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23 April 2021

Published in Slovak Republic
European Journal of Economic Studies
Has been issued since 2012.
E-ISSN: 2305-6282
2021. 10(1): 29-44

DOI: 10.13187/es.2021.1.29
www.ejournal2.com

GDP Modelling and Forecasting Using ARIMA. An Empirical Assessment for Innovative Economy Formation

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Abstract

This article reconsiders the developing of a new forecast model using the interrupted timeseries of the gross domestic product for the Republic of Moldova. The theme arises from a first need to redefine, economic growth in the context of increasing globalization but also the complexity of commercial transactions. The forecasting method used is based on ARIMA each model partly emphasizing the urgent need to redefine, the economic growth in the context of the Association Agreement (AA) with the EU, which includes a Comprehensive Free Trade Agreement (2014) but also future prospects of integration among the countries with an average degree of development. The technique used comes to bring novelty in the field of forecasting, as an alternative to the one which should be —, a simultaneous equations method and traditional VAR. The policy and practical implications of the results are the strengths. The limits are due to the high degree of risk and uncertainty, which is due to the low degree of real convergence of the economy, but also to other factors such as the regional context, the lack of openness of the economy, the diversification of exports and services. The degree of complexity arises from the adaptation and study of the chronological interrupted series 1967–2019 for the branch – information and communications, subgroup GDP, categories of resources, which themselves have specific asymmetries and nuances. The basic ARIMA equations are generally used in conjunction with three sets of assumptions regarding the formation of the gross domestic product, referring to the elasticity of aggregate demand or excess sensitivity supply in the goods and labour markets. Another hypothesis concerns the rigid wage and sticky prices, including deflation with an positive output gap only in the telecom market. Also, the salary is rigid, while the price level is adjusted based on the market of goods and commodities, so that the excess supply appears only in the labour market. Finally, in a third assumption, both markets are assumed to be mutually adjusted. The multipliers of fiscal and monetary policy, besides the conclusions that can be drawn about economic policy, are obviously different in these three assumptions. The article presents a synthetic model that supports the three particular sub-regimes of assumptions of a single adapted ARIMA model, namely the trajectory of New Keynesian Small and Closed Economy Model – a balance in the goods and services, the labour market and the national financial system. In conclusion, the model aims not only to redefine the area of macroeconomic forecasting but also to offer a future perspective of adopting combined techniques such as the Stochastic Dynamic General Equilibrium (K-SDGE) Model with sticky prices and wages – technique, but also the scenario method. This framework is appealing because it has straight forward model setup,

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transparent mechanisms, sharp empirical analysis, and multiple important applications such as rational expectations.

Keywords: economic growth and aggregate productivity, the gross domestic product, innovation and communications, cross-country output convergence, prediction and forecasting methods,time series analysis and modelling, ARIMA modelling, Box-Jenkins method.

1. Introduction

The central motivation of our theoretical-empirical analysis arises from the desire for better understanding the variations of the long-term economic growth, in the context of the high-technology businesses that target the small and medium-sized enterprises in our country. The main contribution of the study is that it explains why models based entirely on endogenous growth, change of factors, perception in business, possibility of innovation can change the saving rates and thus increase the possibilities of the production, accompanied by the development of new pattern — the art of investing and developing within innovation-development (R&D) sector. The model get started from the hypothesis of the existence the discrepancy between the economic growth rates statistically registered not only in the European regional context, but also in the specific case of the economy of the Republic of Moldova. The painting appears to be separated from two distinct elements. On the one hand, the group of states from Central and Eastern Europe (Romania, Republic of Moldova and Ukraine), more specific with increases of over 5 % per year of GDP, which are facing market constraints in the path of "to be" innovative and in the end generate high-tech products for export, by the other hand countries in the group OECD (Organization for Economic Co-operation and Development) which reaches a rate of 1-3 % and generating know-how product, including industrial robotics for pharmaceutical and medical sphere.

Why is this happening? How to better understand this trans-regional phenomenon, explaining the assumptions of the well-known Solow model, which is the reference point for understanding economic growth in general term. More and more, economists in the Eastern Europe, including Poland and Romania, may ask themselves often if there is no generic parallel with the well-known boom period of the 70s, when the big industrial concerns (E.g. FIAT in Italy), have made a significant duty to the economic miracle, characteristic to be as "Asian tiger", a nickname given to the Southeast Asian economies, such as Indonesia, Singapore, Malaysia, Thailand and South Korea, and generating 5-7 % GDP economic growth annually, truly transforming countries, in just two decades, into highly developed countries aimed for innovation, sectorial development and research.

We do not come with any intention to rely on parallels and frameworks of comparisons from those times and times, especially because of the fact that the geo-political context and regional configuration were completely different. Many authors have made a significant contribution to the development of this area of research (Eichner et al., 2010), which find these spectacular period of growth on behalf of small and medium-sized companies, generically named by new SMEs, generators of innovations and technologies.

From now on, our theoretical analysis will focus exclusively on the field of development, innovations and technologies. The periods from the end of the twentieth century gave birth to new economic thinking, which saw new engines generating economic growth in entrepreneurship and innovation. Keynes and Marx's classical theories, based on macroeconomic balance, are connected with Schumpeter's ideas as the leader of that fermentation in the innovation-development sector targeting small and medium-sized enterprises (Heilbroner, 1984). Schumpeterian thinking from a European perspective, has a strong resemblance to the activity of when it linked economic progress with the social-economic context of the regions. As the socio-economic settings are different for the case of the Republic of Moldova, it is imperative to reflect on the comparative perspective (Bronwyn, Ziedonis, 2001). However, we consider that the model in its approach, can find its origin of inspiration within the Anglo-Saxon and the Nippon-Rhine approach.

The comparison of models has attracted the attention of many academics, such as M. Kamien and N. Schwartz (1982) with empirical studies in entrepreneurship. The authors place the issue of strong trans-regional development in the context of national systems of innovation, development. We also, consider that the inclusion of the economic theory of the two models of regional development: Anglo-Saxon and the Nippon-Rhineland – significantly contributes to shaping the regional perspectives characteristic of the Republic of Moldova.

