How demand management can improve planning in childcare centers

To what extent can childcare centers run more efficiently by using the flexibility of parents?

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Preface

In this preface I want to thank some people for their support during this master and especially during my thesis.

First, and most, I would like to thank my wife Anne. Without her I would never be able to finish this thesis and my master. She was always here, to help me with my study, discuss scientific and statistic issues and give me all the opportunities I needed to do this research. Without a doubt, without her, I would not be where I am now, both in study and in work.

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Executive summary

This research investigates if, and to what extent, a childcare center can decrease the number of professionals needed by using the flexibility of parents. A childcare center in the Netherlands spend around 68% of their revenue on staff. Therefore, a decrease in professionals needed can be highly beneficial for the childcare center. This research shows and explains the current situation and surroundings of five childcare centers in the middle of the Netherlands. Sensitivity analysis is used to determine in which cases the number of professionals needed can be decreased by convincing the parents to choose another day of childcare within the same week (off course subject to availability).

Given the chances of decreasing the number of professional-days for a childcare center this research will also consider that not all the children are able to switch days because these children are already visiting the childcare center on the alternative day. By doing so, the number of children who can make the change is calculated. From there, this research calculates the advantages for the childcare centers given a certain flexibility (and willingness) of the parents to change days. Earlier research shows that customers can be influenced by giving incentives. One of these types of incentives is explained within this thesis.

The results of this thesis show that the childcare centers within this research can obtain a decrease in professional-days needed of 6.4% (or 592 professional-days) if the flexibility of parents is 100%. Individual childcare centers can even obtain an advantage of 8% (or 155 professional-days). Although this decrease is subject to flexibility of parents a decrease in professional-days of 6.2% (50% flexibility) or 5.4% (25% flexibility) is possible. Knowing that a childcare center pays around 68% on their revenue on staff, being able to reduce that by a percentage varying from 5% to 8% can increase profitability substantially.

It is possible that childcare centers are forced to recalculate their hourly rate given the savings obtained. Partly to protect the childcare center from competition that will lower their prices and possibly because of the fact the government will lower the maximum rate for which the government provides contributions for parents. When extrapolating the findings of this study to the contribution that the Dutch government gives to parents to pay for childcare, the possible savings could be over 100 million euros if the government will decide to lower the contributions with the same percentage. The advantages for parents can highly vary due to the number of children and the yearly income of the parents. Based on averages spend on childcare in 2016, over € 240 can be saved per household.

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1 Introduction

In the Netherlands, 818,190 children went to a formal kind of childcare in 2016. In this year, 542,000 households used a formal kind of childcare to take care of their children when working (or studying). During 2016, 818,190 children who were going to a formal kind of childcare spend 560 hours on average within this kind of formal childcare. In total more than 458 million hours are spent in these formal kinds of childcare. Remarkable is the fact that since 2011 the number of children in formal childcare decreased (from 836,000 in 2011 until 754,600 in 2014). This trend seems to be turned around since 2015 because ever since that moment more and more parents started to take their children to a formal kind of childcare (until 818,900 in 2016). Although more parents started to use a formal kind of childcare, the average amount of hours spend in formal childcare decreased from 770 hours in 2009 until 560 hours in 2016. According to the CBS-statistics this decrease was caused by more flexibility in working hours and the use of informal kinds of childcare. This research focus on children aged zero, one, two or three whose parents are using a childcare center for childcare during working hours. In total, over 371,000 children used this kind of formal childcare during 2016. With an average of 680 hours, over 252 million hours are spent in this type of childcare.

Over 2016, the CBS (Centraal Bureau voor de Statistiek) calculated the average costs of parents on childcare to be € 5,500. After the mortgage or rent, the costs for childcare are the biggest expenses for many families with young children. The Dutch Government wants to increase the participation of women in the labor market by paying for childcare for families where both parents have a job. In 2016, the Dutch government contributed for over 2.4 billion euros in the costs for childcare, by giving an allowance to parents. Besides that, the government spend 4.883 million euros to the childcare centers as subsidy to improve quality and to be able to match the stricter regulations.

As mentioned in the first paragraph, more children are visiting the childcare center, but the average amount of hours spend within the childcare center declines because of flexible working hours of parents and informal kinds of childcare. Less hours per child but more children in formal childcare demands flexibility from childcare centers. Where parents used to bring their children for entire days for multiple days a week this trend has changed by using less hours of childcare per week. The childcare centers need to take this into account when planning capacity of rooms and personnel, but most of all, when planning groups for the children. Within planning these groups, which now happens with human analysis (within the childcare centers included in this research), the childcare centers need to consider the rules within the “Wet kinderopvang en kwaliteitseisen peuterspeelzalen”. Besides the maximum number of children that is allowed in a group these laws also contain pedagogical elements like a fixed leader and a fixed space within the childcare center

that is assigned to a certain child. Besides these legal requirements, there are several factors that could be taken into account when classifying the groups: the expected outflow of children (fixed when reaching the age of 4), the expected registrations of new children (most of the time months before the first day), an optimal scatter of children during the days of the week and the possibilities of merging groups on days which are less busy. Besides this, the childcare centers need to consider the flexible contracts which are harder to plan and more difficult to predict. Besides the downside of flexible contracts and flexibility of parents, a childcare center might be able to use this in their own advantage.

The ”Waarborgfonds Kinderopvang” (2017) investigated the financial position of 208 organizations that provide children with childcare over the year 2016. Over 23% of the total amount of child-places is involved within this research (for day-care) which makes it a representative research. This research shows that, on average, childcare centers spend over 68% of their revenue on staff. After staff, the biggest costs for the childcare centers are costs for housing, which will take just over 14.5% (off course highly depending on owning or renting the building) of the revenue. After all the costs and taxes, the average childcare center has 2.3% of their revenue left as profit. This research clearly shows that if a childcare center wants to increase profitability by reducing costs, the costs of staff members are the type of costs where the biggest impact can be made.

Knowing the cost-structure of a childcare center and the increasing flexibility of parents, within this research will investigate if, and to what extent, childcare centers can obtain an advantage in decreasing the number of professionals needed. To do so, this research will first explain the legal requirements a childcare center has to follow. After that, this research will show which variables influence the number of children per professional (cp-ratio) to better understand in which ways the decrease in professionals can be obtained. Knowing that, the childcare centers within this research are analyzed by measuring the demand and the number of professionals needed. After introducing the solution design, the possible improvements for these childcare centers are displayed.

Based on the introduction, the following research questions will be investigated:

- Which factors influence the number of professionals needed in childcare?
- How can childcare centers decrease the number of professionals needed by influencing demand?
- To what extend can childcare centers decrease the number of professionals needed by asking parents to switch days within the week, knowing next week’s planning?
- Which saving can be obtained in the Netherlands, using the solution design of this research?

2 Literature review

2.1 Improving planning

2.1.1 Benefits of improving planning

The optimization of schedules can lead to enormous benefits for companies (Ernst et al., 2014). Besides reducing costs or maximizing revenues these optimizations might also help to being able to better match the demand of your customers. Also, the requirements for the staff might be easier to meet. According to Ernst et al. (2014) the scheduling and optimization models are improved significantly over the last couple of decades. Groothedde et al. (2005) suggest that to build a good linear model it is important that your problem consists of an objective function, decision variables and constraints. Van den Bergh et al. (2013) did research in optimization models for planning and scheduling problems. According to Van den Bergh et al. (2013) 75% of these cases had to deal with hard constraints within the optimization model. Particularly in sector which have shortage in staff (which is the case in childcare) the available amount of staff can be a hard constrain. When it's possible to get (mostly more expensive) staff from outside of the company, reducing the hours for the staff is an objective instead of a constraint.

Ernst et al. (2014) also highlights the problem of specific optimization models. Making an optimization model which is useable in different areas may be good for the usability of that model, it probably will not generate the same amount of advantages in comparison to a specific model for one problem within one company. Korporaal et al. (2000) already investigated that it is nearly impossible to get a 100% occupation without having to disappoint one single customer. Therefore, a 100% occupation in childcare without having to disappoint one single customer should not be the goal of the model.

2.1.2 Sensitivity analysis

Sensitivity analysis is widely used to investigate how the outcome will vary when the input data is changed (Park et al, 2004). This way, the effect on the total costs can be analyzed to obtain a better (or just as good) decision. Although some researcher criticized the use of sensitivity analysis, because it might cause incomplete information (Evans & Baker, 1982; Knolmayer, 1984; Jansen et al., 1997) Park et al. suggest that sensitivity analysis can be used to find a more optimal solution within the close reach of the current solution. Jansen et al., (1997) also suggest that when sensitivity analysis is used, getting (and claiming) to find the optimal solution should be done with extreme care.

2.2 Regression analyses

2.2.1 Multivariable regression analysis

To estimate the strength of the linear association between two (or more) variables, a correlation analysis can be used (Tripepi Et al., 2008). This can be used when there is not enough knowledge

about which variable is responsible for the variance in the other variable or when this question is irrelevant in the type of research. When the dependence of the outcome variable (Y) from the independent variable (X) is examined, linear regression analysis can be used. When one independent variable is investigated, a regression analysis is performed. If multiple independent variables are investigated, a multivariable regression analysis will be done (Draper & Smith, 1998).

The equation for the multivariable regression analysis is:

$$Y = \beta_o + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \ldots + B_n x_n$$

Where:

Y = Predicted value of the dependent variable

β_1 = The regression coefficient

β_o = Value of Y when X is zero

X_n = Given value of the predictor variable

This equation shows the impact of the predictor variables on the dependent variables. Every change in the predictor variable (for example plus one) results in a certain mutation in the predicted value of the dependent variable.

2.2.2 Collinearity

According to Mela et al. (2002) collinearity is one of the biggest concerns within research. Mela et al. (2002) investigated the impact of collinearity on regression analysis and mentioned the possible techniques (like vif (variance inflation factor) and ci (condition indices)). Adding more variables into a regression analysis (or a model) can increase the R2 of the regression but can lower the parameter significance which results in smaller coefficients that are less usable to explain the impact of the independent variables (Belsy et al., 1980; Kmenta, 1986). Several diagnostics are used to determine whether collinearity is a problem, although several researchers mention different values as being problematic. For example, Green and colleagues (1998) find a value below 0.9 acceptable, while Tull and colleagues (1990) accept a value below 0.35. As mentioned by Mela and colleagues (2002) most researchers do not report on the diagnosis used to investigate collinearity. This research will show the methods used to discover collinearity and will report on the actions taken to solve the problem of the impact of collinearity.

2.3 Influencing demand & Dynamic pricing

According to Bertini and colleagues (2010) many researchers assume that (financial or other) incentives reinforce desired behavior and will discourage actions from customers that will harm the company. Deci and colleagues (1999) argue this by making the statement that customers will make their decision based on intrinsic motivation. An extrinsic motivation makes the intrinsic motivation

disappear and that will make the offer look less appealing to customer. Bertini and Dholakia (2010) agree that incentives or other marketing promotions can undermine intrinsic motivation and make customers more price-sensitive, more cautious to make decisions and may lead to other less favorable management decisions.

Offering customers lower prices when demand is low, or higher prices when demand is low is considered unfair by customers (Frey, 1993). This research proved earlier research wrong which stated that dynamic pricing is acceptable and understandable for customers. When a customer perceives price unfairness this may have negative consequence for the company (Campbell, 1999). These negative consequences might be lower purchase intentions, complaints by customers, talking negative about the company or leaving the company (Huppertz et al., 1978). Xia and colleagues (2004) offer managers several tools to reduce the negative impact of perceived price unfairness. Although this research mentions several possible tools, all these tools mention the importance of transparency to customers. Explaining customers why a certain price is asked for the product or service and why these prices may differ over time might help to prevent the perception of price unfairness.

