A QUASI-CYCLICAL REGRESSIVE MODEL OF THE PANDEMIC IMPACT ON ROMANIAN E-MARKET

Bogdan Ion Boldea[1]*, Costin Radu Boldea[2]
[1]*West University of Timisoara,Timisoara, Romania.*
[2] *University of Craiova, Craiova, Romania.*

Abstract
The emergence and accelerated spread of COVID-19 has severely affected Romanian and European e-Market, manifested by the explosion of sales of basic products. We propose in this paper a non-linear model of growth of e-Commerce observed in the Romanian retail sector that consider the economic and socials effects of the two pandemic Waves in 2020. Starting from the hypothesis, statistically verified, that the effect of a Pandemic crisis can be strongly related to the global increase of sales in e-Market and the accentuation of seasonal variation of this sector, we obtained a first nonlinear model that can simulate with a high level of confidence (95%) the chaotically effects of a pandemic crisis on the very volatile sector of digital retailing and allows a prediction of the general behaviour of Romanian e-Market for 2021 and 2022.

Keywords
E-market, Non-linear regression model, post-pandemic market behaviour.

JEL Classification
C51, C53.

Introduction

In pandemic conditions, e-Commerce has become the retail alternative of choice for the entire European population. The evolution of purchasing behaviour in this time of crisis follows the logic of Maslow's pyramid of needs, which classifies human needs in order of importance. To meet their physiological and safety needs (at the base of the pyramid), consumers are mainly supplied with food and pharmaceuticals; they make sure they have the basic equipment to stay at home (electronic devices) and save on funds allocated to holidays or products. of luxury.
In this context, why is it important to study the effects and evolution of e-commerce? E-commerce contributes to increasing globalization. The crystallization of a global

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* Corresponding author, **Bogdan Ion Boldea** – bogdan.boldea@e-uvt.ro.

network-based market has the advantage of removing the restrictions imposed by traditional trade. If they also consider the low costs involved in an electronic business transaction, company managers must prefer such a market that provides them with substantial profits (Boldea 2010a).

A special interest presents the relationship between the strong development of retail e-Market and Central Bank monetary policy. From a macroeconomic point of view at a Central Bank, the M0 Monetary Base, the money multiplier, and the M1, restricted money supply, will be severely affected by the development of e-commerce, leading to a significant decrease in primary currency issuance, and hence, the blocking of the transmission of monetary policy through monetary control. This reality also determines the diminution of the right of secrecy of the Central Bank, with a blocking of the actions influencing the main macroeconomic indicators - mainly the financial intermediation, the exchange rate, the balance of payments and the current capital account (Boldea 2010b). For these reasons, the study of effects and evolution of e-commerce in next short and medium term is very important in this period.

This study examines the evolution of e-Commerce observed in the Romanian retail sector in 2020, trying to propose a nonlinear statistical model with three components: main trend, explosion due to reduction of non-essential businesses and distancing restrictions, modelled by logistic components, and seasonal evolution, due to consumers' social reaction, of Romanian e commerce market in 2020.

1. Review of the scientific literature

The COVID-19 pandemic generated rapidly two successive waves in 2020 and another in 2021, forcing the population to adapt to the new situation, both professionally and personally. Isolation measures, as well as the closure of many non-essential businesses imposed by some governments, have resulted in changes in the behavior of current consumption in households (Baker, Farrokhnia, Meyer, Pagel & Yannelis, 2020 for the case of USA; Dou et al., 2020 for the case of China; Ker & Cardwell, 2020 for the case of Canada), as well as changing the way retail customers make their purchases.

Starting from March 2020, new measures to slow the spread of COVID-19 had a significant impact on the way consumers shop in retail. As companies reduced or changed their operations in traditional stores, consumers were also called upon to practice physical distance, with the option of shopping online becoming an important alternative to in-person shopping.