To begin with, we intend not to bring Schumpeter's criticism, but to focus instead on seeking the validity or extension of his theory.

More fundamentally, we should probably look back to the origin of thought in the context of historical periods of economic advancement, recorded by the aforementioned regions. It is worth mentioning that since the mid-20th century, the economies of the Federal Republic of Germany and Japan have been focused mainly on attracting investments in the industrial sector, rather than in IT or Telecom, as it's currently case, when the industry have been emancipated by technological parks and innovation systems that have generated, structural changes of economies some even irreversible.

Government have been increasingly interested in allocating funds and grants, to those who decide to introduce technology and innovation into their models. In fact, every time the public administration proposed to establish a general framework, which will promote economies of scale, and which would propel the system to equilibrium (in some cases in dynamics), to a new stationary state. In order to understand the dynamics of these changes it is imperative to reflect on the global dynamic framework of change, and the presence of "creative destruction", in other words, which stimulated entity to develop their economy, relying on technologies and innovations, and others not. In the current context, at least for the Republic of Moldova, the concept of innovation needs clarification, and it is unlikely to be easily identified by a variable or dimension, or of the type of equation with simple regressions, or polynomial function, like specialists in econometrics, who expressed the term error (residual variable) or white noise, into contribution or share due to certain changes in the sector of innovation, development and technologies. If we limit ourselves to the classical definition, innovation follows the theoretical definition of invention that has successfully been perceived in the social-media, ignoring the elements of the political economy, which describes perfect competition and information asymmetry when capital mobility exists. Other types of innovation, such as innovation in company management (for example, Heilbroner, 1984) and organizational innovation (Hammond, 1984), are explicitly left out of the equation.

In many situations, inventions that describe the market are not only dependent on the efforts of individual firms, but must be viewed as part of industry or market sectors (e.g., industrial investments in electric cars) or as part of the small business incentive framework (innovation or business incubators). The classical economic theories examine the entrepreneur as being at the centre of the innovation process, contributing to the creation of the balance/imbalance inherent situation of the free market system. Perhaps the most important feature of perfect competition is that the entrepreneur strives to achieve profit maximization (perhaps even temporarily), that is, a profit above the one accepted in the industry, where he runs his business. In this way, the competitive process has a dynamic form, being constrained by the intention to seek balance in the medium term. The competitive process is normally driven by the entrepreneur, self-management mechanism, strategical frame, meaning that entrepreneurs are by themselves entities that act rationally, seeking to innovate. The entrepreneur's function is to innovate on a path that microeconomic theory perceives as "new combinations of knowledge" – explicit elements that are – inscribed in the model in the form of constraints: the creation of new products; creation of new production methods; entering new markets; introduction of new products and services; and the development of new forms of organization of small and medium-sized enterprises (SMEs).

This model schematically describes the basis of the business cycle based on Schumpeterian innovation, in which the radical innovator is copied by other players, based on a stock of information as "exogenous". The stock being diminished, thus ends the cycle of innovation. Likewise, it would put an end to the "pure" profit of the entrepreneur and thus marginalize the wave of creative destruction. However, it should be mentioned that innovation processes are characteristic of large companies, where the first three hypotheses are drawn, namely:

Hypothesis 1: Large firms are more capable than smaller firms of generating routine innovation by capturing economies of scale.

Hypothesis 2: Small firms play a decisive role in creating a monopolistic competition.

Hypothesis 3: The greater the market power is, the greater incentive to be engaged in innovation, due to the possibility of lowering costs.

According to Schumpeter, the concept of creative destruction comes to explain that innovation has become an unconditional necessity and synonymous with the survival and growth of companies.

However, there are historical moments, which have shown that regional networks play an important role in the process of innovation and resizing of companies (Basile, 2001). Specifically, it is often mentioned the phenomenon of "Third Italy", introduced by Arnaldo Bagnasco (1977), referring to the northeast and central area of Italy, characterized by a concentrated presence of small and medium-sized enterprises in the field of industry, clothing and textiles. Therefore, the trans-regional and national innovation systems not only became decisive, but it were also considered by natural need for R&D. The phenomenon of creative destruction can be considered as inherent in the case of "industrial areas" in "third Italy" (Brusco, 1982). In these industrial districts, groups of small and medium-sized enterprises (SMEs) are simultaneously engaged in cooperative behaviours, remaining in perfect competition. SMEs cooperate for survival activities, such as training, research and development, but remaining competitive in terms of outcomes. The artisan cooperatives in the textile industry, thus become sources of innovation. Different organizations, such as the private associations of the craftsmen the national chambers of commerce, the associations of the textile activities and the regional development agency have formed cluster information centres. The implications of these industrial districts are able to outline the entrepreneurial behaviour, while taking advantage of economies of scale for innovation.

As mentioned in the first part, institutional arrangements play a major role in even small producers' ability to gain access to information and opportunities to innovate. Taken in part, the small, independently operating producer could not afford the investment needed to engage sufficiently in innovation. In addition, collective effort reduces inefficiency and minimizes costs in terms of effort. In this respect, the ability of smaller companies to collaborate on European cluster networks, not only reduces risk and investment potential, but also builds the capacity to compete outside the regional and national borders, and even to assume them, drawing the courage to develop a new entrepreneurial dimension. The innovation-development model increases its efficiency when it includes in equations both the significant role played by internal resources including human and information technologies: product innovation seems positively associated with the employment of professional technicians, who may demand additional research and development costs – up to at some point, when the temporary equilibrium is reached, in the short term. In the fact, this approach it is not exempted from risks associated with market failure such as moral hazard and adverse selection. Moral risk also, generates unjustified costs, which could explain the cause of decisions taken in the context of asymmetric information. As a result, signals should be issued in order to allow for highlighting, mapping and sketching of scenarios that cannot be taken over by the companies that generate rudimentary bottlenecks in the investment in innovation-development. According to the statistical data, the Republic of Moldova represents a market for about 53600 SME units, generating revenues of over 137.5 billion of Moldovan LEU annually. A pretty big sum if we refer to the gross domestic product. In context of our economy, companies should be more concerned to accept the innovation as being the factor of excluding unfair competition, resulting in higher profits in the medium term. Even if the initial investment essentially presents risks, uncertainty, random walk and multidirectional properties. Of these we can mention, the national political factor, represented by activists, social leaders, politicians, and policy makers who can generate externalities, in the context of decision making (influencing more or less the value of investments, including those in the research category or R&D).

