FORECASTS OF NON-CASH TURNOVER IN POLAND

Jerzy Witold Wiśniewski

ORCID: 0000-0002-7606-2748
Nicolaus Copernicus University in Toruń
Faculty of Economic Sciences and Management, Department of Econometrics and Statistics
Gagarina 11, 87-100 Toruń, Poland
E-mail: Jerzy.Wisniewski@umk.pl

Abstract: *In the initial period of payment card use by bank customers, payment cards were primarily employed for ATM cash withdrawals. This lowered the costs of the banking system as well as facilitated and accelerated the money-holders' access to their cash. Along with the development of the infrastructure for handling non-cash transactions with the use of payment cards, a rapid increase in the number and the value of non-cash payments occurred. The dynamic increase in non-cash transactions is a global trend in payments.*

The purpose of this study is to analyze the process of changes in non-cash payments in Poland, against the background of payment card use for ATM cash withdrawals. It is requisite to answer the question of whether, and to what extent, non-cash payments supersede the cash withdrawn from ATMs by payment card owners.

The tool used to analyze the potential process of cash transaction erosion caused by non-cash payments is a two-equation econometric model with feedback. For this purpose, statistical data, obtained from the National Bank of Poland, in the form of quarterly time series from 2008-2019, was used. Accordingly, clarification is expected regarding the question of whether the Polish payment system is heading towards a dominance of cashless transactions or not. The reaction, in the form of changes in the value of non-cash payment card transactions in Poland, affected by the increase in the wealth of citizens, measured by an increase in the average pay, was examined. Impact of the share of ATM cash withdrawals via payment cards on the share of non-cash transactions, expressed in value, was also measured. The modeling results were used to estimate forecasts of the share of non-cash transactions in the total value of market transactions and of the share of ATM cash withdrawals in the total value of transactions.

Key words: *payment cards, econometric model, non-cash payments*
JEL codes: *G21, C1, C5, G17)*

1. Introduction

The dynamic increase in the number and the value of cashless transactions has been a global trend in payments. In rich countries, cashless transactions have been replacing cash. Payment cards are a well-established instrument for cashless payments. Studies on the payment card market appeared in economic literature as early as the end of the 20th century. Examples include such works as: Humphrey, D. B., Pulley, L. B., & Vesala, J. M. (1996), Hancock, D., Humphrey, D. B., & Wilcox, J. (1999) and many others. More advanced research results were published at the beginning of the 21st century, for instance the works of: Hauswald, R., & Marquez, R. (2003), Amromin G., Chakravorti S. (2007), Rysman M. (2007), Sokołowska E. (2015a), Sokołowska E., Wiśniewski J.W. (2015), Wiśniewski J. W., Sokołowska E., Wu Jinghua (2017), which comprise various results of empirical research on the payment card market. Payment cards belong to innovative financial instruments, as discussed in such works as: Tufano, P. (2003), Wiśniewski J.W. (2018a). The need for and the consequences of the replacement of cash payments with electronic money has been discussed, for example, in an article published by a team of authors: Evans D. S., Webster K., Colgan G. K., Murray S. R. (2013) discusses the of replacing .

The purpose of this study is to analyze the process of changes in non-cash payments in Poland, against the background of ATM cash withdrawals. It is requisite to answer the question of whether non-cash payments are replacing traditional money withdrawn by cardholders from ATMs.

The tool used to analyze the potential process of cash transactions being displaced by non-cash payments will be a two-equation econometric model with feedback. Accordingly, clarification is expected regarding the question of whether the Polish payment system is heading towards a dominance of cashless transactions or not. The final result entails the forecasts of: the share of non-cash transactions in the total value of transactions and the share of ATM cash withdrawals in the total value of transactions.

2. Methodology and Data

In the initial period of payment card use by bank customers, payment cards were primarily employed to withdraw cash from ATMs. This lowered the costs of the banking system as well as facilitated and accelerated the money-holders' access their cash. Along with the development of the infrastructure for handling non-cash transactions with the use of payment cards, a rapid

increase occurred in the number and the value of non-cash payments. Non-cash payments are obligatory in settlements between business entities.