2.4 Expected value of solution design

The expected value (of a solution design) is seen as the average outcome of many repetitions of the experiment (Ross, 2010). When the experiment will be done more frequently, the average outcome will (almost surely) not vary much from the calculated expected value.

The expected value is defined by:

$$E(x) = 1 - P(x) \text{ ^ } n$$

Where:

E(X) = is the expected value of the random variable X

P(x) = is the change that an event will not occur

N = the number of times an event can occur

Although the expected value seems to be a good decision variable, it does not consider that individual decision makers are frequently risk-averse. Therefore, the choice made, might be opposite from the choice that should be made based on the calculation of the expected value (Myerson, 2005). This research will focus on the expected value of the solution design and will therefore not take the risk-averse behavior of people into account.

3 Exploration of practice

3.1 Constraints by law and regulations

When a childcare center is dividing children into different groups they are forced to do that by the rules of the "Regeling kwaliteit kinderopvang peuterspeelzalen 2012" made by the Dutch Government. This legislation ensures that all children within the childcare center are taken care of in a pedagogically responsible way when they are at this childcare center. As part of this pedagogically responsible way of taking care of children, these regulations include measures to ensure that children will spend their day in area they are familiar with and are surrounded by people they know, and therefore feel comfortable and safe.

3.1.1 Constraints in space

Every group of children is assigned to a secluded part of the building within the childcare center. Therefore, every child has a permanent place in the building to go to. Next to the permanent place, every child will have a second place assigned where they will be by exception, for example on a day with lower occupancy, when their fixed group is merged with another group. Since every secluded part of the building is subjected to these sets of rules it is hard for a childcare center to obtain extra groups (with their own secluded part). Most of the times the construction of the building needs to be changed which will lead to extra costs.

To ensure enough space for a child to play and develop skills, the secluded part of the building should contain at least 3,5m2 of inner space to play per child that is taken care of on a day. With a maximum of 16 children per group (only possible with children of a certain age (see Table 1)) the inner space should be at least 56m2. A shared area to play within the childcare center will be equally assigned to all the children within the childcare center on a day. Besides that, there need to be a safe playing ground outside of at least 3,5m2 of space per child in the childcare center.

Groups that contain children that have not yet reached the age of two will also have to realize sleeping places for these children. These sleeping places contain beds that are suitable for these young children (for example a cot for younger children). The number of beds is not imposed by these set of regulations but should be enough according to the number of children and their different needs of sleep.

3.1.2 Constraints in assigned group

To make the best possible development for children in childcare the regulations demand that children are taken care of in a familiar setting. Therefore, besides an assigned secluded part of the building, every child will be assigned to a specific group. When a childcare center wants to change the group of a child, approval of the legal representative of the child (later: parent(s)) must be

requested. The advantage of an assigned group is that children will start to know the other children within their own group (unless they use other days of childcare) and will probably feel more comfortable within this group. The parents of the children are told in which group their child is included, and which professional is working at this group on which days. By law, every child is assigned to three professionals within the childcare center. Every day one of these three professionals should work on the same group that the child is assigned to, regardless of vacation, merging of groups or days with low occupation. By doing so, every child will at least be familiar with one of the professionals working on their group.

Exceptions of the above-mentioned rules can apply during starting times of day-care (before 9.30 am) and the end of the day (after 16.30 pm). This is done to ensure that professionals are not forced to work for 11 hours per day since the day-care can take place from 07.00 am until 18.00 (most commonly). These exceptions are not considered within this research.

3.2 Number of children per professional

3.2.1 Number of children per professional in childcare centers by regulation

The number of professionals a childcare center needs to plan for planning their groups is determined in the "Regeling kwaliteit kinderopvang peuterspeelzalen 2012". Table 1 shows an overview of how many professionals needs to be deployed depending on the number of children and their age. This table is divided into two sectors, in which the first sector is applicable when the children in the group are of the same age and the second sector is applicable when the age varies within a group.

	Code	Children aged	Min. quantity of professionals	Max. number of children	Min. quantity of professionals	Max. number of children	Min. quantity of professionals	Max. number of children	Min. quantity of professionals	Max. number of children
Children of same age	A1	Zero	1	4	2	8	3	12		
	A2	One	1	5	2	10	3	15	4	16
	A3	Two	1	8	2	16				
	A4	Three	1	8	2	16				
Children of different ages	B1	Zero & One	1	5	2	9①	3	14①	4	16①
	B2	Zero, One & Two	1	5	2	9①/ 10②	3	15①	4	16①
	B3	Zero, One, Two & Three	1	5③ / 6④	2	9① / 10② / 11⑤ / 12⑤	3	16①		
	B4	One & Two	1	6	2	11	3	16		
	B5	One, Two & Three	1	7	2	13	3	16		
	B6	Two & Three	1	8	2	16				

① of which maximum 8 children with the age of 0
② of which maximum 7 children with the age of 0
③ of which maximum 4 children with the age of 0
④ of which maximum 3 children with the age of 0
⑤ of which maximum 6 children with the age of 5

Table 1: Number of children per professional, based on different ages.

By working with age groups (defined with a code in the table) the "Regeling kwaliteit kinderopvang peuterspeelzalen 2012" particularly aims to ensure that young children (under the age of one year old) get the care they need. Without an expectation there can be a maximum of eight children aged zero in a single group, and this maximum becomes 16 as soon as the children turns one. When aged zero, every four children get an extra professional which can expand to 8 children per professional at the age of three (as visible in line 1 and 4 of the table). When a group contains children of different

ages (and therefor have a “B”-code), the number of children per professional will vary from five to eight.

The outcome of dividing the number of children in a group by the number of professionals that are needed within a group is called the child-professional ratio (hereafter: cp-ratio). Table 1 shows that the number of children within a certain number of professionals can differ. Two professionals can be needed for five children (in an A1 group), but these same two professionals can also be enough for 16 children (in another age class). Table 1 also shows that if a group contains five children, there is a possibility for one professional (which will result in a cp-ratio of five) and a possibility for two professionals (which will result in a cp-ratio of 2.5).

For a childcare center, adding an extra professional for just one child is unfavorable. In these cases, this last added child forces the childcare center to use an extra professional, and therefore have higher costs. Considering that the costs of an extra professional will overtop the extra revenue of an extra day of childcare, the childcare center will try to avert this situation. As soon as the extra professional is needed, the childcare center will try to add more children in that group because extra revenues will be realized without the extra costs of a professional.

3.2.2 Merging of groups

To avoid extremely high costs for childcare centers the “Regeling kwaliteit kinderopvang peuterspeelzalen 2012” allows childcare center to merge groups still considering the other rules (as mentioned in chapter 3.1). Thus, by merging, the childcare center can decrease the number of professionals that is needed to take care of the children. When, for example a “B1” group of six children can be merged with a “B5” group with four children, the total amount of professionals needed can be decreased from three to two professionals. This example is shown in Figure 1. Every square in this figure (and upcoming figures represent a child, the number within the square indicates the age of the child.

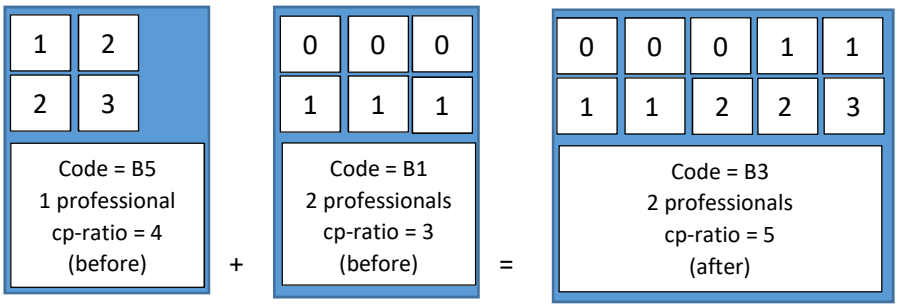

Figure 1: Merging of groups

3.2.3 Chances of age categories within regulation

Given the age classes which are visible in Table 1, the childcare center can use the different age classes in their advantage when forming groups. An example of this is displayed in Figure 2. This Figure shows that a group, containing four children aged one year form a group that will need an extra professional for an extra child during that day. By doing so, the cp-ratio will decrease from four to 2.5. However, adding a child aged two won't increase the number of professionals and therefore improve the cp-ratio to five. This since the group is no longer an "A2" group but will be a "B4" group for which another line of Table 1 is applicable. After adding the two-year-old child, even adding two extra children aged three won't increase the number of professionals because of the fact the group will now classify as a "B5" group which is able to take care of seven children with the use of one professional.

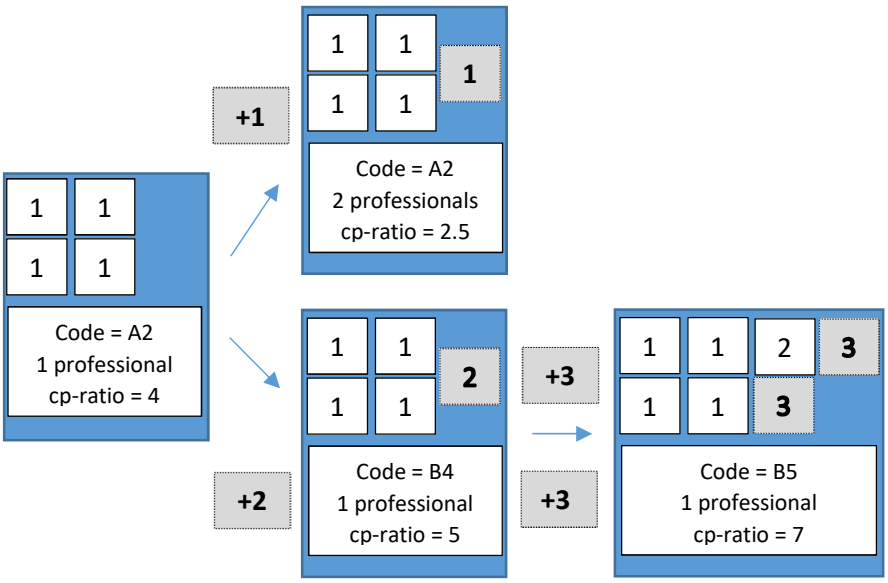

Figure 2: Adding children to an "A2"group, different consequences.

As shown in Figure 3, it is possible to add children to groups that seems to be "full" in the first place. Adding another one-year old child to the group will cause the need of an extra professional. Adding children aged two (or aged three) won't increase the need of professionals for the group.

Besides that, adding children to a group may simultaneous lead to a decrease in the number of professionals that are needed in that group. As shown in Figure 3 adding a three-year-old child to a group of 12 children aged one or two, will change the code of the group from "B4" to "B5" which will decrease the number of professionals from three to two. The cp-ratio of the group will change positively from four to 6.5 as an effect of adding the three-year-old child.

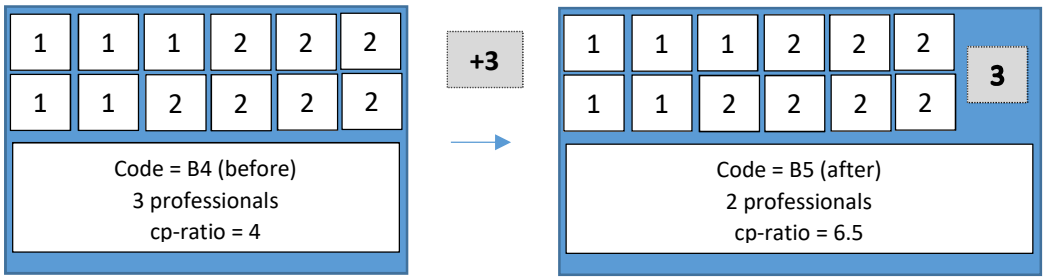

Figure 3: Adding children to a "B4"group, decreasing number of professionals.

