies if they employ less than 50 employees and as medium sized

companies if they employ less than 250 employees. Companies with more than 250 employees are categorized as big companies in this survey. This categorization is not complete, but it is just a rough approximation to extract trends in the used personnel planning tools. The results of this survey will be extensively discussed in section 4.

Throughout section 4 the statistical significance of the differences between companies is handled briefly. To test this significance the Fisher's exact test is applied. The Fisher's exact test is used to test the statistical significance of two proportions with categorical variables (Hill, Griffiths & Lim, 2011). This test is more accurate than the chi-squared test if the observed frequencies are low. The chi-squared test assumes that each cell has an expected frequency of five or more. The Fisher's exact test has no such assumption and can be used regardless of how small the expected frequency is. SPSS version 20 is used to test the statistical significance in this paper. In section 4 some p-values are given to support the conclusions.

4. Human resource planning in practice

This section shows the most interesting conclusions provided by the survey. The main conclusions of the survey will be visualized by graphs and tables to facilitate the comprehensibility for the reader. Not all the companies provided an answer on all the questions. This entails that the sum of all the answers in the tables not always equals 123. Finally, the percentages provided in this section are rounded, which may lead to a total that does not exactly equal 100 percent. Besides discussing the general results for each topic, we will also provide insights into the differences between the results for the small, medium and big companies. The topics addressed in the survey are the planning tools, single versus multiple shifts, (de)centralization, reasons, skills, human factors, flexible versus fixed shifts and cyclicity, overtime and part-time.

4.1. Planning tools

The main goal of this survey is to investigate how Belgian companies plan their personnel and to find out whether pen and paper, Excel or other software are used. According to the survey, Excel is the most popular planning tool in Belgian companies (Table 1). Approximately 53 percent of the companies use Excel as their main planning tool, 21 percent use pen and paper and 26 percent use specific software to plan their personnel. If a Fisher's exact test is applied to test the difference in the use of planning tools between small, medium sized and big companies, we obtain a p-value of 0.000 with 123 valid observations. This indicates that the differences between the different company sizes are significant.

	Pen and paper	Excel	Other software
--	---------------	-------	----------------

All companies	21%	53%	26%
Small sized companies	46%	44%	10%
Medium sized companies	6%	68%	26%
Large sized companies	3%	43%	54%

Table 1: Planning tools

Surprisingly, pen and paper is still used frequently in practice to plan personnel, but mainly in small companies. The average number of employees that are planned in small companies is equal to 19, but the average number of employees that are planned in small companies if pen and paper is used equals 15. This shows that pen and paper is mainly used for smaller scheduling problems. The average number of employees that are planned with Excel and specific software is equal to 24 and 17, respectively. Remarkably, the number of employees planned with specific software is lower than the number of employees planned with Excel. The results of the medium sized companies are significantly different compared to small sized companies ($p=0.000$). Pen and paper is only used in only 6 percent of the companies instead of 46%. The use of Excel increases from 44 percent to 68 percent and the use of scheduling software rises from 10 percent to 26 percent ($p = 0.000$). These results indicate that Excel is an interesting alternative for pen and paper if more employees need to be planned. In bigger companies, scheduling software is the most popular planning tool, while Excel and pen and paper become less popular compared to medium sized and small companies. In comparison with medium sized companies, the use of pen and paper and Excel decreases by 3 percentage points and 25 percentage points, respectively, while the use of scheduling software increases by 28 percentage points ($p=0.045$). The higher degree of automation is also clearly noticeable in Figure 1.

