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Multi-participant Decision-making Based on Digital Platforms: A Case Study for the Romanian Academy

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Abstract. The last decade culminating with the pandemic disrupted traditional business models in various industries and accelerated the digital transformation based on economy platforms. The main aim of this paper is to present the platform for economy framework to facilitate peer-to-peer transactions for different business models and the basic aspects related to multi-participant/collaborative decision-making and evaluation of teleconference platforms and particularize the virtual meetings and conferences. The necessary steps for planning a teleconference and the results of the concept implementation have been extracted from Romanian Academy practical case study referring to multi-participant decision-making using teleconference platforms. A *Seasonal Autoregressive Moving Average model* (SARIMA) is employed to explain the number of participants in an online conference in the Romanian Academy between April 2020 to August 2023. This model has been used to make short-run dynamic and static forecasts on the horizon from September 2023 to December 2023.

Key-words: Blockchain; multi-participant decision-making; platform economy; SARMA model; teleconference platforms.

1. Introduction

The platform economy is a recent work model that promotes peer-to-peer transactions through digital platforms. It has disrupted traditional business models, creating new opportunities and transforming the way goods and services are delivered [1]. Peer-to-peer transactions, also known as the sharing economy or gig economy [2], are those that occur between individuals or businesses without the need for a traditional intermediary. Platform economies connect buyers and sellers through online platforms, such as Amazon, Uber, and Airbnb. Platforms act as intermediaries, facilitating transactions between participants. They often use technology to facilitate communication, payment, and other aspects of the transaction process.

Some examples of platform economies include:

- Transportation: Bolt, Uber, and Lyft;
- Lodging: Airbnb;
- Odd jobs and tasks: TaskRabbit;
- Goods: Amazon, eBay, AliExpress, Overstock, Thrive Market, Target, Uncommon Goods;
- Payments: Stripe, Square, Gumroad, PayPal, Amazon Pay;
- Software development: Huawei, Apple, Samsung, Oppo, Sony, Microsoft, Dell, Lenovo, Salesforce.

Platform economies have created new job opportunities, but they have also been criticized for leading to addictions and precarious work conditions [3]. While some companies with traditional businesses have faced an important crisis during the pandemic because of their incapacity to innovate and recover, others benefit from the acceleration of digital transformation, increasing their market share [4]. Many of them adopt virtual conferences and virtual meetings (as components of the platform economy) to connect participants, promote interactions, and enable multi-participant collaborative decision-making. The differences between virtual conferences and virtual meetings are discussed in terms of formality and goal. Meetings are larger, mostly in one day and are organized to make discussions and come up with ideas, while conferences' scope is to disseminate information over a longer period from one day to several days [5]. Virtual conferences can provide a multi-collaborative environment where the participants can engage in conversations, exchange ideas, and make collective decisions.

Exploring different aspects of how virtual conferences can facilitate collaborative decision-making processes and enhance collaboration among participants, we can mention the following:

- The role of technology in promoting participant communication, information exchange, cooperation, and facilitating multi-participant decision-making. The current solutions include video conferencing, chat capabilities, real-time collaboration tools, document sharing, and polling;
- The collaboration techniques are meant to stimulate active participation, knowledge sharing, and idea exchange, such as virtual breakout rooms for smaller group conversations, polling and survey tools for getting input, interactive Q&A sessions, and collaborative document editing;
- The impact on decision outcomes enabling the integration of various perspectives and knowledge by providing with forum for multi-participant decision-making. Virtual conferences' collaborative nature encourages open conversations, knowledge sharing, and consensus-building, resulting in more informed and well-rounded judgments;

- The online conferences increase the accessibility and affordability for participants by removing the need for travel, lodging, and venue fees associated with physical conferences.

The rest of the paper describes the process of teleconference platform adoption using a practical case study, including a SARMA model to explain and predict the number of participants in online conferences for the Romanian Academy.

