

# Modeling and forecasting the diffusion of ATM/POS terminals and debit/credit cards in Albania

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## Abstract

The advancement of information technology has enhanced delivery of banks' services, and has an enormous effect on development of more flexible payments methods and more user-friendly banking services. Commercial banks in Albania to be competitive have started to offer electronic banking services in year 2004. This paper aims to study the diffusion process of electronic payment instruments in Albania. The main objective of this research is to model and to forecast the diffusion of electronic payment instruments such as ATMs, POS, credit cards and debit cards, using the data from Central Bank of Albania. After it was confirmed that the diffusion of each electronic payment instrument follow the S-shaped curve, the Logistic and Gompertz models were estimated using STATA software. The parameters of Logistic and Gompertz models give information on the diffusion speed and the maximum potential number of each electronic payment instrument, terminals or cards. These findings are useful to regulators, commercial banks, bank customers, other financial institutions, and policy makers.

## 1. Introduction

The banking industry has undergone significant operational changes over the last decade, thanks to advances in information technology. The information technology advancement has produced more effective and efficient channels to deliver banking services. One of the offspring of information technology in banking operations is electronic banking (e-banking). This technology allows banks to get closer to their

customers, to deliver a wider range of services at lower costs, and offer 24-hour banking support to customers.

Albanian banking has come a long way in electronics banking in the past years. At the end of 2017, out of 16 commercial banks operating in Albania, 15 are offering e-banking services (Table 1, Appendix). E-banking products/services offered by banks include: ATM (Automated Teller Machine), EPOS (Electronic Point of Sale), virtual POS, Internet Banking, Phone Banking, Mobile/SMS banking, Electronic (debit, credit, prepaid) Cards. Actually, twelve banks offer Internet banking; eight of them have some form of Mobile Banking and two banks provide mobile payments with 3rd party platform operator. Among all e-banking services offered from banks in Albania, ATM was the most popular channel, followed by electronic credit/debit cards, internet banking and EPOS [SR14].

The proliferation of bankcards and non-cash payment technologies, such as ATMs and POS terminals has been one of the most relevant innovations in payment systems over the past several decades. In 2004 commercial banks in Albania offered for the first time card based services. Debit cards are issued against a current or savings account and their usage is restricted to funds held in the particular bank account. A credit card is essentially a payment instrument through which purchases can be made utilizing credit provided by the issuing bank. ATMs offer considerable benefits to both banks and their depositors. The usage of machines offers depositors cash withdrawal at more convenient times and places for them, than during working hours at bank branches. Banks also aimed to foster the use of cards at the point of sale for purchase transactions, installing POS card payment devices. With the adoption of POS machines by merchants, electronic cards can be alternatively used to make purchases. Therefore, the final usage of debit cards will depend on consumers' attitudes as well as on the availability of POS systems and ATMs. Debit cards are used for cash withdrawals at ATMs and for purchasing transactions at POS terminals. Debit and credit cards have been the

main payment instruments that have substituted cash at the POS terminals.

The promotion of the use of electronic payment instruments for transactions among economic actors is relatively important to the Albanian economy, when considering the fact that the use of cash in the economy has a cost of around 1.7 % of GDP for the Albanian economy [BoA17]. The use of bank cards in ATM and POS terminals shows that cash withdrawals from ATM terminals have the main share in transactions with cards, an indicator of a largely cash-based economy. In 2017, about 18.91 million cards transactions, equal to ALL 200 billion, were processed in total. Of total transactions, about 90% were cash withdrawals from ATMs and only 9.17% were customer payments through cards at POS terminals. Card payments at POS terminals point to a predominant debit card transactions. However, in terms of value, credit card transactions are significantly higher than debit card ones. The low use of cards as a payment instrument shows the familiarity level of the public, the low level of financial education, and the limited infrastructure of POS terminals offered from enterprises.

