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THE PROPERTIES OF ATMs DEVELOPMENT STAGES-AN EMPIRICAL ANALYSIS

Henryk Gurgul[1], **Marcin Suder**[2]

ABSTRACT

This paper addresses the crucial problem of the ATM's network management which is so-called the saturation level of withdrawals. This notion refers to mean level of withdrawals after dropping particular withdrawals realized in the initial time period, (i.e. time period after activation of ATM) and the length of elapsing time period necessary to reach saturation level. One can observe that the level of withdrawals and their number stabilize as time elapses. The paper aims to define average withdrawals after achieving saturation level and mean time necessary to stabilize withdrawals (based on historical data). In addition, we established that – under condition of similarity in terms of location and date of start - ATMs exhibit similar characteristics of the development effects. This allows us for predicting the size of time necessary to achieve saturation and the average withdrawal in the state of saturation.
JEL Classification: C49, C53

Key words: ATM, withdrawals, saturation level.

1. Introduction

The data on the banks shows the changes over time in the use of technology. One can observe the shift to IT-based delivery systems like ATMs and Internet banking. In addition, the expansion of financial technologies such as financial derivatives and off-balance sheet credit commitments can be noticed. The data on banks also shows improvements in bank performance and consolidation of the industry during the deployment of new technologies. However, establishing the links between technological progress and banking industry productivity growth and the structure of this industry requires extended analyses.

There is a large body of literature on financial innovations. The contributors stress importance of the topic for understanding money demand. However, it is not easy to find in the literature the empirical analysis dealing with management problems resulting from the use of the financial innovations such as the increase in the number of bank branches and ATMs terminals.

[1] AGH University of Science and Technology in Cracow. E-mail: henryk.gurgul@gmail.com.
[2] AGH University of Science and Technology in Cracow. E-mail: m_suder@wp.pl.

The extensive analyses on this subject require large amounts of data on customers. This data is necessary in order to improve services conducted by financial institutions. The learning of habits and patterns of customer behavior on the basis of the empirical financial data is very important because it supports customer value management.

The one of the most important issues addressed in our contribution is the time necessary to achieve full functionality of the ATM (i.e. its maturity). The elapsed time determines realization of the expected profits. Besides time of full capacity (maturity) appointment very a important parameter is the size of withdrawals volume achieved after stabilization of weekly withdrawals. The knowledge of stabilization time point is essential in respect for modeling of withdrawals by time series models. The data prior to this point should be removed from the withdrawals time series used in estimation procedure. It is conjectured in the paper that the time point and the size of the stabilized withdrawals depend on consumer habits and on activity of competitive firms acting in the surroundings of the ATMs under study. To the best of our knowledge this topic has not been so far the subject of research in Poland.

The content of this paper is as follows. Next section reviews most important contributions concerning the ATMs. In the third section the dataset and methodology are presented. In the following fourth section the empirical results of estimation of saturation level and stabilization point of ATMs are showed and compared. Fifth section is concerned with the impact of ATM location on maturity of ATM. In the sixth section the examples of forecasts of the length of the development period and the saturation level are cited. Finally, in the last section we summarize major conclusions and suggest directions for future research.

2. Literature overview

The early studies on bank profitability checked many important bank-specific factors that could determine bank profitability (Rhoades and Rutz, 1982; Clarke et al., 1984; Smirlock, 1985; Evanoff and Fortier, 1988; Lloyd-Williams and Molyneux, 1994; Molyneux and Forbes, 1995; Naceur and Goaied, 2001, etc.). They found that some of them had an influence on bank profits. However, none of these studies checked the influence of investment in information technology (IT) systems on bank success.

The business strategies of banks located in Poland with respect to delivery channels have changed in recent years. In the past, the most important strategies involved how to increase the number of branches under the regulations on bank branching. However, in recent years, besides of increasing the number of branches the establishing branches that can offer full services (i.e. banking services, security services, insurance services, trust services, home loan services, etc.) at each branch location have become popular.

Banks also try to use information technology because of fast developments in this field and the popularization of IT in each country. Customers cannot only shorten their waiting time but also use bank services after closing time through Automated Teller Machines and Internet banking. Application of IT may enable banks reduction of excessive personnel costs. In addition, financial institutions can start new businesses which require the use of ATMs and other machines. An effective use of these IT tools makes possible that banks make more profits by introducing IT systems.

Holden and El-Bannany (2004) were the first who stressed the importance of investment in IT systems for bank success. In particular, they were concerned with the effects of investing in ATMs that perform routine banking transactions instead of tellers. The contributors argued that the use of ATMs can reduce banking transaction costs, the number of personnel and the number of manned branches, and can also increase bank profit. The authors used the number of ATMs of individual banks as a proxy for the measure of investment in IT systems, and analysed whether ATMs influenced profits by using data from the United Kingdom. An analysis by Holden and El-Bannany (2004) suggested that ATMs play an important role in increasing Return On Asset (ROA) of banks in the United Kingdom.

Many Japanese banks also took for granted that ATMs are important machines that can reduce banking transaction costs, excessive personal costs and branching costs.

In order to prove this conviction Kondo (2010), based on the type of analysis carried out by Holden and El-Bannany (2004) checked whether the fact that ATMs increase the ROA, as shown for banks in the United Kingdom by Holden and El-Bannany (2004), is also true for Japanese banks. He also tried to prove the effects of ATMs on the fees and commissions (income) and the interest income that could be increased by ATM actions. His results suggested that the ROA of Japanese banks is not fully explained by the variables used by Holden and El-Bannany (2004). In particular, he found that ATMs do not influence the ROA directly in Japan. However, the empirical results of the author do not contradict the thesis that ATMs contribute to increased profits, especially in transactions in which their primary functions are used. Kondo (2010) conducted also further analysis with respect to the effects of ATMs on fees and commissions, including income collected by ATMs, and on interest income, including investment profits produced by using money collected by ATMs. He found that ATMs had positive and significant effects on the fees and commissions from 2000 to 2003, but no significant effects of ATMs were found for 2004. However, positive and significant effects of ATMs on interest income were detected in the following years of the study period. This suggests that banks that actively establish ATMs and collect deposits by ATMs are investing well and succeed in increasing profits.