The vast majority of governments have adopted social distance measures, imposed blockades and temporarily closed certain businesses considered non-vital. All this has led to a growth in the online shopping market, as well as an increased demand for a wide range of digital services, with many consumers opting for purchases made either via the Internet or by telephone; an exhaustive study on the impact of pandemic on the economic policy of governments was published at the end of 2020 (Chen, Igan, Pierri & Presbitero, 2020). Several traditional companies have redirected their resources to e-Commerce. "The increase in the number of consumers using digital services has led digital service providers and telecommunications operators to strengthen their network capacity and provide cheap or even free data sets and services" (WTO, 2020).

From February to May 2020, the total retail sales in Europe fell by 17.9%. However, e-Commerce retail sales almost tripled (+ 174%), with some retailers relying more on this method of sale than on the classic version (Wix E-commerce, 2020).

A comparative study between multiple country about the pandemic effect on the retail market was published by the Bank for International Settlements (Alfonso, Boar, Frost, Gambacorta & Liu, 2021), stating that "the growth of e-commerce has been higher in countries where there were more stringent containment measures and where e-commerce was initially less developed, and the changes in consumers' shopping habits and payment behaviour may be longer-lasting". A global review of the COVID 19 effects on e-market can be founded in a Preprint of United Nations (UNCTAD 2021).

Despite the large interests of researchers in the relationship between Pandemic and the growth of retail market, there are very few mathematical models that can describe this process. A first regression model of the social and economic consequences of the e-market behavior was proposed in December 2020 (Kokh, Frommeyer & Schewe, 2021). It is a multiple linear model with structural equation, derived from four statistical hypothesis verified by authors.

We propose in this paper a first non-linear model with higher correlation coefficient between predicted and observed global amounts of retail market, for the case of Romania.

2. The proposed regression model of e-Market behaviour

The evolution of online sales in Romania also experienced an upward trend in the year of the Pandemic, less pronounced than in other European countries, due in part to the lower spread means of electronic payment or even Internet access to the elderly or rural population. Fig. 1 presents the variation of monthly global online retail sales in Romania, expressed in millions of euros (the data was compiled from Digital Commerce 360, 2021: Europe 500 Databases), starting from the average monthly level of 2019: 360 million Euros (Iqads, 2020). It should be noted the existence of two peaks of strong growth of e-commerce corresponding to anti-COVID19 restrictions related to the two epidemic waves in spring (March-May) and autumn (September-December).
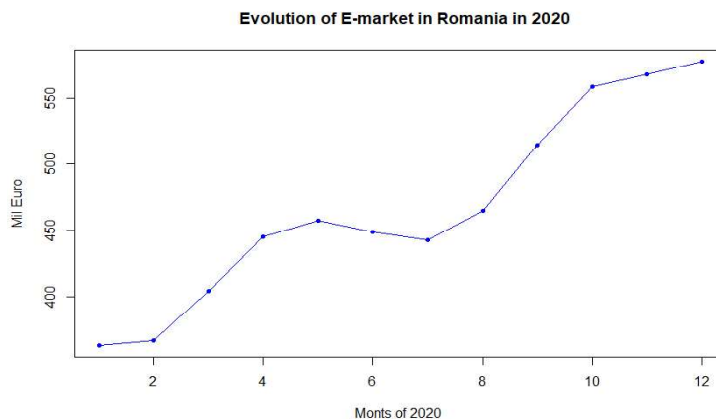
Evolution of E-market in Romania in 2020

Figure no. 1. The evolution of online sales in Romania in 2020, compared to the average monthly value (360mil Euro) in 2019
Source: Digital Commerce 360, 2021

The reduction in online sales during the summer is justifiable in terms of reducing government anti-epidemic restrictions and the seasonal effect of holiday period. Statistically, the Romanian online retail trade reached 5.6 billion euros at the end of 2020, with growth peaks of 27% in May and 60% in December 2020, compared to the average monthly level from 2019. This behavior is consistent with the case of others European countries as Germany, France or United Kingdom (see also Wix E-commerce, 2020).