Most of the literature approximated the S-shaped curve for technological diffusion using either the logistic model or Gompertz model. Both of these models generate S-shaped curves with a few early adopters, then a more rapid period of adoption, then a slower conclusion. The Gompertz curve is less symmetric than the logistic curve, where in the initial growth rate is not as high and its decline more gradually. The Logistic and Gompertz model each have unique characteristics, making them useful models in empirical studies of diffusion. In their study, [MI06] reviewed studies on the modelling and forecasting of the diffusion of innovations. They cover a large body of literature which looks at many different mathematical formulations of an S-shaped diffusion and list fifteen S-shaped growth curve equations. This study imposes two extreme hypotheses that explain this shape, which are those based on the dynamics of a (broadly homogeneous) population and those based on the heterogeneity of the population. In their study, [QCR16] analyzed the diffusion patterns of non-cash payments in China and based on Logistic and Gompertz model they found that POS terminals have shown a higher diffusion rate than ATMs.

Other than the diffusion of an innovation, researchers also consider technological substitution, where an existing technology is replaced by a newer one. Decrease in the price of substitute technology and/or increase in the price of substituted method increase the probability of technology diffusion [KMG11]. Also, the results of the study of [KMG11] provide evidence that degree of substitutability of teller with ATM in India is high, but ATM is not a perfect substitute.

The main objective of this research is to model and predict the electronic payment instruments diffusion in Albania, in order to help businesses and policy makers to implement the most suitable strategies. Once it confirmed that the diffusion of each instrument follows the S-shaped diffusion curve, it was estimated the logistic function and Gompertz function with three parameters, using STATA software. The parameters of both models give information on the diffusion speed, and the maximum potential number of each instrument in the study.

## 2 Material and Methods

### 2.1 Diffusion models

The literature on the diffusion of emerging technology generally uses S-curves to predict the diffusion process. Because the new technology typically at first grows slowly, then exhibits a growth rate greater than 1, followed by a period of slower growth (growth rate less than 1) and finally stops developing. The empirical S-curve literature, in the technology-diffusion context has tended to focus on just two functional forms: logistic model and Gompertz model [Fra94, BN06].

The logistic model is described by the differential equation

$$\dot{y} = ay(c - y) \quad (1)$$

where  $y(t)$  represent the total diffusion at time  $t$ ,  $c$  the saturation level (the maximum expected level) of the technology and  $a$  is the coefficient of diffusion which describes the diffusion speed. The saturation level of diffusion is a critical and often questionable parameter [MVS08]. The diffusion speed is proportionate to the population that has already adopted the service, denoted by  $y$  and the remaining market potential represented by  $(c-y)$ .

The solution the logistic model (1) is given by

$$y(t) = \frac{c}{1 + e^{-a(t-t_0)}} \quad (2)$$

where  $y(t)$  is the estimated diffusion level at time  $t$ ,  $c$  is the maximum level of diffusion such that  $c = \lim_{t \rightarrow \infty} y(t)$ ;  $a$  is the speed of convergence of  $y(t)$  to its limit and characterizes the curvature of the diffusion path or speed of diffusion;  $t_0$  is the moment of time when technology diffusion achieved half of its maximum level.

The Gompertz model is described by the differential equation

$$\dot{y} = a y (\ln c - \ln y) \quad (3)$$

The solution of which is given by

$$y(t) = c e^{-e^{-a(t-t_0)}} \quad (a > 0) \quad (4)$$

where  $c$  is the upper limit of the solution path or maximum penetration level,  $c = \lim_{t \rightarrow \infty} y(t)$ ;  $a$  is a measure of the speed of convergence of  $y(t)$  to its limit and characterizes the curvature of the diffusion path or speed of diffusion;  $t_0$  is the moment of time when technology diffusion achieved the share  $1/e \approx 36.8\%$  of its maximum level.