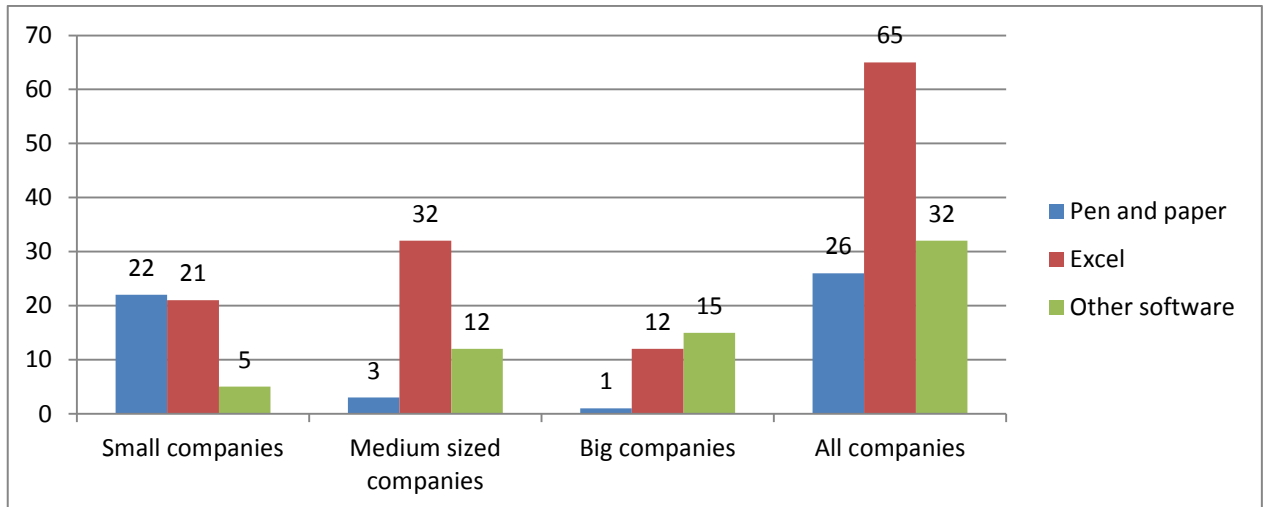


Figure 1: Absolute values of planning tools per company size

Figure 1 shows that the gap between practice and research is quite significant, and it only increases if we take a look at which specific software is used. Out of the five small companies that use dedicated planning software, two companies use Microsoft Outlook and one company uses iCal. These software tools are not able to provide any kind of scheduling or optimization. Similar findings originate for medium and large sized companies. Many of the software tools are in reality nothing more than time registration tools, used to create a link between the financial (i.e., often a third party employers' social-accounting secretariat), and the operational department. This software then records the number of working hours for a specific employee, it can be used to register the holidays, etc., and it automatically calculates the wage for that specific employee. This software can also be provided by ERP-software solutions, such as SAP. The company chooses the modules (at a given cost) it will use. These large ERP-software solutions often provide a tool dedicated to personnel scheduling. However, it is not clear if the four companies that specified this planning solution really use this tool. Chang et al. (2008), who analyze the factors that affect the ERP system usage, indicate that the least-used module of the ERP system is Human Resources in contrast to the Finance module, which is the most popular. Two of the large companies use project planning software to schedule the personnel. One can wonder whether these companies just keep track of the projects which are linked with their employees (i.e., the number of hours a person works on a project) or whether they really try to schedule the personnel as an extra resource in their projects. A similar reasoning can be made for the medium sized company that uses GPS-based software to schedule their personnel. Nevertheless, there are also companies that do take advantage of dedicated commercial personnel scheduling software such as Protime, eWorx, Kronos, etc. Some of the companies developed their own (scheduling) software. This offers the researchers the opportunity to provide personnel scheduling algorithms tailored to the needs of the company and to decrease the gap between research and

application. These companies are, however, the minority compared to the group of companies that uses commercial software, to which typically no extra (personally developed) tools can be linked.

All of the observed companies by Berglund and Karlton (2007) have standard scheduling software, whereas in all cases the end user had developed specific tools and spreadsheets to complement the standard tools and these are used more frequently. This was mainly motivated by the need for reliable data. Another important reason for using spreadsheets instead of scheduling software is the incompatibility between different computer systems.

4.2. Single versus multiple shifts

Approximately 62 percent or 77 companies use multiple shifts and 38 percent or 46 companies use only one shift to maintain their operational activities. From these 77 companies, 24 are small, 29 are medium sized and 24 are big, according to the criteria of the Flemish government explained in section 3. The data obtained by the survey indicate that 50 percent of the surveyed small companies and 40 percent of the medium sized companies do not use multiple-shift scheduling, while approximately 86 percent of the big companies use multiple-shift scheduling. No distinction is made between companies with two and three shifts. It is worthwhile to investigate whether companies with more than one shift use different planning methods compared to companies with only one shift, because the planning of different shifts increases the complexity of the planning problem. Multiple shifts can complicate the planning problem in many ways such as the shift succession constraints. Shift succession constraints depend on the type of shift, e.g., a night shift cannot be followed by a morning shift on the next day. These complications are not important in a one-shift environment. Multiple-shifts offer many advantages for organizations such as the 24 hour coverage of work that allows companies to spread their workload over 24 hours instead of 8 hours and the possibility to lower the lead times, which is an important advantage nowadays. Also employees can benefit from multiple shifts, e.g., employees that work in shifts receive a higher average wage and benefit from less traffic and more free time during the day. Another decision that has to be made by the company is the use of fixed shifts or rotational shifts. Section 4.7 goes more into depth on fixed shifts and rotational shifts.

Table 2 shows the use of pen and paper, Excel and scheduling software in the 77 companies that use multiple shifts to maintain their operational activities in comparison with the 46 companies that use a single shift. The proportion of companies that use pen and paper to schedule their personnel decreases from approximately 30 percent in a single-shift to 15 percent in a multiple-shift environment, while the use of Excel and scheduling software both increase by respectively 8 percentage points and 7 percentage points ($p=0.159$). These numbers indicate that pen and paper is mainly used in single-shift organizations.

The planning problem in single-shift organizations is typically less complex, which might be an important reason for this ascertainment.

	Single shift		Multiple shifts		Total
Pen and paper	14	30%	12	15%	26
Excel	22	48%	43	56%	65
Other software	10	22%	22	29%	32
All planning tools	46	37%	77	63%	123

Table 2: Single versus multiple shifts

It is also interesting to investigate the influence of multiple-shift scheduling. Figure 2 shows the use of planning tools for the different sizes of companies if a single or multiple shifts are used to maintain the operational activities. As already mentioned, only 50 percent of the small companies use multiple-shift scheduling. Scheduling software benefits from the small decrease in importance of Excel and pen and paper. A possible explanation can be the increased complexity of a multiple-shift environment compared with a one-shift system. However, these indications are based on a small subset and are therefore not statistically significant.

For medium and large companies, no statistically significant conclusions can be made since the set sizes are only eight and four, respectively, if multiple shifts are of interest. However, more than in the single-shift case, the size of the company influences the use of the planning tool, especially the use of pen and paper. One can see that for medium sized companies with multiple shifts Excel highly gains importance in comparison with their single-shift variant. Again, these conclusions should be considered as a possible trend, since the set size is too small. For the large sized companies with a single shift, for instance, 100% (i.e., the four companies) use specific scheduling software, which will probably not be the case in reality.