In conclusion, a highly competitive and global business environment, does not call into question the survival of the company itself, this factor depends directly on its ability to manage and develop its business model. Whichever model one chooses, the companies are finally forced to accept, the two ways, either with reference to the atomicity and homogeneity of the products, or the possibility of continuing the metamorphosis chain, similar to the economies in transition. In addition, there are companies that do not perceive competition as generating a function of minimum (in case of costs), and rather one of maximum (in case of profits). Narrowing the analysis of the investment-innovation process at the level of each company, Foray (2004) distinguishes knowledge-based economies as those that require continuous and rapid change due to the nature of technology and scientific discoveries, which are unexpected and unpredictable. In addition, this requires companies to engage in a process of constant updating of technical knowledge. The old certainties under the aegis of Adam Smith's "invisible hand", or today's integrated, diversified and hierarchical business world, are replaced by uncertainty and low marginal costs as the world embraces the knowledge economy and monopolistic type competition as European cluster.

2. Discussion and results

Data. Although the techniques specific to the linear forecasting model are simple and easy to apply, in reality, there are data whose modelling demands a different form than the linear one. Some of these, such as polynomial or exponential models, can be reduced by certain transformations to the linear model, the way they are generically called, linearizable models when there is a danger of confusion with the linear model itself. The present approach to look for a suitable model for modelling the forecast of the information and communications branch of the Republic of Moldova, based on the current realities of the country. The Republic of Moldova can be considered a small and open economy, based on digital services, high-tech products and IT; and the penetration rate of access to information of over 68 % (with reference to the access of the population to the Internet). Next, we try to build a forecast model using the data obtained from the National Bureau of Statistics of the Republic of Moldova, information illustrated in the table below, (Figure 1, pg. 7). The econometric results, including the tests revealed a potential of 10-14 % annually, and taking into account the structure in GDP (6.8-7 %), the gross added value of the branch would generate 1. pp each year to the total growth of the gross domestic product. Econometric testing revealed a potential of 10-14 % annually, and taking into account the structure in the GDP (6.8-7 %), the GAV of the branch would generate every year 1 p.p. to increase the gross domestic product. In the process of creating a sequential data set, the period 1967-1994, GDP calibration has been used (transforming economy GDP backward-looking starting with 95Q1, based on 4 autonomously assumptions "Ex ante" specifically:

1. Buying power of one U.S. dollar compared to 1775 Continental currency up to 2012, using Consumer Price Index for All Urban Consumers: Housing in U.S. City Average (CPIHOSSL), collected from Federal Bank of Saint Louis;
2. Structure of economy GDP, categories of resources, assumpting that from 1967–1994, Republic of Moldova has been subject of a big and closed economy abbreviated to BCE (obs. not to be confused with European Central Bank, an European Authority), is an economy that participates in international trade, but is closed enough compared to its trading partners; furthermore it describing export-import sensitivity refers to its Long Run Aggregate Supply (LRAS);
3. CPI, is expected to be 2-4 % annually between 1967–1992;
4. Firms and technology, was not count significally cause in error term or disturbance (epsilon) of the regression model, it has a limited consideration of innovative plant.

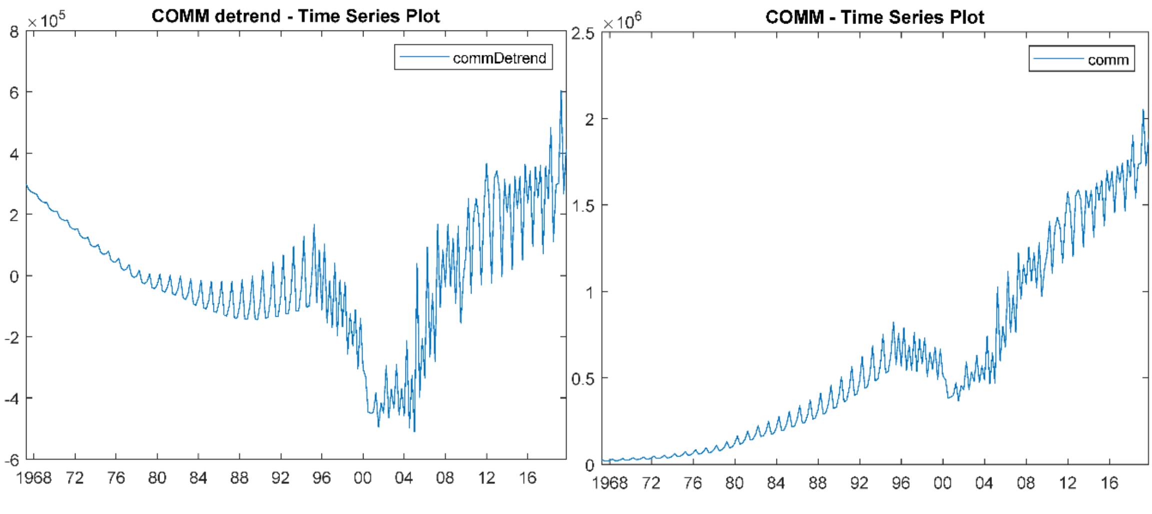

Fig. 1. Quarterly evolution of the communication series (abr. COMM) – thousands lei /Quarterly evolution of the detrend communication series (abr. COMM) – thousands lei
Source: Developed by the author based on NBS data

Econometric testing. Debating econometrics and its short-comings yours truly often gets the response from econometricians that "ok, maybe econometrics isn't perfect, but you have to admit that it is a great technique for empirical testing of economic hypotheses." A stationary time series is one whose properties do not depend on the time at which the series is observed. Thus, time series with trends, or with seasonality, are not stationary – the trend and seasonality will affect the value of the time series at different times. On the other hand, a white noise series is stationary – it does not matter when you observe it, it should look much the same at any point in time. Some cases can be confusing — a time series with cyclic behaviour (but with no trend or seasonality) is stationary. This is because the cycles are not of a fixed length, so before we observe the series we cannot be sure where the peaks and troughs of the cycles will be.