The findings indicate that ATMs of Japanese banks do not influence the ROA that contains the overall profits of bank transactions, which is different from the case in the United Kingdom tested by Holden and El-Bannany (2004), but they do contribute to those particular transactions that best take advantage of their abilities. Thus, it is important for Japanese banks to invest in ATMs in order to increase profitability.

ATMs withdrawals time series are directly or indirectly reflected in daily activity of customers. They are usually recorded on a daily, monthly, quarterly basis or some other period. Cleveland and Devlin (1980) and Liu (1980) found that, e.g. the number of working days and its link with seasonal effects have impact on the size and the number of withdrawals.

Besides the number of working days, the day of the week, the week of the month, other factors such as public holidays or religious events may also affect withdrawals time series. In addition, withdrawals are often overlaid with paydays and seasonal demand, and often follow weekly, monthly and annual cycles. These issues are addressed in papers such as Simutis *et al.* (2008).

Both the correction for calendar and seasonal effects and detection of time of maturity of ATM and the level of withdrawals may help to improve the performance of short-term macroeconomic forecasts (see Carlsen and Storgaard, 2010; Esteves, 2009, Galbraith and Tkacz, 2007).

The results of statistical analysis on withdrawals data were published by Hand and Blunt (2001), Amromin and Chakravorti (2007), Boeschoten (1998) and Snellman and Viren (2009). The authors assumed that individuals replenish their cash when it falls below a certain threshold. The authors detected that ATM users typically had a lower amount of cash than non-users because the cost to them of obtaining cash was lower. Snellman and Viren (2009) modeled the relationship between the cost of obtaining cash and the number of ATMs. The contributors assumed that costs are proportional to distance from ATMs.

In opinion of Findley and Monsell (2009), Findley et al. (1998), Cleveland and Devlin (1980), Findley and Soukup (1999, 2000, 2001), McElroy and Holland (2005) distribution of withdrawals is very important with respect to modeling, forecasting and replenishment strategy. This problem is complex because of mobile holidays like Easter, Ramadan or the Chinese New Year (Gurgul and Suder, 2012).

The advanced models of ATM withdrawals were developed by Brentnall et al. (2008, 2010). The authors noticed that the empirical distribution of random effects performed well because there was large number of individual accounts.

Kufel (2010) showed by regression based on dummies and harmonic analysis that withdrawals time series for ATMs in Torun exhibited yearly, monthly, weekly and daily seasonality.

In the next section we will present dataset properties and methodology.

3. The dataset and methodology

It is not an easy task to get data on ATM’s activity. This is probably one of the main reasons for low number of empirical contributions in this field. The detailed insight is in the following subsection.

3.1. The dataset description

The empirical analysis was based on weekly time series of withdrawals from 93 out of 293 EURONET ATMs located in Małopolskie and Podkarpackie provinces. Our analysis took into account the data from the ATMs, which started operating in 2008 or 2009 and operated continuously until April 20th, 2012. The ATMs which were operating also after 20th of April 2012 could not be taken into the analysis because in such cases the withdrawal data prior to 2008 was unavailable. On the other hand, the time series of withdrawals from the ATMs which started operating after 2009 were too short to conduct the empirical analysis.

The ATMs were divided according to two criteria. The first criterion, called the *population category*, is related to the size of the city/town/village in which the ATM is located. Taking into account the number of inhabitants, this criterion leads to the following clustering:

I. 0 - 20 thousand – Villages and small towns,
II. 21 - 50 thousand – Cities of average size,
III. 51 - 100 thousand – Big cities,
IV. 101 - 200 thousand – Cities of a very large size,
V. Over 201 thousand – Metropolises (Cracow).

The second criterion is related to the characteristics of the ATM's location. In this study we used six types of location of ATM's, namely: bank branch, hypermarket, petrol station, shop, shopping center and the "other" location type. Table 1 presents the data on the number of ATMs in the examined types of locations.

Table 1. The number of ATMs according to the clustering criteria

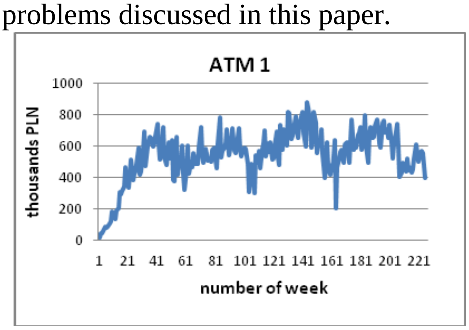
location category \ population category	I	II	III	IV	V	Total
bank branch	0	7	4	7	18	36
hypermarket	0	2	4	2	6	14
other	0	1	0	3	9	13
petrol station	1	1	0	0	4	6
shop	0	5	0	1	9	15
shopping center	1	2	1	3	3	9
total	2	18	9	16	49	93

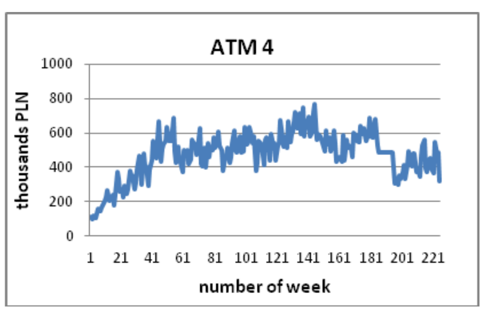
In order to discuss the problems investigated in this paper in a detailed way, we will present the outcomes of an analysis of six selected ATMs, which vary in terms of the location. Table 2 contains basic information about each of the selected ATMs, while Figures 1-6 present the charts of the weekly time series of withdrawals from each individual ATM.