2. Digital Transformation in Romanian Academy – Teleconference Platform Adoption Case Study

Romanian Academy has decided to adopt a teleconference platform as a solution for multiparticipant decision-making during pandemic restrictions. The main objectives have been interconnecting a variable numbers of individuals located in different geographic areas that develop multiparticipant and collaborative activities, via the transmission, in real-time of text, audio and video messages, by resorting to dedicated devices and specific software. The key individuals or groups with certain roles and duties involved in the decision-making process are internal or external individuals or groups in Romanian Academy are the following:

- **Presidium** that composed of the Academy president and vice-presidents, secretary-general, and the chairs of Academy sections;
- **Honorary Members, Corresponding Members, and Full Members:** external or internal individuals with specific voting privileges and participating actively in decision-making processes in section and General Assembly meetings;
- **IT Department:** in charge of handling the technology infrastructure as well as the technical facilitation and other logistical aspects of the decision-making process. They ensure that the tools, platforms, and processes required for effective decision-making are in place. Managing teleconferencing platforms, virtual meeting tools, and collaboration software, and maintaining good communication and information flow during the decision-making process are all examples of what this entails.

The Romanian Academy's journey in adopting a teleconferencing platform-based working style has included the following stages:

1. **Defining the scope:** improvement of

   (a) Department meetings;
   (b) General assembly meetings for the election of new members of the academy, which include an electronic vote;
   (c) scientific events on different topics.

2. **Defining the objectives:**

   (a) Assessment of the project scope;
   (b) Development of new strategies for information and promotion of the services offered;
   (c) Training in the users of the platform.

3. **Defining the implementation plan.** The decision-making *process model* proposed by Herbert Simon [2] has been enriched to correspond to a multi-participant approach [6, 7], including the following major components:

    - ***Awareness and understanding by all relevant parties:*** the advantages, characteristics and influence of teleconferencing on the institution's operations and objectives.
    - ***Needs assessment and analysis:*** to adopt and establish areas of benefit from teleconferencing.
    - ***Platform research and evaluation:*** based on criteria aligned with the organization's goals and priorities (functionality, scalability, ease of use, security, interaction with existing systems, effectiveness, etc.). Evaluation of platforms using criteria that take into account their importance to the organization, for example, suitability, transparency of information, accuracy or response time; quality of implementation, flexibility, scalability or functional transparency, quality of delivery, price, level of independence, the reputation of providers, ease of use and adaptation [7] or integration with other applications [8], number of participants accepted for a session, time limitation, the ease of use of the interfaces, the diversity of the devices with which the connection can be made, the increase in efficiency for both individuals and organizations.

From the extensive list of existing platforms (GoTo Meeting, Webex Meeting, MS Teams, Google Meets, Skype, BigBlueButton, BlueJeans, Slack, Jitsi Meet, Whereby, Blackboard Collaborate, Dialpad Meetings or TrueConf Online [8]), five were selected and analyzed using a set of criteria such as organization type, cost-effectiveness, number of supported participants, usage time limit, platform connection options for different devices, functionalities, security, interaction with existing systems. The market research highlighted the fact that there are platforms with particular characteristics [9] suitable for different contexts. The results of the comparison are included in Table 1 in terms of:

- **Pilot testing:** initiated with a smaller group for detecting issues, gathering feedback, and making necessary changes before expanding the implementation throughout the entire organization.
- **Implementation and integration:** by setting up the appropriate infrastructure (hardware and software elements, knowledge related to the use of certain devices, applications or functions, etc.), training seers, and integrating it with existing systems and current workflows. An effective meeting requires not only the agenda, the participant's number and identity, speakers, the time and duration of the meeting and so on but a high level of efficiency involves teleconference management [15, 16, 17];
- **Adapting the management style:** conveying the benefits, offering assistance and resources, addressing concerns, and encouraging user adoption and involvement to ensure a seamless transition to the new platform;
- **Monitoring and evaluation:** the usage, performance and impact, areas for improvement, addressing concerns, determining the effectiveness of the adoption.
- **Continuous improvement:** the strategy adaptation and refinement based on regular evaluation (customer feedback, integrating new features or upgrades, and adjusting to changing demands and technologies).