The future evolution of this economic sector will also see increases based on the accustoming of the population to electronic means of payment, even in the absence of pandemic restrictions, as well as on the expansion of this market to the level of the European Union. But the growth of the e-commerce sector is not linear, being influenced by the European trend, seasonal variations and possible new waves of epidemics.

In this context, our research starts from the hypothesis:

(H1) The effect of a Pandemic crisis can be positively related to the global increase of sales in e-Market.

For testing this hypothesis, we chose to analyse a possible regression model based on asymptotical bouded logistical growth equation. The second hypothesis was:

(H2) The effect of a Pandemic crisis can be positively related to the accentuation of seasonal variation of e-Market.

The second hypothesis was tested using an F statistical test on the regression equation, including various quasiperiodic terms.

In order to compute the coefficients of the non-linear regression, we used an implementation of NLStool package under R language, a high performant statistical programming language (see Baty 2015 for a reference documentation).

In our model design, from the beginning we excluded the variant of an uniform growth of the economic sector of online sales, given the instability caused by the Pandemic. The main trend is obtained directly from the linear regression on the raw data of the variation of online trade in Romania

$$Sell\ (\%) \sim -5.48 + 5.47 * M \tag{1}$$

where *Sell* represents the percentage of online sales growth compared to the average monthly value in 2019, and M is the time factor expressed in months, which represents an average monthly increase of 5.47%, with an error of 0.48% and the confidence factor $R2 = 0.92$. The correlation coefficient between the real Sell data and the prediction of model (1) is
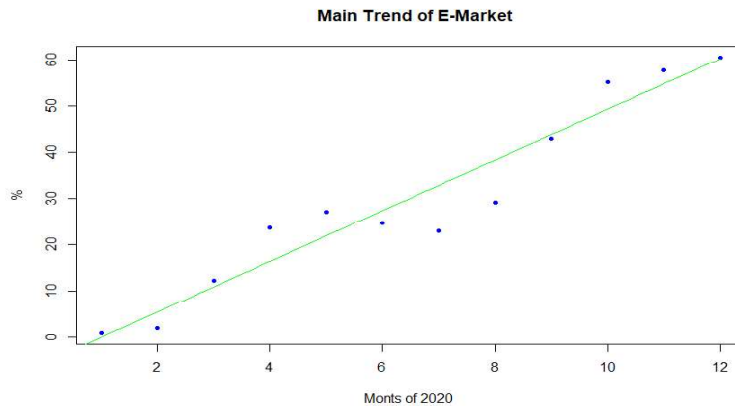
Correl1 = 0.963.

Figure no. 2. The main trend of online sales growth in Romania in 2020, compared to the average monthly value in 2019
Source: Digital Commerce 360, 2021

First we tested the hypothesis that the main effect of the pandemic crisis on the e-market behavior can be modelled by introduction of a new bounded term described by a logistic asymptotic equation, a model induced by the sudden change of interest in the online sale of current products, inspired by a previous work (\Boldea & Boldea 2012):

$$Sell\ (\%) \sim [c0 + c1 * M] + [c2/(0.5 + \exp(c3 * (M-c4)))] \tag{2}$$

We obtain the coefficient estimation of the model using the facilities of R language, the NLS package:

$$c0 \sim -1.76,\ c1 \sim 4.211,\ c2 \sim 6.074,\ c3 \sim -0.91,\ c4 \sim 7.5$$

The model has a residual error 5.793 on 8 degree of freedom and pass the Fisher test of significance with Fcalc = 63.59> Fcritical=4,45. The correlation coefficient between the real Sell data and the prediction of model (2) is **Correl2 = 0.966**. The model is represented in Fig. 3.
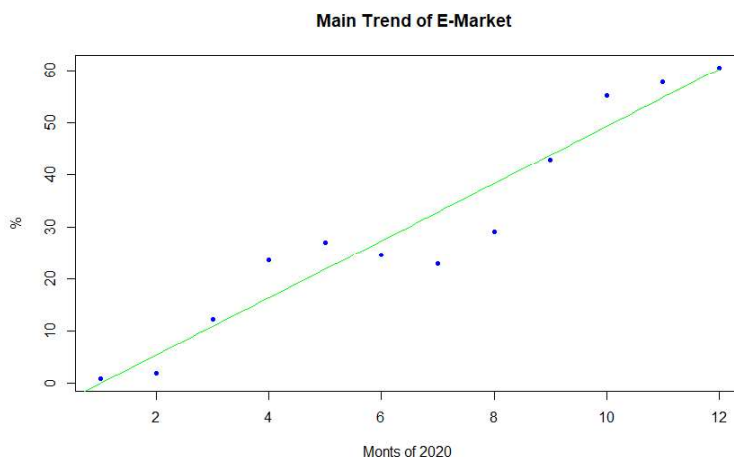
Main Trend of E-Market

Figure no. 3. The logistic regression model of online sales growth in Romania in 2020, compared to the average monthly value in 2019

In the second part, we introduced a seasonal factor related to the more pronounced variation of sales in the period corresponding to the Easter or winter holidays. We tested various types of cyclical or quasi-cyclical models in order to identify the equation that produce the best fit of predicted values with the original data. At the end, we retained a classical periodical model, with exponential attenuation, model that can include the increasing of e-sales variation phenomena in function of seasonal term.

The final model therefore contains three components:

$$\text{Sell (\%)} \sim [c_0 + c_1 * M] + [c_2/(0.5 + \exp(c_3*(M-c_4)))]$$
$$+ [\sin(\pi/3*(M-c_5))/(\exp((M-c_6)/12))] \qquad (3)$$

where the third factor, bi-annual seasonal, has a slow exponential decline in variation over time, based on the assumption that the effect of the Pandemic in 2021 and 2022 will be much smaller due to intensive vaccination campaigns.

The coefficients of nonlinear Regression Model (2) obtained with R were:

$$c_0 \sim 7.48, \; c_1 \sim 2.31, \; c_2 \sim 13.05, \; c_3 \sim -0.91, \; c_4 \sim 7.5, \; c_5 \sim 3.2, \; c_6 \sim 3.01$$

The standard error of the model is 0.93%, the F-test of relevance being passed with a trust level 95%, for Fcalc = 1759> Fcritical=4,737 , well above the significance limit, and the relevance coefficient of the model was $R2 = 0.998$; the correlation coefficient between the real Sell data and the prediction of model (2) is

$$\text{Correl2} = 0.999,$$

which represents a significantly higher value than in the case of linear regression, undoubtedly allowing the use of this model in short- and medium-term predictions of the behavior of the online sales market in Romania.
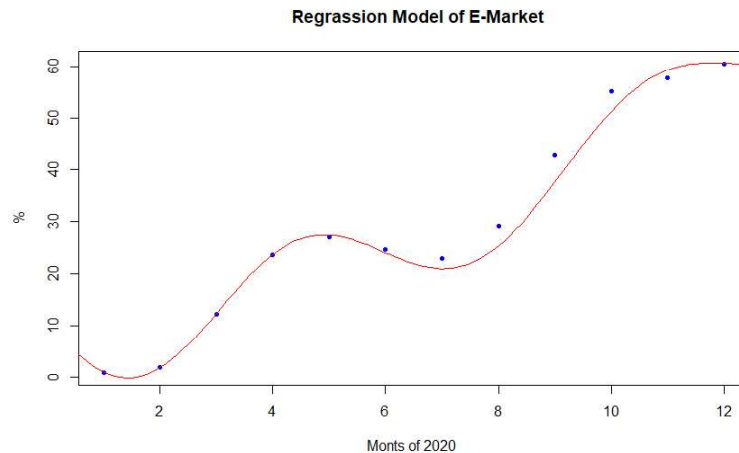
Figure no. 4. Nonlinear regression model including seasonal quasi-cyclic factors and pandemic effect

Fig. 4 presents a comparative graph of the model obtained versus the initial data of the increase in online sales in 2020 (expressed as a percentage). Our model is the first non-linear model of global behavior retail market in pandemic conditions, after the multi-linear model form. (Kokh, Frommeyer & Schewe, 2021).