This paragraph shows that the distribution of ages within a certain group can affect the cp-ratio and the number of professionals. Therefore, it is important for a childcare center to monitor the average and distribution of ages within their groups. Besides the advantages that can be obtained (as seen in this paragraph) the distribution of ages could possibly be a risk to the childcare center. For example, when the three-year-old child, that was added in the example of Figure 3, reaches the age of four and will leave the childcare center to go to school, this child leaving the daycare will result in an increase in professionals needed and therefore a decrease in the cp-ratio.

3.2.4 Different strategies due to age categories

As seen in Table 1, the number of children per professionals increases once the children within the group gets older. Especially when a group includes very young children, more professionals are needed. To take advantage of the favorable cp-ratio with (only) older children within a group, the childcare centers within this research chose to form their groups based on age which can be seen in Figure 4 (which clearly shows groups of babies: C1B, C2B, C3B, C4B, C5B and groups of toddlers: C1T, C2T, C3T, C4T and C5T). Other childcare centers in the region of the childcare centers which are included within this research are known to form their group without paying attention to the age of a certain child. These childcare centers believe that children in this setting, will be raised by learning from older children and taking care of younger children within their group. Besides pedagogical effects, this will probably have an impact on the planning and number of children per professional. In Figure 4, the average age per group is displayed. Every set of two groups (for example C1B+C1T, C2B+C2T) forms a childcare center. With group C5B and C5T as an exception (where the distribution is less clear), it shows that all childcare centers choose to form their groups based on age. Especially in the combination of group C2B&C2T the maximum age of children in group C2B approaches the minimum age of children in group C2T.

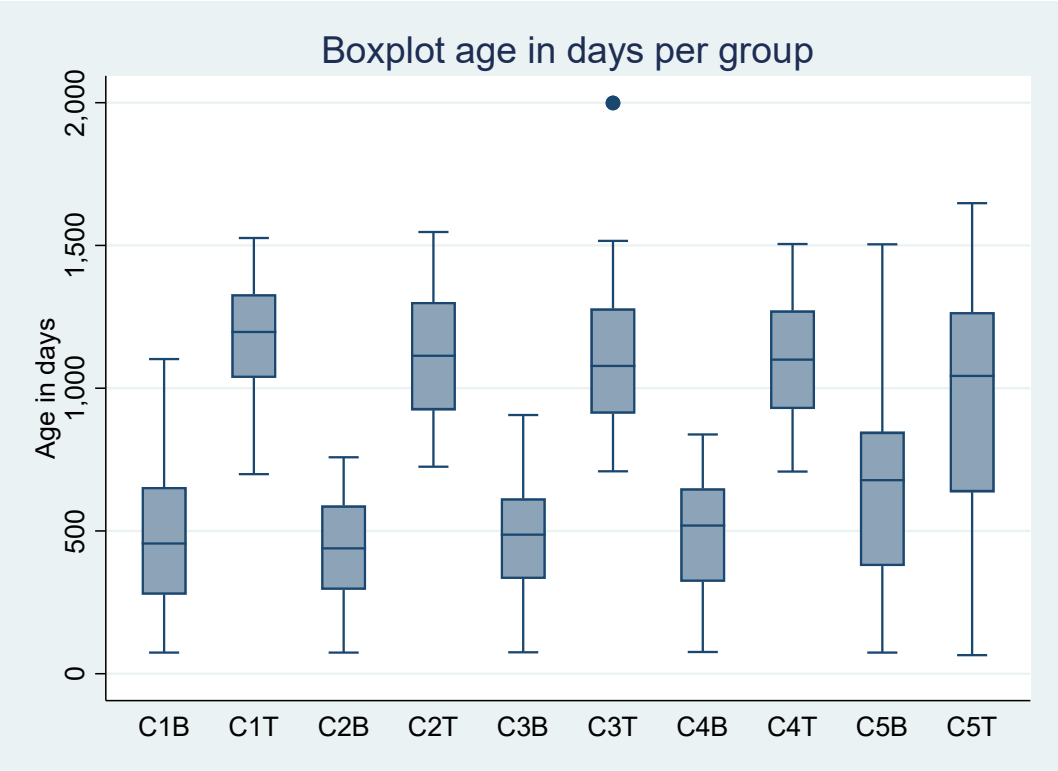

Figure 4: Distribution of the average age (in days) within groups (each column indicates a group (with 2 or 3 subgroups) that can merge within the regulations as mentioned in 3.1).

3.3 Costs and revenues

As mentioned before, the parents who are using a flexible contract pay a higher price per hour of childcare. Within the contract, the amount of days of childcare is mentioned and could be determined or could vary over time. Every day consists of 11 hours to be paid (from 07.00 until 18.00), regardless of the hours spend in the childcare center. Regardless of the contracts the prices per hour of childcare within the childcare centers included in this research vary from € 7.18 until € 8.48. Knowing the Dutch minimum wage is at least € 9.04 (and the costs for the employer higher) this shows that an extra professional for just one extra child will be loss-making. Even needing an extra professional for two children is not clearly profitable for the childcare center because all childcare centers within this research needs to pay wages above the minimum wage to get enough professionals. Besides that, other costs, like diapers and food for the children should be analyzed to confirm or decline the profitability of two children per professional.

4. Data analysis

In this chapter the data collection and the preparation of the data used in this research are explained. Moreover, the variables that influence a successful planning (in which the cp-ratio is desirably as high as possible (which makes it more cost-efficient, because less professionals are needed)) are provided and explained. Lastly, the current situation, based on historical data, is calculated and presented.

4.1 Data description

The data used in this research was made available by five childcare centers located in the middle of the Netherlands. These five childcare centers are all divided in two groups, which all contain two or three subgroups. The data was gathered over one single year (in this case: 2017) because the regulations vary over the years which makes a comparison over the years complicated and the solution design (partly) irrelevant. The data consists of a single line of data for every child that goes to the childcare center on a specific date. Each line consists of the date, name and date of birth of the child and the subgroup which the child is in. Because most analyses contain information by subgroup, the data is separated by subgroup per day. In total 46,314 children-days (and therefore rows of data) of childcare are involved within the data, divided over the five childcare centers, which are varying in magnitude from 6,058 children-days to 12,290 children-days of childcare over 2017.

The data used for this research is derived from the lists that the childcare centers need to have available (due to regulation and demands of the fire departments) within the childcare center on a specific date. This list contains all the names that are inside the facility on that specific date. This data is used to measure the quality of a planning but may differ from the actual planning due to illness or other reasons of absence of one of the children. In these cases, the actual situation reflects a cp-ratio that differs from the one in planning. Since this only happens on an incidental basis, and especially because when it happens it will influence the cp-ratio positively and negatively, the data is considered to be suitable for this research.

By restructuring the data, the number of children per day (divided by age) can be obtained. Considering the age of the children, every (sub)group will get a code based on which the number of professionals can be calculated (see Table 1). This procedure shows that on 69 days of childcare per subgroup (out of 6,058 total) the total amount of children exceeded the maximum of 16 children. On these days, the total amount of professionals needed is set to five. This is done to make sure that the solution design might possibly resolve this violation of law. Besides this, the days that contain zero children within a group are deleted from the sample. For example, Christmas, Kings day, Easter and Ascension days do not influence means and standard deviation by adding an extra line of data consisting zero visits to the childcare center.

4.2 Fluctuation in demand

With 46,314 children-days of childcare in 2017, divided over 633 unique children and 253 days during 2017 the demand is not evenly divided between the children, days and months of the year. The amounts of days that a child is going to the childcare center varies from one single day in the year until a maximum of 191 days within this year. Fluctuation in demand will not only occur in the days of the week or the month within a year not being evenly divided but will also occur because of flexible contracts. Within this type of contract (which have a higher hourly rate) parents can chose when and how often they will use the services of the childcare center shortly before that day.

4.2.1 Fluctuation between days of the week

As seen in Figure 5, the demand within the child care centers varies strongly between the days of the week. Especially the Friday and Wednesday have a significantly lower occupancy compared to the other days of the week. According to the management of the childcare centers within this research, the lower occupancy on the Fridays is mainly caused by parents not working fulltime and prefer a longer weekend (which also explains the slightly lower occupancy on Mondays). Because of this, using an alternative for a formal childcare (like grandparents) will also happen more frequently because it is more likely that this informal childcare is available on these days. The childcare centers within this research have less staff working at their childcare center on Wednesdays and Fridays. All the childcare centers mentioned this distribution is based on demand of parents and not a consequence of the availability of staff. Obtaining extra staff is easier for the childcare centers on Wednesday and Friday because the childcare center can convince their staff to work extra days, while extra staff on other days requires recruiting off new staff which is difficult due to the shortage of staff.

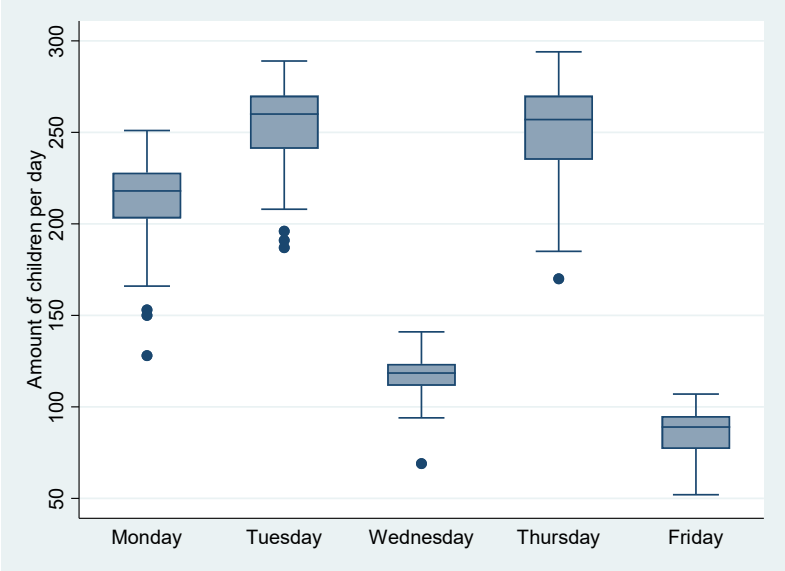

Figure 5: Distribution of number of children that visits the childcare centers per day.

Another day that significantly differs from the days with the highest occupancy (Tuesday and Thursday) is the Wednesday. The lower occupancy on this day is mainly because one of the parents will stop working on Wednesdays to "break the week in half". This effect will increase as soon as brothers or sisters are going to a regular school, which is closed on Wednesday in the afternoon.

As shown in Figure 5, Tuesdays and Thursdays have the highest occupancy. The resources (like the secluded parts of the building, and the square meters of inner- and outer space) of the childcare centers are aligned to cope with this higher occupancy. Thus, the less occupied days, will have an unused surplus of resources available (which are already paid). According to the management of the childcare centers within this research the biggest challenge to achieve growth is to convince parents to choose to use their services on Monday, Wednesday or Friday, mainly because there is almost no possibility to obtain extra days of childcare on Tuesdays and Thursdays.