Table 2. Basic information on selected ATMs

ATM's number	ATM 1	ATM 2	ATM 3	ATM 4	ATM 5	ATM 6
province	Małopolskie	Małopolskie	Podkarpackie	Podkarpackie	Małopolskie	Małopolskie
town/city	Niepołomice	Andrychów	Stalowa Wola	Rzeszów	Kraków	Kraków
population category	I	II	III	IV	V	V
location type	shopping center	petrol station	bank branch	hypermarket	other	shop
start date	02-01-2008	02-01-2008	01-12-2008	02-01-2008	12-03-2008	05-11-2008
number of obs.	225	225	178	225	215	181
average of daily withdrawal	541 127	342 015	289 524	475 722	277 245	194 353
coefficient of variation	30,04%	28,56%	46,07%	27,87%	24,46%	22,67%
minimum	13 650	52 400	250	99 400	31 900	63 700
maximum	877 500	508 350	537 370	76 9900	417 850	292 650

The data presented in Table 2 indicates significant differences among six ATMs selected for the analysis, which ensures a comprehensive approach to the problems discussed in this paper.





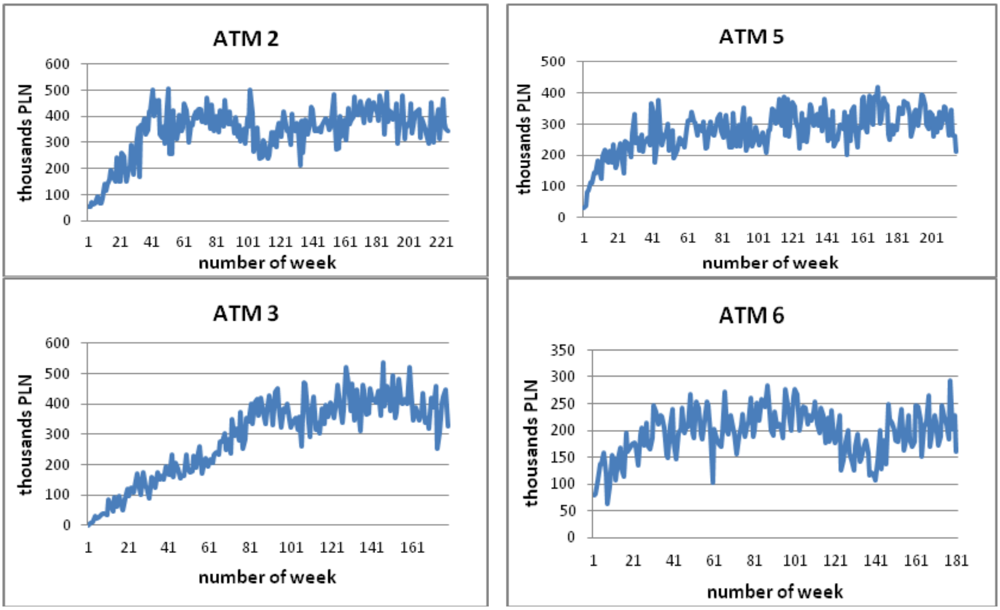


Figure 1. Weekly withdrawals from ATMs 1-6

The analysis of Figure 1 provides a basis to claim that in the initial phase the size of the withdrawals increases significantly for each ATM. However, after some time the growth rate drops markedly. Moreover, one can even see some evidence of stabilization of the withdrawals over time (taking into account the presence of seasonality). In addition, we noted that the time required for the withdrawals to stabilize differs slightly among the selected ATMs.

In the next subsection we cite simple models used in our analysis.

3.2. The methodology

In general, the analysis of the length of the development phase of ATMs was based on two methods.

The first method was based on the analysis of the local trends. In order to determine the time point, at which the withdrawals from the ATM stabilize, i.e. the ATM starts to work in its usual rhythm (taking into account the calendar effect), one should fit the following trend function to the examined dataset:

$$f(t) = \begin{cases} a_1 t + b_1 & if \quad t \le t_0 \\ a_2 t + b_2 & if \quad t > t_0 \end{cases}.$$

By the ordinary least squares (OLS) method the coefficients a_1, b_1, a_2, b_2 and the point t_0 were estimated. Assumption that the trend function takes the form of the piecewise function consisting of two linear functions allows to determine the point in time at which the significant change in the dynamics of the development of the ATM takes place. In particular, we aim to prove that for the examined data the slope coefficient of the trend function $f_1(t) = a_1 t + b_1$ is much higher than the slope coefficient of the function $f_2(t) = a_2 t + b_2$. The value of the parameter t_0 may be interpreted as the length of the ATM's development phase. On the other hand, the coefficients a_1 and a_2 allow to specify the average growth rate of withdrawals during the period of development and the stable period. Finally, the value of the coefficient b_2 will determine the saturation level of the ATM.

The second method is based on modeling the size of withdrawals from ATMs with the logistic function. We assumed that the development of a specific ATM (size of withdrawals) follows the logistic curve $f(t) = \frac{a}{1 + b \cdot e^{-c \cdot t}}$ where $a, b, c > 0$. This type of function is often used to study the development of the market after an introduction of a new product. The parameter a determines the level of saturation, e.g. sales volume of the new product or (as in our case) the size of withdrawals from an ATM. The logistic function has a point of inflection at $t = \frac{\ln b}{c}$ and changes from convex to concave, which implies that in the neighborhood of the point $t = \frac{\ln b}{c}$ the increase in the value of the function changes from more than proportional to less than proportional[1].

In order to examine the impact of the calendar effect the analysis was performed on the series of weekly withdrawals and the seasonally adjusted series. Since the results obtained for both types of series were in general the same, we will present only the results obtained for the original (unadjusted) data.

In the following section the results of the conducted empirical analysis are showed.

4. Empirical results

In this section we report and evaluate the empirical results derived by local trend method and logistic regression. Next, we will compare the results by both approaches.