Table 1. Platform comparison

Platform comparison	Organization type	Cost-effectiveness /no of participants/time limits. Free/participants no vs. Paid/participants no		Platform connection options for different devices	Functionalities, security, interaction with existing systems
Zoho Meeting	Medium and large	Free for 100 participants or less/ no more than 60 min/session	Up to €20/month up to 250, for Meetings, and up to 3000, for Webinars, in c ontinuous sessions of 24 hours / Meetings and Webinars cost up to €20/month and up to 250, respectively up to 3000 participants, considering in continuous sessions of 24 hours.	Desktop applications for various operating systems like Linux, Windows, Mac; mobile applications (iOS and Android) using Google Chrome and Firefox extensions	Virtual backgrounds Audio/VoIP, webcam, and file sharing capabilities Consent prompts for turning on video, adding to calendar, and receiving reminders Basic reporting and analytics Organization-level and automated email settings Two-factor authentication Session recording
Zoom	Different sized groups of people	Free for 100 participants or less/ no more than 40 min/session	Paid (Business, Enterprise, Pro, Business Plus)/ for 100 up to 1000 participants) prices from €13.50/month, high level of application integration for more than 100 participants and sessions of 30 hours	Desktop mobile applications for Android and for iOS	High-definition video and integration with over 2000 other applications Powerful security f eatures, including Secure Socket Layer encryption Whiteboard editing and sharing, team chat and email, calendar facilities, recording and transcription features Cloud storage and Essential Apps (available for purchase) [8, 10, 11]
Webex Meeting		Free for 100 participants or less/ no more than 60 min/session	Paid starting from 14,50$/license/mo for Business and Enterprise versions/ 150 to 1000/sessions lasting even for 24 hours	Desktop and board	Advanced security features for meetings The ability to pin videos and shared content to customized stage layouts Tools for voice optimization and noise removal Standard messaging, screen and whiteboard sharing, recording tools, and cloud storage and file management/transfer [8, 12]

Platform comparison	Organization type	Cost-effectiveness /no of participants/time limits. Free/participants no vs. Paid/participants no		Platform connection options for different devices	Functionalities, security, interaction with existing systems
Microsoft Teams	Different sizes on a global basis, including educational units few individuals and large groups of people, including corporations (most of the Fortune 500 companies using it)	Free for 100 participants or less/ no more than 60 min/session	Microsoft Teams Essentials, 365 Personal, Family, and Business plans cost $4 to $12.50 per month and allow for one-on-one and group meetings of up to 30 hours with 300 participants	Desktop Android and IOS using a b rowser on PC or MAC	Integration with Office applications Calling and video online meetings, with the ability to join meetings without an account Customized backgrounds, scheduled meetings, noise suppression, Outlook calendar visualization, screen and to-do list sharing, task assignment, file storage, and consistent phone and web customer support [8, 13]
Google Meet	Mainly recommended for small businesses	Free for 100 participants or less/ no more than 60 min/session	Business Starter, Standard, Plus and Enterprise more than $6/month for 1 year of commitment/ from 100 to 500	Desktop applications for Android	High-definition video conferencing platform integrated with Google products such as Gmail and Google Calendar. It offers a consistent level of security (data encrypted in transit) and standard to enhanced support. Features include screen and whiteboard sharing, live captions, on-meeting hand raising, Q&A polls, 30 GB recording, and unlimited storage capacity for paid versions of this product [8, 14]

3. Data and Methodology

3.1. Collected data

Let us consider the number of participants attending the official online meetings organized by the Romanian Academy in the period April 2020 – August 2023. The data series is modelled using a SARMA approach that is also employed as forecasting method for the horizon September 2023 – December 2023. The evolution of this times series in the analyzed period represented in the Figure 1 suggests lack of participants during the summers due to vacations, while in the rest months of the year growth of the number of participants is observed. The period analyzed in this study covers two sub-periods: before the use of the teleconferencing platform (April 2020 – August 2020) and after the introduction of this platform (the rest of the period until August 2023).

