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CALENDAR AND SEASONAL EFFECTS ON THE SIZE OF WITHDRAWALS FROM ATMS MANAGED BY EURONET

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ABSTRACT

This study analyses the calendar effects on withdrawals from Automated Teller Machines (ATMs) (daily data) managed by the Euronet network for the period from January 2008 to March 2012. Our study focuses on the identification of specific calendar and seasonal effects in the ATM cash withdrawal series of the company in the Polish provinces of Małopolska and Podkarpackie. The results of the analysis show that withdrawals depend strongly on the day of the week. On Fridays more cash is withdrawn than on other days, and Saturdays and Sundays are the days of the week with the lowest level of withdrawals. In a month, it can be seen that cash withdrawals take place more often in the second and in the last weeks of the month. This observation suggests that withdrawals from ATMs can be related to the profile of wage withdrawals. In Poland, in the public sector wages are paid at the beginning of the month, and in the private sector at the end of the month. The time series of withdrawals also reflect seasonality. The largest amounts are withdrawn in July, August and December. Reason for the increased demand for cash are the summer holidays and the Christmas season. The results reflect consumer habits which show pronounced calendar and seasonal effects.

Key words: calendar effects, seasonal effects, replenishment management.

1. Introduction

The most important virtual banking services are phone banking, mobile banking, Internet banking and ATM banking. Banks collect large amounts of data on their customers. They try to use these data in order to make better decisions. Trends and seasonal patterns of behaviour that are reflected in the data may be used to improve a bank's customer value management strategies. This is important with respect to risk management, profit maximization, fraud detection

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and marketing (Bretnall et al. 2008). On the basis of trends and seasonal patterns econometric models may be suitable for short-term forecasting. These forecasts may help to adjust the replenishment to the need of customers and at the same time to avoid a large, unnecessary (and unproductive) cash flow waiting in ATMs for their customers instead of being profitably invested.

In the last two decades of the 20th century *Automated Teller Machines*, which formed ATM networks, were an important addition to the banking system. The first ATM was installed in New York in Chemical Bank at the end of the seventies. This dynamic rise in the number of ATMs in recent years has reached saturation level (this is the upper bound of the number of ATMs necessary to fulfil the needs of the inhabitants of a country) in developed countries. As per the data for 2009, the relative availability of ATMs is found to be highest in Canada (1,800), followed by the USA (1,382) and Australia (1,230). In some countries the number of ATMs installed has shown a tendency to fall (Gerdes et al., 2005, Schmitz and Wood, 2006). The reason for this observation is the policy of banks. From the point of view of bank managers the distribution of cash by ATMs generates significant costs.

In addition, using ATMs reduces deposits and, therefore, the profits of banks have a tendency to decrease. However, the elimination of cash flow through ATMs would not be desirable for banks because many bank clients prefer cash services. Therefore, the elimination of ATMs could mean the loss of many clients (Takala and Viren, 2007). Many banks regard ATMs as important tools that can reduce banking transaction costs, excessive personal costs, branching costs, etc.

This is true especially in the case of villages and small towns in developed countries and in developing countries, where cash is still the main medium of transactions.

As Kumar and Kumar (2014) stress, the use of Automated Teller Machines (ATM) in India is so popular that many people understand ATM as Any Time Money. In metropolitan cities in India, if you walk half a kilometre in any direction, then you will get at least one ATM. On the basis of the information we can imagine the importance of ATM in the day-to-day life of many people across the world.

One of the benefits of ATMs in recent years has been that a person holding a card of any bank can withdraw money from an ATM of any other bank, although the number of transactions without charge is limited in different countries (in India to 5 per month).

The first ATM in Poland was installed in the late eighties in the division III of PeKaO in Warsaw. However, the ATM started to play a significant role in Poland at the end of the nineties.

The increase in the number of ATMs implies a rise in operations, the share of ATMs in cash operations and in the turnover in ATMs. The number of ATM operators has also increased. Empirical studies have proved a significant statistical dependence between the number of ATMs and the number of ATM networks operating in a city, region or country.

The Euronet network was created in 1994 in Budapest. In the same year it installed the first ATM in the Hotel Marriott in Warsaw. Meanwhile, the number of ATMs operated by Euronet expanded rapidly. Currently, the total number of ATMs in the Euronet network amounts to approximately 4.5 thousand. Its share in the total number of ATMs installed in Poland is approximately 25%. The total number of withdrawals from Euronet ATMs in the first quarter of 2012 was approximately 2.5 billion PLN.

The management of this large network has become an important issue. The most important keywords of the management process are ATM localization, the size of replenishment, the time of replenishment and the convoy logistics. These factors incur most of the costs of operating the ATMs which are covered by Euronet. When it comes to reducing the cost of operating ATMs the forecasting of cash withdrawals from ATMs may have an essential role. Correct forecasts can contribute to a reduction in ATM management costs; there should not be too much inert money, which does not generate any profit in ATMs. However, an ATM may not be empty, which is very important from the point of view of customer satisfaction. This topic also seems to be important from other points of view. The revenue of the network operator is proportional to the number of transactions. The size of withdrawals has no impact on revenue. The number of withdrawals is a stable variable, so that the number of withdrawals may be one of the exogenous variables which explain the size of withdrawals. Moreover, the size of withdrawals can be forecasted by the number of withdrawals - we can use the average withdrawal as a proxy.

In addition, forecasting the number of withdrawals is important with respect to the throughput of an ATM. The lack of queues is a very important issue from the point of view of customer satisfaction.

The prediction of cash demand from a given ATM makes it possible to determine the risk level and replenishment strategy. Forecasts must take into account not only the number and nature of people in the neighbourhood of an ATM but also the behaviour and habits of potential customers of the ATM. Since withdrawals have the structure of time series in modelling, there should be taken into account not only systematic factors but also stochastic determinants. The time series of withdrawals show “calendar effects” in particular. This means that the size of withdrawals depends usually on the season, month of the year, day of the week, time of the day, etc. The identification of calendar effects is of great importance with respect to the choice of strategy and principles for the replenishment of ATMs.

This paper mainly deals with calendar and seasonal effects, therefore the second section of this paper provides an overview of the literature concerning the calendar effect and questions which arise from ATM management. Section 3 describes the dataset and gives the most important descriptive statistics with respect to different localizations of ATMs. In the following sections the results are presented and calendar effects are analyzed. A summary of results is given in the concluding section.

2. Literature overview

The research on statistical properties of time series of the number of withdrawals from ATMs is important with respect to building relevant forecasting models for the ex ante prediction of withdrawals. The owners of ATM networks can use the forecasts in two ways. First of all. the network operator supplies services to debit card issuers. This is a source of income (charges – the so-called interchange) for every transaction conducted.

Proper forecasts make it possible to determine the total charges for using ATMs. In addition, the forecasting of withdrawals is an important factor for managing replenishment in ATMs. Proper withdrawal forecasts can reduce the costs of managing ATMs.

ATM cards became a common part of life in the last 30 years. However, the statistical properties of withdrawals from ATMs have not yet been investigated thoroughly, with respect to several aspects, from both a theoretical and practical point of view.

A better knowledge of consumer habits is very important with respect to the replenishment strategy of ATMs (Galbraith and Tkacz, 2007). An understanding of these habits may be helpful in the prediction of individual consumption (Esteves, 2009, and Duarte et al., 2016) or in forecasting the retail sales statistics (Carlsen and Storgaard, 2010).

Holden and El-Bannany (2004) demonstrate that Automated Teller Machines (ATMs) play an important role in increasing Return On Asset (ROA) in their analysis of banks in the United Kingdom. Kondo (2010) investigates whether this conclusion also applies to Japanese banks. He finds that ATMs do not have any influence on ROA of Japanese banks. However, he documented that ATMs had positive effects on fees and commissions (income) from 2000 to 2003, and positive effects of ATMs on interest income have also been seen recently. Kondo (2010) concludes that in Japan, ATMs do not influence ROA, which includes the overall profits of bank transactions. However, they contribute to particular businesses in that they can make the most of their abilities.

A study by Snellman and Viren (2009) reported results on the dependence between the structure of banking systems, the number of ATM networks and the location of ATMs.

Calendar effects are frequently observed in economic time series, including financial time series. This follows from the observation that most economic time series depend directly or indirectly on hours, days, months, quartals and other time intervals. The phenomenon of the time dependence of the investor, customer, and consumer activity on time were discovered in the seventies by Cleveland and Devlin (1980) and Liu (1980). They stressed the importance of the number of working days in the week and their link with seasonal effects. These data determine the dynamics of the time series being studied to a large extent. The importance of seasonal effects is reflected in updating these effects in statistics

(national accounts). National accounts update not only seasonal effects but also effects of working days in the period being studied.

Beside the number of working days, the day of the week, the week of the month, the month of the year and other calendar effects such as national or church holidays also have an impact on the dynamics of respective time series. Findley and Monsell (2009) stressed that there is a necessity to take into account the days of the week. Monthly activity can depend on the number of days in a particular month and on what days of the week are being studied.

A major effect can be caused by the Easter season. This season is not at invariant time. Every year the Easter season may vary, usually beginning in March, but sometimes in April. Thus, it is difficult to approach the Easter season by quarters. Sometimes it is in the first quarter, sometimes in the second. The Easter season may have an impact on quarter indices a year apart, e.g. on the ratio of the values of time series in the first quarter of the following year and in the first quarter of the previous year.