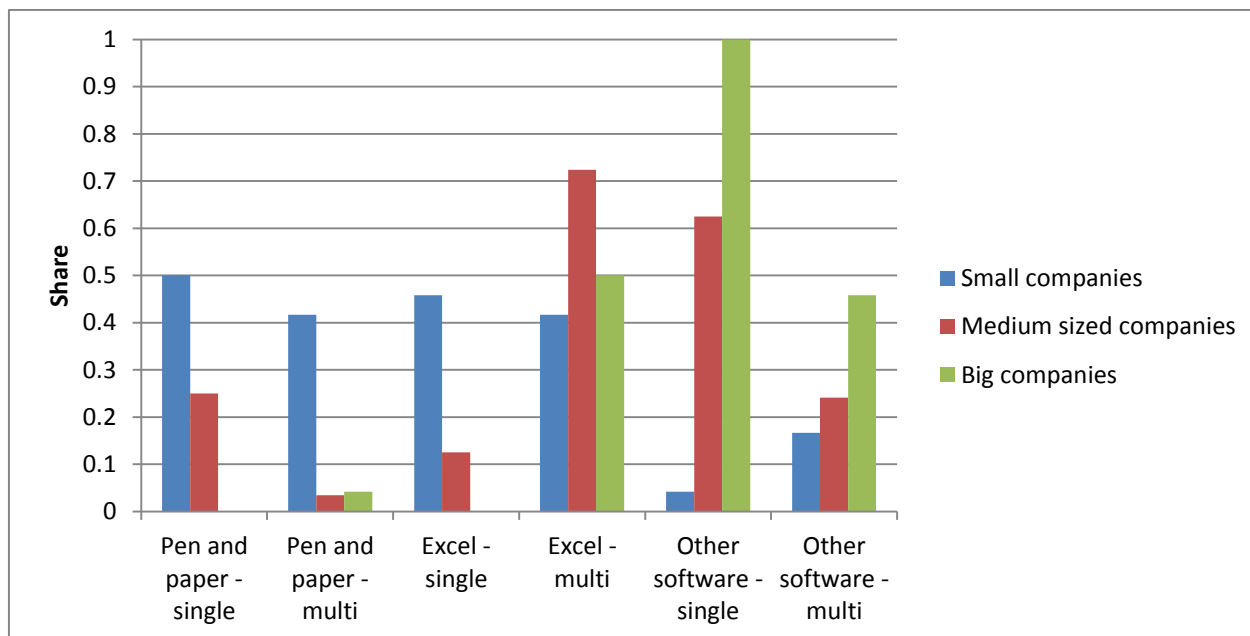


Figure 2: Share of companies according to size and number of shifts, divided over planning tools

4.3. (De)centralization

Table 3 shows the proportion of companies that use a centralized personnel planning system in comparison with companies that decentralize their planning. 44 or more than 90 percent of the small companies keep their personnel planning centralized. With an average of 19 employees to be planned, it is obvious that a decentralization of the personnel planning is not necessary to preserve a good overview. Furthermore, the number of employees of the companies with a decentralized personnel planning is respectively equal to 45, 42, 32, and 13 employees, with an average of 33 employees. This is considerably higher than the global average of 19 employees in small companies. These four companies plan their personnel in groups of respectively 6, 10, 15 and 5 employees. These results indicate that the decentralization grows with increasing number of employees that need to be planned.

	Centralized	Decentralized
All companies	79	40
Small sized companies	44	4
Medium sized companies	26	18
Large sized companies	9	18

Table 3: Centralized versus decentralized planning policy

On average 126 employees need to be planned in medium sized companies. Table 3 shows an interesting evolution towards more decentralized planning in comparison with smaller companies

($p=0.000$). Medium sized companies that decentralize their planning, schedule on average 20 employees per business unit. Due to this decentralization, the average number employees that need to be planned in medium sized companies decreases from 126 to 96 employees. Of the big companies, 67 percent decentralize their planning, which is significantly higher than in medium sized companies ($p=0.031$). Big companies have different business units that plan their personnel separately. This results in smaller planning problems and a more efficient control in the different business units. Big companies that decentralize their planning have to plan 47 employees on average in the different business units. Although a planning problem with 47 employees is small compared with the average of 1,063 employees to be planned in the large sized companies, scheduling software can deliver important advantages in centralizing all the information from different business units. This centralization of information ameliorates the transparency and can deliver an important benefit over direct competitors. For example, one of the biggest distribution firms in Belgium decentralizes their planning, but information systems are important to maintain communication between the different business units to obtain an efficient supply chain. Furthermore, the trend of decentralization in bigger companies is confirmed. The degree of decentralization goes from 8 percent in small companies to 66 percent in big companies.

4.4. Reasons

The main reasons for the use of a specific planning tool include financial reasons, user friendliness and the compatibility with other systems. Figure 3 shows the responses for the 84 companies that answered the question on why they opt for a certain planning tool. It is important to note that companies were able to provide more than one answer on this question, which entails that the percentages of the answers exceed 100 percent. In total 75 percent of the companies indicate that user friendliness is an important reason to obtain for their specific planning tool, followed by the financial consequences and the compatibility with other systems. Mostly, companies indicate that a combination of different reasons is important in their company.

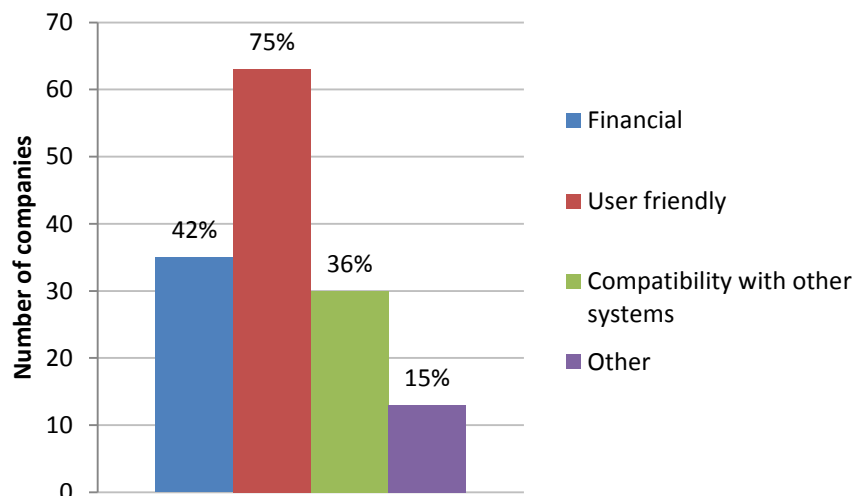


Figure 3: Reasons for using a specific planning tool

Table 4 summarizes the main reasons per planning tool. First of all, user friendliness is the primary reason to use pen and paper. In total, 60 percent of the companies that use pen and paper indicate that user friendliness is an important reason. As already mentioned in section 4.1, smaller companies do not have the financial power to invest in specific scheduling software and the implementation might not result in time or money savings.