4.2.2 Fluctuation between months of the year

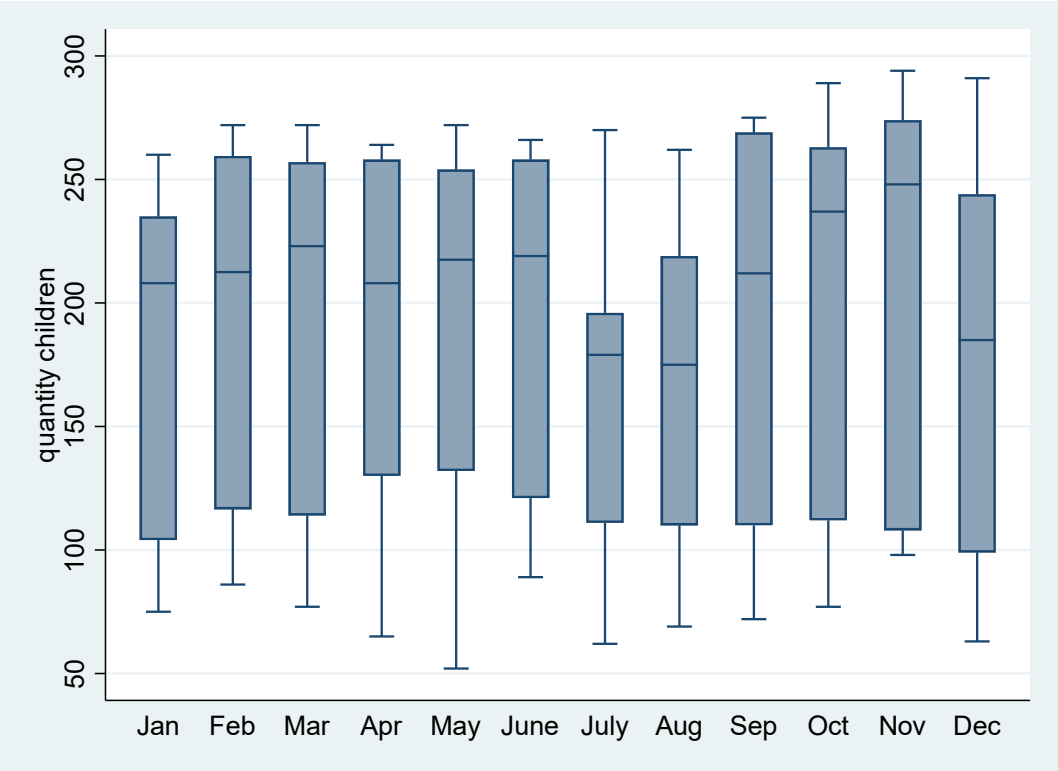

Figure 6: Distribution of number of children that visits the childcare centers between the moths of the year.

As seen in Figure 6 the distribution of the total amounts of children per subgroup is relatively equally distributed over the months per year. The averages in July and August are lower which is due to the summer holidays. Many people do not have to work during several weeks of these summer months. All the childcare centers anticipated on this by offering contracts with 48 weeks of child care which can freely be used during the year. This phenomenon also appears in December, where especially the days between Christmas and New Year's Eve are having a very low occupancy.

Besides the holidays, this boxplot is influenced by the number of Tuesdays and Thursdays that are included within a month (which are the days with the highest occupancy as seen in the previous paragraph). For example: April has a lower average number of children per day compared to March. March 2017 had five Thursdays and four Tuesdays which is more in comparison to April which had four Tuesdays and four Thursdays. Although December is different due to holidays, the growth of the child care centers in this research is visible in the period after the summer break, which is in accordance with the information that was obtained in the interviews with the managers of the childcare centers.

4.2.3 Fixed or flexible contracts

The childcare centers within these research offers different types of contracts. Besides a different number of weeks of childcare within a year (52 or 48 weeks) the contract may differ in the amount of days within a week. The days within a week are typically a fixed amount of days within a week and mostly the days within the week are laid down in the contracts. A parent can also obtain a flexible contract, in which the amount and distribution of the days may vary over time to suit the individual needs of the parents. These types of contracts are mostly used by parents who have jobs with fluctuating times and days within the week (for example jobs in healthcare).

Group	Children-days	Children-days within fixed contract	Children-days within flexibel contract	Children-days within fixed contract in %	Children-days within flexibel contract in %
C1B	6,242	6,069	173	97.2%	2.8%
C1T	5,356	5,283	73	98.6%	1.4%
C1	11,598	11,352	246	97.9%	2.1%
C2B	3,897	3,876	21	99.5%	0.5%
C2T	4,368	4,281	87	98.0%	2.0%
C2	8,265	8,157	108	98.7%	1.3%
C3B	3,477	2,838	639	81.6%	18.4%
C3T	4,599	3,826	773	83.2%	16.8%
C3	8,076	6,664	1,412	82.5%	17.5%
C4B	2,558	2,219	339	86.7%	13.3%
C4T	3,527	3,145	382	89.2%	10.8%
C4	6,085	5,364	721	88.2%	11.8%
C5B	5,490	4,636	854	84.4%	15.6%
C5T	6,800	5,682	1,118	83.6%	16.4%
C5	12,290	10,318	1,972	84.0%	16.0%
Total	46,314	41,855	4,459	90.4%	9.6%

Table 2: Distribution of fixed and flexible contracts by group (every n represents a day of childcare).

Table 2 shows that most contracts the childcare centers within this research has are fixed contracts. The management of these childcare centers prefer fixed contracts over flexible contracts mainly due to the challenges flexible contracts cause. When a group contains multiple flexible contracts, the childcare center should have enough capacity available in planning for these children to come to the childcare center, but it might be possible that these children won't come to visit the center on these days. In these cases, the childcare center might have reserved too much space (but often not professionals, because these professionals are planned after the weeks of childcare are planned) which can possibly lead to a lower cp-ratio.

4.3 Regression analysis

The dependent variable in this study is the cp-ratio and is calculated by dividing the number of children by the number of professionals needed. To better understand the fluctuation in the cp-ratio a regression analysis is done to obtain knowledge about the effect that different variables might have on the cp-ratio. This research investigates the influence of four different independent variables on the cp-ratio: the average age of the children, the number of children in a group, the type of group (babies or toddlers) and the number of flexible contracts within a group. This section will use multivariable linear regression analyses to better understand the impact of these independent variables on the cp-ratio.

4.3.1 Multivariable regression analysis

To control for possible spurious effects regarding the independent variables, a multivariable linear regression analysis is performed, including all the aforementioned independent variables in one model. Especially the effect of the variables average age and the type of group (baby or toddler) could possibly cause a spurious effect because the average age in a group of toddlers is by definition higher than the average age in a group of babies.

The cp-ratio (number of children divided by the number of professionals) is highly depending on four variables which results in the formula:

$$Y = \beta_0 + \beta_1 * \text{avg age} + \beta_2 * \text{NCG} + \beta_3 * \text{BABY} + \beta_4 * \%\text{Flexible}$$

In which:

Y = The cp-ratio (number of children divided by the number of professionals)
avg age = The average age in days of the children visiting the group
NCG = The number of children within a group on a given day
BABY = dummy variable, 0 for group of toddlers, 1 for group of babies
%Flexible = The amount of children in the group with a flexible contract

All the ten groups within this research are included within this multivariable regression analysis. Every group contains around 253 days of childcare within 2017 (total n = 2,524). As seen in the

outcome of the multivariable regression analysis (Table 3) especially the average age (in days) is a good indicator of the cp-ratio of children per professional. The higher the average age, the higher the cp-ratio (b=.0027, p=.000). The low standard error in relation to the coefficient indicates little variation within the cp-ratio. Besides that, the average age in days can vary strongly from 432 days in group C to 1,179 days is group B. Therefore, the coefficient of the average age in days has the possibility to be multiplied by a high amount, resulting in a bigger movement of the cp-ratio (difference of 747 days, resulting in an adjustment of the cp-ratio of 2).

Source	SS	df	MS	Number of obs	=	2,524
				F(4, 2519)	=	788.99
Model	2370.69532	4	592.673831	Prob > F	=	0.0000
Residual	1892.21987	2,519	.751178989	R-squared	=	0.5561
				Adj R-squared	=	0.5554
Total	4262.9152	2,523	1.68962156	Root MSE	=	.86671

cpratio	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
Avgage	.0026855	.0001694	15.85	0.000	.0023532	.0030177
NCG	.0117191	.0017902	6.55	0.000	.0082086	.0152296
Baby	-.2395563	.1048656	-2.28	0.022	-.4451878	-.0339248
Flexibel	-.009546	.0025026	-3.81	0.000	-.0144534	-.0046386
_cons	2.995533	.1942112	15.42	0.000	2.614703	3.376363

Table 3: Multivariable linear regression analysis

Besides the average age, the number of children per group also influences the cp-ratio. A higher number of children per group will increase the cp-ratio of children per professional (b=.0117, p=.000). An increase of four children, for example, will increase the cp-ratio with almost 0.05 (4 * .0117). Knowing this, the childcare center should try to increase the number of children per group (most desirably by obtaining more (new) customers). As mentioned in section 3.3.1 this is hard for the childcare center because of the fluctuation in demand within the week. The number of children on Mondays, Wednesdays and Fridays could be higher (due to restrictions in capacity, Tuesdays and Thursdays are harder) but the demand for these days is lower. Increasing the demand on these days, possibly by using incentives, could improve the cp-ratio of children per professional.

The effect of the type of group (babies or toddlers) has the highest coefficient but because this is a dummy-variable, the possible impact is smaller. The coefficient of -0.2396 cannot be multiplied because of the fact this is a dummy-variable (0/1). Nevertheless, this effect cumulates with the difference in average age, a group of babies will also have a lower average age, which will also cause a decrease in the cp-ratio. Besides this, the multivariable regression analysis shows that the more children with a flexible contract a group contains, the lower the cp-ratio will be (b-.0096, p=.000). The percentage of children with a flexible contract varies in the data from 0.54% until 18.38%, this difference will cause an effect on the cp-ratio of 0.17.

4.3.2 Collinearity

By definition the average age of children within a group and the type of group (bay or toddler) correlate high, which can result in collinearity problems in the regression analysis. The variables are checked whether this collinearity indeed occurs, to check for possible other variables that might mitigate the effects of collinearity. Therefore, the correlation between the variables and the variance inflation factor within the regression are measured, which are shown in Table 4.

	Avgage	NCG	Baby	Flexibel
Avgage	1.0000			
NCG	0.0990	1.0000		
Baby	-0.9438	-0.1201	1.0000	
Flexibel	-0.0672	-0.0498	0.0460	1.0000

Variable	VIF	1/VIF
Baby	9.24	0.108255
Avgage	9.22	0.108515
NCG	1.02	0.981413
Flexibel	1.01	0.990454
Mean VIF	5.12	

Table 4: Correlation between variables and variance inflation factor.

This table shows, as expected, a high correlation between the two independent variables average age of children within a group and the type of group (-.9438). To investigate whether both independent variables influence the cp-ratio, the multivariable regression is also performed both without the variable average age or the type of group. The result of the regression analysis without the type of group shows that all three remaining independent variables are still very significant (p=.000). When the type of group is included, and the average age of children is excluded then the significance of the type of group changes from p=.022 (see Table 3) to p=.000 (see Table 5). The R-square will only grow from .5552 to .5561 by adding the type of group within the regression analysis. Because of the high VIF and the high correlation between the average age and the type of group and the small change of the R-square-value, the regression analysis is performed with three variables: average age of children, number of children per group and the types of contract (fixed or flexible). The results of this regression analysis are showed in Table 5.