The important feature of the Gompertz path is that the diffusion goes faster at the beginning but becomes slower over time. This leads to a relatively short period of rapid expansion and to a relatively long period of gradual growth up to the maximal level. The logistic curve is more symmetric, the growth rate (measured as  $\dot{y}/y$ ) is initially not as high as in the Gompertz curve and it declines more gradually [JSF07].

## 2.2 Data

The data used for this analysis are taken from the Central Bank of Albania database [BoA18]. The dataset contains information about the number of ATMs, POS terminals, debit cards and credit cards for the period of time 2004-2017 in Albania.

To estimate the parameters of the Logistic and Gompertz models the nonlinear least squares method and STATA software were used.

For forecasting, a model that fits best to the in-sample data does not necessarily provide more accurate forecasts. Therefore, the performance of out-of-sample forecasts is used to help for the selection of a diffusion

model. The out-of-sample data cover the two last year (2016-2017).

The choice of functional form for a particular technology provides important insights. It helps to characterize the dynamics of the trend. Certain technologies are described best by one functional form and other technologies by another. There are many different model selection criteria. Since our models have only one explanatory variable, the time, and the same number of parameters, they are all equivalent to minimizing the sum of squared errors (SSE). Some other criteria used here are, Akaike Information Criteria (AIC) and Bayesian Information Criteria (BIC). The best model is the model which has the smaller value of AIC and BIC. To evaluate the performance of the best fitted or forecasted model is used the Root Mean Square Error (RMSE) given by the following

$$\text{equations: } RMSE = \sqrt{\frac{1}{n} \sum_{i=1}^n (y_i - \hat{y}_i)^2} .$$

## 3 Results

### 3.1 Descriptive analysis

According to the Central Bank of Albania data, the number of ATM terminals was increased from 93 in 2004, to 826 in 2015 and to 747 in 2017. The higher number of ATMs was in year 2015. The figure 1 indicates that the number of ATM is increased from 2004 to 2015 and then in years 2016 and 2017 the number of ATMs is decreased. At the end of 2017, the number of ATMs decreased by 6.63% compared with 2016.

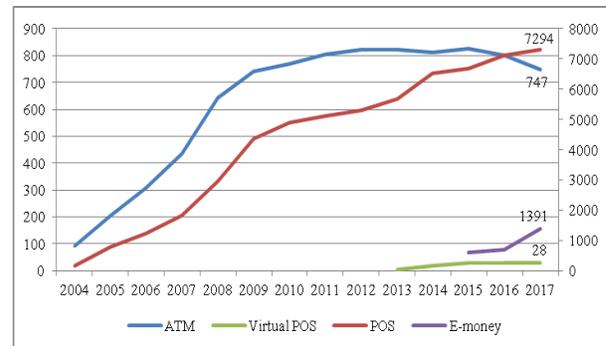


Figure 1: Development in ATM and POS terminals  
The number of POS terminals is increased from 155 in 2004, to 4903 in 2010, and to 7294 in 2017 (Figure 1). At the end of 2017, the number of POS terminals increased by 2.57% compared with 2016. The number of virtual POS terminals is increased from 3 in 2013, to 20 in 2014, and 28 in years 2016 and 2017. Terminals for the use of electronic money cards recorded very positive developments. They showed an increase from 597 in 2015, to 680 in 2016 and 1391 in 2017; the increase was 104.56% compared with the end of 2016.