	Pen and paper		Excel		Other software	
<i>Financial</i>	5	50%	16	37%	14	34%
<i>User friendly</i>	6	60%	33	77%	24	59%
<i>Compatibility</i>	2	20%	8	19%	21	51%
<i>Other</i>	4	40%	6	14%	3	7%

Table 4: Main reasons per using each planning tool

Secondly, Table 4 shows that companies opt for Excel because the program is user friendly. In total 77 percent of the companies that use Excel indicate that user friendliness is an important reason. Excel provides an accessible overview based on spreadsheets, which makes it possible to analyze, manage and share information easily. The different visualization tools and the possibility to perform mathematical operations on a big dataset may increase productivity, simplify work and save time. Furthermore, Excel allows import of data from and export of data to a variety of external data sources and the relatively low price of Excel is undoubtedly an important aspect for many companies. Nevertheless, Excel also has some disadvantages such as the lack of compatibility with Linux and other operating systems. The compatibility with other systems and other reasons are not of primary importance if Excel is used. According to the survey of Lourens and Brughmans (2006, p. 69, PA Consultancy Group), one of the main reasons for the

implementation of human resource information technology is a cost reduction. The data of the survey confirm that the financial aspect is quite important for the implementation of scheduling software in Belgian production companies, but the user friendliness remains the fundamental reason. In total 59 percent of the companies that use scheduling software indicate that user friendliness is an important reason. Further, the compatibility with other systems gains in importance compared to the use of Excel or pen and paper. The incompatibility between software systems is also one of the major reasons why real-life schedulers prefer spreadsheets (Berglund & Karlton, 2007). Software providers such as SAP offer a wide range of solutions that cover the whole organization. If these systems are implemented, the compatibility becomes an important aspect for the centralization and exchange of information. This is confirmed by the data of the survey. If SAP is used to develop the personnel planning, all companies indicate that compatibility with other systems is one of the main reasons. Furthermore, GET software provides a connection with SAP and the three companies that use GET argue that the compatibility with other systems is one of the main reasons for their choice. These findings are comparable with the results retrieved by Chang et al. (2008). They show that social factors are the most significant determinant affecting the ERP system usage (i.e., top management can enforce their employees to use the system), followed by compatibility. Also the perceived near-term consequences, a measure for the belief of enhancements in terms of quality and efficiency to the users' job after using the ERP system have a positive effect on the usage. Therefore, researchers should act more like marketers, focusing on the positive aspects of using scheduling algorithms, such as saving time, decreasing costs and most likely, leading to less rescheduling in the future by developing more robust schedules.

In section 4.1 we have shown that scheduling software gains in importance in bigger companies. Nowadays bigger companies possess an immense amount of data, but it is vital to centralize these data and extract useful information to obtain a competitive advantage. Software solutions can help to realize this centralization and extraction of useful information.

4.5. Skills

This section goes more into depth on the aspects that influence the complexity of the planning problem. In section 2 the most important aspects according to De Causmaecker et al. (2004) are given. Most of these aspects will be investigated in this section such as the overtime regulation and the flexibility of the schedule. Furthermore, we examine to what extent Belgian production companies are flexible in terms of employee preferences, allocation of employees and the planning of part-time personnel.

First of all, Figure 4 indicates whether skills and/or education are taken into account in the allocation of employees to tasks. Approximately 46 percent of the companies consider both skills and education, 45

percent only incorporate skills and 5 percent only education. Finally, 4 percent of the companies take neither skills nor education into account.

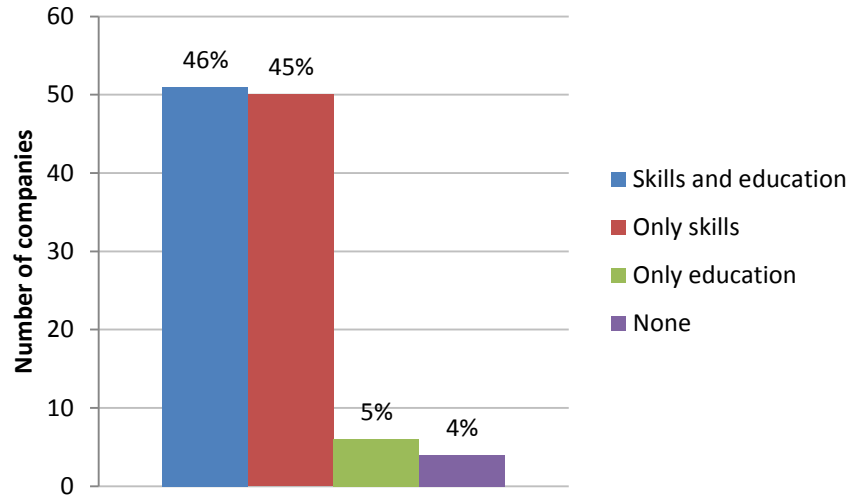


Figure 4: Are skills and education taken into account?

In total 51 companies use both skills and education in their allocation process. The rise in complexity causes an increase in the proportion of companies that use scheduling software and a decrease in the proportion of companies that use pen and paper and Excel. Table 5 compares the use of different planning tools when both skills and education are taken into account with the remaining options. In total, there is an increase in the use of scheduling software of 22 percentage points, a decrease in the use of Excel of 9 percentage points and a decrease in the proportion of companies that use pen and paper of 13 percentage points. Generally, there is a significant difference between the planning tools used if both skills and education are taken into account and the remaining other options. The Fisher's exact test results into a global p-value of 0.020 with 110 valid observations.