In modern countries, cash transactions have been lapsing. Cash is being replaced by electronic money. The subject of this study entails analysis of the mechanisms characterizing the changes in the share of non-cash payments, against the background of ATM cash withdrawals in Poland, in the total value of transactions as well as analysis of the impact of the increase in the wealth of citizens on those changes. An attempt will be made to answer the question of how the electronic payment system has been developing and how electronic money has been displacing cash transactions in Poland.

The following variables characterizing the payment market in Poland will appear in the econometric equations presented in this work:

CNPAY – quarterly share of the value of non-cash transactions in the total transaction value (%),

CASHP - quarterly share of the value of ATM cash withdrawals in the total transaction value (%),

APAY – average monthly pay in the enterprise sector in quarter t (in PLN).

We assume that a feedback loop exists between the variables CNPAY and CASHP:

$$\text{CNPAY} \rightleftharpoons \text{CASHP}$$

A linear econometric model will be used in the study, in the following form:

$$y_t = \sum_{j=0}^{k} \alpha_j x_{tj} + \sum_{i=1}^{4} \beta_i y_{t-i} + \sum_{l=1}^{4} \sum_{j=1}^{k} \lambda_{lj} x_{t-l,j} + \alpha_{k+1} t + \lambda_1 dq1 + \gamma_2 dq2 + \gamma_3 dq3 + \eta_t, \quad (1)$$

where:

y_t – observations on the dependent variable (t = 1, …, n),

x_{tj} – observations on exogenous variables,

t – the time variable,

$dq1$, $dq2$, $dq3$ – dummy variables, with the value of 1 in the quarter distinguished and 0 in the remaining quarters

η_t – the equation's random component,

α_j, β_i, λ_{lj}, γ_p (j = 0,1, …,k, i = 1, …,4, l = 1, …, 4, p = 1, 2, 3) – structural parameters of the equation.

The dependent variables of both equations belong to the category of the so-called limited variables, i.e. variables with a minimum value (y_{min}) and a maximum value (y_{max}). Accordingly,

transformations of the observations on these variables will be applied, i.e. basic transformation in the first step, which is limited on one side:

$$y_t^{(p)} = \frac{y_t^{(o)} - y_{min}}{y_{max} - y_t^{(o)}}. \quad (2)$$

Ultimately, logit transformation of the limited variable will be used in the model equations:

$$y_t^{(l)} = \ln y_t^{(p)} = \ln \frac{y_t^{(o)} - y_{min}}{y_{max} - y_t^{(o)}}. \quad (3)$$

The type (3) logit transformation is characterized by a lack of limitation, both bottom-up and top-down, which it is particularly important when using such variables in forecasting. Due to the prognostic use of the empirical equations, the ordinary least squares method (OLS) will be used to estimate the parameters.

The equations' endogenous variables will therefore be defined as follows:

LCNPAY – the logit of the quarterly share of the value of non-cash transactions in the total transaction value,

LCASHP – the logit of the quarterly share of the value of ATM cash withdrawals in the total transaction value.

A negative feedback loop between the variables LCNPAY and LCASHP can be expected, and thus a negative feedback between the original variables (CNPAY and CASHP).

The forecasts estimated for the next 8 quarters ($LCNPAY_{Tp}$ and $LCASHP_{Tp}$) will be expressed in the logits of the variables forecasted (Wiśniewski J.W. (2018c)). It is therefore necessary to transform the logits from the percentage value, using the following formula:

$$exp\left(y_{Tp}^{(l)}\right) = \frac{y_{Tp}}{100 - y_{Tp}}. \quad (4)$$

The general forms of y_{Tp} forecasts will obtain a specific shape of the forecasts of the share of non-cash payments in the total payments and the forecasts of the proportion of ATM withdrawals in the total value of payments ($CNPAY_{Tp}$ and $CASHP_{Tp}$).