The time series of ATM withdrawals reflect such calendar effects as days, when money is due, holidays, seasonality of demand, cycles and trends. These calendar effects are analyzed in papers, e.g. Simutis et al., 2008, in the framework of the logistics of ATM services.

In practice calendar effects often coincide with seasonal effects. Calendar effects can be detected after different volatility sources have been analysed. The most important procedure is filtering, which removes seasonal effects. The methods for extracting seasonal variations are not proper tools for extracting calendar effects, which are not periodic (Cleveland and Grupe, 1983). As demonstrated by Findley et al. (1998), properly accounting for calendar effects broken down by day is of great importance. The reason is that in this way the statistical properties of the time series of withdrawals become better and one can apply more adequate models.

In the scientific literature there are several methods for the detection, estimation and correction of time series which show calendar effects. On the basis of a large sample, Cleveland and Devlin (1980) established the empirical distribution for the monthly time series of withdrawals. They detected the main frequencies for these time series. Findley and Soukup (1999, 2000, 2001) examined the usefulness of empirical distribution for the detection of the day-effect. McElroy and Holland (2005) used a nonparametric test in order to assess maxima in samples.

In order to assess the importance of the day of the week, dummy days of the week are usually used. However, these dummies are strongly correlated from one side. They also show seasonal effects, so in order to establish stable estimations of the day-effect, proper computer programmes are necessary, as demonstrated by Young (1965), Bell and Hillmer (1983), Cleveland and Grupe (1983). The best known of them, such as X-12-ARIMA and Tramo-Seats, allow the user to combine calendar effects, national holidays and the calendar effects of other holidays. This problem is complex because of movable feasts (holidays like

Easter, Ramadan or Chinese New Year). Findley and Soukup (2000) assumed that the cost of ignoring calendar effects may be considerable. Hansen et al. (2005) take for granted that all the potential calendar effects do not follow from an economic theory. Therefore, it is necessary to take into account all the potential calendar effects.

Kufel (2010) cites two methods for the detection of cyclicity. The first one uses a panel of dummies and the second one harmonic components. He detected cyclicality within the periods: year, month, week and day, in the time series of withdrawals from one ATM in Toruń.

Calendar effects are most important in the case of daily withdrawals from ATMs because this topic is not sufficiently handled in the scientific literature (Rodrigues and Esteves (2010)).

Rodrigues and Esteves analyzed the following calendar effects in their paper on ATMs installed in Portugal:

- *day-of-the-week effect*: in this case it is assumed that withdrawals are dependent on the day of the week.
- *week-of-the-month* effect: in Portugal wages and salaries are paid monthly, thus the intra month effects of withdrawals cannot be ignored.
- *month-of-the-year effect*: the analysis comprises *12 month-of-the year effects*. This analysis can take into account typical seasonality of consumption.
- *Holidays:* Christmas, New Year, two movable feasts (Carnival and Easter) and other holidays with permanent dates. In their analysis, Rodrigues and Esteves (2010) also used the time series of withdrawals directly before and after holidays, based on Sullivan et al. (2001). Preholiday periods comprise days before the closing of banks and post-holiday periods refer to periods just after the banks close.

Empirical research by Rodrigues and Esteves (2010) have proven the presence of significant calendar effects on withdrawals from ATMs installed in Portugal.

To some extent, our research refers to the investigations presented by Rodrigues and Esteves (2010). In the next section we will present the dataset used in the empirical part of our paper.

3. Dataset and its properties

The research on calendar effects and seasonal effects occurring in the time series of the number of withdrawals from ATMs was based on data on withdrawals from ATMs operated by the Euronet company and located in two areas of Lesser Poland (Małopolskie) and Subcarpathia (Podkarpackie). The analysis was based on data on 222 ATMs covering the period January 2010-December 2012.

Information on the location of the ATMs may be found in Table 1.

Table 1. The number of ATMs in different types of locations in the two voivodeships

Province	Małopolskie		Podkarpackie		Total	
Type of localization	N	%	N	%	N	%
Bank Branch	47	27.49	25	49.02	72	32.43
Hipermarket	28	16.37	8	15.69	36	16.22
Shop	25	14.62	6	11.76	31	13.96
Shopping Center	24	14.04	6	11.76	30	13.51
Petrol Station	22	12.87	2	3.92	24	10.81
Transport	4	2.34	0	0.00	4	1.80
Entertainment	1	0.58	0	0.00	1	0.45
Hotel	1	0.58	0	0.00	1	0.45
Other	19	11.11	4	7.84	23	10.36
Total	171	77.03	51	22.97	222	100.00

Due to the large number of time series examined, detailed empirical results will be presented for the sum of the number of withdrawals from all ATMs and for six selected ATMs which operate in different locations.

In Figure 1 we present a graph of the time series of the overall number of withdrawals from all ATMs, while in Table 2 we provide descriptive statistics for this time series.

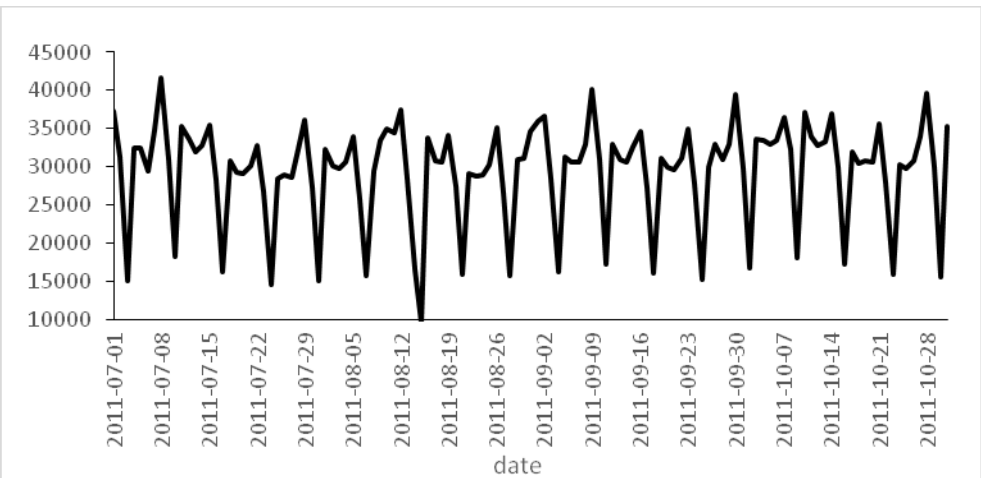

Figure 1. Overall number of daily withdrawals from all the 222 ATMs in the time period July 2011-October 2011

Table 2. Descriptive statistics of the time series of the overall number of daily withdrawals

Average	Median	Standard deviation	Coeff. of variation	Minimum	Maximum	Skewness	Kurtosis
29 139.2	30 810.5	7835.02	26.89%	0	48 178	-1.28	1.47

The analysis of the time series shown in Figure 1 proves that there was not a clear trend in the overall number of withdrawals from ATMs over the period being studied. The preliminary analysis confirms, however, that in this series one can observe a number of seasonal as well as calendar effects (a notable example is the increase in the number of withdrawals in May, June, November and December). In addition, the data presented in Table 2 allows the claim that approximately 30 000 withdrawals a day take place in the selected ATMs. Therefore, there are approximately 130 daily cash withdrawals in each of the machines on average.

More information on the structure of the number of withdrawals from the ATMs follows from the analysis of plots of the time series of the number of withdrawals from the selected ATMs (Figure 2) and their descriptive statistics (Table 3).

Table 3. Descriptive statistics of the time series of withdrawals from selected ATMs.

	ATM 1	ATM 2	ATM 3	ATM 4	ATM 5	ATM 6
Province	Małopolskie	Małopolskie	Podkarpackie	Podkarpackie	Małopolskie	Małopolskie
Town/city	Wieliczka	Zakopane	Stalowa Wola	Rzeszów	Kraków	Kraków
Location type	Shop	Petrol Station	Bank Branch	Shopping Center	Hipermarket	Other (pharmacy)
Average	121.44	157.78	112.69	274.29	200.11	125.74
Std. deviation	47.237	68.05	41.92	94.68	66.49	47.61
Coefficient of variation	38.89%	43.13%	37.20%	34.51%	33.22%	37.87%
Minimum	0	0	0	0	0	0
Maximum	271	462	218	523	412	226
Skewness	-0.54	1.004	-0.695	-0.733	-1.19	-0.547
Kurtosis	0.112	1.30	0.113	0.034	2.279	0.537

It can be seen that there are differences in the structure of the number of withdrawals from particular ATMs. For example, the time series of the number of withdrawals from ATM No. 2 shows trend and seasonality. For the remaining time series, a visual inspection does not establish the presence or absence of seasonal effects or calendar effects. The analysis of the information presented in Table 3 proves that the values of basic statistical measures of the number of withdrawals from ATMs are quite varied. For example, by comparing the average

number of daily withdrawals for the six selected ATMs one may notice that these values are quite different. For example, for ATMs installed in shopping centres there are around 120 withdrawals on average, while more than twice that number took place in a shopping centre in Rzeszów. The number of withdrawals is also affected by such factors as the type of location and availability of ATMs in particular locations. In the case of the remaining variables one can also notice significant differences among the selected ATMs.

Figure 1 for ATM 2 provides evidence about the cycle of one year (Figure 3 encompasses full three years). In the case of other ATMs we do not find a cycle of one year. However, one can detect 1 week seasonality. Thus, the plots of time series are for a time frame of 4 months.