[1] In the literature various methods of estimation of the logistic model were introduced, e.g. the Hotelling method or the method of arbitrary fixing the parameter a (saturation level). One can also use some professional statistical software. However, if it comes to widely available computer software, it is recommended to perform the calculations in MS Excel Solver package. In this paper, the estimation method was based on minimizing the sum of the squared errors in MS Excel Solver framework.

4.1. Duration of development phase of ATMs by local trend approach

The analysis of the length of the development phase as well as the determination of the saturation levels was carried out for 93 time series. However, the complete results will be presented only for the six selected ATMs. In the further part of this section the descriptive statistics and the distribution of the length of the development phase for all 93 ATMs will be presented.

Figure 2 contains the result of fitting the trend function to the weekly withdrawals from ATM 5. On the other hand, Table 3 contains the results of the analysis performed for the six selected ATMs. We present the estimated values of the coefficients, the significance levels and the values of the coefficients of determination (R^2) for each examined model.

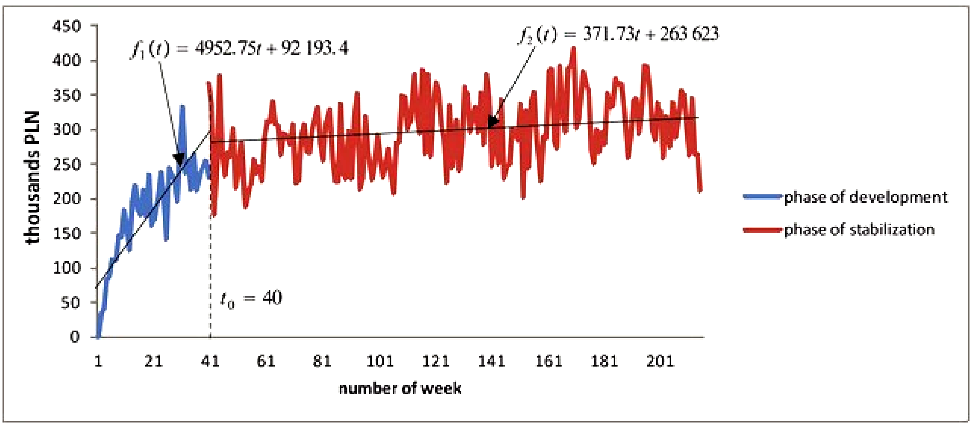


Figure 2. Local linear trend analysis for ATM 5

Table 3. Estimation results (local trend approach) for six selected ATMs

ATM's number	t_0	a_1	b_1	a_2	b_2
ATM 1	41	16 473.1***	10 230.5	351.91**	54 8735***
		R^2=90.57%		R^2=2.56%	
ATM 2	45	9355.51***	9452.55	173.75**	355 638***
		R^2=86.92%		R^2=2.45%	
ATM 3	71	6373.64***	150 213	764.77***	506 132***
		R^2=73.72%		R^2=8.99%	
ATM 4	43	8559.28***	101 182***	1428.5*	479 942***
		R^2=81.08%		R^2=7.27%	
ATM 5	40	4952.75***	92 193.4***	371.73***	263 623***
		R^2=68.53%		R^2=13.68%	
ATM 6	30	6327.84***	76 321.5***	467.22***	252 810***
		R^2=69.99%		R^2=15.65%	

The results show that for all selected ATMs one can easily indicate the point in time at which the stabilization of the size of the withdrawals takes place. For example, for the series of withdrawals from ATM 5 the period after which the stabilization occurs is approximately 40 weeks l (see Figure 2). It turns out that the slope coefficient of the trend function for the first 40 data points is equal to 4952.75. Thus, in this initial phase the size of the weekly withdrawals increases (on average) by 4952.75 zł per week. In the second period ($t_0 > 40$) the slope coefficient of the trend function is equal to 371.73, which implies that the growth rate of the withdrawals decreases by more than 13 times in comparison to the first period. The estimated saturation level of the ATM is equal to 263 623 zł. A similar analysis performed for the daily data and the seasonally adjusted data confirmed these results. Thus, the analysis of the ATM 5 clearly proves that this ATM reached the stabilization of the withdrawals after about 40 weeks. For ATMs 1, 2 and 4 the length of the stabilization period is similar as it varies between 38 and 45 weeks. For ATM 3 the development period is much longer (about 70 weeks). On the other hand, in case of ATM 6 this period is shorter (about 30 weeks).

An important issue in this analysis is the fact that for all ATMs the slope coefficient of the trend function in the first period (development phase) is much higher than the value of the slope coefficient of the trend line for the second period (stable period). In addition, the values of the slope coefficients in the second period are relatively small and their positive values may be associated with a general tendency to increase the size of withdrawals from ATMs with time (e.g. inflation rate, etc.).

An analogous analysis performed for the remaining 87 ATMs proved that in 85 cases the slope coefficients of the trend functions in the first phase were much higher than the slope coefficients in the second period. Only for two ATMs the slope coefficients of the trend function f_1 were lower than the slope coefficients of the function f_2. It is likely that this situation was caused by some additional events which took place in the close neighborhood of the ATMs, e.g. opening of a new shopping center, a new transport hub, etc.

Table 4 presents the descriptive statistics for the lengths of the development phases of the 91 ATMs (as already mentioned, for two ATMs it was difficult to determine the point t_0).

Table 4. Descriptive statistics of the lengths of the development periods of the ATMs

mean	median	Standard deviation	coefficient of variation	minimum	maximum
49.03	49	18.21	37.13%	9	83

Figure 3 presents the distribution of the lengths of the development phases of the ATMs.