Source	SS	df	MS		
Model	2366.77526	3	788.925087	Number of obs	= 2,524
Residual	1896.13994	2,520	.752436482	F(3, 2520)	= 1048.49
Total	4262.9152	2,523	1.68962156	Prob > F	= 0.0000
				R-squared	= 0.5552
				Adj R-squared	= 0.5547
				Root MSE	= .86743

cpratio	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
Avgage	.0030506	.0000562	54.24	0.000	.0029403	.0031609
NCG	.0120614	.0017854	6.76	0.000	.0085604	.0155625
Flexibel	-.0092237	.0025007	-3.69	0.000	-.0141275	-.00432
_cons	2.575445	.0625129	41.20	0.000	2.452863	2.698027

Table 5: Multivariable regression analysis.

4.4 Current situation

Based on Table 1, and the number of children who visited the childcare center in 2017 on a specific date, the number of professionals is calculated. Dividing the number of children by the number of

professionals will result in the cp-ratio for each group and an overall cp-ratio. This is done before and after merging of groups because this will be an issue in the solution design. Merging these groups (as mentioned in section 3.2.2) can decrease the number of professionals. In the case of these five childcare centers merging the groups decreases the amount of professional(days) by 962 (a decrease of 9.38%). In total, for the 46,314 days of childcare, the childcare center needs to hire a total of 9,298 days of professional labor.

Group	Children-days	Professional-days needed before merging	Professional-days needed after merging	Decrease in professional-days needed after merging	Decrease in professional-days needed after merging in %	Child-professional-ratio before merging	Child-professional-ratio after merging	Increase of child-professional-ratio by merging
C1B	6,242	1,569	1,468	101	6.4%	3.98	4.25	0.27
C1T	5,356	1,002	834	168	16.8%	5.35	6.42	1.08
C1	11,598	2,571	2,302	269	10.5%	4.51	5.04	0.53
C2B	3,897	1,061	970	91	8.6%	3.67	4.02	0.34
C2T	4,368	759	695	64	8.4%	5.75	6.28	0.53
C2	8,265	1,820	1,665	155	8.5%	4.54	4.96	0.42
C3B	3,477	930	865	65	7.0%	3.74	4.02	0.28
C3T	4,599	824	793	31	3.8%	5.58	5.80	0.22
C3	8,076	1,754	1,658	96	5.5%	4.60	4.87	0.27
C4B	2,558	739	623	116	15.7%	3.46	4.11	0.64
C4T	3,527	655	566	89	13.6%	5.38	6.23	0.85
C4	6,085	1,394	1,189	205	14.7%	4.37	5.12	0.75
C5B	5,490	1,336	1,187	149	11.2%	4.11	4.63	0.52
C5T	6,800	1,385	1,297	88	6.4%	4.91	5.24	0.33
C5	12,290	2,721	2,484	237	8.7%	4.52	4.95	0.43
Total	46,314	10,260	9,298	962	9.4%	4.51	4.98	0.47

Table 6: Current situation of professionals needed (with and without the merging of groups).

This table clearly shows the outcome of the multivariable regression analysis. All groups with a higher average age (as mentioned in section 3.2.4, group C1T, C2T, C3T, C4T and C5T) clearly shows higher cp-ratio's in comparison to the other groups with whom they are forming a childcare center. In general, it (not as clear as the average age) is visible that a childcare center with more days of childcare can obtain better cp-ratios. This table will be compared to the possible solution in the chapter solution design.

Knowing this situation and knowing the effect of flexible contracts on the cp-ratio a childcare center can calculate whether the flexible contracts influence the childcare center positively or negatively. Decreasing the number of flexible contracts with 8.6% (to 0%) will increase the cp-ratio with 0.08 to 5.06. From there, increasing the number of flexible contracts with 100% will lead to a decrease of cp-ratio of 0.92 to a cp-ratio of 4.14. Therefore, the difference between no flexible contracts (5.06) to 100% flexible contracts (4.14) is 22.2%. Given the fact that the hourly rate of a flexible contract (€ 8.48) is 18% higher compared to a flexible contract (7.18), the price difference seems reasonable to the extra costs (knowing that other costs will remain the same).

5. Solution design

5. 1 Description of heuristic

5.1.1 Objective of solution design

The objective of this solution design is to find an assignment of children to days to decrease the number of professional-days needed during a given week. It is assumed that the staff is paid for days worked within a month. This solution design will be executed by asking parents to use the childcare center on another day of the upcoming week (on a one-time basis) to decrease the number of professional-days needed on the day that a child is withdrawn. When the alternative day will not need an extra professional to take care of the children, this change of days will lead to the saving of one professional-day for the childcare center. Convincing parents to choose for other days of childcare on an occasional basis to improve the planning of the childcare center is an approach that the childcare centers within this research are not using (yet).

5.1.2 Constraints

During the use of the solution design, the constraints as mentioned in chapter 3 of this research should not be violated, which for example means a child can only be taken care of within their own group, own space within the childcare center and with their well-known professionals. Besides that, the solution design is not allowed to decrease the number of days within a week that a certain child visits the childcare center. Therefore, a child can only be moved within the same week. There are no constraints within this research regarding the contracts of the professionals because all the childcare centers are frequently using professionals with flexible contracts or professionals that are working for an employment agency. By decreasing the number of professionals needed, a childcare center can easily cancel one of the professionals with a flexible employability.

5.1.3 Example of solution design

Figure 7 shows an example of the solution design using two days within a week. The top blue boxes of the Figure represent the planning before using the solution and contains six children on Tuesday (every square indicates a child, the number in the square is the age of the child) and seven children on Thursday. In this example, one three-year-old child is switched from Thursday to Tuesday, which is indicated in the grey boxes in the middle of the figure containing a “+3” and a “-3”. The bottom blue boxes of the figure contain the groups after the change in days. Every box also includes the day, code of the group (which is shown in Table 1), the number of professionals needed and the cp-ratio.

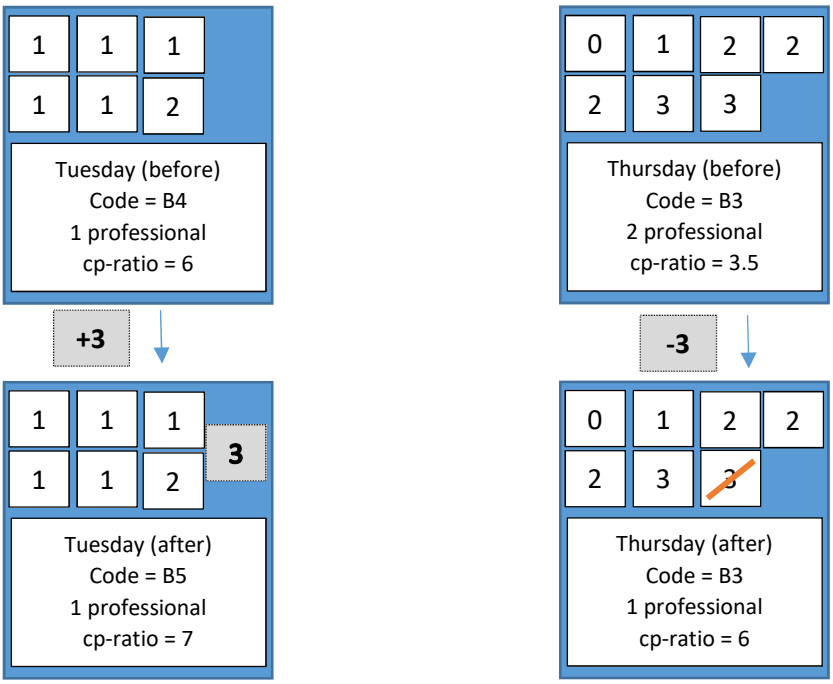

Figure 7: Possible example of solution design, showing that changing days for a child can decrease the number of professionals needed.

As seen in Figure 7, decreasing the number of children on Thursday will decrease the number of professionals that is needed on that day (top square has two professionals whilst the bottom square needs one professional). To achieve this decrease in the number of professionals the parents of the children within this group are asked to change the day of childcare. In this example, the parents of the three-year-old child decided to switch the Thursday for the Tuesday. The number of professionals needed on Thursday will decrease from two to one (and the number of children per professional will increase from 3.5 to 6). As an alternative for the Thursday, the three-year-old child will visit the childcare center on Tuesday. As seen in the left squares of Figure 7, adding the three-year-old to the group will not lead to an extra professional needed. This shows that by convincing the parents to change a day of childcare within a week to another day, can decrease the number of professional-days needed for the childcare center.

5.1.4 Input and output of solution design

The input for this solution design will be the initial planning for the upcoming weeks, which is mostly available at least two weeks in advance. The output of the solution design will be a new planning and show the amount of professional-days saved by using the solution design (which can be more than one per week).

5.1.5 Steps of the heuristic

The solution design of this research is divided in four different steps which are explained within this section. Section 5.2 of this thesis will calculate these steps, based on the data of this research. The steps of the solution design are as following:

1. Identify all the possibilities of removing one child that can reduce the number of professionals

To provide insight on the possible decrease in number of professional-days that can be obtained by the solution design, this section will use a heuristic method to obtain the possible advantage. Therefore, a sensitivity analysis is performed to investigate whether removing a child will lead to a lower number of professionals needed. This is done for every age (zero, one, two or three) because it does not matter which child will be removed. Because of a possible change in the code of the group (as mentioned in Table 1), the age does matter. At this stadium of the research it is not yet researched if an alternative is possible within the same week (which will be done in step 2). As an outcome of this step, a list of days that could improve the planning is generated, at every day of this list the age of children that can be removed to obtain a decrease in the number of professionals needed is mentioned.

2. Eliminate possibilities that have no alternative day

Section 5.2.1 finds possible decreases in the amount of professional-days needed by removing one child from a group. As mentioned in the explanation of the solution design, this child should be assigned to a different day within the same week. To investigate whether adding a child of a certain age will not lead to an increase of the number of professionals needed, a sensitivity analysis is performed. This analysis will show if adding one child (aged zero, one, two or three) will increase the number of professionals needed. After that, adding two children is investigated because that will make more improvements (during the same week) possible. After this, all the remaining possible improvements are investigated whether a change in days is possible due to the other days that the child already visits the childcare center by a heuristic process. When a change in days from Monday to Friday is suggested, but all these children are already visiting the childcare center on Friday, no decrease of professional-days is possible.

Because the parents of these children have their obligations during the week, it is likely that (if a parent wants to cooperate by not bringing the child to the childcare center on that specific date) this parent wants to use another day of childcare within the same week. Figure 8 shows an example in which removing the child (aged zero) from the Tuesday (as visible in the left squares of the figure) will decrease the number of professionals needed. However, adding this child on

another day of the week will increase the number of professionals needed which makes the switch needless and useless.