A preliminary analysis proves that the number of withdrawals varies significantly among the ATMs analysed. It seems interesting to test whether such variability is also true in the case of seasonal and calendar effects.

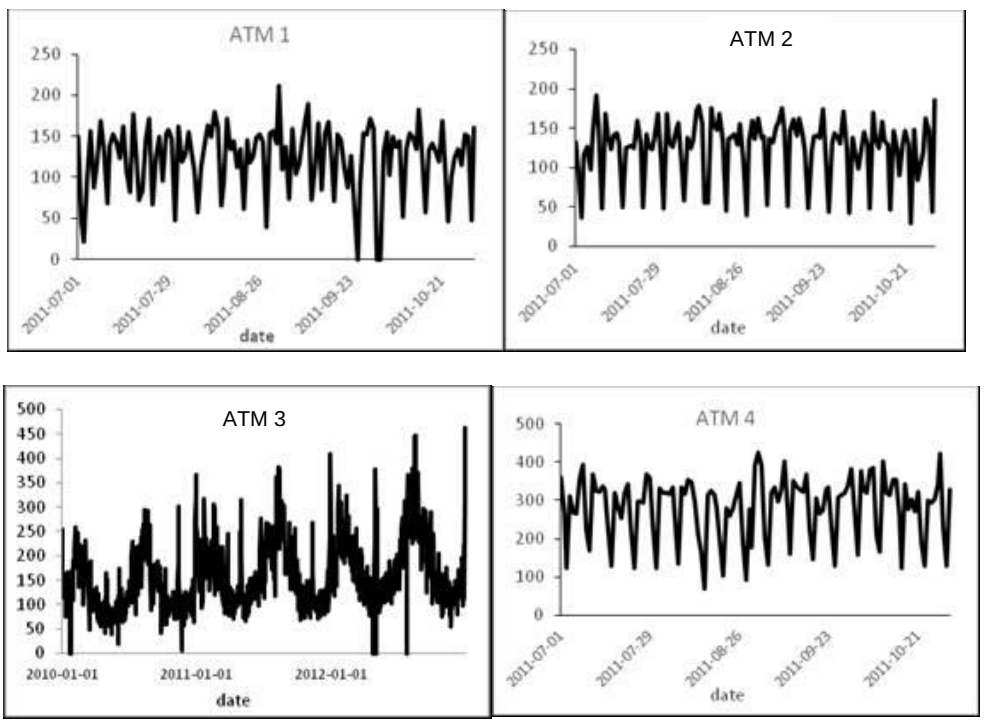

Figure 2. Plots of the time series of the numbers of withdrawals in selected ATMs

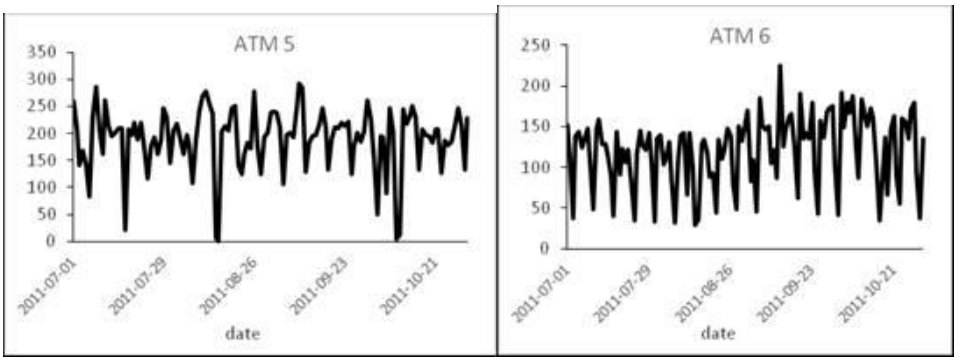

Figure 2. Plots of the time series of the numbers of withdrawals in selected ATMs (cont.)

4. Methodology and empirical results

The deterministic structure of most time series can be described using two basic classes of components: trend and seasonality. In some cases, there may be additional components such as calendar effects. The trend represents a general non-linear (or linear) component, which allows an assessment of the overall direction of the dynamics of the phenomenon examined during the period under consideration (e.g. a linear trend in a stable period, an exponential trend during a development phase). Formally, a seasonal component represents a regularly repeated pattern in the behaviour of the phenomenon analysed.

In this part of the article we present the methods for testing the presence of such components of the time series as seasonality and calendar effects. We also discuss the results of the empirical analysis. We stress that the analysis in our paper is conducted within framework of deterministic seasonality. We do not aim in this study to establish the impact of stochastic factors on seasonality pattern.

4.1. Seasonal effects

In the case of many time series (e.g. electricity or gas consumption) the presence of seasonal effects can be relatively easy to verify solely on the basis of a visual inspection. In the case of the time series of the number of withdrawals from ATMs, the verification of the presence of seasonality solely on the basis of a visual inspection of the respective plots was possible only in the case of some ATMs.

Based on Figure 2, which presents the plots of the numbers of withdrawals, one can determine the presence of seasonality only in the case of the ATM located in Zakopane (ATM, No. 2). In the case of the remaining ATMs, the identification of the presence of this deterministic component turned out to be impossible based on a visual inspection of the respective plots.

In order to identify seasonality in the time series examined in this paper we use a method based on spectral density estimators, also known as periodograms.

For the time series $x_1, x_2, ..., x_n$ the periodogram is defined as:

$$I_n\left(\omega_j\right) = \frac{1}{n}\left|\sum_{k=1}^{n} x_k \exp\left\{-2\pi i\left(k-1\right)\omega_j\right\}\right|^2 \tag{1}$$

where $\omega_j = j/n$ j-th frequency for $j = 1, 2, ..., \left[\frac{n}{2}\right]$, and $\left[x\right]$ stands for the floor of number x.

The results of a spectral analysis of the time series of the overall number of withdrawals are presented in Figure 3.

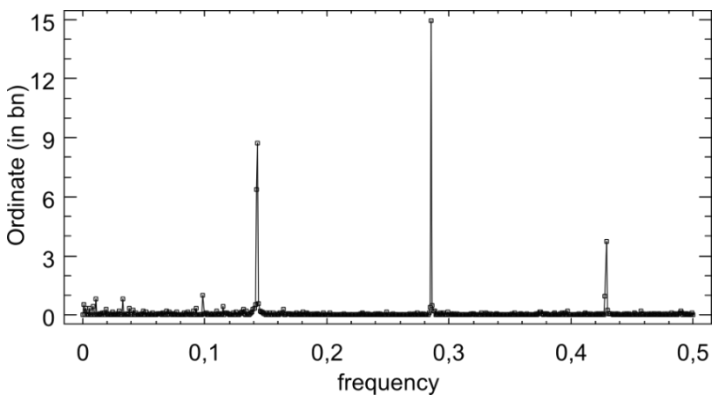

Figure 3. Periodogram of the time series of the overall number of withdrawals

A spectral analysis of the time series of the total number of withdrawals from ATMs confirms the existence of a weekly cycle. The peak which appears for frequencies near to 0.14 indicates the presence of weekly seasonal effects. In the above periodogram one can also see changes in spectral density for frequency 0.285 and 0.428, which are referred to as harmonic fluctuations (Franses, 1996). This indicates the existence of length cycles of 3.5 and 2.33 days respectively, that is cycles whose multiple is the weekly cycle. For the examined time series of the overall number of withdrawals from ATMs, the spectral analysis showed no presence of monthly or annual seasonality.

The results of spectral analysis of the time series of the ATMs selected are presented in Figure 4.

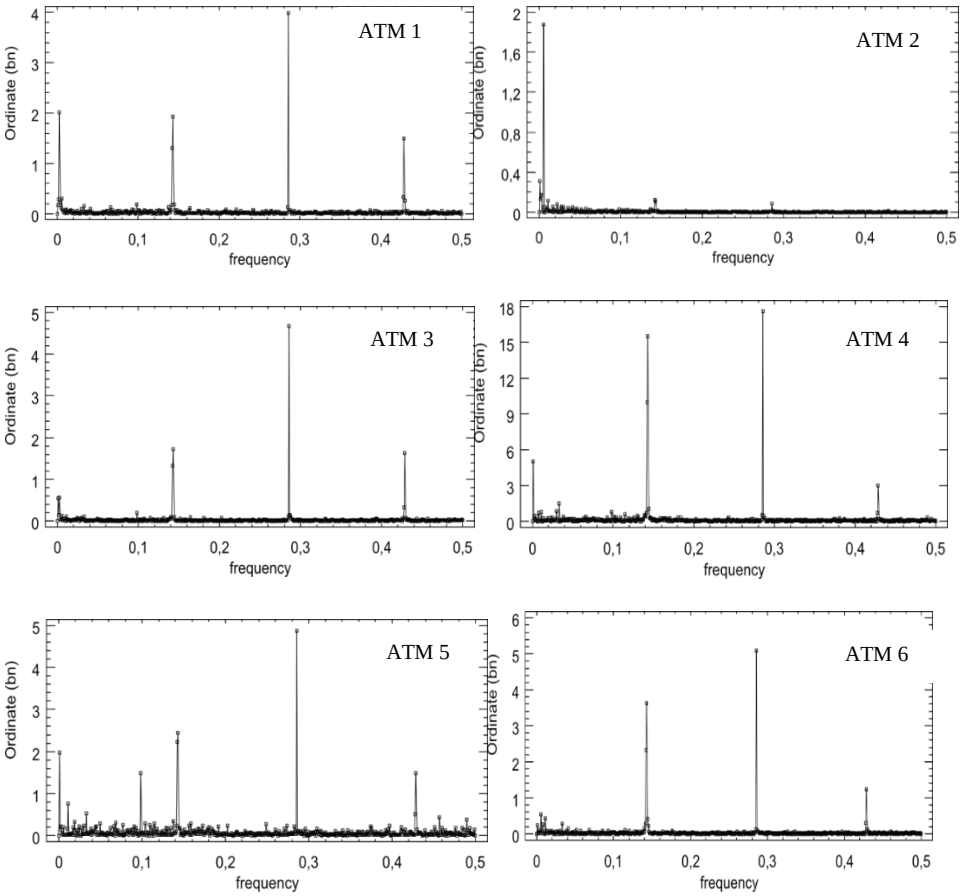

Figure 4. Periodogram of the time series of the number of withdrawals in selected ATMs