Tests for stationarity (unit-root). A stationary series, y_t, follows an *AR (p)* process if the condition is met under DF statistics (Dickey, Fuller, 1979):

Augmented Dickey-Fuller Test

Null Hypothesis: commDiff contains a unit root

$$y_t = c + \delta t + \phi y_{t-1} + \beta_1 \Delta y_{t-1} + \ldots + \beta_p \Delta y_{t-p} + \varepsilon_t$$

$$H_0 : \phi = 1$$

$$H_a : \phi < 1$$

Test Parameters

	Lags	Model	Test Statistic	Significance Level
1	0	AR	t1	0.05

Test Results

	Null Rejected	P-Value	Test Statistic	Critical Value
1	true	0.001	-35.1923	-1.9422

Fig. 2. Difference communication series and the stationary tests Augmented Dickey Fuller
Source: Developed by the author based on NBS data

The Phillips-Perron test (Phillips, Perron, 1988) is constructed to perform a nonparametric correction of Dickey-Fuller criteria in conditions of autocorrelation and/or heteroskedasticity of errors. If the errors are not autocorrelated and not heteroskedastic, then the Phillips-Perron test leads to the same results as the simple Dickey-Fuller test.

Phillips-Perron Test

Null Hypothesis: commDiff contains a unit root

$$y_t = c + \hat{I}' t + \alpha y_{t-1} + \varepsilon_t$$

$$H_0 : \alpha = 1$$

$$H_a : \alpha < 1$$

Test Parameters

	Lags	Model	Test Statistic	Significance Level
1	0	AR	t1	0.05

Test Results

	Null Rejected	P-Value	Test Statistic	Critical Value
1	true	0.001	-35.1923	-1.9422

Fig. 3. Difference communication series and the stationary tests Phillips-Perron
Source: Developed by the author based on NBS data

The null hypothesis of the KPSS test (Denis Kwiatkowski, Peter C. B. Phillips, Peter Schmidt & Yongcheol Shin, 1992) is that the analyzed time is stationary, around a constant *(c_t)*, or a trend linear determinists $(c_t + \delta_t)$. KPSS writes the time series (y_t) as a sum between a deterministic trend, a random process (u_{2t}) and the error (u_{1t}), which is assumed to be stationary:

KPSS Test

Null Hypothesis: commDiff is trend stationary

$$y_t = c_t + \delta\, t + u_{1t}$$
$$c_t = c_{t-1} + u_{2t}$$
$$u_{2t} \sim i.i.d(0, \sigma^2)$$
$$H_0 : \sigma^2 = 0$$
$$H_a : \sigma^2 > 0$$

Test Parameters

	Lags	Include Trend	Significance Level
1	0	true	0.05

Test Results

	Null Rejected	P-Value	Test Statistic	Critical Value
1	false	0.1	0.0042291	0.146

Fig. 4. Difference communication series and the stationary tests KPSS
Source: Developed by the author based on NBS data

The null hypothesis of the Laybourne-McCabe test (B.P.M. McCabe & S.J. Leybourne, 1994) assesses that a univariate time series (y_t) is a trend stationary *AR(p)* process, against the alternative that it is a nonstationary ARIMA (p, 1, 1) process.

Leybourne-McCabe Test

Null Hypothesis: commDiff is a trend stationary AR(p) Process

$$y_t = c_t + \delta\, t + b_1 y_{t-1} + \dots + b_p y_{t-p} + u_{1t}$$
$$c_t = c_{t-1} + u_{2t}$$
$$u_{1t} \approx i.i.d(0, \sigma_1^2)$$
$$u_{2t} \approx i.i.d(0, \sigma_2^2)$$
$$H_0 : \sigma^2 = 0$$
$$H_a : \sigma^2 > 0$$

Test Parameters

	Lags	Include Trend	Test	Significance Level
1	0	true	var2	0.05

Test Results

	Null Rejected	P-Value	Test Statistic	Critical Value
1	false	0.1	0.0012256	0.146

Fig. 5. Difference communication series and the stationary tests Laybourne-McCabe
Source: Developed by the author based on NBS data

All stationarity tests revealed the presence of a unitary root of the series, so the series has a stochastic or perhaps even random character, over some time segments. In order to eliminate the phenomenon of non-stationarity, the detrend or differencing procedure was chosen. Based on the results obtained by validating the econometric model, the author proposes the following recommendations: it is appropriate to increase investments in R&D, by attracting FDI. More is required for some time, the acceleration of the development of the productive sectors, which would allow to move the stationary balance to a new point (to be seen Chapter 1: The Solow Growth Model from the book of D. Romer entitled Advanced Macroeconomics, 5th edition, USA, McGraw-Hill Education; 2018) with higher production capacity, to continue the implementation of the Association Agreement/Deep and Comprehensive Free Trade Area (AA/DCFTA, 2014) within assistance programs funded by the European Union.

Tests for autocorrelation. The Ljung–Box test (named for Greta M. Ljung and George E.P. Box, 1978) is a type of statistical test of whether any of a group of autocorrelations of a time series are different from zero. Instead of testing randomness at each distinct lag, it tests the "overall" randomness based on a number of lags.