3. Results and Discussion

Using the statistical data obtained from the National Bank of Poland, empirical equations describing the variables LCNPAY and LCASHP will be constructed. These equations will be used in the forecasting procedure. This will allow estimation of $LCNPAY_{Tp}$ and $LCASHP_{Tp}$ forecasts, expressed in logit terms. Based on equation (4), it will be possible to construct

forecasts for: $CNPAY_{Tp}$ and $CASHP_{Tp}$, which will be expressed in percentage points. The empirical equations describing the variables LCNPAY and LCASHP are presented in Tables 1 and 2. Both equations are characterized by high accuracy of the dependent-variable description; the R^2 factors are 0.997 and 0.980 respectively. The negative feedback in this pair of variables is confirmed. The variable LNCPAY is also subject to the corrective impact of the lagged variable LCASHP_3. One important factor in the equation under consideration is the average monthly pay, which has simultaneous positive as well as delayed-by-3-quarters impacts. This variable's negative impact occurs with a delay of 1 quarter, resulting in a correction of the simultaneous and the delayed-by-3-quarters impacts. A positive linear trend of the variable LNCPAY and a positive first-order autoregression is noted, denoting a significant inertia. In the second quarter, a positive seasonal deviation is observed (see: Wiśniewski J.W. (2018b, chapter 3)).

The empirical equation of the variable LCASHP has a less complex structure, compared to the previous equation. Apart from the negative feedback with the variable LCNPAY , which means that along with the increase in the share of cash transactions in the total amount of transactions, the demand for the cash withdrawn from ATMs by bank customers decreases. The increase in the average monthly pay results in an increase in the demand for ATM-withdrawn cash. A positive linear trend and a positive second-order autoregression additionally occur in the equation, indicating the system's inertia.

Tab. 1 Empirical equation of the variable LNCPAY, observations used 2008:4-2019:4 (N = 45)

Variable	Coefficient	t-statistic	Prob. p	Significance
const	−1,08621	−5,678	<0,0001	***
LCASHP	−0,199369	−4,818	<0,0001	***
LCASHP_3	0,105165	3,556	0,0011	***
APAY	0,000212341	4,571	<0,0001	***
APAY_1	−0,00021763	−3,691	0,0007	***
APAY_3	0,000165226	4,759	<0,0001	***
time	0,00613469	2,947	0,0056	***
dq2	0,0450370	3,061	0,0042	***
LCPAY_1	0,471714	4,299	0,0001	***
Mean dependent var.	0,575566	S.D. dependent var.	0,449412	
Sum squared resid.	0,156677	S.E. of regression	0,064211	
R-squared	0,982369	Adjusted R-squared	0,979586	
F(8, 36)	352,8923	Prob(F-statistic)	9,70e-32	
Log likelihood	63,50293	Akaike info criterion	−113,0059	
Schwarz criterion	−100,3592	Hannan-Quinn criterion	−108,2913	
Autocorrel. coeff. (rho1)	0,182391	Durbin h-statistic	1,588494	

Source: own calculation using the GRETL package

Tab. 2 Empirical equation of the variable LCASHP, observations used 2008:3-2019:4 (N = 46)

Variable	Coefficient	t-statistic	Prob. p	Significance
const	−2,28203	−4,912	<0,0001	***
LCPAY	−1,73554	−7,743	<0,0001	***
APAY	0,000221238	2,908	0,0058	***
time	0,0213054	4,376	<0,0001	***
LCASHP_2	0,398802	5,004	<0,0001	***
Mean dependent var.	0,588595		S.D. dependent var.	0,453090
Sum squared resid.	0,185941		S.E. of regression	0,067343
R-squared	0,979872		Adjusted R-squared	0,977909
F(8, 36)	499,0003		Prob(F-statistic)	3,56e-34
Log likelihood	61,48113		Akaike info criterion	−112,9623
Schwarz criterion	−103,8190		Hannan-Quinn criterion	−109,5372
Autocorrel. coeff. (rho1)	0,186541		Durbin-Watson statistic	1,613356

Source: own calculation using the GRETL package

Construction of the CNPAY and CASHP forecasts requires availability of forecasts of the average monthly pay in Poland ($APAY_{Tp}$). It is therefore necessary to have a tool to generate the $APAY_{Tp}$ forecast. One effective forecasting tool is an autoregressive equation with a trend which takes seasonal fluctuations into account. The empirical equation describing the variable APAY is presented in Table 3.