A spectral analysis of six selected ATMs shows differences among these machines. A weekly cycle was found for all ATMs, except for ATM No. 2. On the other hand, the noticeable peaks for a frequency close to 0 that occur for ATMs No. 1, 2, 4 and 5 indicate the presence of annual seasonality. A slight increase in the value of the spectral density for frequencies near 0.033, which occurred for ATMs No. 4 and 5, corresponds to a cycle around 30 days in length, i.e. a monthly cycle. One should take this into account and draw attention to the fact that due to the different lengths of individual months of the year, the spectral analysis may not prove the presence of monthly seasonality even when the effect of the day of the month has a significant impact on the dynamics of the series of withdrawals.

The last stage of research aimed at tracing cycles of different lengths was the spectral analysis conducted for the remaining 216 ATMs. Table 4 shows the results of the analysis, which focused on testing whether there are cycles of

different lengths for all ATMs with respect to the type of location (nominal and percentage values).

Table 4. Nominal and percentage results of spectral analysis.

Location type	Weekly cycle		Monthly cycle		Annual cycle	
	N	[%]	N	[%]	N	[%]
Bank Branch	72	100.0	16	22.2	35	48.6
Hipermarket	36	100.0	8	22.2	16	44.4
Shop	30	96.8	6	19.4	12	38.7
Shopping Center	30	100.0	7	23.3	15	50.0
Petrol Station	22	91.7	4	16.7	11	45.8
Transport	4	100.0	2	50.0	2	50.0
Entertainment	1	100.0	0	0.0	1	100.0
Hotel	1	100.0	0	0.0	0	0.0
Other	23	100.0	5	21.7	11	47.8
Total	219	98.6	48	21.6	103	46.4

Thus, the analysis of spectral density confirmed the presence of weekly cycles for almost 99% of the time series analysed. In addition, in the case of almost 50% of the ATMs examined we found annual seasonality, and for slightly more than 20% of the ATMs analysed we confirmed the existence of monthly cycles.

The results obtained indicate that seasonality and the cycles present in the time series of withdrawals are important components, which should be taken into account when selecting the models used for prediction purposes.

4.2. Calendar and seasonal effects

Calendar and seasonal effects are a common phenomenon observed in economic time series, including financial time series. The latter follows from the fact that most of economic time series directly or indirectly refer to particular days, months, quarters and other units of time. One should also pay attention to the fact that the presence of weekly cycles may be considered in the context of seasonal effects. The same applies to the analysis of the properties of monthly withdrawals (annual cycle). However, in the case of analysing the impact of the day of withdrawals (the monthly cycle) one should conduct the analysis in the context of calendar effects. This follows from the fact that not all months are of the same length.

Some indication of the possibility of the existence of calendar effects in the time series examined follows from a visual inspection of the plots of the series being studied.

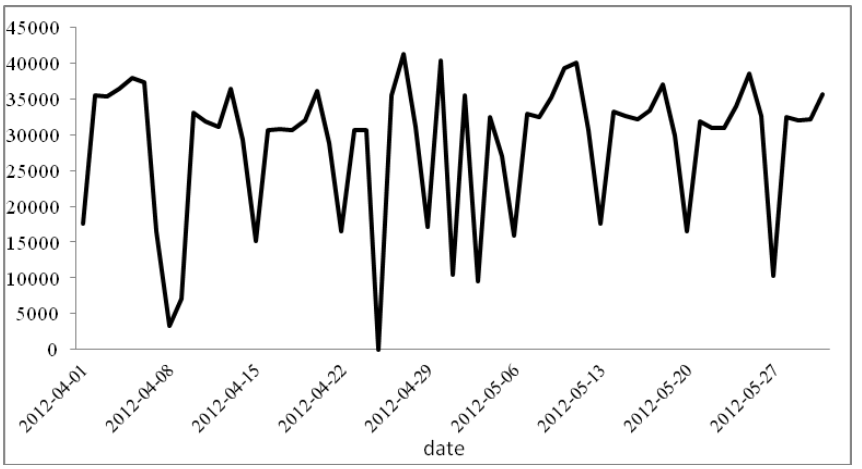

Figure 5. Time series of the overall number of withdrawals in the period April-May 2012

Analysing Figure 5, which presents the time series of the overall number of withdrawals for the period April-May 2012, one may notice that the number of withdrawals on Sundays is much smaller than on other days of the week. In addition, if Sundays are also non-trading days (e.g. Easter, or the Feast of Pentecost) the number of withdrawals is even smaller. Moreover, quite visible calendar effects include the increase in the number of withdrawals prior to upcoming holidays and longer periods when people do not work ("long weekends") and an increase in the number of withdrawals just before the 10^{th} and 30^{th} day of each month.

The analysis of the plots of time series is only suggestive of the occurrence of the calendar effect. In order to formally verify whether seasonal and calendar effects are indeed present in the series being studied we performed an analysis based on an examination of the variability of the average withdrawals in an individual year, month or week, and then calculated and compared other basic descriptive statistics (quantiles, minimum, maximum, standard deviation, coefficient of variation, skewness and kurtosis). The verification of individual calendar effects was based on comparing the respective withdrawals at individual moments. We proceeded with mean tests, such as the non-parametric analysis of variance (Kruskal-Wallis ANOVA rang test) and the Dunn test. In all the tests the significance level was set equal to 5%.

As in the case of testing for seasonality, the examination of calendar effects was conducted in two stages. First, we tested the existence of seasonal and calendar effects using the sum of the daily withdrawals from all 222 ATMs. This approach was used to determine the general trends, which are present in time series of withdrawals from ATMs during days of the week and particular periods of a month or on special days of the year.

The second stage was a similar analysis carried out separately for each of the ATMs. Detailed results of this analysis will be presented for the six ATMs selected. The knowledge of the occurrence of individual calendar effects for each ATM may turn out to be very useful when choosing methods of predicting the number of withdrawals.

In the analysis the following types of calendar effects were taken into account:

- Day of week. This effect allows us to capture differences in the numbers of withdrawals in ATMs over different days of the week.
- Day of month. This effect allows us to select the days of the month on which the number of withdrawals significantly rises/drops.
- Month. In this analysis it is assumed that in some months of the year the number of withdrawals may significantly rise.
- A Special event in the year. This effect allows us to analyse the number of withdrawals from ATMs on special days like holidays or long weekends. Five special events which may influence the number of withdrawals were taken into account:
- E1-non-trading days, e.g. New Year's Day, Easter, Christmas; E2- trading days during a long weekend; E3-trading days prior to a long weekend or holidays; E4-trading days after a long weekend or holidays; E5-holidays, for example Grandfather's Day, Grandmother's Day, Valentine's Day, Women's Day.

The study of the effect of the day of the week was carried out using original data. Since some effects may overlap, although the effect of the day of the week affects the evolution of the number of withdrawals most strongly, the remaining effects were examined based on weekly-seasonally-adjusted data.

4.3. The effect of the day of the week

In Figure 6 boxplots for the time series of the overall number of withdrawals on different days of the week in the period 2010-2012 are presented. Information on measures of position, measures of dispersion and asymmetry for withdrawals on different days is presented in Table 5.

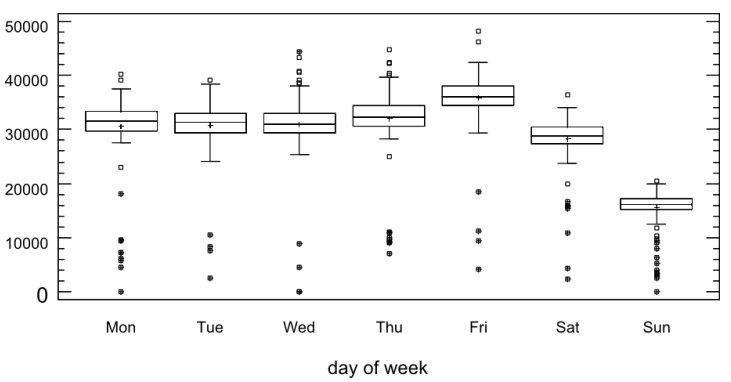

Figure 6. Boxplots of the overall number of withdrawals in the period April-May 2012

The results of the analysis indicate a variation in the number of withdrawals for individual days of the week. It can be seen from Figure 6 that, on average, the highest number of withdrawals from ATMs takes place on Fridays, and the lowest - on Saturdays and Sundays. From Monday to Thursday the average number of withdrawals is relatively stable. This test indicates the statistical significance of the differences between the average numbers of withdrawals on individual days of the week (p-value ≈ 0). These results were also confirmed by the Dunn test.