3. The results of the statistical simulation and their interpretation

Extending the simulation period of the model (2) by 24 months (Fig. 5), we note the appearance of a phenomenon of constant growth of predictable online sales with an increasingly better-defined trend, having seasonal variations with growth peaks on the months of April-May, respectively October-December, economically significant as they correspond to the periods of maximum commercial activity induced culturally by the spring and winter holidays, respectively.

It should also be noted that this quasi-oscillating stretch with an average growth trend of 2.31% per month in the perspective of the next two years is justified by the growing interest of young people (aged 16-24) for e-Commerce, according to the raw data at European level (Eurostat 2021).

One of the direct effects of pandemic restriction measures was the massive conversion of almost the entire young population (16-24 years old) to the massive use of the Internet, especially for online courses and socialization activities; given that over 78% of them use the electronic environment for shopping at least once a month, we can expect a doping effect on online commerce.
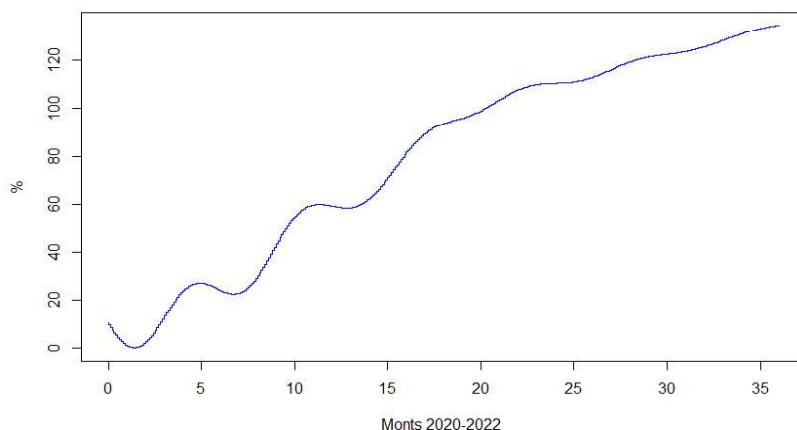
Figure no. 5. The expected growth (in percent) of online sales in Romania in the period 2020-2022, compared to the average monthly value in 2019
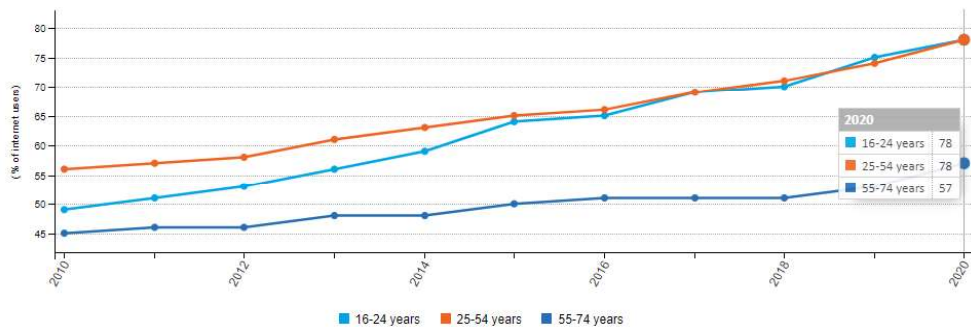

Figure no. 6. Percentage of Internet users accesing online sales services in Europe 27 (excluding UK) at least once a month, by age category