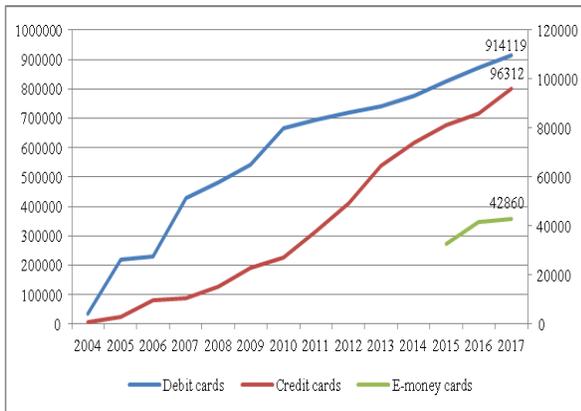


Figure 2: Developments in debit, credit and e-money cards

The number of cards in circulation is increased, from 33288 debit cards in 2004 to 914119 debit cards in 2017; and from 806 credit cards in 2004 to 96312 credit cards in 2017. In 2017, the number of debit and credit cards increased by 4.9% and 12.1%, respectively, compared with 2016. The number of electronic money cards is increased from 32873 in 2015 to 42860 in 2017.

### 3.2 Results of diffusion models

The results of Logistic model for ATM terminals number indicated a maximum level of 829 and the speed of convergence to the saturation (maximum) level was 0.794. ATM technology has achieved half of its maximum level in year 2006. The results of Gompertz model indicated a maximum level of 848

ATM terminals, the speed of diffusion was 0.522 and half of its maximum level was achieved in 2005. The results show that logistic model has the best performance in describing the ATM technology diffusion. The fit of each model is measured by the values of AIC, BIC, and RMSE. These measures indicated that logistic data fits best to the actual data and also is the best to predict the number of ATMs.

Table 1: Estimated parameters of the diffusion models for ATM and POS terminals

Parameter	ATM terminals		POS terminals	
	Logistic	Gompertz	Logistic	Gompertz
$c$	828.84*	848.56*	6264.78*	6890.75*
$a$	0.794*	0.522*	0.623*	0.365*
$t_0$	2006.63*	2005.84*	2008.24*	2007.44*
$R^2$	0.9993	0.9982	0.9953	0.9964
$R^2$ adj	0.9990	0.9975	0.9937	0.9952
AIC	<b>108.95</b>	120.34	177.05	<b>173.74</b>
BIC	<b>110.41</b>	121.79	178.51	<b>175.19</b>
In-sample	<b>17.65</b>	28.37	301.37	<b>262.67</b>
Out-of-sample	<b>61.09</b>	76.75	880	<b>565.86</b>

Note: Significance level: \*,  $p < 1\%$ .

The results of Logistic model for POS terminals indicated a maximum level of 6264 and the speed of diffusion was 0.623. POS technology has achieved half of its maximum level in year 2008. The results of Gompertz model indicated a maximum level of 6890 POS terminals, the speed of diffusion was 0.365 and half of its maximum level was achieved in 2007. The results indicate that Gompertz model has the best performance in describing the POS technology diffusion. The values of AIC, BIC, and RMSE reveal that Gompertz data fits best to the actual data and also is the best to predict the number of POS.

The results of Logistic model for the number of debit cards indicated a maximum level of 791086 cards and the speed of diffusion was 0.568 and half of its maximum level was achieved in year 2007. The results of Gompertz model indicated a maximum level of 828036 debit cards, the speed of diffusion was 0.370 and half of its maximum level was achieved in 2006.

The results show that Gompertz model has the best performance in describing the diffusion of debit cards. The values of AIC, BIC, and RMSE indicate that Gompertz data fits best to the actual data, and Gompertz model is the best to predict the number of debit cards.

Table 2: Estimated parameters of the diffusion models for debit and credit cards

Parameter	Debit cards		Credit cards	
	Logistic	Gompertz	Logistic	Gompertz
$c$	791086*	828036.6*	108504.2*	206043.5*
$a$	0.568*	0.370*	0.429*	0.150*
$t_0$	2007.25*	2006.29*	2012.33*	2014.33*
$R^2$	0.9959	0.9971	0.9984	0.9978
$R^2$ adj	0.9946	0.9961	0.9978	0.9970
AIC	292.68	<b>288.60</b>	<b>218.96</b>	222.67
BIC	294.13	<b>290.06</b>	<b>220.41</b>	224.12
In-sample	37282.7	<b>31464.26</b>	<b>1727.34</b>	2016.03
Out-of-sample	108166.5	<b>85615.42</b>	<b>2841.14</b>	9050

Note: Significance level: \*,  $p < 1\%$ .