The analysis of the results presented in Table 5 shows that the variation in the number of withdrawals for the individual days of the week is on a similar level. The coefficient of variation is quite low for all days of the week (14-22%).

In addition, withdrawals on all days are characterized by relatively high left asymmetry. In other words, the predominant number of withdrawals is greater than the daily average. High kurtosis, on the other hand, indicates a high level of flattening of the distribution, and thus the existence of a large number of values is similar to the mean value for all days of the week.

Table 5. Descriptive statistics of the time series of the overall numbers of withdrawals on different days of the week

Day of the week	Average	Median	Standard deviation	Coeff. of variation [%]	Skewness	Kurtosis
Monday	30 538.5	31 569	6308.62	20.66	-3.00	9.97
Tuesday	30 848.1	31 266	4704.21	15.25	-3.27	16.06
Wednesday	31 066.8	30 947.5	5616.18	18.08	-2.96	15.24
Thursday	31 986.7	32 300.5	5743.08	17.95	-2.44	8.66
Friday	35 820.9	36 025	5016.39	14.00	-3.36	18.04
Saturday	28 235.7	28 850	4383.95	15.53	-3.25	14.59
Sunday	15 519.3	16 149	3384.46	21.81	-2.57	7.33

A similar analysis was performed for the six ATMs selected. The results are presented in Figure 7.

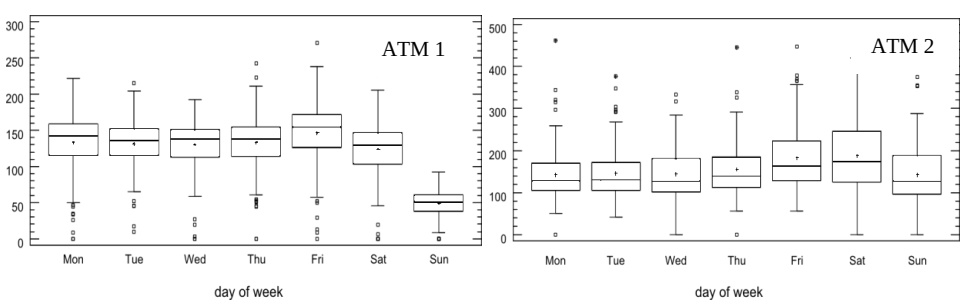

Figure 7. Boxplots of the overall number of withdrawals in six selected ATMs on different days of the week

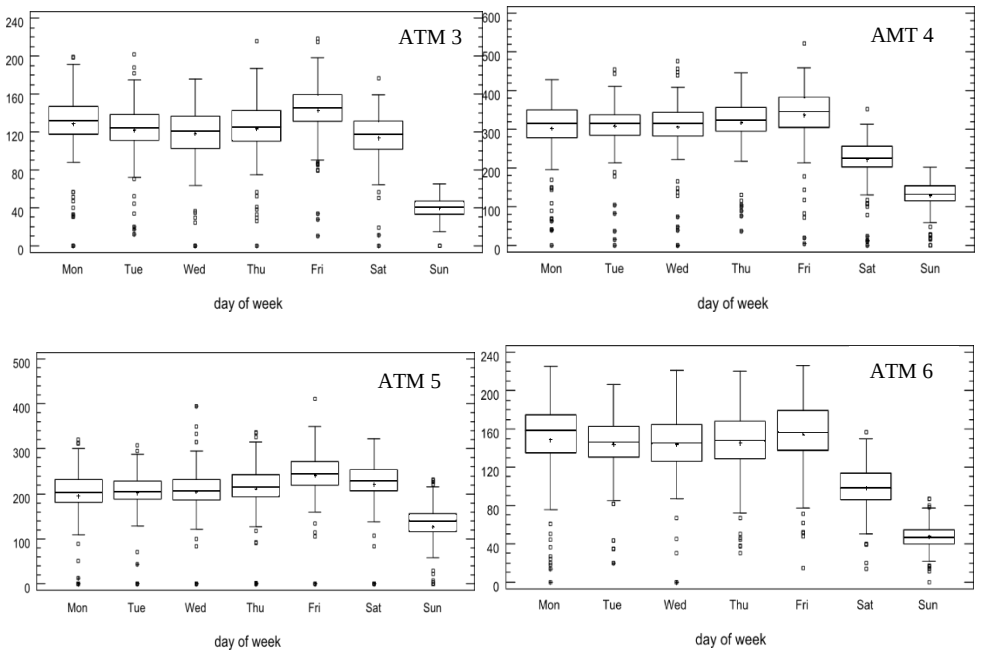

Figure 7. Boxplots of the overall number of withdrawals in six selected ATMs on different days of the week (cont.)

The results of the analysis obtained for the six ATMs selected confirm the earlier findings obtained for the sum of withdrawals on individual days of the week for all the ATMs. It is worth noting that for the cash machine located in Zakopane (ATM machine No. 2) the average number of withdrawals on Sunday did not differ significantly from the corresponding values on other days of the week. For ATMs No. 1 and No. 5, located in a store and a hypermarket, the average number of withdrawals on Saturday does not deviate significantly from the number of withdrawals on weekdays.

4.4. The effect of the day of the month

In many economic publications the effect of the 10th day of the month is examined. This phenomenon is related to the fact that a significant part of society receives salaries (by bank transfer to bank account or in the form of cash) on this particular day of the month. In order to verify whether the day of the month causes significant differences between the number of withdrawals from ATMs, the boxplots of the numbers of withdrawals on different days of the month are presented in Figure 8. Table 6 presents the basic descriptive statistics of the series.

An analysis of the boxplots presented in Figure 8 shows that the number of withdrawals from ATMs varies among different days of the month. It is noteworthy that the average number of withdrawals rises between the 6th and the 10th day of the month. On the 10th day of the month the average reaches its

maximum. This phenomenon can be explained by the fact that immediately prior to that date and right after that day many people pay cash to make various payments (e.g. to pay the bills) since the withdrawal date very often falls on this day. In contrast, the number of withdrawals on the 11th day of the month is significantly smaller than the day before.

Similar results were obtained by Kufel (2010). However, he noticed the highest number of withdrawals not only on the 10th but also on the 11th days of the months. He claimed that the latter follows from the fact that many people receive salaries in their bank accounts before the 10th day of the month.

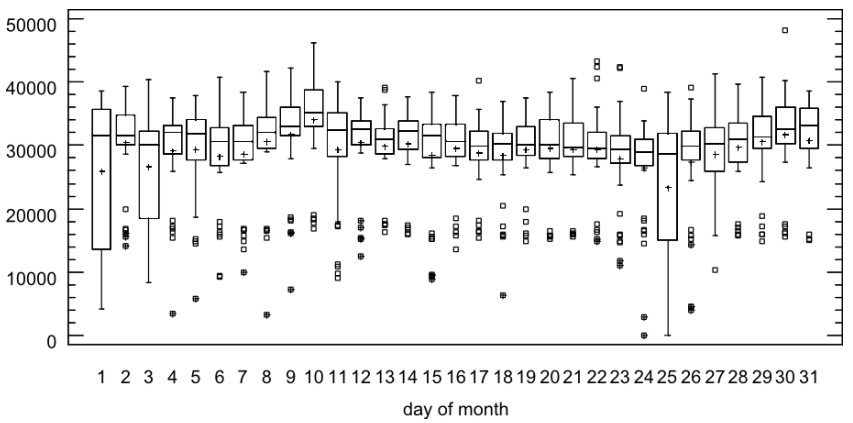

Figure 8. Boxplots of the overall number of withdrawals in the six selected ATMs on different days of the month.

A similar structure and variability in the number of withdrawals is observed between the 25th and 30th day of the month and on the 31st day of the month. Between the 25th and 30th day of the month the average number of withdrawals rises and reaches the maximum on the 30th day of the month and then significantly drops on the 31th day of the month. The source of this phenomenon seems similar to the previously described one.

When analysing the descriptive statistics calculated for the number of withdrawals on individual days of the month (Table 6) one may note quite a high coefficient of variation for the 1st day of the month compared to other days of the month. This is due to the fact that on the first day of the month there are three holidays a year (in January, May, November), and withdrawals on these days are relatively small. A similar situation can be observed on the 3rd, 11th and 25th day of the month. Holidays also fall on these days (Constitution Day, Independence Day, Christmas), although in the case of these dates the differences between the numbers of withdrawals compared to other days of the month are less pronounced. The results of the means and the median tests in each group indicate that the day of the month in fact leads to differences between the numbers of withdrawals from ATMs.

Figure 8 shows the results of a similar analysis for the six ATMs selected. The results obtained confirm the general rule concerning the number of withdrawals on particular days of the month. There are, however, some differences between the results obtained for each of the ATMs, namely the effect of the 10th day of the month is notable for five out of the six ATMs analysed. For ATMs No. 1 and No. 5 this phenomenon is especially visible because the average number of withdrawals on this day exceeds by far the number of withdrawals on the remaining days of the month.

As expected, the effect of the 10th day of the month is not evident for the ATM machine located in Zakopane. This follows from the fact that this machine is used mainly by tourists who normally plan their trip in advance and do not expect that they will receive their cash or transfer exactly on the 10th day of the month.