Ljung-Box Q-Test

Null Hypothesis: The first m autocorrelations of commDiff are jointly 0

$$H_0 : \rho_1 = \rho_2 = \ldots = \rho_m = 0$$

$$H_a : \rho_j \neq 0,\ j \in 1, \ldots, m$$

Test Parameters

	Lags	DOF	Significance Level
1	20	20	0.05

Test Results

	Null Rejected	P-Value	Test Statistic	Critical Value
1	true	0	1565.7037	31.4104

Fig. 6. Difference communication series and the autocorrelation Ljung-Box Q-Test
Source: Developed by the author based on NBS data

Tests for heteroskedasticity. An uncorrelated time series can still be serially dependent due to a dynamic conditional variance process. A time series exhibiting conditional heteroscedasticity or autocorrelation in the squared series, is said to have autoregressive conditional heteroscedastic (ARCH) effects. Engle's ARCH test is a Lagrange multiplier test to assess the significance of ARCH effects. Consider a time series $(r_t^2)=\alpha_0 + \alpha_1 r_{t-1}^2 + \ldots + \alpha_L r_{t-L}^2 + \varepsilon_t$, where $\alpha_0 + \alpha_1 r_{t-1}^2 + \ldots + \alpha_L r_{t-L}^2 + \varepsilon_t$ is the conditional mean of the process, and (ε_t) is an innovation process with mean zero. Suppose the innovations are generated as $(\varepsilon_t)= \sigma_t \zeta_t$, where (ζ_t) is an independent and identically distributed process with mean 0 and variance 1. Thus, $E\ (\varepsilon_t, \varepsilon_{t+L}) = 0$ for all lags $L \neq 0$ and the innovations term (ε_t) are uncorrelated. Let (H_0) denote the history of the process available at time (t). The conditional variance of (r_t) is Var $(r_t | H_{a-1})$ = Var $(\varepsilon_t | H_{a-1})$ = Var $(\varepsilon_t^2 | H_{a-1}) = \varepsilon_t^2$. Thus, conditional heteroscedasticity in the variance process is equivalent to autocorrelation in the squared innovation process.

Engle's ARCH Test

Null Hypothesis: commDiff exhibits no ARCH Effects

$$r_t^2 = \alpha_0 + a_1 r_{t-1}^2 + \ldots + \alpha_L r_{t-L}^2 + \varepsilon_t$$

$$H_0 : \alpha_j = 0, \ j = 0, \ldots, L$$

$$H_a : \alpha_j \neq 0, \ j \in 0, \ldots, L$$

Test Parameters

	Lags	Significance Level
1	1	0.05

Test Results

	Null Rejected	P-Value	Test Statistic	Critical Value
1	true	1.0277e-11	46.275	3.8415

Fig. 7. Difference communication series and the heteroskedasticity tests Engle's ARCH
Source: Developed by the author based on NBS data

Tests for random-walk. The forecasts from a random walk model are equal to the last observation, as future movements are unpredictable, and are equally likely to be up or down. Thus, the random walk model underpins naïve forecasts.

Variance Ratio Test

Null Hypothesis: commDiff is a random walk

$$y_t = c + \phi\, y_{t-1} + \varepsilon_t$$

$$H_0 : \phi = 1$$

Test Parameters

	IID Innovations	Period	Significance Level
1	false	2	0.05

Test Results

	Null Rejected	P-Value	Test Statistic	Critical Value	Ratio
1	true	3.0387e-14	-7.5967	1.96	0.15759

Fig. 8. Difference communication series and Variance Ratio test
Source: Developed by the author based on NBS data

The Box-Jenkins method. ARMA (autoregressive moving average) models are univariate models – models by which dependent variable is modelled on its own observations. This model class includes:

- Autoregressive models *(AR);*
- Models with mobile environments *(MA).*

ARMA models – which specifically combine the two types of processes. When data have a trend, the autocorrelations for small lags tend to be large and positive because observations nearby in time are also nearby in size. So the ACF of trended time series tend to have positive values that slowly decrease as the lags increase. When data are seasonal, the autocorrelations will be larger for the seasonal lags (at multiples of the seasonal frequency) than for other lags. When data are both trended and seasonal, you see a combination of these effects.

Differencing. Transformations such as logarithms can help to stabilise the variance of a time series. Differencing can help stabilise the mean of a time series by removing changes in the level of a time series, and therefore eliminating (or reducing) trend and seasonality.

As well as looking at the time plot of the data, the ACF plot is also useful for identifying non-stationary time series. For a stationary time series, the ACF will drop to zero relatively quickly, while the ACF of non-stationary data decreases slowly. Also, for non-stationary data, the value of r_t is often large and positive. The *AR (p)* process is stationary if the absolute values of the roots of its characteristic polynomial are strictly less than 1. For a stationary autoregressive process, the mean of the process it is finite and independent of time; the process returns to the mean (it is mean reverting). If the process is non-stationary, the average is not a finite value. The additional conditions for the process to be stationary (in covariance) are: 1. The variance of the process does not depend on time; 2. Covariance does not depend on time. Because most financial time series have the characteristics of processes autoregressive, *AR (p)* models are the most widely used forecasting models. But, certain series follow other types of processes, called mobile environment *MA (q)* processes. E.g, according to the statistical tests presented in the specialized literature, the S&P stock index 500 follows an *MA (q)* process rather than an *AR (p)*.

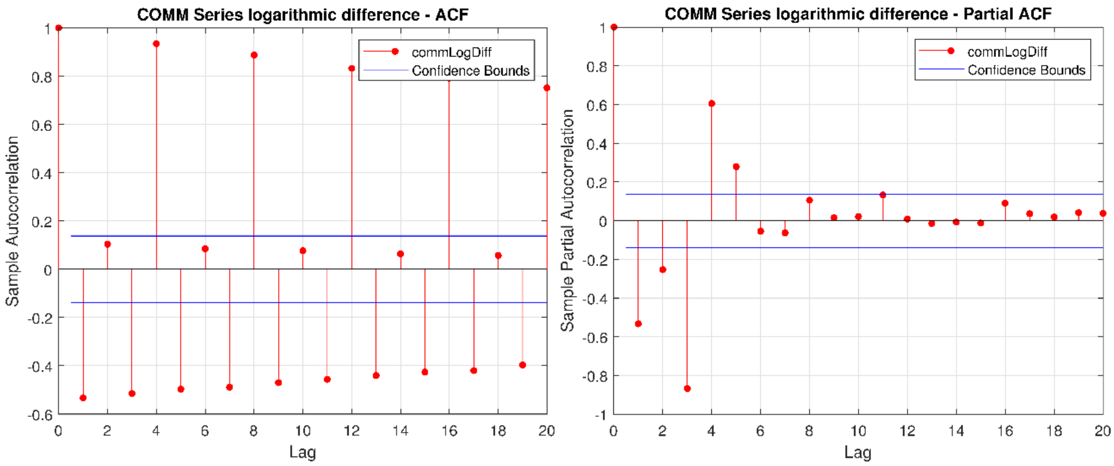

Fig. 9. Logarithmic difference communication series and functions ACF, PACF
Source: Developed by the author based on NBS data