Tab. 3 Empirical equation of the variable APAY, observations used 2008:3-2019:4 (N = 46)

Variable	Coefficient	t-statistic	Prob. p	Significance
const	−191,188	−2,013	0,0512	*
dq1	−102,952	−2,850	0,0070	***
dq2	−164,705	−4,797	<0,0001	***
APAY_1	0,978756	6,361	<0,0001	***
APAY_2	−0,358817	−2,910	0,0060	***
APAY_4	0,469633	4,880	<0,0001	***
Mean dependent var.	3928,468		S.D. dependent var.	584,3696
Sum squared resid.	133349,7		S.E. of regression	59,23852
R-squared	0,990919		Adjusted R-squared	0,989724
F(8, 36)	829,2840		Prob(F-statistic)	1,08e-37
Log likelihood	−238,7972		Akaike info criterion	489,5944
Schwarz criterion	500,2995		Hannan-Quinn criterion	493,5644
Autocorrel. coeff. (rho1)	0,011339		Durbin h-statistic	1,890465

Source: own calculation using the GRETL package

The empirical equation in Table 3 indicates that the average monthly pay did not show a trend, but only a strongly positive 1st and 4th order autoregression and a correcting (negative) second-order autoregression. The autoregression indicates a dynamic increase of the variable APAY . Negative seasonal fluctuations also occur in the first and the second quarter of the year.

The description accuracy of the variable APAY is very high, because $R^2 = 0.991$, which, along with the lack of residuals' autocorrelation, results in the empirical equation's good predictive properties. This leads to the average monthly pay forecasts presented in Table 4 and Figure 1. These forecasts are characterized by high accuracy, since the relative prediction errors range from 1.12% to 2.33%. Having $APAY_{Tp}$ forecasts, it is possible to calculate forecasts of the endogenous variables remaining in the feedback loop ($LCNPAY_{Tp}$ oraz $LCASHP_{Tp}$). Having these forecasts enables estimation of $CNPAY_{Tp}$ i $CASHP_{Tp}$ forecasts by using the transformation expressed in equation (4).

Tab. 4 Forecasts of the average monthly pay in subsequent quarters of 2020-2022

Forecasted period (T)	Forecasts ($APAY_{Tp}$)	Average prediction error (V_T)	Relative prediction error (V_T^*) (%%)
2020:1	5301.30	59.2	1.12
2020:2	5381.83	82.9	1.54
2020:3	5592.72	90.2	1.61
2020:4	5793.05	91.2	1.57
2021:1	5858.75	95.7	1.63
2021:2	5827.23	108.1	1.85
2021:3	6036.55	121.6	2.01
2021:4	6346.82	128.9	2.03
2022:1	6503.29	133.7	2.06
2022:2	6468.55	140.5	2.17
2022:3	6641.42	151.1	2.27
2022:4	6968.79	162.2	2.33