Table 6. Descriptive statistics of the time series of the overall numbers of withdrawals on different days of the month

Day of the month	Average	Median	Standard deviation	Coeff. of variation [%]	Skewness	Kurtosis
1	25832.3	31453	12182.5	47.16	-0.75	-1.14
2	30384.4	31548.5	6857.15	22.57	-1.25	0.75
3	26654.3	30141	8957.86	33.61	-0.92	-0.43
4	29242.5	32046	7429.04	25.41	-1.80	3.25
5	29414.3	31902	7357.85	25.01	-1.66	2.32
6	28275.1	30603.5	7677.42	27.15	-1.12	0.66
7	28686.4	30573.5	7442.66	25.94	-1.18	0.36
8	30617.1	32158	7965.74	26.02	-1.59	3.27
9	31630.1	33019	8114.45	25.65	-1.36	1.54
10	34033.5	35230.5	7501.26	22.04	-1.10	0.89
11	29401.3	32400	8892.48	30.25	-1.25	0.33
12	30422.6	32679	6386.73	20.99	-1.79	2.25
13	29924.3	31026.5	5713.61	19.09	-1.22	1.20
14	30239.1	32301.5	6079.01	20.10	-1.48	1.28
15	28528	31569	8352.45	29.28	-1.35	0.65
16	29577.5	30714.5	6095.58	20.61	-1.33	1.29
17	28795.7	29810.5	5713.33	19.84	-1.03	0.99
18	28382.9	30174.5	6787.38	23.91	-1.52	2.35
19	29335.9	30077	5754.76	19.62	-1.29	1.26
20	29467	30116	6517.18	22.12	-1.02	0.59
21	29392.6	29770.5	6488.82	22.08	-0.85	0.59
22	29330.2	29534	6730.48	22.95	-0.44	0.86
23	27928.6	29404.5	7650.05	27.39	-0.65	0.31
24	26514.5	28907.5	8400.37	31.68	-1.71	2.93
25	23369	28703	12362.9	52.90	-0.86	-0.65
26	27449.1	29926	9216.56	33.58	-1.47	1.43
27	28671.5	30178.5	6766.04	23.60	-0.82	0.93
28	29713.8	30916	6376.17	21.46	-0.95	0.49
29	30553.1	31315	6921.78	22.65	-0.95	0.58
30	31693.4	32540	7681.09	24.24	-0.78	0.60
31	30867.6	33090	7267.9	23.55	-1.38	0.98

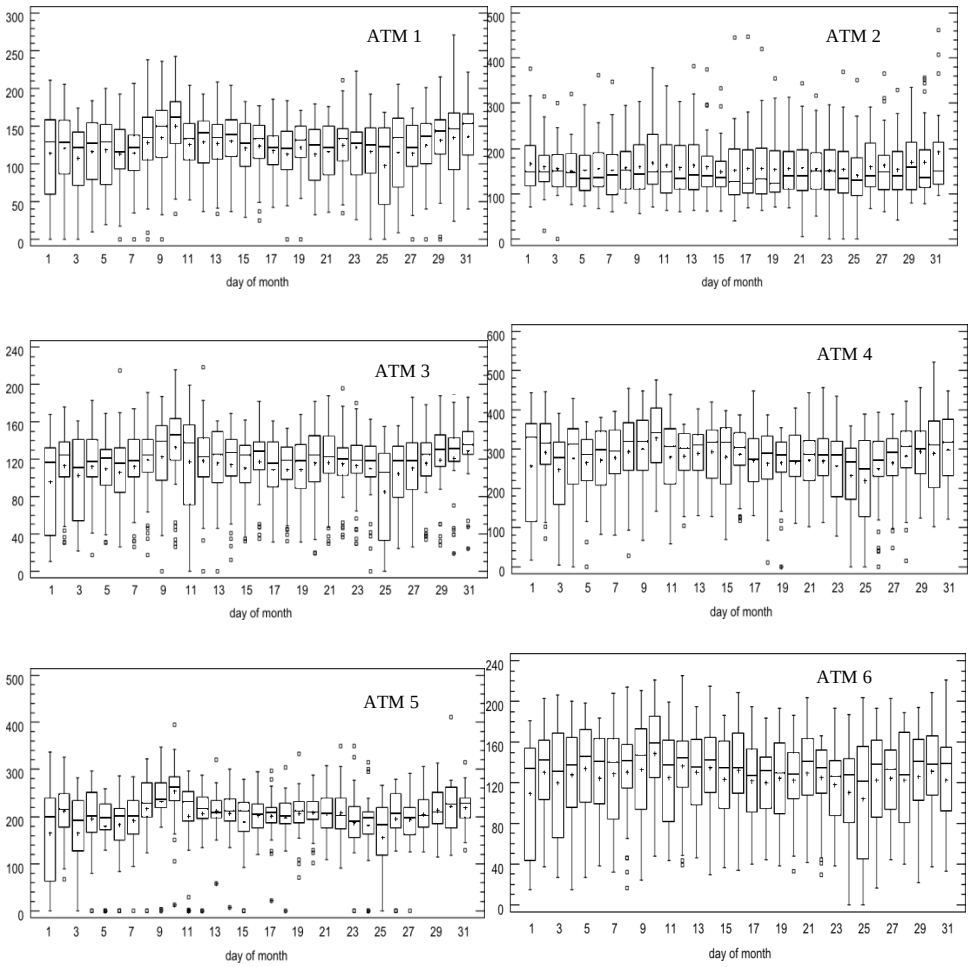

Figure 9. Boxplots of the overall number of withdrawals in the six selected ATMs on different days of the month

4.5. The effect of the month of the year

In this subsection we present the results of examining the differences between the numbers of withdrawals from all ATMs in particular months of the year. The results are presented in Table 10 and Figure 11.

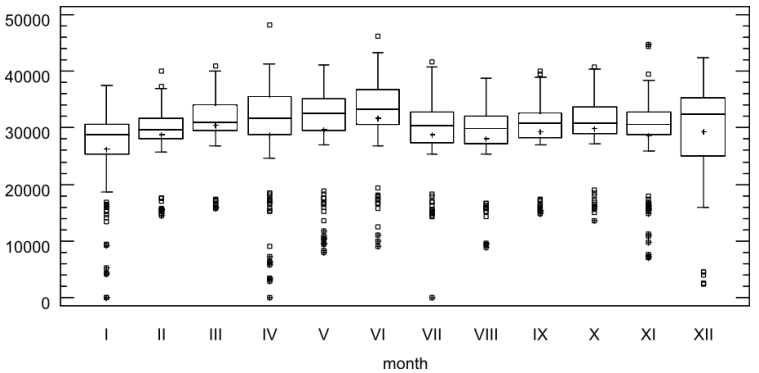

Figure 10. Boxplots of the overall number of withdrawals in all ATMs in different months of the year

The results presented in Figure 10 indicate that in the early months of the year the average number of withdrawals from ATMs achieves lower values compared with other months of the year. The latter may be a consequence of the usual increase in household expenditure during the holiday period (St. Nicholas', Christmas, New Year's Eve), which implies a greater demand for cash (see the boxplots for December) and leads to a reduction in the financial capacity of the public at the beginning of the year.

The slightly increased number of withdrawals in June also seems worth underlining. This may be related to the beginning of preparations for the holidays. The results of the analysis of variance for medium-sized withdrawals in individual months indicate statistically significant differences. For both tests p-value ≈ 0.

For most months of the year the value of the coefficient of variation (see Table 7) calculated for the number of withdrawals reached low levels (approximately 20%). Slightly higher values of this measure were reported for January, April, May, November and December.

Table 7. Descriptive statistics of the time series of the overall number of withdrawals in different months of the year

Month	Average	Median	Standard deviation	Coeff. of variation [%]	Skewness	Kurtosis
I	26292.8	28865	8604.66	32.73	-1.36	1.35
II	28738.4	29693	5894.62	20.51	-1.16	0.92
III	30377.1	31036	6009.74	19.78	-1.28	1.18
IV	28749.5	31677	10307.1	35.85	-1.24	0.80
V	29741.9	32605	8734.87	29.37	-1.24	0.38
VI	31683.5	33335.5	8144.14	25.70	-1.20	0.76
VII	28767.6	30412	7090.69	24.65	-1.39	2.36
VIII	28118.4	29826	6623.56	23.56	-1.38	1.20
IX	29285.9	30723.5	6116.2	20.88	-1.23	0.95
X	29927.8	30854	6384.43	21.33	-1.16	0.74
XI	28615	30608.5	8047.09	28.12	-1.15	0.90
XII	29395.7	32428	9637.02	32.78	-1.31	1.27

Figure 11 shows the results of the analysis of the effect of the month of the year for the six ATMs selected. In general, the results of this analysis confirm the general trends observed in the time series of overall withdrawals from all ATMs in different months. For all six ATMs the test results showed significant differences between the numbers of withdrawals in individual months. Special attention must be paid to the results obtained for ATM No. 2, which is located in Zakopane. The average number of withdrawals clearly indicates the months in which the largest number of tourists visit Zakopane. These are the months during the summer holiday season and during the winter holidays. A relatively high average number of withdrawals occurs also in December and January, i.e. during Christmas and the New Year holiday period.