The most suitable model is chosen using various analysis criteria. Thus, it is choose the model that has the highest value for the adjusted R or the value the lowest for the residue variance or dispersion. It is also chosen the model with the lowest values for the information criteria (Akaike, Schwartz). The *AR (p)* process is stationary if the absolute values of the roots of its characteristic polynomial are strictly less than 1. For a stationary autoregressive process, the mean of the process it is finite and independent of time; the process returns to the mean (it is mean reverting). If the process is non-stationary, the average is not a finite value. In order to choose the correct model, ACF and PACF functions must be checked, (Figure 9, pg. 10).

Set up the Model. The chosen model is one of autoregressive type *AR (3),* with including the seasonal component. This was chosen for the following two reasons: 1. The branch started to have seasonality since last years. 2. There is the premise of a bigger growth if we evaluate the fact that in the last 2 years, the "series" has taken a breakthrough, generated by structural changes in the industry, with the role of generating new jobs and investments in technologies.

$$y'_t = c_t + \delta\, t + \varphi_1 y'_{t-1} + \ldots + \varphi_p y'_{t-p} + u_{1t} \quad (1)$$

$$c_t = c_{t-1} + u_{2t} \quad (2)$$

$$u_{1t} \approx i.i.d\,(0, \sigma_1^2) \quad (3)$$

$$H_0: \sigma^2 = 0 \quad (4)$$

$$H_a: \sigma^2 > 0 = 0 \quad (5)$$

Where, (y'_t), is the differenced series (it may have been differenced more than once). The “predictors” on the right hand side include both lagged values of (y'_t) and lagged errors. We call this an ARIMA(p, d, q) model, where:

• (p) = order of the autoregressive part;
$(1-\varphi_1 B - \ldots - \varphi_p B^p) \leftarrow AR(p)$
• (d) = degree of first differencing involved;
$(1-B)^d y_t \leftarrow d, differences$
• (q) = order of the moving average part.
$c+(1+\theta_1 B + \ldots + \theta_q B^q)u_{1t} \leftarrow MA(q)$

The Dickey-Fuller test verifies the null hypothesis (H_0), (φ) = 1 (non-stationarity) against the alternative hypothesis, (φ) ‡ 1 (stationarity). Based on previous section, we've rejected the null hypothesis (H_0), against the alternative hypothesis (H_1), if t <(φ), where (τ φ) is one of the critical (negative) values in the Dickey-Fuller distribution table. The equation of the model is represented in (Box 8, pg. 13). As a result, the value of a series in a given period depends on the value of the series in the previous period and a random error term whose expected value is 0. Thus, the best forecast of the series value is its previous value. This model is widely used in the analysis of financial markets and especially the exchange rate change. This process is non-stationary (explosive), and therefore has no average. The simplest method of testing the process is to test the term $\varepsilon_t = y_t - y_{t-1}$ (representing the first difference in the series): testing the average of the series ε_t: which must be zero; testing the stationarity of the series ε_t: the series must be stationary. The information and communications ACF and PACF functions highlights the ascending character of the series, also presents the seasonal character from 2014. The cyclical variation highlights the fact that the branch is exposed to shocks, but also to the uncertainty that results from the real business-cycle theory, RBC theory (to be seen Chapter 5: Real-Business-Cycle Theory from the book of D. Romer entitled Advanced Macroeconomics, 5th edition, USA, McGraw-Hill Education; 2018). The chosen model is one of Autoregressive type *AR (3)*, with including the seasonal component. This was chosen for the following two reasons: 1. The branch has no seasonality until the last years. 2. There is the premise of a bigger growth if we evaluate the fact that in the last 2 years, however, the branch has taken a breakthrough, generated by structural changes in the industry, with the role of generating new jobs and investments in technologies.

ARIMA(3,1,0) Model Seasonally Integrated with Seasonal MA(1) (Gaussian Distribution) (SARIMA_commLog)

Seasonal ARIMA model of time series commLog with the following equation:

$$(1-\phi_1 L - \phi_2 L^2 - \phi_3 L^3)(1-L)(1-L)y_t = (1+\Theta_1 L)\varepsilon_t$$

Model Estimation

Estimation Results

Parameter	Value	Standard Error	t Statistic	P-Value
Constant	0	0		
AR{1}	-0.98882	0.029739	-33.2501	2.0378e-242
AR{2}	-0.96571	0.039237	-24.6121	9.3657e-134
AR{3}	-0.95462	0.024689	-38.6661	0
SMA{1}	-0.45776	0.035139	-13.0273	8.5633e-39
Variance	0.0052016	0.00028141	18.4836	2.7976e-76

Goodness of Fit

AIC	-500.8143
BIC	-484.175

Fig. 10. The equation of the COMM Series Model and the Goodness of Fit
Source: Developed by the author based on NBS data