Source: own calculation using the GRETL package

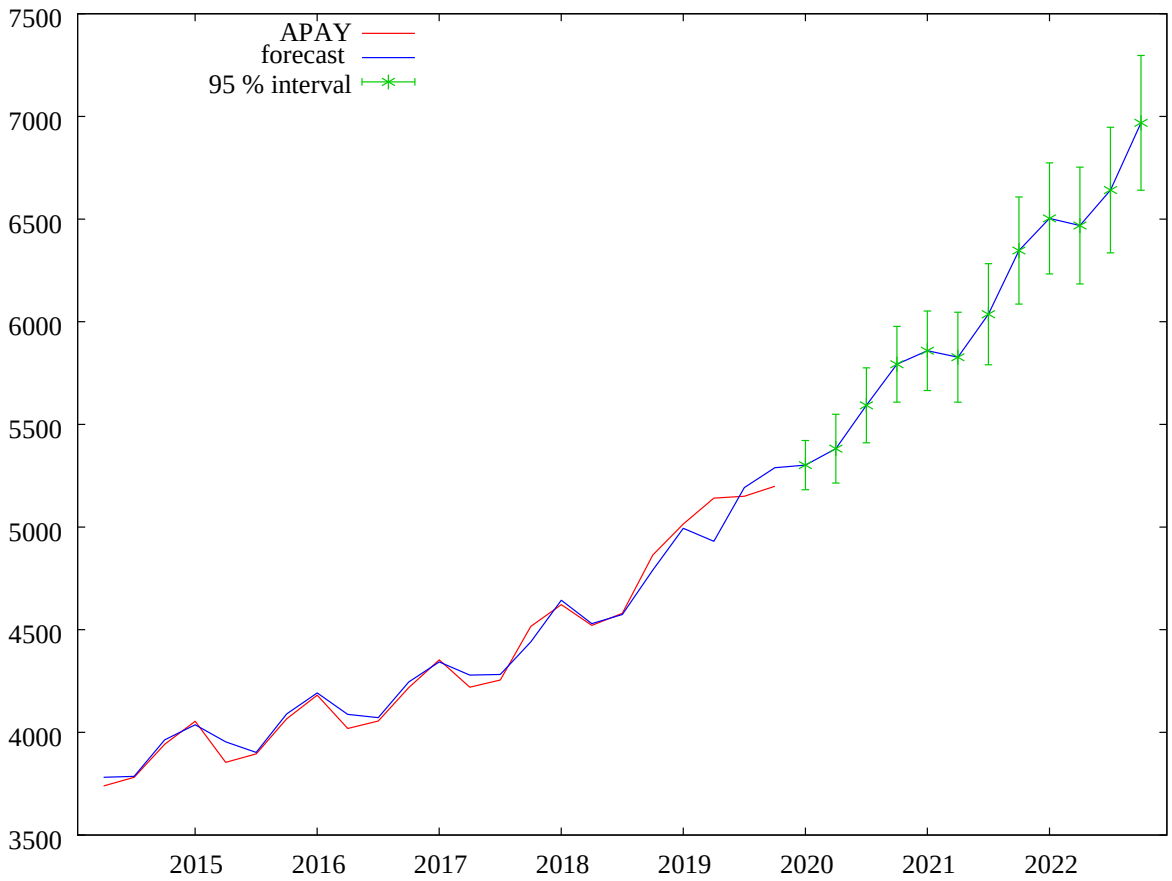
Forecasts of the variables LCNPAY and LCASHP will be estimated using the iterative method proposed in the work of Wiśniewski J. W. (2016) and then developed in the works of Wiśniewski J. W. (2018b, 2018c). The initial equation describes the variable LCNPAY. It was necessary to perform 23 iterations to obtain convergence of the $LCNPAY_{Tp}$ and $LCASHP_{Tp}$ forecasts expressed in logit terms. The convergent forecasts are presented in Tables 5 and 6 and in Figures 2 and 4. The forecasts in logit units have been transformed into the $CNPAY_{Tp}$ and the $CASHP_{Tp}$ forecasts, which are expressed in percentage points. They are presented in Tables 5 and 6 and in Figures 3 and 5.

The forecast accuracy varies between subsequent forecasted periods. The forecasting-precision specificity for both forecasted variables entails the quite high relative errors of prediction in the quarters of 2020 and their decrease in the subsequent quarters of 2021-2022. This means that the forecasts for further periods can be considered admissible, with doubts as

to the accuracy assessment for the quarters of 2020. This may result from the specificity of the logit transformation of the variables (LCNPAY and LCASHP), which leads to small-scale forecasts for the next quarters of 2020, expressed in logit terms.

The forecasts indicate that in subsequent quarters of 2020-2022, a significant decrease in the demand for ATM-withdrawn cash should be expected. As early as in 2020, the share of the value of ATM cash withdrawals in the total value of transactions may decline to approximately 41.2% in the first quarter of 2020, decreasing in subsequent quarters to a level of approximately 30% in the fourth quarter of 2020. In the following quarters of 2021 and 2022, the share of the value of ATM cash withdrawals in the total value of transactions will continue to decline to the expected value of approximately 13.1% in the fourth quarter of 2022. The demand for cash will conform to the situation in the most developed and the richest countries in the world.

Fig. 1 Forecasts of the average monthly pay in subsequent quarters of 2020 – 2022 (in PLN)



Source: Table 4

Forecasts of the variables LCNPAY and LCASHP will be estimated using the iterative method proposed in the work of Wiśniewski J. W. (2016) and then developed in the works of