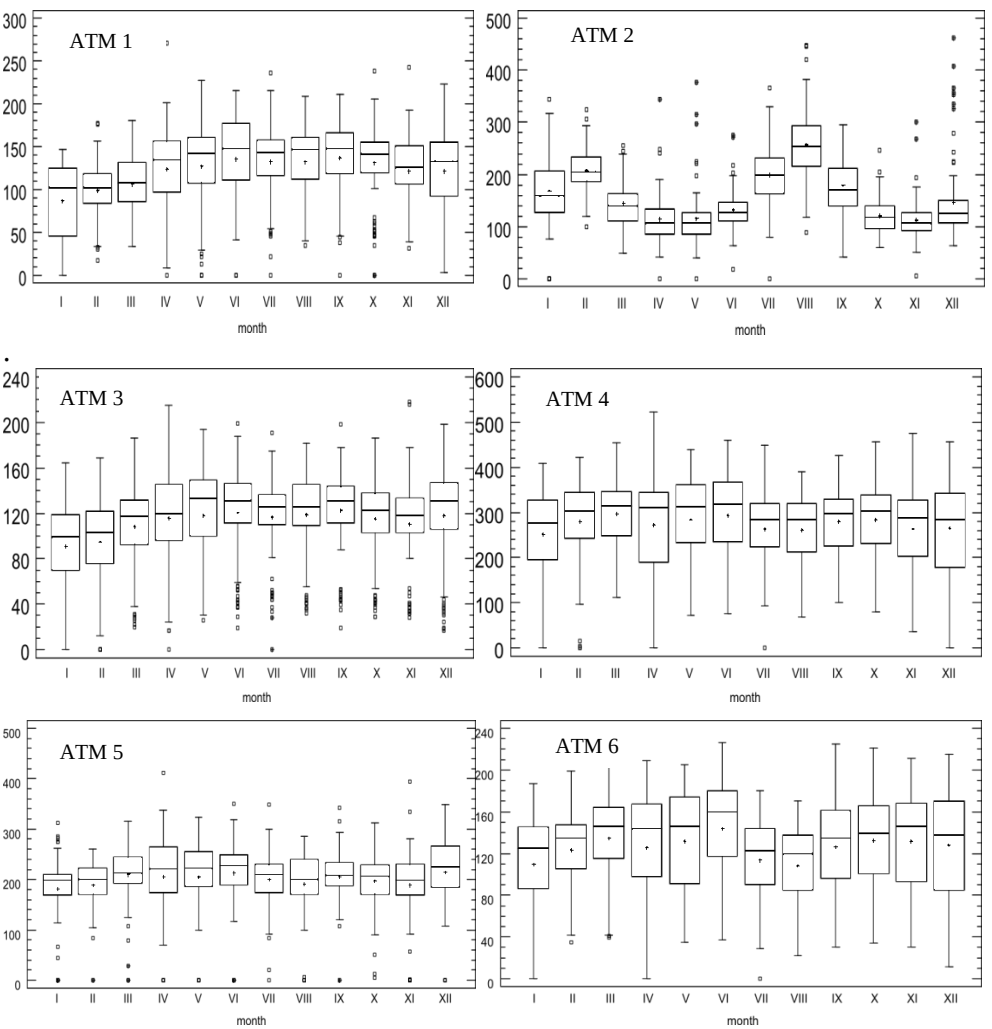

Figure 11. Boxplots of the overall number of withdrawals in the six selected ATMs in different months of the year

4.6. The effect of special days

In the last stage of the research we examined whether the number of withdrawals on the five types of the special day defined in previous sections is significantly different from the corresponding values reported for usual calendar days. The results of this comparison are presented in Table 8.

The comparison of means and medians for the days when the events E1, E2, E3, E4, E5 took place and for the regular calendar day shows that the number of withdrawals is indeed significantly different (p-value in nonparametric ANOVA close to zero).

In order to judge which events during the year cause differences between the numbers of withdrawals the Dunn test was additionally performed. This test shows the significance of the difference between the means in two selected subgroups. The results indicate that only the E4 event (the day after a long weekend) does not significantly affect the number of withdrawals from ATMs in comparison with other days. The remaining types of events statistically significantly affect the number of withdrawals from ATMs. The analysis of the boxplots presented in Figure 12 also confirms the results of the test.

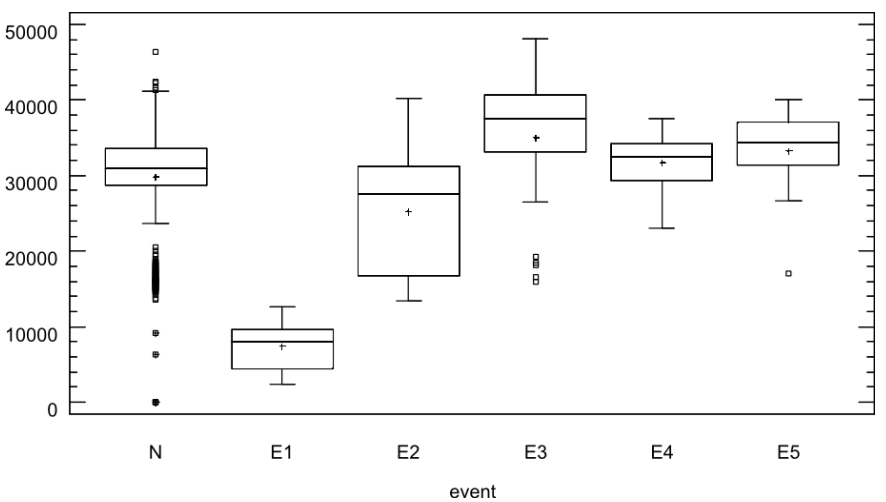

Figure 12. Boxplots of the overall number of withdrawals from all ATMs on five types of the special day and remaining (usual) days.

Table 8. Descriptive statistics of the time series of the overall numbers of withdrawals on five types of the special day and remaining (usual) days.

Type of special day	Number of days	Average	Median	Standard deviation	Coeff. of variation [%]	Skewness	Kurtosis
N	945	29843.6	30927	6532.5	21.89	-1.33	2.06
E1	38	7473.03	8090	3040.64	40.69	-0.29	-1.23
E2	42	25253	27657	8426.37	33.37	0.08	-1.47
E3	33	35065.8	37465	8612.17	24.56	-1.10	0.40
E4	22	31773.8	32564	3653.17	11.50	-0.62	0.41
E5	16	33350	34367	5726.79	17.17	-1.64	3.48

On E1-type days, i.e. on non-trading days, one may notice a reduction in the average number of withdrawals in comparison with other days. This is due to the fact that during the holidays, most shops are closed and potential customers usually leave or stay at home. As a result, the availability of ATMs is reduced and the demand for cash falls, and hence also the number of withdrawals.

The same is true on business days that occur within long weekends. On such days the number of cash withdrawals also decreases. This is most likely a consequence of the fact that people take trips away from home. However, on these days the number of withdrawals may rise in tourist destinations like Zakopane.

An increase in the number of withdrawals from ATMs on days before holidays or long weekends (E3) may result from the fact that before this type of event many people usually withdraw more cash in order to prepare for celebrations or trips. It seems natural that after such events, i.e. after spending cash previously withdrawn, there is a need to once again take cash from an ATM. The results of the research show that the average number of withdrawals after a long weekend (E4 event) is slightly higher than on normal days, but this is not a statistically significant difference. As already mentioned, the analysis showed a significant increase in the number of withdrawals from ATMs on occasional holidays. One can, therefore, presume that before this type of holiday the demand for cash increases. The following Figure (Figure 13) shows the results of similar studies carried out for the six ATMs selected.

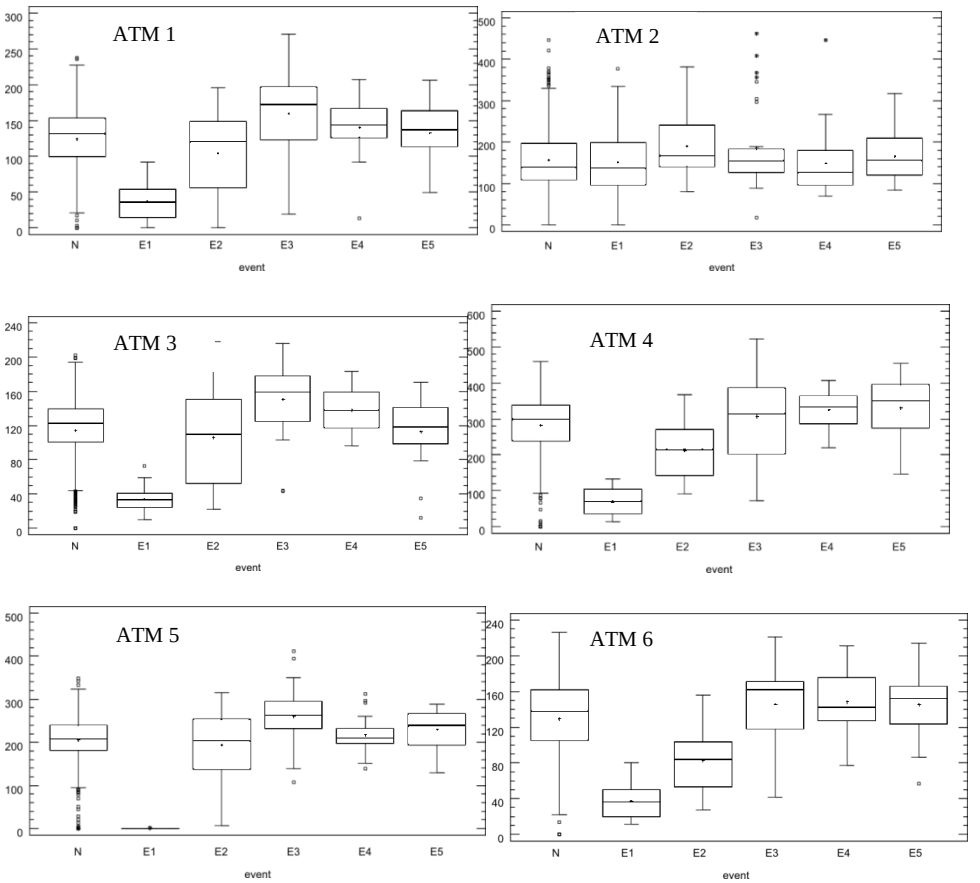

Figure 13. Boxplots of the overall number of withdrawals from the six selected ATMs on five types of the special day and remaining (usual) day.