The results of Logistic model for the number of credit cards in Albania indicated a maximum level of 108504 cards and the speed of diffusion was 0.429. Half of the maximum level of credit cards was achieved in year 2012. The results of Gompertz model indicated a saturation (maximum) level of 206043 credit cards, the speed of diffusion was 0.150 and half of its saturation level was achieved in 2014. The results show that Logistic model has the best performance in describing the diffusion of credit cards. The values of AIC, BIC, and RMSE indicate that Logistic data fits best to the actual data and also the Logistic model is the best to predict the number of credit cards in Albania.

### 3.3 Prediction of ATM and POS terminals

In the figure 3 are shown the actual and predicted data for ATM terminals. The saturation level of 828 ATMs, generated by logistic model, was achieved in 2015. Figure 4 shows the actual and predicted data for POS terminals using both models. The saturation level of

6890 POS terminals, generated by Gompertz model, was achieved in 2016

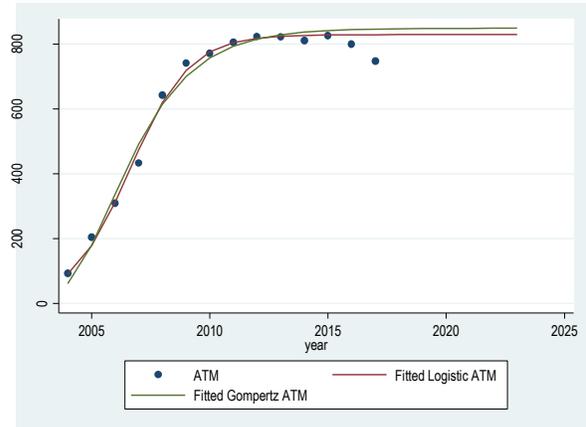


Figure 3: Actual and predicted number of ATM using Logistic and Gompertz functions

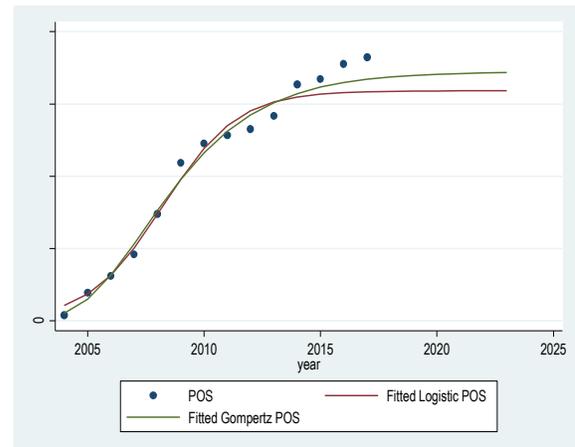


Figure 4: Actual and predicted number of POS using Logistic and Gompertz functions

### 3.4 Prediction of debit and credit cards

In the figure 5 are shown the actual and predicted data about the number of debit cards using both models. The saturation level of 791086 debit cards obtained from logistic model was achieved during the period 2014-2015.

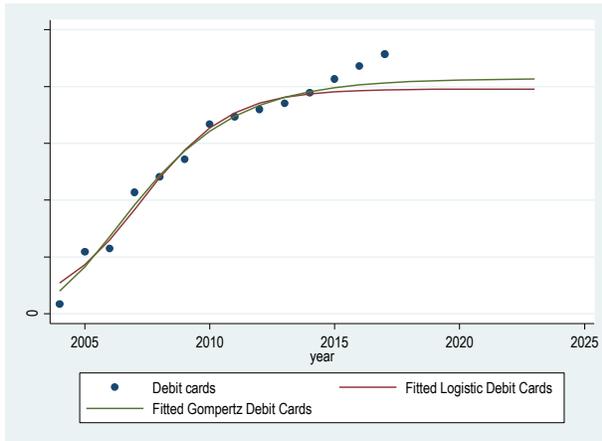


Figure 5: Actual and predicted number of debit cards using Logistic and Gompertz functions