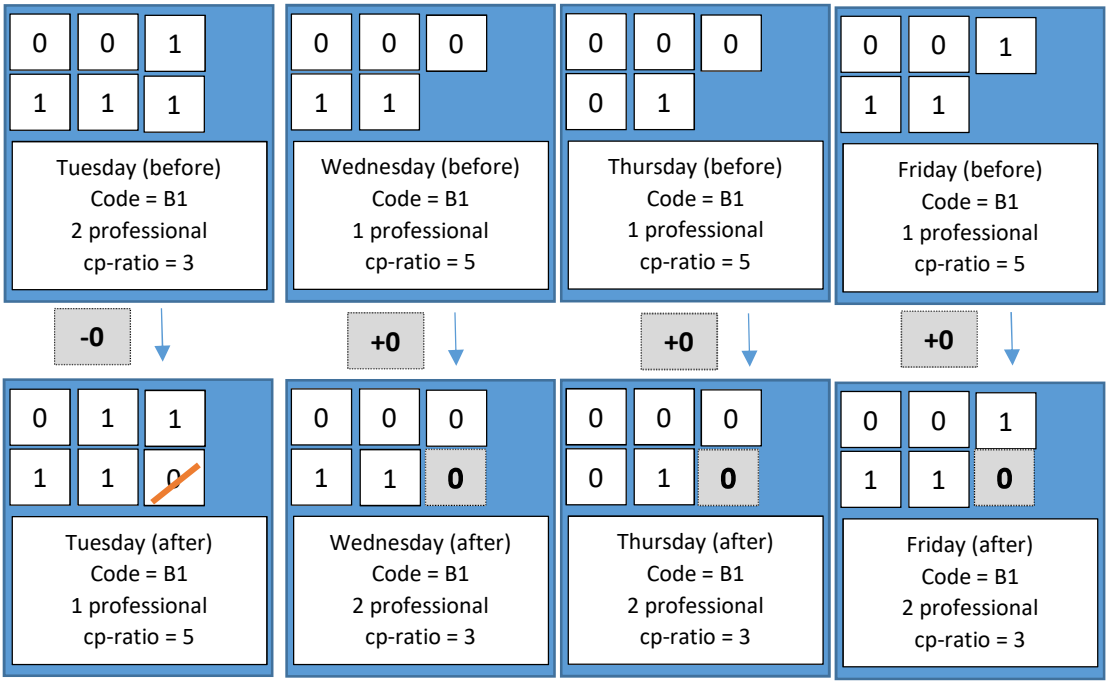

Figure 8: Example of lack of alternative days within the week (Monday is public holiday).

3. Eliminate incompatible improvements

Because the heuristic analysis, conducted in the previous two steps does not compare the different possible decreases in the number of professional needed, this paragraph compares the output of the two before mentioned sections. It might be possible that two possible improvements want to make use of the same day as an alternative day of childcare or that one day will be used for a possible decrease in the number of professionals and will be used as an alternative day for another possible decrease in professionals needed. For example, reducing the number of children on Tuesday and Thursday within a week will decrease the number of professionals needed. In the case that adding a child on Monday, Wednesday or Friday will increase the number of professionals these two possible improvements will not be able to do together. One possible decrease is possible, because removing on Tuesday and adding on Thursday is possible (or the other way around). Therefore, all the possible alternative days, are compared to the possible improvements. Days which are used as (the only) alternative and as possible improvement are merged into one single possible decrease in professionals needed.

4. Determine number of children able to change days

Every opportunity of improvement is analyzed to investigate which day within the same week can handle an extra child without the need of an extra professional (considering the age of the

children). When a child already visits the childcare center on the alternative days, these children are extracted from the possible solution design. Besides that, the analysis of this section considers that the removal of a child might lead to a different code to the group (as mentioned in Table 1) and therefore possibly a higher or lower number of professionals. The remaining number of children that can change days within the week are calculated within this paragraph for each possible decrease of the number of professionals. As an output of this step, a list of children that can change days, to decrease the number of professional-days needed is made available to the childcare center.

5.2 Applying the heuristic to real-life case

5.2.1 Description of data

Figure 9 shows a boxplot of the number of occurrences with a number of children in a group and the cp-ratio on that given day. The bigger the circle, the more it has occurred during 2017. This figure clearly shows lines for the number of professionals needed which is indicated at the left side of the line of dots.

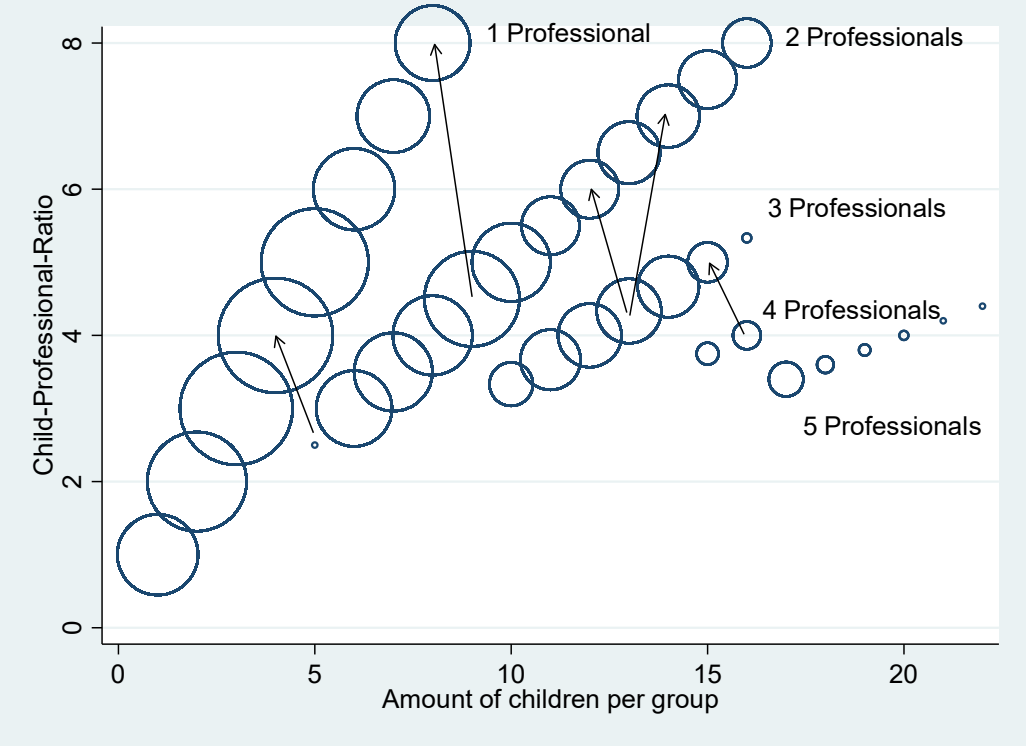

Figure 9: Possibilities of number of children per group and the cp-ratio as a consequence, the bigger the dots, the higher the number of appearances.

Figure 9 shows examples (not limited) of how a decrease in the number of children per group can lead to a higher cp-ratio (mainly because of the lower number of professionals needed) by placing arrows for possible decreases. The fourth arrow (from the left) shows a rarer case, in which adding a child can lead to a lower number of professionals needed (because of a changing in the group code).

Each type of group (from A1 to B6) has their own number of children per professional, therefore the unfavorable number of children within a group (where the last added child requires an extra professional differs for each type of group. For example, a B6 group, consisting of nine children needs two professionals where eight children need just one professional. Figure 10 shows a histogram of (unmerged) B6-groups. The columns between the red lines, where the number of children is nine or 17, represents the target for this solution design. This since decreasing the number of children from nine (two professionals) to eight (one professional) will result in the need of one professional less. The histogram of the other (unmerged) groups are included in the appendix.

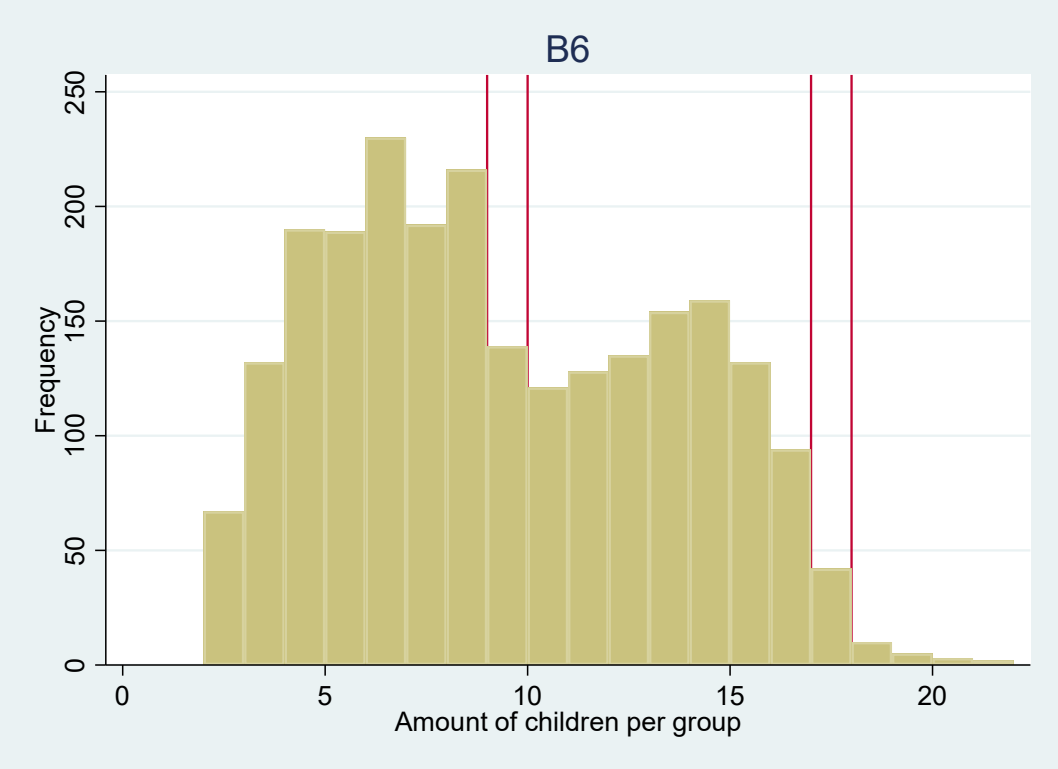

Figure 10: Amount of children in a "B6" group and the frequency it occurs.

The 139 B-groups with nine children and the 42 B-groups with 17 children, shown in the histogram, are not fully suitable for the solution design presented in the first paragraph. Especially the B-groups with nine children might be merged with another B6-group which contains less than eight children on that specific day. For that reason, a decrease of the number of professionals needed due to this solution design will not occur since the childcare center already secured the decrease of professionals by merging these groups. The opposite of this can happen as well, where two groups with four and five children, aged three and four, separately offers no possible decrease in the number of professionals needed by using this solution design. Merged, this group contains nine

children which makes it suitable for this solution design. For this reason, the merged and unmerged groups are considered by calculating the possible benefits of this solution design.

5.2.2 Results solution design

As mentioned in section 5.1.4 the potential benefits will be shown in four different steps. Each of these steps will be explained in this section. Section 5.2.2a shows the number of days were removing a child will decrease the number of professionals needed. Section 5.2.2b eliminates the possibilities in which making the switch to an alternative day, within the same week, is not possible. After that, section 5.2.2c will eliminate possible improvements if different options are not possible to be realized together. After that, Section 5.2.2d will calculate the number of children that are possible to make the change to obtain the desired decrease in number of professionals

5.2.2a Decrease in number of professionals when 1 child removed

Analyzing the current situation with the heuristics as mentioned in Section 5.1.4, this research finds 640 possible solutions for decreasing the number of professionals in a week by removing one child from a single group. Divided by five childcare centers, 128 professional-days can be saved on average per childcare center. With a maximum of 162 professional-days saved and a minimum of 102 professional-days saved the variation in the possible advantage is 60 professional-days. This possible advantage is mainly achievable in groups consisting of babies (383 over 257). With 178 possible improvements, Thursdays seems to be the most likely to achieve improvement in the planning followed by the Monday (140) and the Tuesday (138). Wednesdays (96) and Fridays (86) are less likely to achieve big improvements. In 373 times, the possible improvement originate in one single subgroup the other 267 possibilities of improvement originates in merged subgroups.

5.2.2b Eliminate possibilities that have no alternative day

As seen in the previous section, this research finds 640 possibilities to decrease the number of professionals on a certain day for all five childcare centers together by removing one child from a group. In 47 of the before mentioned 640 possibilities it is not possible for the childcare center to offer an alternative day of childcare within the same week, if the childcare center wants to obtain their advantage. In 42 out of the mentioned 47 cases, adding the child on an alternative day to their own group will result in the need of an extra professional (and therefore will be useless). In five of the 47 cases, children that need to exchange days within the week are not able to change because all the children (suggested for a change in days) are already visiting the childcare center on the alternative days within the week.