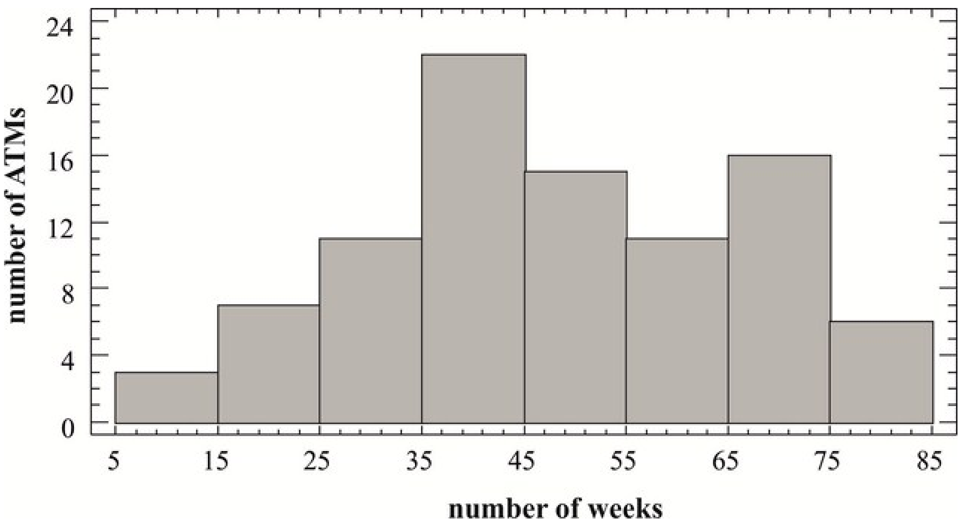


Figure 3. Distribution of the length of the development phase for weekly withdrawals from the ATMs (local trends approach)

The results of the analysis showed that the average length of the development phase of ATM is equal to 49 weeks, i.e. almost one calendar year. Variability of the length of the first phase is rather moderate and reaches the value of about 37%. The histogram suggests that the most common length of the development phase ranges between 36 and 48 weeks. The analysis showed that the development period was less than 12 weeks (3 months) only in one case. On the other hand, the group of ATMs for which the development period exceeds 72 weeks is quite large. Our analysis also showed that the results obtained for weekly data and seasonally adjusted daily data are very similar.

The results of alternative empirical approach by logistic regression are reported in the next subsection.

4.2. Saturation level estimated by logistic function

The application of the logistic function in the study on the phase of stabilization of ATMs withdrawals allows verifying and extending the previously obtained results (based on local trends approach). It also makes possible to determine the point in time in which the change of the dynamics takes place and estimate the level of saturation more accurately. On the other hand, some difficulties with determining the unique point in time in which the withdrawals stabilize may also occur. In this paper, we assumed that the point t_0 (stabilization point) is such a point in which The slope of tangent becomes not significant. On the basis of the analysis of the figures we assumed that a dramatic drop of the slope (6-7 times) determines approximately the stabilization point.

Figure 4 contains results of fitting the logistic function to the time series describing the weekly withdrawals from ATM 5.

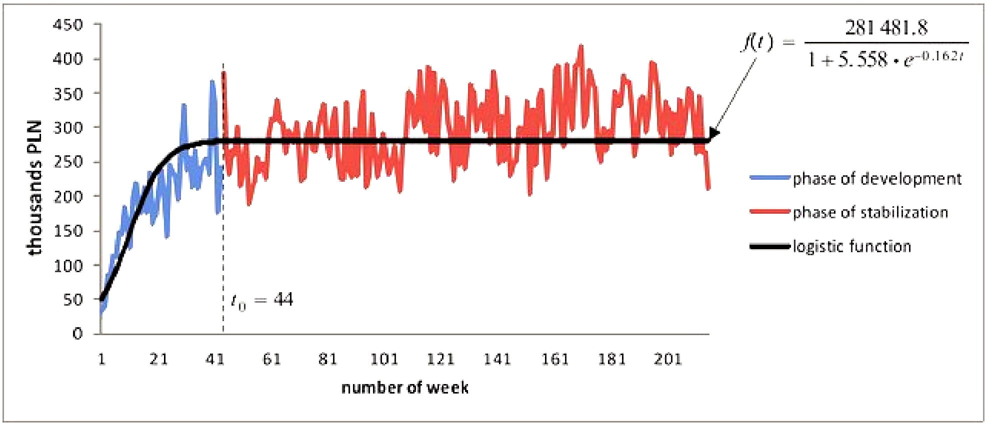


Figure 4. The results of fitting the logistic function to the weekly withdrawals from ATM 5

One can see (Figure 4) that the logistic function fits quite well to the dataset of weekly withdrawals. It does not capture the calendar effect or the seasonality. This, however, is not one of the main goals of our analysis.

Table 5 presents the results of the analysis performed for six ATMs (the estimated coefficients, the points of inflection and the stabilization points).

Table 5. The results of fitting the logistic function to the time series of weekly withdrawals from six selected ATMs

ATM's number	ATM 1	ATM 2	ATM 3	ATM 4	ATM 5	ATM 6
a	583 233.80	392 913.83	460 408.02	522 098.50	281 481.80	234 002.57
b	18.523	11.744	7.930	4.481	5.557	1.473
c	0.178	0.116	0.038	0.083	0.162	0.102
point of inflection	16.403	21.256	54.882	18.036	10.608	3.800
t_0	39	51	82	64	34	42

Similarly to the previous case, the analysis of the fit of the logistic function was performed for 91 out of 93 ATMs.

The distribution of the length of the development of ATMs and some basic descriptive statistics obtained after fitting the logistic function are presented in Table 6 and on Figure 5.

Table 6. Descriptive statistics for the length of the development phase

mean	median	Standard deviation	coefficient of variation	minimum	maximum
52.48	50	14.64	27.88%	11	84

Figure 5 presents the distribution of the length of the development phase.