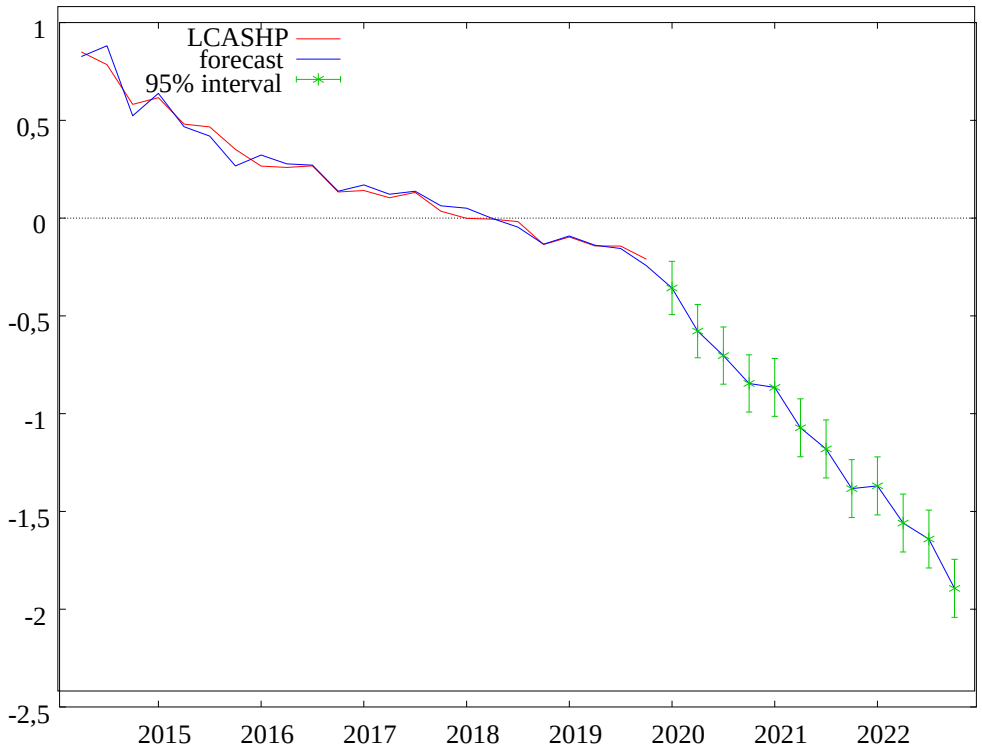
Wiśniewski J. W. (2018b, 2018c). The initial equation describes the variable LCNPAY. It was necessary to perform 23 iterations to obtain convergence of the $LCNPAY_{Tp}$ and $LCASHP_{Tp}$ forecasts expressed in logit terms. The convergent forecasts are presented in Tables 5 and 6 and in Figures 2 and 4. The forecasts in logit units have been transformed into the $CNPAY_{Tp}$ and the $CASHP_{Tp}$ forecasts, which are expressed in percentage points. They are presented in Tables 5 and 6 and in Figures 3 and 5.

Tab. 5 Quarterly forecasts of the share of the value of cash withdrawals in Poland in the total transactions, expressed in logits ($LCASHP_{Tp}$) and percentages ($CASHP_{Tp}$), for the years 2020-2022

Forecasted period (T)	Forecasts ($LCASHP_{Tp}$)	Forecasts ($CASHP_{Tp}$)	Relative prediction error (V_T^*) (%%)
2020:1	-0.357327	41.2	18.8
2020:2	-0.577897	35.9	11.7
2020:3	-0.703247	33.1	10.3
2020:4	-0.845649	30.0	8.6
2021:1	-0.865655	29.6	8.5
2021:2	-1.07220	25.5	6.8
2021:3	-1.18058	23.5	6.2
2021:4	-1.38343	20.0	5.3
2022:1	-1.36935	20.3	5.4
2022:2	-1.55934	17.4	4.7
2022:3	-1.64123	16.2	4.5
2022:4	-1.89357	13.1	3.9