5.2.2c Eliminate incompatible improvements

Besides the limitations of possible improvement mentioned in section 5.2.1, the situation mentioned in the previous paragraph can decrease the amount of possible improvements. Two of the before

mentioned possibilities of improvement are not compatible as an improvement. In this case, making one child switch from Tuesday to Thursday will decrease the number of professionals by one. But otherwise, making one child switch from Thursday to Tuesday will have the same effect. Doing both will not affect the number of professionals, because the number of professionals will remain the same on both days. Therefore, these two possibilities are combined to one possible decrease of professionals in the data. Considering these restrictions in decreasing the number of professionals needed, 592 possible improvements are left to decrease the number of professionals needed. The distribution of these possible advantages by group are shown in Figure 11.

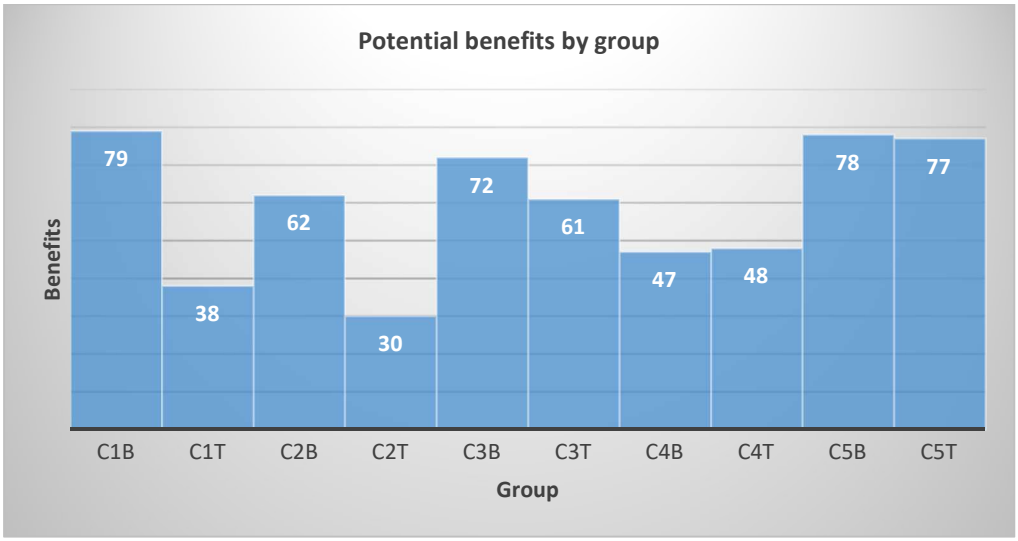

Figure 11: Potential benefits by group

5.2.2d Determine number of children able to change days

Section 5.2 investigates how many professional-days can be saved when one child can change the day to visit the childcare center. As seen in Table 1, a group consists of 16 children or less. Which child within a group will change the day will mostly not matter to the childcare center. When nine children form a group, that will need one professional less if one of them will switch days, will give the childcare center nine chances to be able to make the change in days. They can therefore approach nine parents, of which only one will have to agree with switching days. Thus, the more children can make the change, the better the chance is for the childcare center to decrease the number of professionals needed. Figure 12 consists a histogram of the number of children that can make a change in the day to visit the childcare center which will decrease the number of professional-days needed by one. For example, 24 days have a possibility to decrease the number of professionals by convincing the parents of one out of 17 children to change days within the week.

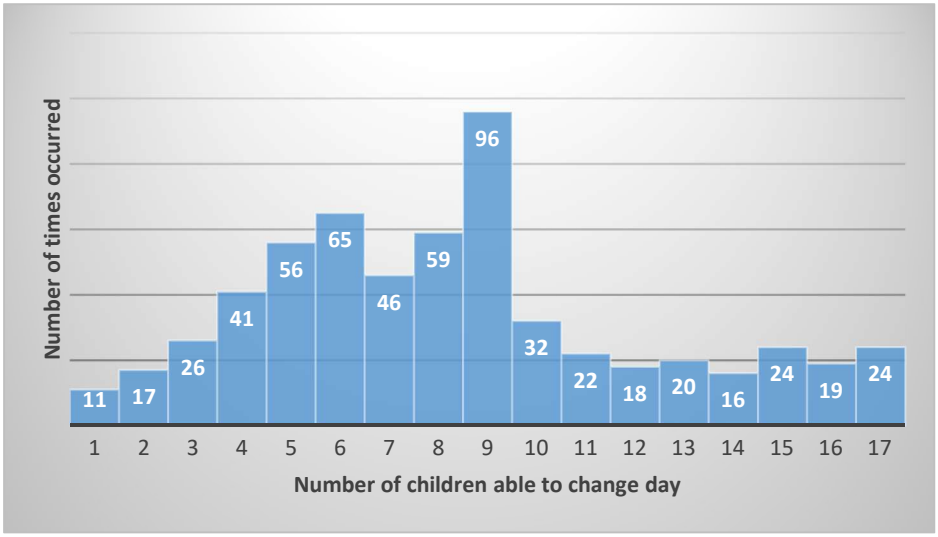

Figure 12: Number of children that can change days within the week and the number of occurrences.

5.2.3 Results of modeling parent behavior

Section 5.3 delivers the possible decreases in the number of professional-days needed and the number of children that are possible to change days within that same week, respecting all the constraints applicable. This section will calculate which decrease in professionals can be obtained given a certain flexibility of parents by individually analyzing the possible improvements and using the calculation of the expected value of a solution design.

As mentioned in the introduction, CBS explains the decrease in average hours of childcare by the more flexible working environment of parents. This flexibility is needed to make the solution design of this thesis work. To make this solution design work, parents should have the possibility to bring their child to the childcare center on another day within the week as originally planned. As seen in section 4.2.3 most parents have a fixed contract with the childcare center, most likely because their working environment encourages this routine. Parents with flexible contracts are less likely to be flexible towards the childcare center because they are using the flexibility of the childcare center to solve the lack of flexibility in their working environment.

The expected value of the decrease of number of professionals on a given day given a certain flexibility can be calculated by:

$$E(x) = 1 - P(x)^{n}$$

Where:

E(X) = is the expected value of the decrease in professionals needed on a certain day

P(x) = is the chance that a parent is not flexible to change days

N = the number of children that can change days.

Section 5.3 shows a histogram of the number of children that can switch days within a week. If parents were fully willing (an able) to corporate, 592 professional-days could be saved over the complete year of 2017. Figure 13 shows the expected decrease of professional-days given a different percentage of flexibility of parents by the calculated expected value. This flexibility contains the factor of being able to change days and willing to make the change in days (possible by being offered an incentive).

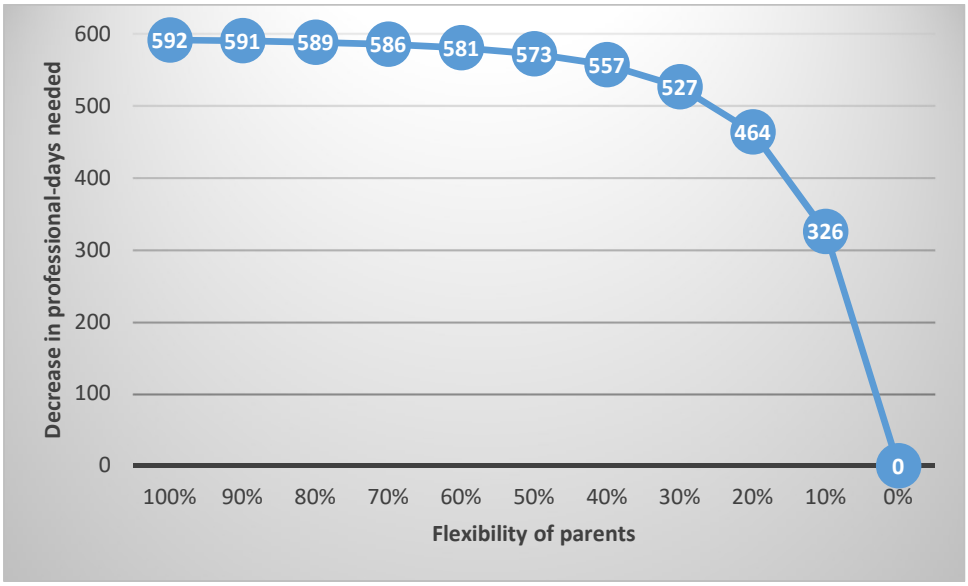

Figure 13: Decrease in number of professionals needed given a certain flexibility of parents.

This graph clearly shows that as soon as the flexibility of parents is decreased, the expected value of the decrease in the number of professional-days needed will decrease as well. Because most days have multiple chances (since just one of the children needs to change days) a decrease in flexibility from 100% to 90% will only lower the total expected value with one professional-day. Given a flexibility of 50%, the expected value is 573, which is 3% less compared to 100% flexibility. Even when the flexibility drops 80% to a given flexibility of 20%, the expected value of the solution design drops with 11% and 65 professional-days to a total of 527.

5.3 Discussion of practical implementation

5.3.1 Sequence of approaching parents

To make the parents change days in which day will bring their child to the childcare center the parents should be approached. All the childcare centers within this research are using a custom build

portal, which can also be used to send messages or questionnaires to a designated group of parents (in case the parents that are suitable for the solution design within a certain week). These surveys could also be made unavailable as soon as one of the parents chooses to change days. Since the children are interchangeable within this solution design (because removing or adding a child within the same age category will result in the same effect, a possible different effect due to age is excluded in section 5.2.2d) it does not matter which of the children is able to change days. The childcare center should inform parents that the offered change (and the possible incentive) is only given to the parents of one child.

5.3.2 Possible incentives

As stated in chapter two of this thesis, costumers are more likely to make decisions in favor of their service provider when they are encouraged to do so by an incentive. Although this research does not study the quality and effectiveness on these incentives, this paragraph introduce a possible incentive including the consequenses and availability of this incentive. Because of the possible negative impact, this research will not use dynamic pricing because of the possibility of the perception of undair pricing. A childcare center might choose to give parents, who choose to change days, an extra half day of childcare for free (maybe a full day is needed to convince parents). This day can only be used in consultation with the childcare center when this extra child will not force the childcare center to schedule an extra professional. Because of that, the childcare center will only have to pay for extra diapers and food, no other extra costs will occur.

Figure 14: Number of days available that can be given to parents as an incentive

To offer an extra (half) day of childcare (without the need of an extra professional), these places need to be available within the childcare center. To investigate whether these days are available, a sensitivity analysis is done which shows if an extra professional is needed when the amount of children is raised by one in the same age category (this sensitivity analysis could possibly extract

points of data that are also part of the possible benefits in section 5.2). All the groups together (10 in total), have 1,733 days (out of 2,600 days) where adding a single child will not influence the amount of professionals needed. Figure 14 shows the distribution of these posibilities over the childcare centers and the groups.

As seen in section 4.2.1 the distribution of the days within the week are far from equal. Therefore it is expected that especially Tuesdays and Thursdays are less likely to be used as an incentive (because of the limitation that no extra professional is needed). Figure 15 shows that these two days have indeed a lower amount of possibilities to be used as an incentive. The Thursday (with 278 possibilities) still has the possibility to be used as an incentive in more than 50% of the cases (10 childcare centers with 52 weeks, makes 520 possibilities). Therefore, this paragraph concludes that giving an extra (half) day of childcare (without the need of an extra professional) is achievable with the current occupation.