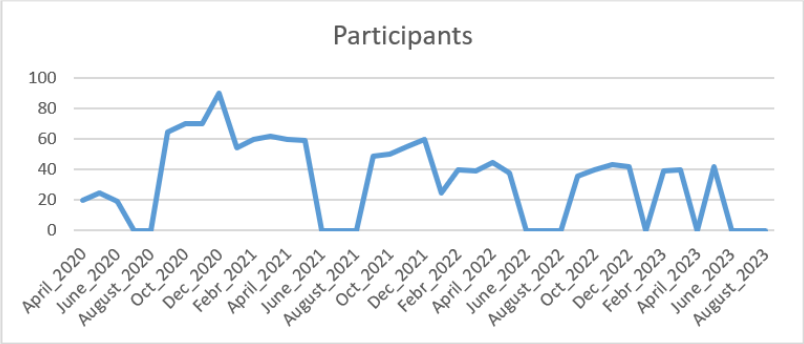

Fig. 1. The number of participants to online conferences organized by the Romanian Academy in the period April 2020- August 2023. Source: Authors' graph.

The period of maximum utilization of the platform September 2020 – December 2020 due to restrictions related to Covid-19 pandemic. The highest level of participants registered in this period is 90 persons and corresponds to December 2020. The hybrid meetings begun their organization since January 2021 and, consequently, the number of participants to online meeting diminished. In the next three years (2021, 2022 and 2023), in the summer months (June, July, August) online meetings were not organized.

SARIMA models are an extension of ARIMA models that account for seasonal patterns in time series data. The seasonal component of a SARIMA model can be described by three parameters:

- Autoregressive seasonal order (P): The number of lagged seasonal terms that are used to predict the current value of the time series.
- Moving average seasonal order (Q): The number of lagged seasonal error terms that are used to predict the current value of the time series.
- Seasonal differencing order (D): The number of times the time series must be differenced to make it stationary.

To identify a SARIMA process, it is necessary to examine the *autocorrelation function* (ACF) and partial autocorrelation function (PACF) of the time series. If the time series has seasonal factors, then the ACF and PACF will have significant spikes at lags that are multiples of the seasonal period.

The general form of a stationary SARIMA model with D=0 is:

$$\phi(L)\varphi(L^s)(y_t - \mu) = \theta(L)\Theta(L^s)\varepsilon_t \tag{1}$$

where: $\varphi(L)$ and $\theta(L)$ are the autoregressive and moving average operators, respectively, of order p and q, $\varphi(L^s)$ and $\theta(L^s)$ are the autoregressive and moving average seasonal operators, respectively, of order P and Q, y_t the time series, μ is the mean of the time series, ε_t is the error term.

In other words, a SARIMA model predicts the current value of a time series by considering its past values, both seasonal and non-seasonal, as well as its past error terms.

The seasonal components with different periodicity are written as:

$$\text{SAR(P): } \varphi(L^s) = 1 - \varphi_1 L^s - \varphi_2 L^{2s} - \cdots - \varphi_P L^{P_s} \tag{2}$$

$$\text{SMA(Q): } \Theta(L^s) = 1 - \Theta_1 L^s - \Theta_2 L^{2s} - \cdots - \Theta_Q L^{Q_s} \tag{3}$$

The representation of non-seasonal components that control for short-term effect is ensured by:

$$\text{AR(p): } \phi(L) = 1 - \phi_1 L - \phi_2 L^2 - \cdots - \phi_p L^p \tag{4}$$

$$\text{MA(q): } \phi(L) = 1 - \theta_1 L - \theta_2 L^2 - \cdots - \theta_q L^q \tag{5}$$