Source: own calculation using the GRETL package

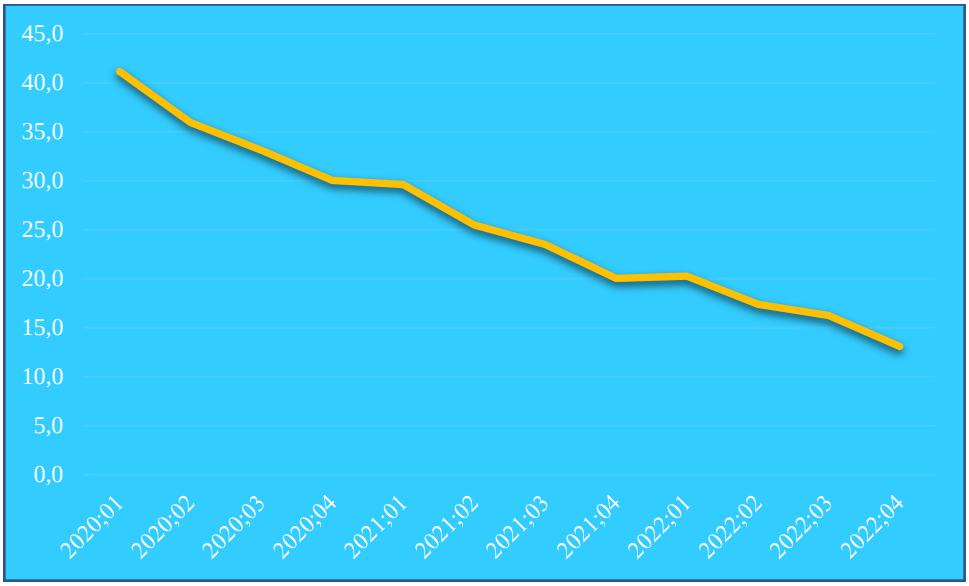
Fig. 2 Quarterly forecasts of the share of the value of cash withdrawals in Poland in the total transactions, expressed in logits ($LCASHP_{Tp}$), for the years 2020-2022



Source: Table 5

The decrease in the demand for cash in Poland will denote a significant increase in the share of the value of non-cash transactions in the total value of transactions in Poland, in the subsequent quarters of 2020-2022. The forecasts indicate that an increase in the share of the value of non-cash transactions in the total value of transactions in Poland should be expected, to a level ranging from 53.4 % in the first quarter of 2020 to around 60.3% in the fourth quarter of 2020. In the subsequent quarters of 2021-2022, a further increase in the forecasted variable can be expected. This will lead to a forecast for the fourth quarter of 2022, with the value of $CNPAY_{IV.2022p}$ = 73.9%.

Fig. 3. Quarterly forectasts of the share of the value of ATM cash withdrawals in total transactions (%%) quarterly for the years 2020-2022



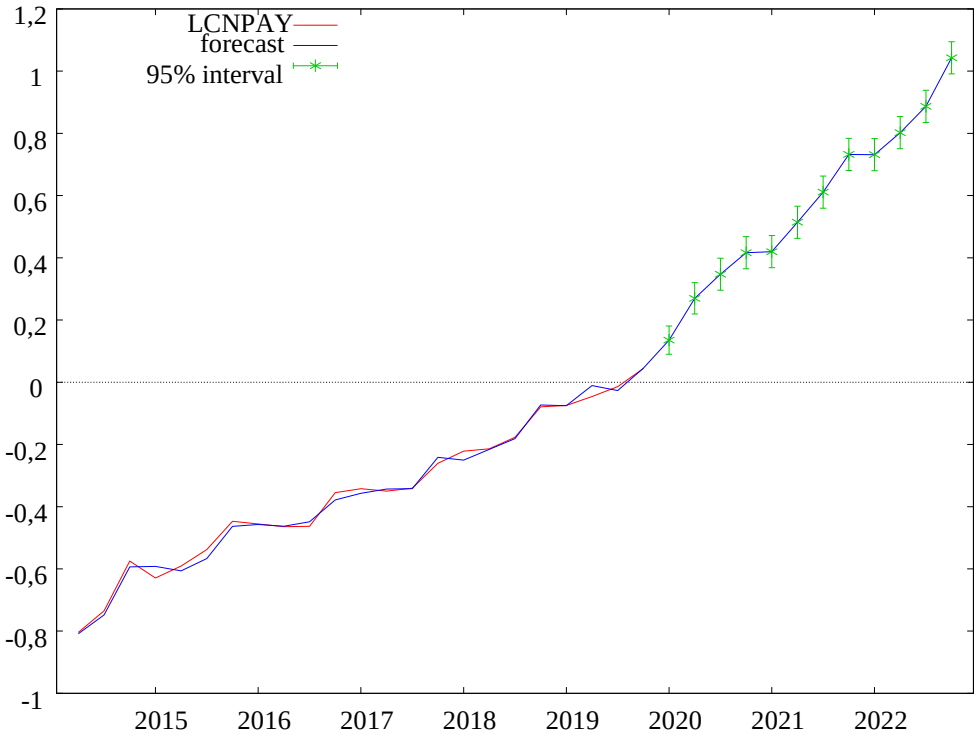
Source: Table 5

Tab. 6 Quarterly forecasts of the share of the value of non-cash transactions in Poland in total transactions, expressed in logits ($LCNPAY_{Tp}$) and percentages ($CNPAY_{Tp}$), for the years 2020-2022