Thus, the seasonal component, strongly accentuated in 2020 (see Fig.5):
$$Sell2 \sim 9.91*\sin(\pi/3*(M-3.2))/(\exp((M-3)/12)) \tag{4}$$
with the two pronounced peaks of growth from April-May, respectively October-December, overlaps with the introduction of mandatory online courses for young people and social distancing restrictions, thus being amplified in 2020 by changing the social behavior of pupils, students, and young people in general.
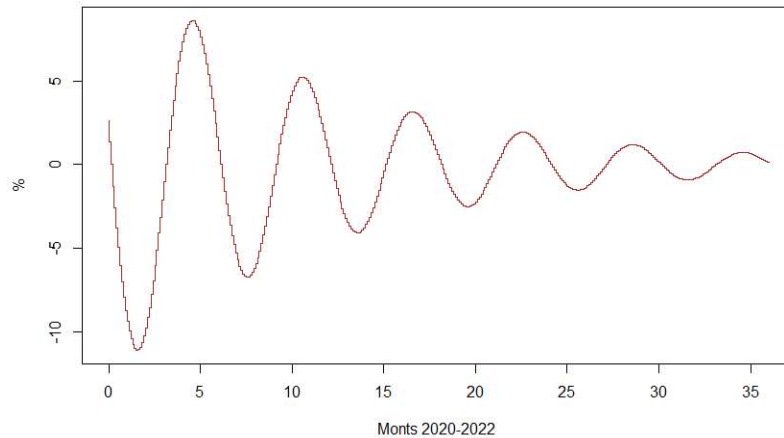
Figure no. 7. The term of seasonal variation (in percentages) of online sales in Romania, related to the main trend of forecast growth of this sector in the period 2020-2022

The proposed model does not consider any significant new waves of epidemic, given that we can expect a gradual return to normality after the massive vaccination campaign at European level, probably at the end of 2021. According to our model, it is expected an increase in online commerce until 610 million euros per month in Romania, in April and May 2021, respectively exceeding 920 million euros per month at the end of 2022, with 5% marge of error. Considering the evolution of the European e-Market (WIX E-commerce 2020), Romanian e-commerce sector will continue to be below European average.

Conclusions

The regression model we proposed in Section 3, based on the combination of online sales doping, driven by the effects of pandemic restrictions, with a natural seasonal effect - greatly amplified by the drastic change in the behavior of young shoppers in particular - has a relevance coefficient, respectively the correlation of the prediction with the real data, very high, both of over 99%, the model being able to be used in predictions for the next two years of the e-Market of consumer products behavior.

The model is justified by the increase in the number of users of electronic means of payment in various European countries, the diversification of the supply of traders and distributors, as well as the slower return to the classic system of purchases of consumer goods directly from stores by consumers already accustomed to the e-Market and can be used to forecast the possible evolution of e-Market sector at short and medium term.

At our knowledge, it is the first nonlinear regression equation that can model with a high level of confidence the chaotically effects of a pandemic crisis on the very volatile sector of digital retailing. Compared with the multiple linear regression equation

proposed by Kokh, Frommeyer & Schewe (2021), having a correlation index of the prediction with the real data 96%, our model is more precise, but take into consideration only the global behavior of the e-Market, without separation between direct economic effect of Pandemic on the retailers and the effect on the consumers' preferences. Following the results of this statistical study, we can say that the change in consumer behavior in the direction of e-Commerce is irreversible, and the codifications that accelerated this trend during the pandemic are a natural evolution of e-Market.

Therefore, the current Pandemic situation will have a sustained impact on e-Commerce even after the end of the pandemic restrictions, in several economic areas, not only those that include basic products. The portrait of the online consumer has certainly changed, at least for now, forcing retailers to adapt to the new online market. From this point of view, our study can be considered as one of the first steps in the direction of codification of a pandemic crisis effect on the e-Market. A more extended study that will take also into consideration the new possible waves of pandemic and the future governmental reaction can be very useful for the economic analyst in a process of forecasting the evolution of this economic sector.

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