The orders are chosen as to have $p < 0.5s$ and $q < 0.5s$. $(p, q) \times (P, Q)_{s,s'}$, where s is autoregressive component seasonality and s' is moving average component seasonality is represented as:

$$\phi(L)\varphi(L^s)(y_t - \mu) = \theta(L)\Theta(L^{s'})\varepsilon_t \tag{6}$$

The representation of seasonal components is given by:

$$\text{SAR(P): } \varphi(L^s) = 1 - \varphi_1 L^s - \varphi_2 L^{2s} - \cdots - \varphi_P L^{P_s} \tag{7}$$

$$\text{SMA(Q): } \Theta(L^{s'}) = 1 - \Theta_1 L^{s'} - \Theta_2 L^{2s'} - \cdots - \Theta_Q L^{Q_{s'}} \tag{8}$$

The representation of non-seasonal components is:

$$\text{AR(p): } \phi(L) = 1 - \phi_1 L - \phi_2 L^2 - \cdots - \phi_p L^p \tag{9}$$

$$\text{MA(q): } \phi(L) = 1 - \theta_1 L - \theta_2 L^2 - \cdots - \theta_q L^q \tag{10}$$

Unit root/stationary tests like ADF (Augmented-Dickey Fuller) test, PP (Phillips-Perron) test and KPSS (Kwiatkowski–Phillips–Schmidt–Shin) test are applied before the construction of SARIMA model. Let us consider the three regressions used in the construction of ADF test:

(trend and constant): $\Delta y_t = \alpha y_{t-1} + \beta + \gamma t + \sum_{j=1}^{p} \delta_j \Delta y_{t-j} + \varepsilon_t$

(constant): $\Delta y_t = \alpha y_{t-1} + \beta + \sum_{j=1}^{p} \delta_j \Delta y_{t-j} + \varepsilon_t$

(no trend and no constant): $\Delta y_t = \alpha y_{t-1} + \sum_{j=1}^{p} \delta_j \Delta y_{t-j} + \varepsilon_t$

$\alpha, \beta, \gamma, \delta_j$ – coefficients, t- time index

ε_t – white noise (independent errors of null mean and constant dispersion).

The null hypothesis for PP and ADF sets up non-stationary character of time series and it is formulated as $H_0 : \alpha = 0$. On the other hand, the null hypothesis of KPSS test states stationarity series. The descending sequential procedure of Dickey and Pantula [18], and Pantula [19] is employed to check the presence of unit roots. The procedure starts with the data series in the second difference and checks step by step the significance of the coefficients for the model with trend and constant, model with intercept and model without tendency and intercept before selecting the appropriate one [19, 20].

4. Results

The unit root/ stationary tests are employed to verify the characteristics of the time series associated to the number of participants to online conferences organized by the Romanian Academy is checked. The results are reported in Table 2.

Table 2. The results of unit root/stationary tests for the analyzed time series in the period April 2020 – August 2023

Type of data series	Appropriate model for ADF test	ADF stat.	Appropriate model for PP test	PP stat.	Appropriate model for KPSS test	KPSS stat.*
data in the second difference	no linear trend and no intercept	–7.193280 (<0.01)	no linear trend and no intercept	–29.95300 (<0.01)	intercept	0.281679
data in the first difference	no linear trend and no intercept	–7.795125 (<0.01)	no linear trend and no intercept	–8.917404 (<0.01)	intercept	0.119681
data in level	linear trend and intercept	–5.429303 (0.0006)	intercept	–3.274032 (0.0229)	intercept	0.024859

Source: own computations in Eviews.
Note: critical value for 1% significance level 0.739; p-values are reported in brackets

All the applied tests suggest that the time series for the analysed variable is stationary in level at 5% significance level. In the case of KPSS test, the stationary is fulfilled even at 1% significance level. According to Akaike Information Criterion, a SARMA (1,0) (1,0)12 model is the best one out of more alternative models of this type.

According to the results reported in Table 3, the coefficients are statistically significant based on t-Student test at 5% significance level. DW statistic is close to 2, which suggests independent errors. Moreover, the correlogram of residuals in Appendix 1 [21] confirms no serial correlated errors.