Forecasted period (T)	Forecasts ($LCNPAY_{Tp}$)	Forecasts (CNPAYTp)	Relative prediction error (V_T^*) (%%)
2020:1	0.135346	53.4	16.6
2020:2	0.269652	56.7	9.2
2020:3	0.347257	58.6	7.3
2020:4	0.416395	60.3	6.1
2021:1	0.419808	60.3	6.1
2021:2	0.514290	62.6	5.0
2021:3	0.611190	64.8	4.2
2021:4	0.732401	67.5	3.5
2022:1	0.731559	67.5	3.5
2022:2	0.802340	69.0	3.2
2022:3	0.886963	70.8	2.9
2022:4	1.04279	73.9	2.4

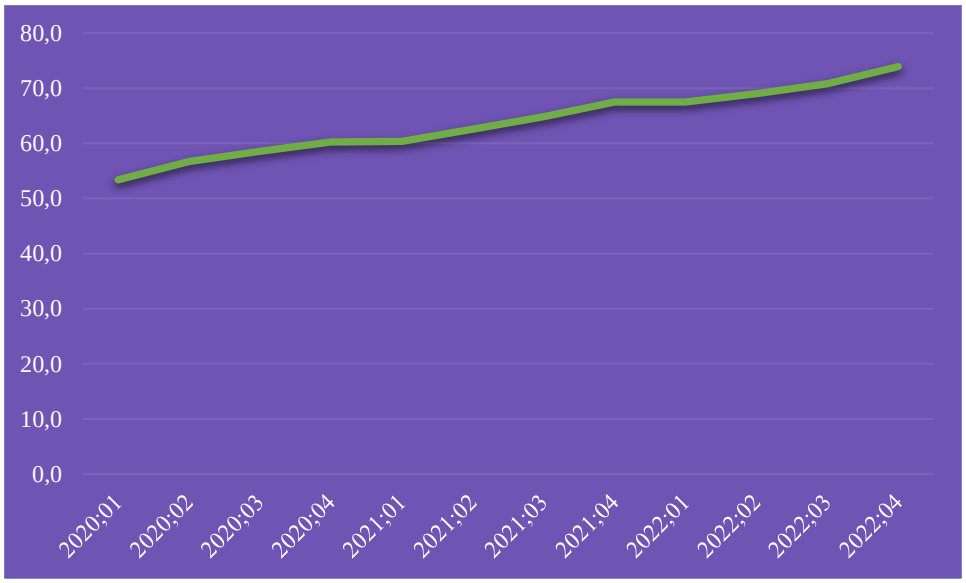
Source: own calculation using the GRETL package

Fig. 4 Quarterly forecasts of the share of the value of non-cash transactions in Poland in total transactions, expressed in logits ($LCNPAY_{Tp}$), for the years 2020–2022



Source: Table 6

Fig. 5. Quarterly forecasts of the share of the vaoue of non-cash transactions in total translactions in Poland for the years 2020-2022 (%%)



Source: Table 6

4. Conclusions

The results of the modeling and econometric forecasting of the changes in payments indicate a continuation of the trends denoting a decrease in the demand for cash and a significant increase in the share of non-cash transactions in subsequent years in Poland. The Polish system is becoming similar to the most innovative ones in the most developed countries in the world. Cash will be relatively quickly replaced in Poland by non-cash payments, especially through the use of payment cards.

The forecasts pf cashless transactions on the payment card market in Poland ore of a conditional nature. They were constructed with specific assumptions. The most important assumption is the dynamic increase in the citizens' wealth, expressed by the increasing average pay in the enterprise sector. The pay forecasts indicate a dynamic growth of pay in the subsequent quarters of 2020-2022. The accuracy of the forecasts of the changes in non-cash payments and in the demand for cash depends, to a large extent, on the accuracy of average pay forecasts. Potential changes to the assumptions may mean significant changes in the volumes of the forecasts in the research area analyzed.

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