	All options		Both skills and education		Only skills or only education or none	
<i>Pen and paper</i>	21	19%	6	12%	15	25%
<i>Excel</i>	59	54%	25	49%	34	58%
<i>Other software</i>	30	27%	20	39%	10	17%
Total	110	100%	51	100%	59	100%

Table 5: Use of planning tools if all options or both skills and education are taken into account

Finally, we investigate whether skills and/or education are taken into account if multiple shifts are used. In 39 of the 77 multiple-shift companies (i.e., 51%) both skills and education are taken into account

for the allocation of employees, while for the remaining options only 12 out of 46 companies (i.e., 26%) take both skills and education into account. We can conclude that in a multiple-shift environment both skills and education are important ($p=0.006$).

Figure 5 shows the way skills are defined. Skills can be defined hierarchical, which means that higher ranked employees can automatically perform tasks of lower ranked employees. Skills can also be fixed, which means that task X requires skill Y and only employees with that skill are allowed to perform task X. Finally, skills can be undefined, which leaves more flexibility in the planning of employees. Figure 5 indicates that skills are mostly fixed in Belgian production companies. Furthermore, many companies also indicate that they do not strictly define the skills of their employees. In total, 104 companies provided an answer on this question. The companies were able to give more than one answer. In total 52 companies use fixed skills, 48 companies do not strictly define skills and 17 companies define the skills of their employees hierarchical.

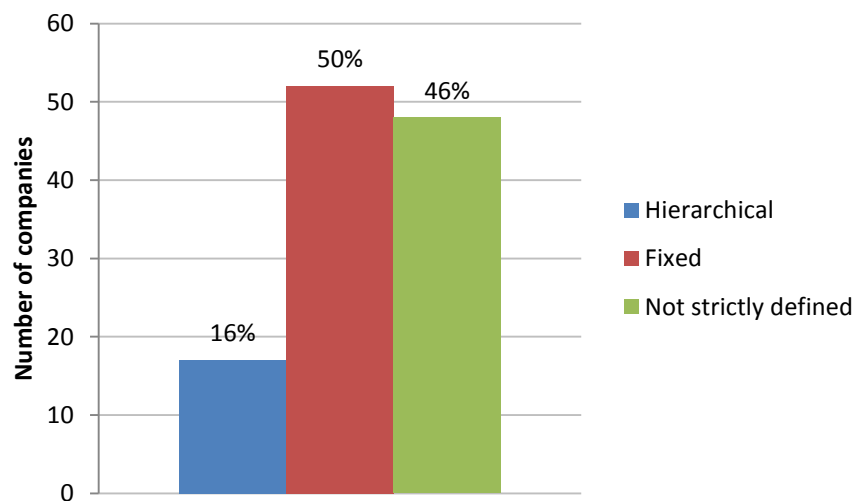


Figure 5: How are skills defined?

Considering small companies, 23 do not strictly define the skills of their employees to allocate them to tasks and 15 companies use fixed skills. Contrarily, in medium sized companies 15 companies do not strictly define their skills, while 28 companies use fixed skills. Finally, in 10 big companies skills are not strictly defined and in 9 big companies skills are fixed. Table 6 summarizes all the absolute numbers and percentages per company size and per planning tool. Particularly, medium sized companies use fixed skills to allocate their personnel to tasks. In small companies the use of pen and paper is considerably lower if skills are fixed compared with companies that do not strictly define skills. Although no significant differences were found, this ascertainment suggests the decrease in the use of pen and paper if complexity

increases, while the use of Excel and scheduling software is higher if fixed skills are used to allocate employees.

	Not strictly defined		Fixed skills	
Small companies				
Pen and paper	13	57%	4	27%
Excel	9	39%	8	53%
Other software	1	4%	3	20%
Medium sized companies				
Pen and paper	1	7%	1	4%
Excel	10	67%	19	68%
Other software	4	27%	8	29%
Big companies				
Pen and paper	0	0%	0	0%
Excel	4	40%	4	44%
Other software	6	60%	5	56%

Table 6: Use of planning tools if skills are not strictly defined or fixed

4.6. Human factors

The following aspects that influence the complexity of the planning problem are the preferences of the employees. Approximately 18 percent of the companies do not take employee preferences into account. Those 18 percent include 50 percent small companies, 32 percent medium sized companies and 18 percent big companies. This suggests that smaller companies are less flexible towards their employees. Contrarily, 82 percent of the companies take at least one preference of their employees into account. Figure 6 shows that 85 companies or 69 percent of all surveyed companies allow their workforce to state their holiday preferences. Furthermore, 25 percent of the companies considers preferences for certain tasks, 24 percent takes preferences for certain shifts into account and 8 percent tries to plan employees together with their preferred colleagues.

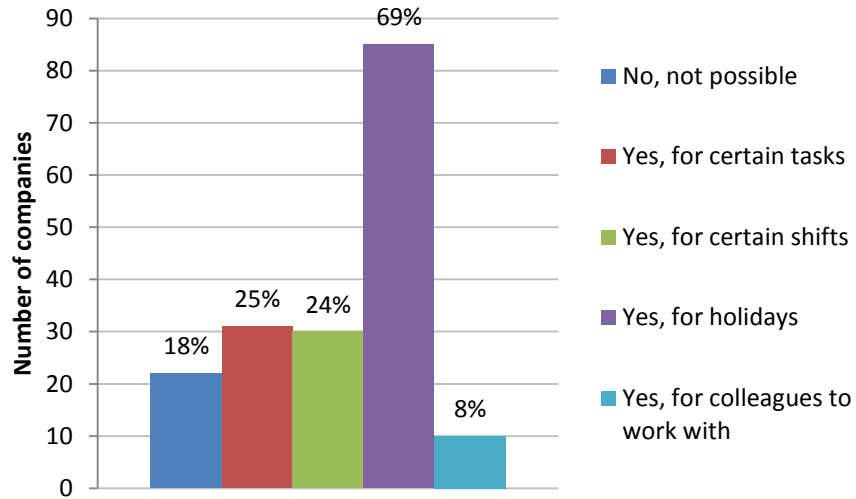


Figure 6: Is it possible for employees to state their preferences?