The analysis of the number of withdrawals from the six ATMs selected on five types of the special day gives mixed results (see Figure 13). The results of the analysis of variance for all ATMs showed a significant difference between the average numbers of withdrawals on different types of the special day. However, when focusing on the six ATMs selected the difference between the average numbers of withdrawals on special days and on normal ones was not significant in all cases.

For all ATMs except ATM No. 2 the average number of withdrawals on holidays was different from the average number of withdrawals on normal days. The effect of working days during the long weekend causes a difference in the number of withdrawals for four out of the six ATMs (except ATMs No. 3 and No. 5).

The effect of pre-holiday days significantly affects the average number of withdrawals from five out of the six ATMs (except ATM No. 4), while the effect of after-holiday days (E4) significantly affects the number of withdrawals in

ATMs No. 3, 4, 6. The effect of specific days of E5 type turned out to be important only for ATM No. 3.

To sum up this part of the analysis, it can be concluded that all the effects examined have a significant impact on the number of withdrawals from ATMs operated by the Euronet company for at least half of the six ATMs selected. Only in the case of the number of withdrawals on the E5-type days (occasional holidays like Grandmother Day, Grandfather Day, Valentine's day, Women's Day) were no statistically significant differences found for most of the ATMs. One can note, however, that certain properties are individual to each ATM. For this reason, it seems that in order to effectively use calendar effects in forecasting models the respective testing should be carried out separately for each ATM.

Tables 9 and 10 contain information on the number of ATMs (nominal and percentage) for which the individual calendar effects turned out to be a statistically significant (at the level of 5%) factor influencing the average number of withdrawals. What was also examined was whether the type of location can significantly affect the structure of withdrawals on the five types of the special day.

On the basis of Table 9 one may claim that the day of the week substantially affects the number of withdrawals in 221 out of the 222 ATMs analysed. For more than 70% of the ATMs, it also turned out that the day of the month is an important factor affecting the volume of withdrawals. A statistically significant effect of the day of the month on the number of withdrawals was reported for all devices in the category "other". Also in the case of the group of ATMs linked directly with trade locations (supermarkets, shopping centres) the share of machines for which significant differences between the average number of withdrawals on different days of the month occurred was high and oscillated at around 80%. For the remaining types of location this share was lower. For a very high share of ATMs (93.9%) the number of withdrawals turned out to depend on the day of the month. In this category the smallest impact was reported in the case of ATMs located in bank branches (85.7%).

Table 9. The results of testing calendar and seasonal effects (the effects of days, weeks, months)

Type of localization	Day of the week		Day of the month		Month of the year	
	N	[%]	N	[%]	Number	[%]
Bank Branch	72	100	43	59.5	62	85.7
Hipermarket	36	100	30	82.5	34	95
Shop	31	100	20	64	30	96
Shopping Center	30	100	26	85.7	29	95.9
Petrol Station	23	95.8	16	64.9	23	97.3
Transport	4	100	3	78.6	4	100
Entertainment	1	100	1	66.7	1	100
Hotel	1	100	1	50	1	100
Other	23	100	23	100	23	100
Total	221	99.5	158	71.3	208	93.9

Table 10. The results of the analysis of calendar effects (the effect of special types of day)

Type of localization	E1		E2		E3		E4		E5	
	N	[%]	N	[%]	N	[%]	N	[%]	N	[%]
Bank Branch	69	96.4	42	58.3	29	40.5	14	19.1	2	2.4
Hipermarket	36	100	22	60	7	20	4	12	0	0
Shop	30	95.9	15	46.9	9	28.6	4	12.2	0	0
Shopping Center	26	87.5	11	37.5	17	55	6	20	1	2.5
Petrol Station	24	100	14	56.8	5	21.6	3	10.8	1	5.4
Transport	3	83.3	1	16.7	1	16.7	1	16.7	0	0
Entertainment	1	100	0	16.7	0	0	0	16.7	0	0
Hotel	1	90.5	0	28.6	0	38.1	0	19.1	0	7.1
Other	17	75	12	50	6	25	12	50	6	25
Total	210	94.5	105	47.4	77	34.5	37	16.7	7	3.1

In Table 10 we present the similar results for the time series of withdrawals on special days. The analysis shows that for 69 ATMs the average number of withdrawals on E1-type days significantly differs from the average on normal days (Normal (usual) days are understood as the days which are not E2-E5 special days). In this group of ATMs the lowest sensitivity to changes in the number of withdrawals on specific days is shown by these ATMs which are located in places that belong to the "other" category, and the highest sensitivity for the ATMs located in hotels, petrol stations and shops.

In the case of other types of the special day changes in the number of withdrawals turned out to be considerably smaller. The average number of withdrawals on trading days during holidays or long weekends (E2-type days) differs significantly from the average volume of withdrawals on normal days for almost half of the ATMs. However, this share is distributed very differently for each location: in the case of ATMs located in stores and bank branches this is around 60%, while for ATMs in entertainment centres the share is only about 16.7%.

On E3-type days, that is days before holidays and long weekends, the number of withdrawals from ATMs changes significantly in the case of 34.5% of all ATMs. Usually these changes affect ATMs operating in hypermarkets.

Of all the types of the special day the smallest changes in the number of withdrawals were observed for E5 type days. Only for nine ATMs (3.1% of the total number of machines analysed) the nonparametric ANOVA shows a statistically significant difference between the average number of withdrawals on these days and normal days.

Differences between the results of research on the importance of some of the effects in the first and second part of the analysis (i.e. the results reported in the section dealing with the overall number of withdrawals and withdrawals from the six individual ATMs) arise from the fact that the impact of the withdrawals from specific ATMs on the time series of the total number of withdrawals is significantly different. This means that the statistical significance of the calendar

effect is mostly caused by withdrawals from those ATMs which are generally characterized by the largest withdrawals (i.e. ATMs located in shopping malls and hypermarkets in large cities).

The results of the analysis of calendar and seasonal effects, which were carried out in the framework of consumer behaviour, which shows the overall number of withdrawals, clearly demonstrate the importance of the phenomena discussed. The results of the study show that trends associated with selected moments within a week, month or year in which money is withdrawn in larger or smaller amounts, reflect certain regularities and habits which characterize customers.

The conclusions of the second part of the study, in which calendar and seasonal effects were examined at the level of individual ATMs, suggest the necessity of ATM-specific adjustment of prognostic models. Taking into account only those calendar effects which turned out to be significant in describing withdrawals from a particular ATM allows us to create an optimal individual prediction model. In other words, the results of the study suggest that for understanding and predicting the number of withdrawals from ATMs it is necessary to take into account such effects as the effects of the day of the week, the effects of the week of the month, the effects of the month of the year, as well as the effects of holiday days.

5. Conclusions

In the eighties the ATM became an important part of the international financial system with respect to financial services. The role of ATMs in Poland is still very important and it seems to us it is going to be even more important. The sound management of an ATMs network can reduce the operating costs of ATMs. This is important not only for the operator but also for the customer. A lower cost of average ATM maintenance can convince the owner to install further ATMs in order to save the customers' time, especially of those who are residents in suburbia and on the outskirts.

The main part of the total cost is cash, which is in an ATM and does not bring any profit. Instead of generating profit it works for the customer. In ATM logistics it is very important that the proper amount of cash is in an ATM. Cash should be available to the customer for 24 hours a day but should be not in excess, because cash in ATMs does not generate any profit. Thus, an important problem is how to stock on ATM with cash. From this point of view it is very important to forecast correctly customer demand for cash (withdrawals) in the area where the ATM is installed.

In our paper we assess the main factors determining forecasts of demand for cash from ATMs. On the basis of the time series of withdrawals from ATMs from Małopolska and Podkarpackie provinces delivered by Euronet we prove the existence of calendar effects.

The results of our study indicate that the size and the number of withdrawals are different on particular days. The dependence of the size of withdrawals on the day of the week, the week of the month or the month of the year is well established in the case of customers from the regions being studied.

Since many factors determine the number and size of withdrawals, and for particular ATMs the characteristics may be quite different, forecasts should be calculated for each ATM separately. It is necessary to take into account only those calendar effects which are significant.

The most important properties are reflected in seasonality and calendar effects. The presence of these effects has been proved in this contribution. The authors did not check other properties of ATMs time series like stationarity or long memory. However, the authors are going to conduct further analyses with respect to these properties.

As mentioned in the introduction, the pattern of withdrawals (seasonality, calendar effects) and their statistical properties may be helpful in choosing the proper methods and models for forecasting withdrawals from ATMs.

Our results confirm the importance of calendar effects on withdrawals from the ATMs which we studied.

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