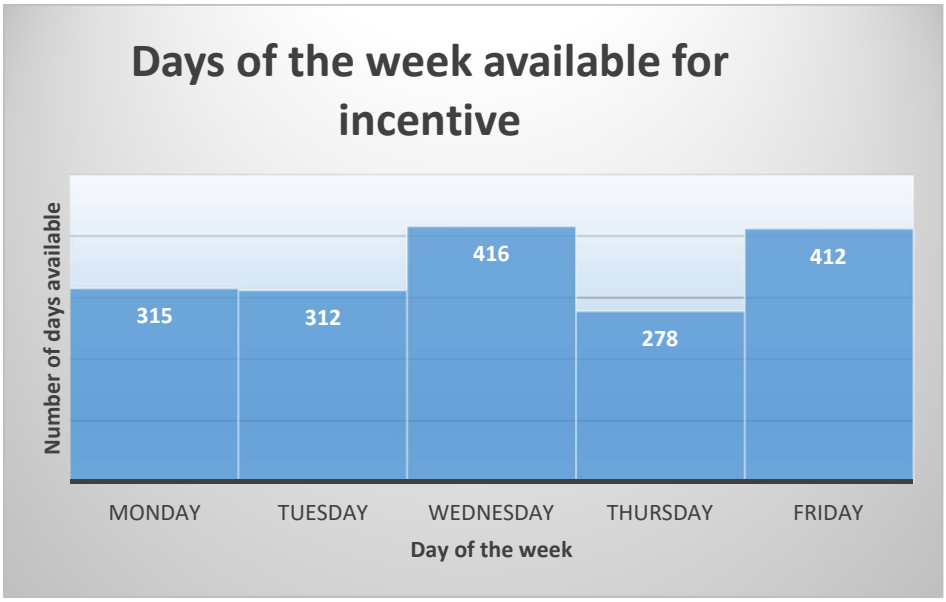

Figure 15: Days of the week available to give to parents as an incentive and number of occurrences.

6. Conclusion and recommendations

6.1 Conclusion

As mentioned in the introduction, the costs for wages are the biggest sort of costs for a childcare center. Knowing that, saving costs on professionals needed will have a great impact on the profitability of a childcare center. The solution design of this research suggest that the childcare centers can proactively approach parents to incidentally change the days in the week in which they are using the service of the childcare center. The childcare center does this, knowing the planning of the upcoming week and therefore knowing, when a decrease in professionals is possible. To convince parents to change these days, the childcare center can offer an incentive for the parents to make the desired change in days.

Table 6 shows the possible advantages for the childcare centers, divided by group and childcare center. This table shows that the possible advantages vary given a certain flexibility (and willingness) of parents to change days. If this flexibility is at 100%, 592 professional-days can be saved using this solution design. But even with a flexibility of 25%, 502 professional-days (and 5.4% of the normal amount of professional-days needed) can be saved within the childcare centers. At this flexibility of 25%, childcare center 3 can take the biggest advantage out of this solution design by saving 7% of their needed amount of professional days (116 days). Childcare center 2 will need “only” 4.3% of professional-days less according to the normal situation.

Knowing this, a childcare center can choose whether to implement this solution design in their childcare center. A childcare center can also choose their incentive for convincing parents to change days in favor of the childcare center. Improving the flexibility (and willingness of parents (over the five childcare centers together) to change days from 25% to 50% will increasing the savings from 502 professional-days to 573 professional-days, the childcare center can therefore choose a bigger or smaller incentive. Trying to improve flexibility from 50% to 75% is less profitable, because this will save 15 professional days (588 minus 573) instead of 71 professional days (573 minus 502).

Knowing the possible savings, the childcare centers can make the decision whether to implement the solution design of this research. Each childcare center can obtain their possible advantages out of Table 6 and need to compare these savings to the costs of implementing this solution design and the costs of the incentive the childcare center wants to use. Whether or not the childcare center wants to implement this solution design, this research shows that substantial savings (up to 7% of the biggest costs of the childcare centers) can be obtained.

	Current situation			100% flexibility of parents				75% flexibility of parents				50% flexibility of parents				25% flexibility of parents			
	Children-days	Professionals needed current situation	cp-ratio	Professionals needed 100% flexibility of parents	Decrease in professional-days needed	Decrease in professional-days needed in %	New cp-ratio	Professionals needed 75% flexibility of parents	Decrease in professionals needed	Decrease in professional-days needed in %	New cp-ratio	Professionals needed 50% flexibility of parents	Decrease in professionals needed	Decrease in professional-days needed in %	New cp-ratio	Professionals needed 25% flexibility of parents	Decrease in professionals needed	Decrease in professional-days needed in %	New cp-ratio
C1B	6,242	1,468	4.25	1,389	79	5.4%	4.49	1,390	79	5.3%	4.49	1,391	77	5.2%	4.49	1,401	68	4.6%	4.46
C1T	5,356	834	6.42	796	38	4.6%	6.73	796	38	4.5%	6.73	797	37	4.5%	6.72	799	35	4.2%	6.70
C1	11,598	2,302	5.04	2,185	117	5.1%	5.31	2,186	116	5.0%	5.31	2,188	114	5.0%	5.30	2,200	102	4.4%	5.27
C2B	3,897	970	4.02	908	62	6.4%	4.29	910	60	6.2%	4.28	914	56	5.8%	4.27	925	45	4.6%	4.21
C2T	4,368	695	6.28	665	30	4.3%	6.57	665	30	4.3%	6.57	665	30	4.3%	6.56	669	26	3.8%	6.53
C2	8,265	1,665	4.96	1,573	92	5.5%	5.25	1,575	90	5.4%	5.25	1,579	86	5.2%	5.23	1,594	72	4.3%	5.19
C3B	3,477	865	4.02	793	72	8.3%	4.38	793	72	8.3%	4.38	795	70	8.1%	4.37	805	60	6.9%	4.32
C3T	4,599	793	5.80	732	61	7.7%	6.28	732	61	7.7%	6.28	733	61	7.6%	6.28	737	56	7.1%	6.24
C3	8,076	1,658	4.87	1,525	133	8.0%	5.30	1,525	133	8.0%	5.29	1,528	130	7.9%	5.29	1,542	116	7.0%	5.24
C4B	2,558	623	4.11	576	47	7.5%	4.44	577	46	7.4%	4.43	579	44	7.0%	4.41	589	35	5.5%	4.35
C4T	3,527	566	6.23	518	48	8.5%	6.81	518	48	8.4%	6.80	519	47	8.3%	6.80	523	44	7.7%	6.75
C4	6,085	1,189	5.12	1,094	95	8.0%	5.56	1,095	94	7.9%	5.56	1,098	91	7.6%	5.54	1,111	78	6.6%	5.48
C5B	5,490	1,187	4.63	1,109	78	6.6%	4.95	1,109	78	6.6%	4.95	1,111	76	6.4%	4.94	1,122	65	5.5%	4.89
C5T	6,800	1,297	5.24	1,220	77	5.9%	5.57	1,220	77	5.9%	5.57	1,221	76	5.8%	5.57	1,228	69	5.3%	5.54
C5	12,290	2,484	4.95	2,329	155	6.2%	5.28	2,330	155	6.2%	5.28	2,332	152	6.1%	5.27	2,350	134	5.4%	5.23
Total	46,314	9,298	4.98	8,706	592	6.4%	5.32	8,711	588	6.3%	5.32	8,725	573	6.2%	5.31	8,797	502	5.4%	5.27

Table 6: Effect of solution design

6.2 Extrapolation of conclusion

As seen in the last section, given a flexibility of parents of 50%, a childcare center can obtain a decrease in costs of staff 6.2%. As mentioned in the introduction, a childcare center spends 68% on average of their revenue on staff. Based on costs, around 70% of the costs are related to cost of staff. Based on the total costs, a childcare center can obtain a decrease of 4.34%. This advantage can, and probably partly will be, calculated in the hourly rates. Knowing the lower costs for the childcare center, it is likely that the Dutch government will lower their contributions to parents as well.

If the Dutch government will indeed lower their contribution to keep the childcare affordable the savings for the Dutch government can vary based on the percentage the Dutch government will choose to lower the contribution, which will always be a political debate in the Netherlands. If the Dutch government will lower their contribution with the same percentage as a childcare center can lower their costs, the Dutch government will save almost 105 million euros based on the expenses of 2016. This advantage will probably grow in the future because of the rising number of children visiting childcare centers in the Netherlands.

As mentioned in the introduction, on average, a family pays € 5,500 on childcare on a yearly basis, after the contribution of the Dutch government. If the childcare center will lower their hourly rates by the same percentage as they are able to lower the costs, a family can save almost € 240 per year. This amount can vary strongly based on the contribution by the government for a single parent. This contribution can vary from 33.3% (first child and a family income of a least € 99,999 a year) to 95% (second child and a family income € 22.117 a year or lower).

6.3 Limitations

This research is conducted with data of five childcare centers in the middle of the Netherlands. In total, the Netherlands had 7,499 childcare centers and all in different sizes. The results of this research, and the possible benefits in amounts of professional-days needed, can possibly differ for different childcare centers. Therefore, calculating the possible benefits for other childcare centers should be done with care, because these childcare centers may differ in size, effectiveness of planning, distribution in demand or other variables. Although, this research shows that significant benefits can be achieved and found no reason for the assumption that other childcare centers could not achieve this decrease in professional-days needed. In section 6.2, the conclusion of this research is extrapolated. These numbers should be viewed with extreme caution. Although there is no reason to think that the five childcare centers are not representative for the entire population, they represent only a very small part of the population. Therefore, the possible savings could vary which could influence the total savings for the Dutch government.

The data of this research was extracted from the list that the childcare centers need for the common health service (GGD) containing the realized occupation during a given day. Out of this data, this research extracts possible improvements in the planning. On an occasional basis the planning may differ from the realized occupation (for example due to illness), therefore it might be possible that some of the improvements found in this research, could not be realized beforehand. The possible effect of this is not measured, because insufficient data is available to do so. Nevertheless, the expected deviation because of this is expected to be very low. Some possibilities might disappear because of this reason, but it is very likely that other opportunities to decrease the number of professionals might occur.

To measure the improvement of the solution design, chapter 6 shows a comparison between the amount of professional-days needed before and after the solution design. Both situations are calculated using the data. Therefore, it might be possible that the used amount of professional-days may differ from the calculated need of professional days. Because of this, an inefficiency in planning (where more professionals are used above the minimum needed) is considered not to exist. The situation before using the solution design and after using the solution design is better because of this (the comparison is made on same assumption) but might differ from the number of professional-days that were used by the childcare center.

6.4 Further research

6.4.1 Unknown flexibility of parents

The solution design shows a possible decrease in professional-days needed given a certain flexibility of parents. Further research should be done to investigate whether parents are indeed able to change days because of their flexible working contracts, as the CBS mentioned. Knowing this, the childcare centers have a better understanding in the possible advantages of this solution design and can therefore better choose whether to implement this solution design within the childcare center. This research can be done by asking the parents about their flexibility in surveys that the childcare centers already do to measure customer satisfaction.

6.4.2 Incentives for parents

As seen in chapter 2, incentives might influence your customers, and therefore demand, in a positive way. Chapter 5 of this research suggested to grant parents with extra day(s) of childcare if they are willing to change days in favor of the childcare center. This research does not investigate whether this incentive will increase the number of parents willing to change the days of childcare within a week on an occasional basis. More extremely, these incentives might even lead to a negative attitude towards the childcare center because of a possible perception of price unfairness and will therefore change the behavior in a way that can harm the childcare center. Therefore, further research should

be done on the incentive (or possibly no incentive at all) that should be given to the parents before implementing the solution design of this thesis.

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