4.7. Flexible versus fixed shifts and cyclicity

As already mentioned in section 4.2, 77 companies out of 123 surveyed companies use more than one shift to maintain their operational activities. Approximately 61 percent of those companies use fixed shifts and about 39 percent indicate that there is space for flexibility. There are several types of flexible shifts, but these are not examined by the survey. A common decision that employers need to make is to use fixed shifts or rotational shifts. With a rotation schedule, the shifts of employees change periodically. Under a fixed schedule, employees work the same hours every day. The main advantages of rotating shifts are the balance of skills and experience across all shifts and equal exposure to the day shift of all employees. However, unbalanced workloads are difficult to manage with rotating shifts and most employees prefer fixed shifts. Fixed shifts provide stable work hours for the employee, which makes it easier to organize their activities. But fixed shifts might create a gap between the different shift teams, which can affect productivity, safety and other performance measures of the company.

Again we compare the use of the planning tools if flexibility is possible or not. Table 7 provides all the absolute numbers and percentages of companies that use fixed shifts and companies that allow flexibility. Especially big companies mainly use fixed shifts. Approximately 75 percent of all the big companies use fixed shifts, but the subset of flexible shifts in big companies is too small to draw conclusions. In small and medium sized companies the number of companies that use fixed shifts equals more or less the number of companies that use flexible shifts.

	Fixed shifts	Flexible shifts
Small companies		

Pen and paper	4	36%	6	46%
Excel	5	45%	5	38%
Software	2	18%	2	15%
Medium sized companies				
Pen and paper	0	0%	1	7%
Excel	11	73%	10	71%
Software	4	27%	3	21%
Big companies				
Pen and paper	1	5%	0	0%
Excel	11	52%	1	33%
Software	9	43%	2	67%

Table 7: Use of planning tools with fixed and flexible shifts¹

Table 8 indicates that 78 percent of the companies use cyclical personnel rosters. 50 percent of the companies that use non-cyclical personnel rosters are medium sized companies. In total 12 medium sized companies use non-cyclical personnel rosters, which is equal to 25 percent of all medium sized companies. Furthermore, 53 percent of the companies that adopt non-cyclical personnel rosters use Excel. This suggests that Excel is a flexible planning tool, which allows to deal with irregular schedules. Small companies and big companies use more cyclical personnel rosters. Only 14 percent of the surveyed big companies and 17 percent of the small companies use non-cyclical personnel rosters. Finally, note that 14 companies did not provide an answer on this question. This is the reason why the second column of Table 8 only has 109 companies in total.

	Non-cyclical personnel rosters		Cyclical	
Small companies	8	33%	34	40%
Medium sized companies	12	50%	29	34%

¹ The Fisher's exact test indicates that there is a significant difference between small, medium sized and big companies in the use of fixed and flexible shifts with a p-value of 0.004 and 77 valid observations. Firstly, there is no significant difference between small and medium sized companies with a p-value of 0.785 and 53 valid observations. Secondly, the Fisher's exact test does indicate a significant difference between medium sized and big companies with a p-value of 0.008 and 53 valid observations. Finally, the p-value of the difference between small and big companies equals 0.005 with 48 valid observations. Big companies use more frequently fixed shifts in comparison with small and medium sized companies.

Big companies	4	17%	22	26%
All	24	22%	85	78%

Table 8: Non-cyclicity in small, medium sized and big companies²

4.8. Overtime

Figure 7 shows whether it is possible to make overtime in Belgian companies and how this overtime is limited. In total, 102 companies provided an answer on this question. It was possible to indicate more than one answer on this question. The answers are more or less equally spread, but overtime limited per year is the most popular way to limit overtime in Belgian production companies. In total, 30 companies or 29 percent of the companies indicate that overtime is limited per year. Overtime limited per day is used in 25 companies, overtime limited per week is implemented in 21 companies and overtime limited per month is adopted in 16 companies. Finally, 20 companies or approximately 20 percent of the companies do not allow employees to make overtime. From those 20 companies, approximately 65 percent are small companies, 30 percent are medium sized companies and 5 percent are big companies. Finally, six companies indicate several possibilities to limit overtime in their company: 4 of them limit their overtime per day, but also per week. This could mean that employees are allowed to make overtime every day, which is accumulated at the end of the week, but at the end of the month the average needs to be zero.

Further, Table 9 shows that in big companies, overtime is allowed more frequently than in small companies ($p=0.005$). Only one of the respondents of the big companies indicated that overtime was not used in the company to deal with excessive or irregular workload. Overtime, however, has no statistical significant influence on the choice for a planning tool.

² The Fisher's exact test does not indicate significant differences in the cyclicity of the personnel rosters between small, medium sized and big companies.