Table 3. The best SARMA (1,0) $(1,0)_{12}$ model to explain the number of participants to online conferences organized by the Romanian Academy in the period April 2020 – August 2023

Variable	Coefficient	Std. Error	t-Statistic	p-value
Constant	31.83421	13.69442	2.324612	0.0257
AR (1)	0.534059	0.119979	4.451266	<0.01
SAR (12)	0.719094	0.138753	5.182539	<0.01
Sigma squared	237.3949	48.13680	4.931671	<0.01
R-squared: 0.645908	Adjusted R-squared: 0.617198	F-statistic: 22.49756	Durbin-Watson statistic: 2.095792	Jarque-Bera stat.: 2094104 (0.350971)

Source: own computations in EViews. Note: p-value in brackets

There is no evidence to reject the normal distribution at 1% significance level, according to the Jarque-Bera test. Durbin-Watson statistic is around 2, which supports the errors independence. Moreover, the correlogram of residuals in Appendix 1 [21] confirms that the errors are not auto-correlated (serial correlated) at 1% significance level. The valid model is used to construct dynamic and static forecasts. These predictions are assessed using specific forecast accuracy measures. More of these indicators indicate that static forecasts are more accurate than the dynamic ones (Theil inequality coefficient, mean absolute percentage error, root mean squared error, mean absolute error). According to static forecasts, the predictions of the number of participants to online conferences for the next four months, by the end of 2023, are: 45 participants (September 2023), 47 participants (October 2023), 47 participants (November 2023), 54 participants (December 2023).

The COVID-19 epidemic has had a huge impact on working styles, compelling many to use teleconferencing systems to allow remote work and communication. The major lesson acquired both before and after the implementation of teleconferencing platforms during the pandemic is the necessity of the implementation of teleconferencing platforms due to adaptation and resilience, increased effectiveness and efficiency, increased communication and collaboration.

5. Conclusions and Further Works

A comprehensive model for decision-making activities consists of more stages but for the Romanian Academy, these stages have been adapted to the pandemic period. The number of platforms included in the evaluation and the criteria were based on organizational needs and priorities based on a scoring system or matrix to evaluate platforms against each criterion based on their importance to the organization. After the decision of the teleconference platform, another important step was the entire process of teleconference management: planning, organization, leading, evaluation and control, change management and adoption based on continuous monitoring and evaluation. Continuously improving the teleconference management strategy boost productivity, engagement, and overall effectiveness of the virtual meeting experience.

Proper teleconference usage means creating a productive and engaging meeting experience for all participants, effective communication, stakeholder engagement, and training for the successful integration of teleconferencing into the institution's operations and attaining the anticipated advantages. Proper management of teleconferences assumes avoiding unexpected events

or errors reduced to a minimum or eliminated, but also for the acquisition of a good reputation among the beneficiaries of such services and for increasing trust in collaboration tools, increases productivity, engagement and overall experience and effectiveness. Based on these platforms organizations improve collaborative decision-making, allowing informed decisions and fostering a sense of reliability and accountability within the platform ecosystem.

Some prospective study areas relating to the platform economy and teleconferencing can be investigated further to better understand and solve the rising issues and opportunities in the platform economy and the changing teleconferencing landscape. In-depth study in these areas can help to expand knowledge, inform policymaking, regulation and laws and encourage innovation in the sector: exploration of Methods to Improve User Experience and Engagement in Virtual Conferences; Teleconferencing Platforms' Privacy and Security; study of the importance of trust and reputation systems in the platform economy, specifically in teleconferencing platforms; socioeconomic implications of Remote Work and Teleconferencing; environmental Sustainability in Virtual Conferences. In future research by addressing and solving these issues, the platform economy can progress toward a more sustainable future that takes into account social equality, environmental stewardship, and long-term economic sustainability. Adopting sustainable practices can help not only workers and society but also the platform economy's general resilience and success.

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