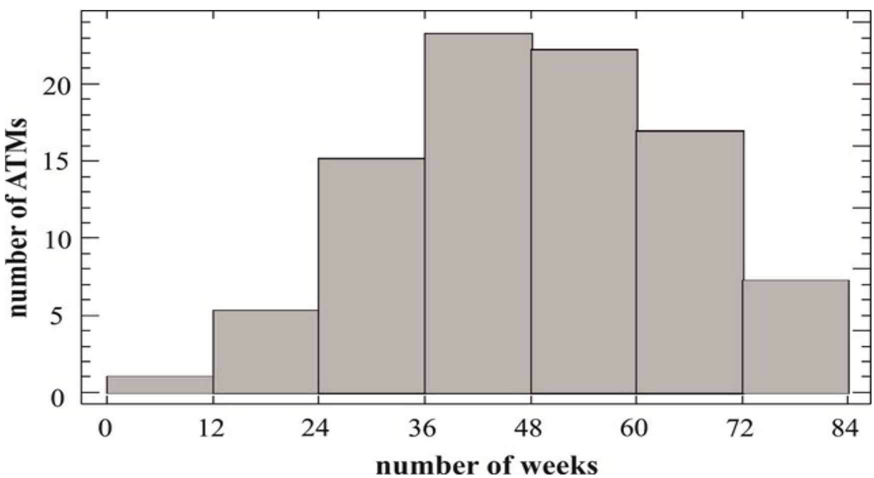


Figure 5. Distribution of the length of the development period for weekly withdrawals (logistic function approach)

The average length of the development phase of ATMs obtained after the application of the logistic function is approximately one year (52.48 weeks). Thus, it is slightly higher than the length obtained by the local trend approach. However, the variation of the length of the development period turned out to be smaller, as the coefficient of variation reached the level of 27.88%. We also found slight differences between the distributions of the length of the development period.

The analysis of the development of ATMs was carried out by two methods: the local trend approach and the application of the logistic function.

Therefore, in the next subsection we compare them.

4.3. Comparison of the empirical results

The results obtained after the application of both methods turned out to be very similar. Beside the length of the development phase of ATM, the issue of withdrawals saturation is also very important, especially from the perspective of managing the ATMs network.

In tables 7-8 the results of the comparison of the lengths of the development periods (expressed in weeks) and saturation levels are presented. In case of the analysis performed via local trend approach the constant term in function $f_2(t) = a_2 t + b_2$ was interpreted as the saturation level.

Table 7. Comparison of the results of analysis of the lengths of the development periods

Method	ATM 1	ATM 2	ATM 3	ATM 4	ATM 5	ATM 6
Linear local trend approach	41	45	71	43	40	30
Logistic function	39	51	80	50	44	36

Table 8. Comparison of the results of analysis of the saturation levels

Method	ATM 1	ATM 2	ATM 3	ATM 4	ATM 5	ATM 6
Linear local trend approach	548 735	355 638	506 132	564 846	263 623	252 810
Logistic function	583 233	392 913	460 408	522 098	281 481	234 002

The comparison of the results of the length of the development period provides basis to claim that for 5 out of 6 selected ATMs the logistic function indicated longer length of the development period. However, the lengths of the development periods of the selected ATMs did not differ by more than about 10 weeks. Comparison of the results obtained for all ATMs leads to similar conclusion as in the case of six selected ATMs. Namely, the results of the analysis of the logistic function fitted to the dataset of 88 ATMs indicated a bit longer length of the development phase. However, in all cases the difference did not exceed 12 weeks, i.e. about 3 months. Thus, one may claim that the two methods lead to similar results in terms of estimating the length of the development phase, however, some differences are also noticeable. These differences may be a consequence of the choice of methodology of establishing the point of stabilization by application of the logistic function.

Similar results were obtained in case of determining the level of saturation. Although in this case it is difficult to indicate a method which gives higher values of the saturation level, the stabilization levels are similar. For the selected ATMs a relative difference between the saturation levels determined after the application of logistic function and the piecewise function built for local linear trend function did not exceed 11%. For all examined ATMs the average error was around 8%. The maximal value of the error did not exceed 15%.

The results of a comparison of the two methods of determining the length of the development phase and the levels of saturation of the sizes of withdrawals provide a basis to claim that the values obtained during these analyzes are correct and may turn out to be helpful in managing the ATMs networks.

One of the main factors in development of ATMs can be location. This issue is addressed in the next section.

5. The impact of location on the development period of the ATMs

The results presented in previous section suggest that the average length of the development period of the ATMs is equal to approximately one year. However, one can see (comp. Fig. 3, Fig. 5) that there is relatively large group of ATMs for which the length of the development period differs significantly from the average. In addition, the detailed analysis conducted for six selected ATMs suggests that the type of location may have an impact on the length of the development phase. Therefore, we examined whether such characteristics as: province, size of population or type of location have an impact on the differences between the lengths of the development periods. In tables 9-11 the descriptive statistics for the lengths of the development periods for different location types are presented. In addition, the *p*-values obtained during an analysis of variance were calculated to check whether the differences among the lengths of the development periods are statistically significant.

Table 9. Descriptive statistics calculated for the lengths of the development periods in two provinces

province	Number of ATMs	mean	median	coefficient of variation	minimum	maximum	*p*-value
Małopolskie	69	48.45	51	38.59%	8	84	0.6049
Podkarpackie	24	50.70	48	33.49%	22	83	

The results of the analysis (comp. Table 9) proved that the average length of the development period of the ATMs located in Podkarpackie province is higher than the corresponding length in Małopolskie province. The difference, however, is not statistically significant.

Table 10. Descriptive statistics calculated for the lengths of the development periods among different population categories

Population category	Number of ATMs	mean	median	coefficient of variation	minimum	maximum	*p*-value
I	2	56.71	56	40.61%	40	73	0.2068
II	17	48.21	49	38.30%	15	74	
III	9	41.98	43	55.12%	9	79	
IV	16	57.87	57	27.27%	34	83	
V	49	47.41	47	36.70%	13	84	

The analysis of outcomes presented in Table 10 provides a basis to claim that the longest development period characterizes the cities with population at the level of 101-200 thousand. On the other hand, the development period is shortest in case of the cities with the population at the level of 51-100 thousand. Once again the differences in the average lengths of the development periods are not statistically significant (p-value=0.2068).