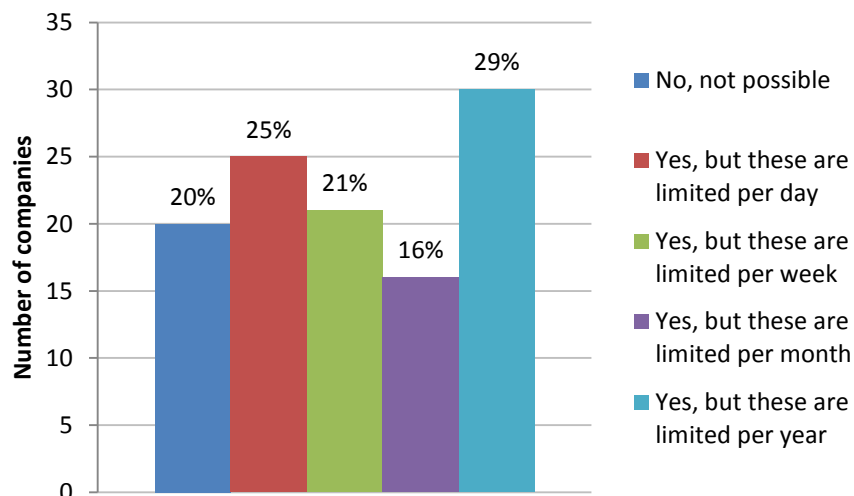


Figure 7: Is it possible to work overtime?

Table 9: Size of company and overtime

	Overtime allowed		Overtime not allowed	
	Count	Percentage	Count	Percentage
Small companies	26	67%	13	33%
Medium sized companies	32	84%	6	16%
Large companies	24	96%	1	4%
All companies	82	80%	20	20%

4.9. Part-time

The final aspect handled in this section is the way companies plan their part-time personnel. In total 98 companies provided an answer on this question, of which 10 companies indicated that they use both a variable and a fixed schedule for their part-time personnel. Table 10 shows that 64 companies or approximately 60 percent adopt a fixed schedule for their part-time personnel and 42 companies or approximately 40 percent apply a variable schedule for their part-time personnel. A variable schedule for part-time employees increases the complexity of the planning problem, but a variable schedule also has some benefits. It enables temporary replacement of ill employees and increased flexibility for the employer to cope with unbalanced workloads. Table 10 also compares the use of the planning tools if a fixed schedule or a variable schedule is used for part-time personnel. In small companies, the use of pen and paper surprisingly increases with the increased complexity. An explanation for this might be that a planning developed with pen and paper is easier to adapt to certain changes. In medium sized companies, Excel solves the necessity of increased flexibility. And finally in big companies, specific software is mainly used if a variable schedule is used for part-time personnel.

Table 10: Use of planning tools with fixed or variable schedules for part-time personnel

	Fixed schedule		Variable schedule	
Small companies	20	31%	15	36%
Pen and paper	6	30%	9	60%
Excel	12	60%	6	40%
Other software	2	10%	0	0%
Medium sized companies	30	47%	12	28%
Pen and paper	2	8%	0	0%
Excel	18	60%	10	83%
Other software	10	33%	2	17%
Big companies	14	22%	15	36%
Pen and paper	0	0%	1	7%
Excel	8	57%	6	40%
Other software	6	43%	8	53%
All	64	100%	42	100%

4.10. Discussion and future objectives

The companies were asked to give a brief overview of the evolution in human resource planning. Furthermore, they were requested to indicate whether there are planned investments or future objectives concerning the personnel planning. At the end of this section some general comments provided by the companies are mentioned.

From the 123 companies, 25 companies emphasize the increasing influence of information technology in the human resource department of their company. Furthermore, some companies note that it is not useful to automate their personnel planning, because they face fluctuating workloads. Especially seasonal companies do not rely on information technology for their personnel plan, because they employ many temporary workers and perform overtime in peak periods. This overtime can be exchanged for extra holidays in off-peak periods. Furthermore, smaller companies depend on clients or parent companies for their production rate. Mostly, the planning of the clients is not adapted to the planning of the suppliers, which makes it more difficult to set up a personnel schedule. This entails that smaller companies develop their personnel schedules for relatively short periods with possibly much overtime and flexible adoption of extra holidays. The fluctuating workload can be seen as a source of uncertainty, which tends to be left out of the models of the research community, as stated by Van den Bergh et al. (2013). This is one of the major causes for the existence of the research-application gap. Also the schedulers themselves see the lack

of uncertainty incorporation as a trigger to use spreadsheets rather than dedicated scheduling software (Berglund & Karlton, 2007). Of course, one cannot encounter all possible sources of uncertainty, but these findings can be seen as a motivation for researchers who want to see their algorithms implemented and being used by real-life schedulers to focus on both proactive and reactive scheduling policies. The proactive scheduling policies are then used to ensure some robustness in the schedules, preventing the uncertainty sources to cause disruption. The reactive scheduling policies should be able to restore the schedule if these (major) disruptions take place.

Furthermore, there also exists an increasing trend towards standardized solutions such as ERP-systems that are configurable to the specific needs of the companies. On the one hand, one company explicitly mentioned the time-saving advantage of an ERP-system and the reduced risk for mistakes. On the other hand, another company comments that the functionalities of their current system equal the functionalities offered by SAP at lower cost and lower time investment. This was also addressed by Berglund and Karlton (2007) who state that the schedulers criticize the available systems for providing insufficient decision support for the scheduling task. Specifically, the data availability and accuracy, performance measurement, organizational embedding and interaction with the human schedulers are inadequate.

The following aspects are the future objectives and planned investments in human resource management and personnel planning in specific. Around 30 companies have explicit plans to invest in information technology in the future. Many of these companies will invest in an optimization or adjustment of their existing system. Companies also indicate that there is an increasing trend towards decentralization. The different business units are responsible for developing their own personnel planning and they are free to choose the appropriate planning tool. Furthermore, some companies outsource their human resource department and also the development of their personnel planning.

Finally, some general comments provided by the companies are mentioned briefly. Some companies indicate that the high wages and the lack of flexible planning are disadvantages of the Belgian labor market. These are the main reasons for the disappearance of labor intensive professions. Belgian employees are willing to work in shifts, but they ask a big compensation in return for their flexibility in comparison with the employees of our neighbor countries. Furthermore, the high union power in Belgium also decreases the possibilities for companies to attract flexible workers. One company that completed the survey is part of a German concern. This company indicates that they encounter many more difficulties with flexible planning in comparison with their German parent company.