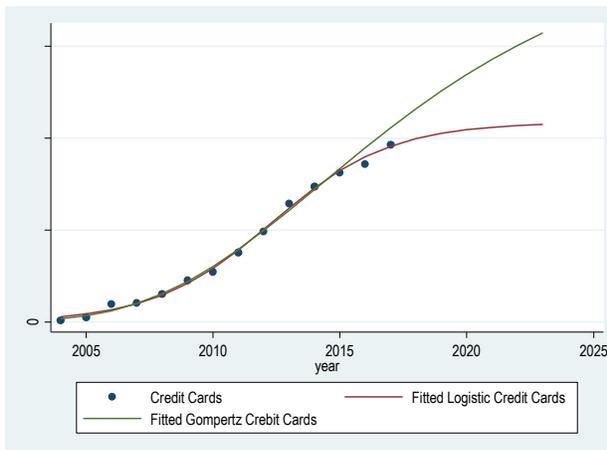


Figure 6: Actual and predicted number of credit cards using Logistic and Gompertz functions

Figure 6 indicate the actual and predicted data about the number of credit cards using both models. The number of credit cards will continue to increase and according to the results of logistic model the saturation level of 108504 is predicted to achieve around the year 2025.

The results of estimated models indicated that the diffusion of ATM and POS terminals, and also debit cards have achieved their saturation levels, whereas the diffusion of credit cards is increasing and its saturation level is predicted to achieve around the year 2025.

## 4 Conclusions

Developing models that explain the growth process is critical for policy formulation, capacity planning and introduction of new products and technologies. Electronic payment instruments (growth) projection informs providers of these services/ products about the potential consumer base.

In this paper, Logistic and Gompertz models were used to describe and to forecast the number of ATM/POS terminals and debit / credit cards in Albania. The results indicated that:

- related to ATM terminals, logistic data fits best to the actual data and logistic model is the best to predict the number of ATMs;
- about POS terminals, Gompertz data fits best to the actual data and Gompertz model is the best to predict the number of POS terminals;
- related to debit cards, Gompertz data fits best to the actual data and Gompertz model is the best to predict the number of debit cards; and
- about credit cards, logistic data fits best to the actual data, and logistic model is the best to predict the number of credit cards in Albania.

Also, the results indicated that the diffusion of ATMs and POS terminals, and also debit cards have achieved their maturity level, whereas the diffusion of credit cards is increasing and its maturity level is predicted to achieve around the year 2025.

In the future research, the factors influencing the diffusion process of electronic payment instruments can be studied using panel data modeling. Also, the diffusion of virtual POS terminals, e-money terminals and e-money cards can be studied in future research.

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## Appendix

Table 1: E-banking products and services offered by commercial banks at the end of 2017

Bank	ATM	POS	POS virtual	PayBox	Internet Banking	Phone Banking	Mobile/SMS banking	Electronic card (debit, credit, prepaid)
Raiffeisen Bank	√	√	√		√		√	√
National Commercial Bank	√	√			√		√	√
Tirana Bank	√				√	√	√	√
NBG Albania Bank	√							√
Alpha Bank Albania	√	√			√		√	√
Procredit Bank	√	√		√	√			√
First Investment Bank Albania	√				√			√
Credins Bank	√	√	√		√			√
Union Bank	√	√			√		√	√
Societe Generale Bank Albania	√				√		√	√
Intesa SanPaolo Bank Albania	√	√			√		√	√
Veneto Bank	√	√			√			√
International Commercial Bank	√						√	√
American Bank of Investments	√				√			√
United Bank of Albania								√

Source: Bank of Albania, Supervision Annual Report 2017.