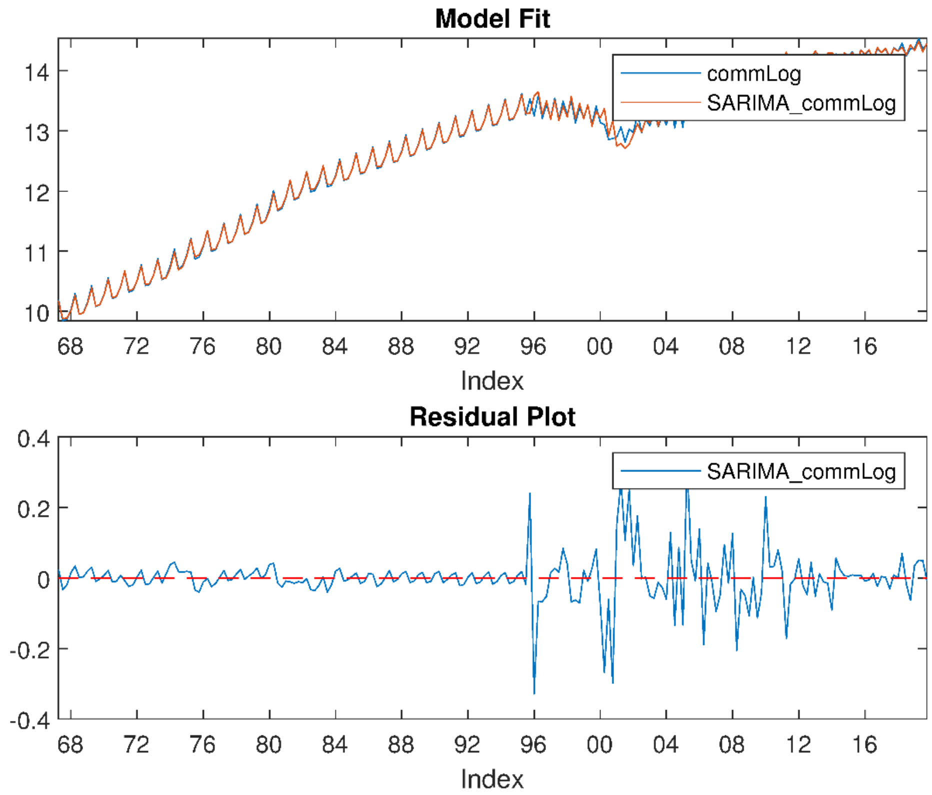

Fig. 11. Relevance of the trend logarithmic communication series forecast model (abr. COMMLOG) – the Fit model/SARIMA_COMMLOG model Residual distribution characteristics.
Source: Developed by the author based on NBS data

Model matching (Model Fit procedure) shows that the ARIMA model series follows with a high degree of accuracy the trend of the commLog logarithmic series. Of these models, the best is the ARIMA $(3,1,0)(0,1,1)_4$ model (i.e., it has the smallest AICc value, and smallest p-value) showed in (Table 1, pg. 13). The residual variation shows that the errors are normal, independent and identically distributed, with zero mean, which also verifies the conditions of the fundamental-Gauss-Markov hypotheses, namely:

Table 1. Model selection, BJ method

Model	**AICc**	**BICc**
ARIMA$(3,1,0)(0,1,2)_4$	-501.9	-482.0
ARIMA$(3,1,0)(0,1,1)_4$	-500.8	-484.1
ARIMA$(3,1,0)(1,1,1)_4$	-497.1	-477.1
ARIMA$(3,1,0)(1,1,0)_4$	-505.8	-489.2
ARIMA$(3,1,0)(2,1,2)_4$	invalid	invalid
ARIMA$(3,1,0)(2,1,1)_4$	-518.1	-494.8
ARIMA$(3,1,0)(2,1,0)_4$	-504.0	-484.1

Source: elaborated by the author based on the NBS information

- normality of errors: $\varepsilon_i \epsilon N, \forall\, i = \overline{1,n}$;
- error independence: $\operatorname{cov}(\varepsilon_i, \varepsilon_j) = 0, \forall\, i,j = \overline{1,n}, i \neq j$;
- errors are identically distributed (homeskedatic model): $M(\varepsilon_i) = 0, V(\varepsilon_i) = \sigma^2, \forall i = \overline{1,n}$.

Once the shape of model is specified, together with the numerical value of the parameters, we can use the model for the forecast. Basically, the forecast calculation answers the question: "What is the future, unobserved value (apart from the data obtained by the NBS), which can be calculated using an Autoregressive *AR (3)* Model. For the graph we included the confidence interval for a forecast value (the default value is 95 %). Of these models, the best is the ARIMA(3,1,0)$(0,1,1)_4$ model (i.e., it has the smallest AICc value, and smallest p-value)

Output parameters: the fundamental information related to the ARIMA model (coefficients, graphical representation, forecast, confidence intervals, etc.) incorporated in an interactive graphical interface. We will finally present two real problems taken over, namely that the economy is vulnerable to risks and uncertainty results highlighted in (Table 2, pg. 13). Thus, as an alternative method of forecasting, the Monte Carlo simulation method was chosen. It will finally be seen that the model is very well suited to the ARIMA model, the associated technique that involves testing whether the model can be used for future calculations. Naturally, it is assumed that the model can be used for forecasting. With the analysis of the observed points together with the curves that describe the confidence intervals in the graph, one can advance the hypothesis that the model obtained by the simulation method is relevant. Trend, error spread indicators can be simply estimated using the Quantile-Quantile Plot option. The time series diagram shows that the SARIMA Model follows the normal distribution.