Table 11. Descriptive statistics calculated for the lengths of the development periods in respect to different location types

Location type	Number of ATMs	mean	median	coefficient of variation	minimum	maximum	*p*-value
bank branch	36	56.62	56	31.82%	22	84	0.0015
hypermarket	14	40.18	42	34.91%	9	67	
other	13	35.40	36	40.88%	13	57	
petrol station	6	53.47	46	29.92%	40	76	
shop	15	46.09	42	40.00%	15	70	
shopping center	9	54.04	57	28.97%	30	71	

The results of the analysis show that the type of location has a significant impact on the length of the development phase of the ATMs (cf. Tab. 11). The longest development period occurs in case of ATMs located at bank branches. This period was about 57 weeks long (on average). The shortest average period of development characterizes the ATMs located in “other” category. ATMs located in supermarkets also become "mature" relatively fast.

The analysis of the impact of location on the length of the development period was carried out for the results of the analysis of the local trends. However, a similar analysis performed for the results obtained from fitting a logistic function gave very similar results.

The results based on historical data allowed estimating the saturation level and the stabilization point. In the next section we will attempt to forecast these main characteristics of ATMs.

6. Forecasting of the length of the development period and the saturation level

The previous analysis was based on an examination of some properties of time series of historical data. It has been shown that for every ATM it is possible to determine the point in time at which the size of withdrawals stabilizes. In addition, the level of the withdrawals during the stable period has been estimated. However, from the perspective of managing the ATM network, an important issue is to determine the parameters associated with the development of the ATM in case of those ATMs which are relatively “young”. The ability to forecast the level of saturation and the length of the development period allows assessing whether the functioning of the ATM will be profitable in the future.

In case of the ATMs which have just started functioning, one of the methods of determining the parameters of the development can be based on a comparison of the similarity of time series. Namely, if one manages to show that for a group of ATMs with similar location type, the lengths of the development periods and the saturation levels are relatively close, then whenever starting a new ATM the predicted values of the development parameters should be equal to the average values of the parameters for the ATMs in the same location. A preliminary analysis showed that the ATMs which are characterized by the same type of location (province, size of population, surroundings) and which started at a similar time of the calendar year, are characterized by a very similar length of the development period. However, such an approach significantly reduces the possibility of forecasting because when a new ATM is started it is not certain whether it will be possible to find an already functioning ATM with similar properties, location, and a similar start date. Therefore, we were forced to look for other methods that would allow for estimation of the parameters associated with the development of ATMs.

In chapter 6 it was demonstrated that the logistic function can be successfully applied to describe the change in the size of the ATM’s withdrawals in the time dimension. However, the estimation of the coefficients was based on the historical data which clearly excludes the possibility of formulating the forecasts.

In this part of the paper we investigated whether the estimated parameters of the logistic function based on the historical data covering only some initial period differ significantly from the estimates obtained from the full dataset. Such an approach would allow predicting the form of the logistic function of the ATM, in particular, forecast of such parameters as the length of the development period and the level of the saturation.

For this purpose, for all ATMs the coefficients of the logistic function were estimated based on the weekly data covering first 12, 16, 20, 24, 28.…. and 52 weeks. Then these results were compared with the results obtained from the estimation based on the full dataset. Figures 6 and 7 present the plots of the logistic functions obtained in the above-mentioned procedure based on the data for ATM 5.

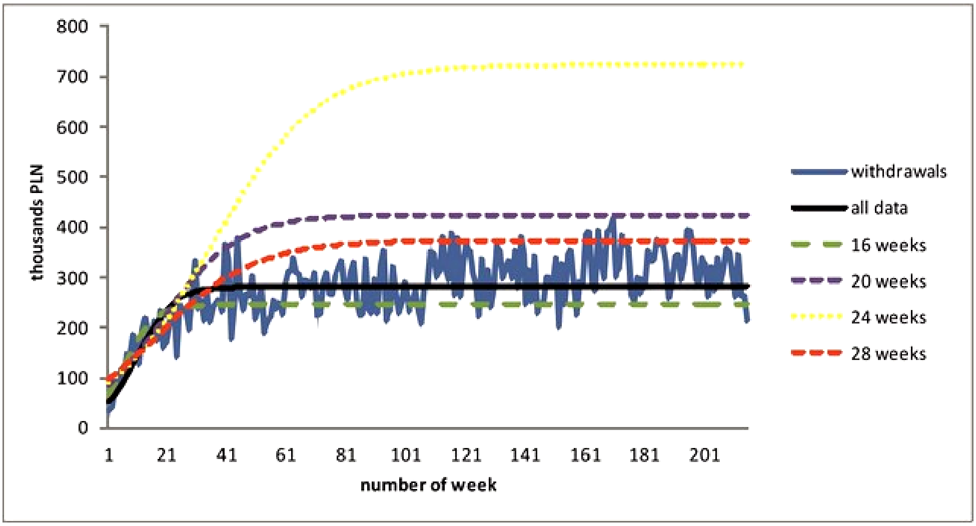


Figure 6. The logistic function based on data covering first: 16, 20, 24, 28 weeks and all data

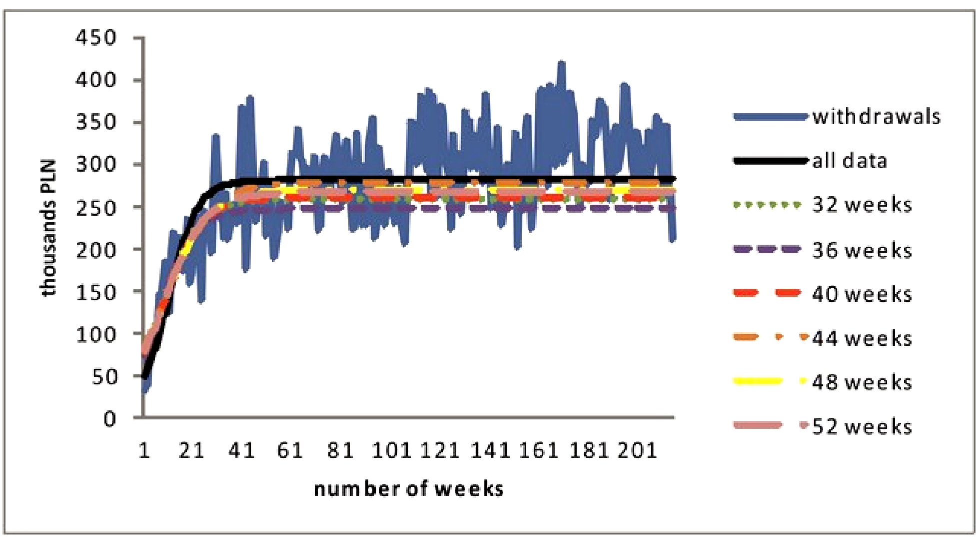


Figure 7. The logistic function based on data covering first: 32, 36, 40, 44, 48, 52 weeks and all data