5. Conclusions

This paper investigates the personnel planning in Belgian production companies. The most important part of this paper is the online developed survey, completed by 123 Belgian production companies of different sizes. The survey investigates the planning tools used in Belgian production companies and different aspects that influence the use of the planning tools. Excel appears to be the most popular planning tool among the 123 surveyed companies. If we compare the use of the planning tools in different company sizes, we see that pen and paper is mainly used in small companies, while scheduling software is more established in bigger companies. Moreover, if we take a look at the specifications of the dedicated software, many of the companies are actually doing time registration rather than personnel scheduling. Furthermore, different aspects of the personnel scheduling problem have been investigated such as employee preferences, overtime regulation and cyclicity of personnel rosters. There is not one right planning tool if the planning problem becomes more complex. The different aspects indicate that different planning solutions are used in different circumstances.

From the researchers' point of view, we know that many academics focus on the design and development of algorithms, based on real-life data. However, these algorithms are hardly ever implemented. This phenomenon is known as the research-application gap. This empirical study confirms the existence of the research-application gap. According to Van den Bergh et al. (2013), who focused on the researchers' perspective, one of the major causes for this gap is the lack of uncertainty incorporation. This was confirmed by Berglund and Karlton (2007), who address the scheduler's point of view. For these real-life schedulers, the numerous sources of uncertainty are the trigger to use spreadsheets rather than dedicated scheduling software. This behavior is confirmed by our survey, which indicates that spreadsheets are by far the most popular planning tool in Belgian companies. If the research community is willing to bridge the gap between reality and application, they should focus on creating proactive and reactive scheduling algorithms that incorporate or at least do not neglect uncertainty sources, rather than winning milliseconds in execution time. Other reasons why spreadsheets are more popular than scheduling software is the lack of integration with other software systems, the complexity and the inadequate data availability and accuracy, which makes that the available systems provide insufficient decision support for the scheduling task (Berglund & Karlton, 2007). Therefore, we want to stress on the importance of addressing more than just the personnel scheduling problem when other resources or scheduling decisions, etc., also influence this problem.

References

- Berglund, M. & Karlton, J. (2007). Human, technological and organizational aspects influencing the production scheduling process. *International Journal of Production Economics*, 110(1–2), 160-174. doi: <http://dx.doi.org/10.1016/j.ijpe.2007.02.024>

- Chang, M.-K., Cheung, W., Cheng, C.-H. & Yeung, J. H. Y. (2008). Understanding ERP system adoption from the user's perspective. *International Journal of Production Economics*, 113(2), 928-942. doi: <http://dx.doi.org/10.1016/j.ijpe.2007.08.011>
- De Causmaecker, P., Demeester, P., Vanden Berghe, G. & Verbeke, B. (2004). *Analysis of real-world personnel scheduling problems*. Paper presented at the International Conference on Practice and Theory of Automated Timetabling (PATAT 2004), Pittsburgh, USA.
- Deadrick, D. L. & Gibson, P. A. (2007). An examination of the research–practice gap in HR: Comparing topics of interest to HR academics and HR professionals. *Human Resource Management Review*, 17(2), 131-139. doi: <http://dx.doi.org/10.1016/j.hrmr.2007.03.001>
- Deadrick, D. L. & Gibson, P. A. (2009). Revisiting the research–practice gap in HR: A longitudinal analysis. *Human Resource Management Review*, 19(2), 144-153. doi: <http://dx.doi.org/10.1016/j.hrmr.2009.01.003>
- Hill, R. C., Griffiths, W. E. & Lim, G. C. (2011). *Principles of Econometrics*: Wiley.
- Kellogg, D. L. & Walczak, S. (2007). Nurse Scheduling: From Academia to Implementation or Not? *Interfaces*, 37(4), 355-369. doi: 10.1287/inte.1070.0291
- Lodree Jr, E. J., Geiger, C. D. & Jiang, X. (2009). Taxonomy for integrating scheduling theory and human factors: Review and research opportunities. *International Journal of Industrial Ergonomics*, 39(1), 39-51. doi: <http://dx.doi.org/10.1016/j.ergon.2008.05.001>
- Lourens, J. & Brughmans, I. (2006). *HR Nieuwe stijl: naar excellente dienstverlening tegen lage kosten*. Alphen aan den Rijn: Kluwer.
- Mayson, S. & Barrett, R. (2006). The 'science' and 'practice' of HRM in small firms. *Human Resource Management Review*, 16(4), 447-455. doi: <http://dx.doi.org/10.1016/j.hrmr.2006.08.002>
- Petrovic, S. & Vanden Berghe, G. (2012). A comparison of two approaches to nurse rostering problems. *Annals of Operations Research*, 194(1), 365-384. doi: 10.1007/s10479-010-0808-9
- Van den Bergh, J., Beliën, J., De Bruecker, P., Demeulemeester, E. & De Boeck, L. (2013). Personnel scheduling: A literature review. *European Journal of Operational Research*, 226(3), 367-385. doi: <http://dx.doi.org/10.1016/j.ejor.2012.11.029>
- Vanden Berghe, G. (2012). *Personnel scheduling: challenging combinatorial optimisation problems with a personnel scheduling component*. Paper presented at the International Conference on the Practice and Theory of Automated Timetabling (PATAT 2012), Son, Norway.
- Werner, S., Jackson, S. E. & Schuler, R. S. (2012). *Human Resource Management*: South-Western Cengage Learning.
- Zülch, G., Rottinger, S. & Vollstedt, T. (2004). A simulation approach for planning and re-assigning of personnel in manufacturing. *International Journal of Production Economics*, 90(2), 265-277. doi: <http://dx.doi.org/10.1016/j.ijpe.2003.11.008>