Table 2. GDP growth rates of GDP information and communication branch, %

Year	Information and communication sector (GDP) Q1	Q2	Q3	Q4	annual
		Actual/forecast (*)			
2014	3,5	4,4	2,7	3,1	3,4
2015	3,7	5,0	4,4	3,3	4,1
2016	3,1	5,6	1,4	3,2	3,2
2017	3,1	0,7	2,1	1,8	2,0
2018	9,0	5,0	-1,6	5,0	4,3
2019	8,1	12,36	8,6	8,3	9,2
2020	5,9	-6,9	*8,9/**9,0	*7,1/**9,3	*7,2/**4,6
2021	*5,5/**10,0	*8,0/**28,1	*8,3/**8,9	*7,0/**8,8	*7,1/**13,10
2022	*5,9/**8,0	**9,1	**8,9	**8,8	**8,7
2023-2031	-	-	-	-	**8,8

Note: the data presented with (*), asterisk – represents forecast data on 23AUG19,
(**), asterisk – represents forecast data on 13SEP20
Source: elaborated by the author based on the NBS information

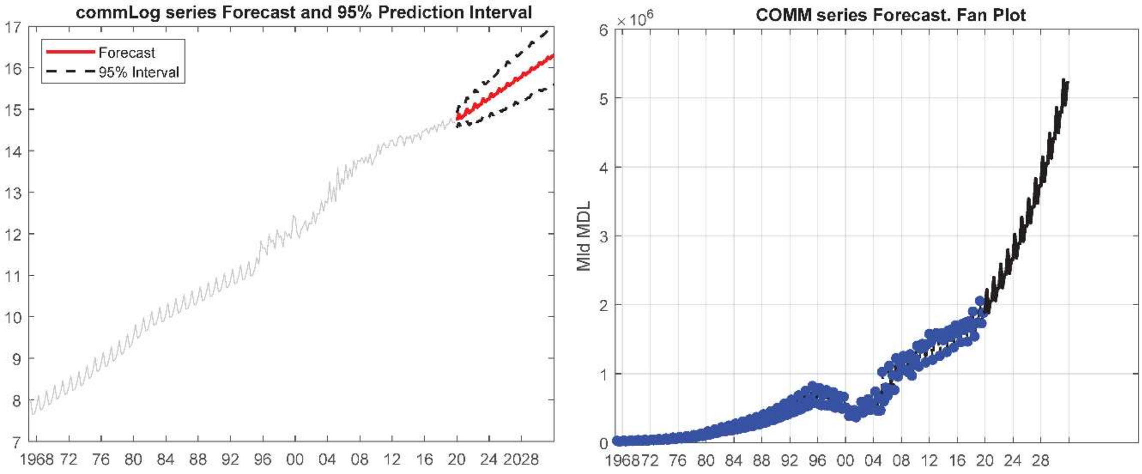

Fig. 12. Forecasts of quarterly series COMM communications using a deterministic trend model (Forecast) and a stochastic trend model (95 % Interval) and Fan Plot chart
Source: Developed by the author based on NBS data

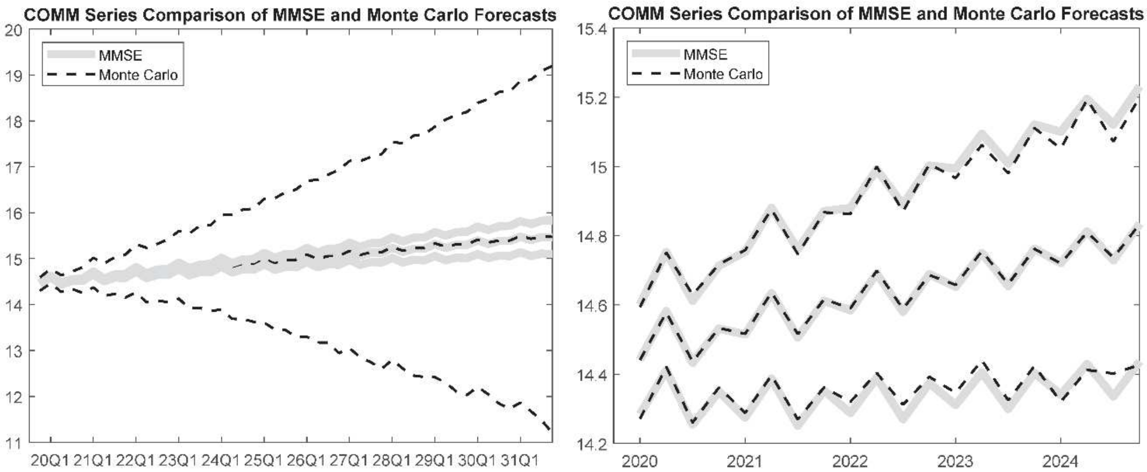

Fig. 13. Econometric calculation technique - simulation method "Monte Carlo" Scenarios – I and II
Source: Developed by the author based on NBS data

We consider that the economic sector of information and communications can be a design pattern for attracting foreign direct investment (FDI) in our country, also taking into account the National Institute of Economic Research (NIER) objectives, to provide a theoretical-empirical framework for policy makers. From a scientific point of view, our growth theory is based on the phenomenon "A Treia Românie" (the third Romania), 1998–2016, period of high economic growth, namely :

- If two countries have the same rate of investment but different levels of income, the country with lower income will have higher growth.
- If two countries have the same level of income but different rates of investment, then the country with a higher rate of investment will have higher growth.
- A country that raises its level of investment will experience an increase in its rate of income growth (R. Barro & X. Sala-i-Martin, Economic Growth, Second Edition, 2004).

3. Conclusion

Moreover, the data presented by the NBS highlights the fact that the net flow of FDI in the national economy has increased considerably since 2013. We also consider that the analysed sector could be considered a model for innovation and development taking into account the perspective of the series and the expected economic growth of 10-14 % (potential GDP). The author intends to evaluate in another form of analysis the gross domestic product, as an extension to the present study. The main objective of the forecasting model came from the need to create more detailed forecasts, so far, in order to improve the performance of the companies in the field, but also to increase the incomes, the profits and the satisfaction of the consumers at the microeconomic level. Also, a hybrid forecast model can be the foundation of an early warning system, which would transmit the information more accurately to the small and medium-sized enterprises (SMEs) sector, to prevent asymmetric shocks and which would ultimately lead to the optimization of economic processes, improving the accuracy of making optimal decisions, but also evaluating potential system risks.

4. Acknowledgements

This article is a result of the grant "ASEM doctoral grants for the period 2019-2023" funded from the state budget during the doctoral studies, but also during activity I carried out as a scientific researcher at the National Institute for Economic Research (NIER) in Chisinau, Moldova – between May 2019 and December 2019.

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