The plots presented in Figure 6 provide a basis to claim that the shape of the logistic function estimated on the basis of the data from the first 20, 24 and 28 weeks differs significantly from the shape of the function estimated on the basis of the full dataset. However, in case of the function estimated on the basis of first 16 weeks the results are quite similar with the full-sample-based one. In addition, the logistic functions estimated on the basis of the data covering first 32, 36, ..., 48, 52 weeks (Figure 7) are also very similar to the full-sample-based one. Therefore, one may note that in case of the ATM 5 the form of the logistic function could be successfully forecasted after 32 weeks. Moreover, the saturation level and the length of the development phase may also be forecasted after this period.

A similar analysis was performed for the time series describing the size of the weekly withdrawals from remaining ATMs. Table 12 contains the estimated values of the saturation level and the length of the development period based on the full dataset and the forecasts based on the data covering first: 12, 16, 20, ...,48, 52 weeks. The results are based on the analysis of the six selected ATMs.

Table 12. The results of forecasting the length of the development period and the saturation level

	ATM 1		ATM 2		ATM 3		ATM 4		ATM 5		ATM 6	
	t_0	Saturation level	t_0	Saturation level	t_0	Saturation level	t_0	Saturation level	t_0	Saturation level	t_0	Saturation level
all data	39	583233	51	392913	80	460408	50	522098	44	281481	36	234002
12 weeks	18	182040	65	6.36E+11	35	255461	75	1.10E+08	120	1.10E+08	100	1.10E+08
16 weeks	58	2576349	49	264524	75	2531592	70	238595	26	245446	52	128625
20 weeks	42	787107	50	427439	75	488065	47	426366	67	423595	40	424669
24 weeks	38	617636	52	423450	82	485498	51	521171	102	722244	38	219514
28 weeks	36	544126	54	380442	83	507194	45	567528	80	373126	34	222053
32 weeks	39	578750	58	399751	85	520531	49	578054	40	258825	37	233251
36 weeks	40	622082	60	426887	81	484344	54	585813	42	256859	38	217520
40 weeks	40	653230	58	470009	78	464126	60	606937	41	260624	37	231456
44 weeks	41	635873	57	510969	79	442209	65	752042	47	278595	35	217414
48 weeks	41	613171	56	481703	76	422527	67	822777	43	269402	33	211585
52 weeks	39	594272	60	463468	74	452394	63	803468	42	266658	37	219332

*Grey color – forecast error not greater than 10%. Slate gray color - forecast error not greater than 5%.

The analysis of the results presented in Table 12 leads to conclusion that there are two types of possible outcomes. In case of ATMs 1, 3, 5 and 6 satisfactory estimates of the unknown parameters were obtained on the basis of the data covering first 20-32 weeks. After increasing the sample size we obtained better forecasts. For ATMs 2 and 4 the prediction errors were smaller than 10% if the estimation was based on the data from the first 20-36 weeks. However, in these cases increasing the number of data points leads to prediction errors which were greater than 10%. This phenomenon may seem a bit strange, however, it can be explained quite easily. The reason of such a situation is the fact that some ATMs are more sensitive to the presence of the calendar effects. An unexpected rise or drop in the size of the withdrawals, which is due to some calendar effects (e.g. the beginning of Christmas or holiday), may cause an overestimation or underestimation of the level of saturation, and have a negative impact on the accuracy of the forecast of the length of the development phase.

However, after combining the findings from the analysis of the ATMs of the first and second group we can see that the optimal length of the period after which the forecast errors of the parameters do not exceed 10% is about 36 weeks.

The analysis performed for the remaining 85 ATMs showed that in all cases the prediction based on the data covering first 28-36 weeks leads to optimal predictability of the length of the development phase and the saturation level.

It should be underlined that the possibility of prediction of the discussed values after a period slightly longer than half a year gives the managers an ability to take appropriate decisions regarding the future of the ATMs.

On the other hand, one should not forget that the presented methodology is quite sensitive to the calendar effects. Therefore, each application of this procedure must be accompanied by an opinion of an appropriate expert specialized in the issue of cost-effectiveness of the ATMs network.

In the following final section we will summarize results and conclude.

7. Conclusions

One of the key elements of the ATM's network management is the ability to determine the time at which the ATM begins to operate in its regular rhythm and estimate the level of saturation of the withdrawals (average level of the withdrawals in the stable period). In this paper we have shown that for every ATM it is possible to determine the values of both these parameters on the basis of historical data.

In addition, we found that the ATMs characterized with similar type of location and similar start dates are also similar in terms of the development effects. This allows predicting the size of these values.

We have shown, however, that in order to forecasts the values of selected development indicators one can use a forecasting method based on the application of the logistic function estimated on the basis of the data covering first 28-36 weeks. As a consequence, after about half a year, we are able to estimate the time at which the withdrawals from ATM will stabilize reaching the level of saturation. Such information can turn out to be helpful in making the decisions on the future of the ATMs. After about half a year the managers can decide whether the ATM will be profitable in the future.

However, it should be emphasized that the presented methodology is sensitive to the calendar effects and thus it cannot be applied without second thought as it requires appropriate expert's supervision.

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