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CONCEPTUAL FRAMEWORK CONCERNING THE ROLE OF BIG DATA ANALYTICS IN INTELLIGENT DECISION-MAKING SUPPORT SYSTEMS DURING THE COVID-19 CRISIS

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Abstract: *The purpose of this paper is to identify the utility and the role of big data analytics in the frames of the intelligent decision-making processes. The chosen period for this research has been the present and the last two years, speaking concretely of the Covid-19 pandemic. The study has been conducted from a project perspective within tech-orientated enterprises. Furthermore, the applied methodology has been the creation of a conceptual framework by performing a literature review of big data analytics and intelligent decision-making systems and by applying some of the author's observations and experiences within a few examples. It seems like the approached subject is a key element during the current crisis and keeps growing exponentially. IT-companies (information technology) work actively to develop new related applications and to cope with the quick and constant changes.*
KEYWORDS: data analytics, covid-19 crisis, tech-companies, intelligent decision-making, big data

1. INTRODUCTION

The most interesting, powerful and common thing right now is the fact that the "normal" current generations knew would never be the same. Nowadays everything changes quickly and few things remain the same. The Covid-19 pandemic has affected the whole globe at high rates in the past years and nobody knows when it will be over. The effects have been major and, yes, most of them negative, however there were some positive outcomes.

Concerning exclusively the tech-orientated companies, they are the ones that took the most advantages out of the current crisis, even though they also went, are still go through tough times. One of the well-known changes within such companies is the reorientation to remote work, rather than the traditional, on site, work. This action was completely necessary, however over the past ca. two years employees, customers and businesses faced both positive and negative outcomes.

Despite the home comfort, the workforce got distant from socializing and the mental health decreased terribly. The study of SAP, Qualtrics, and Mind Share Partners showed that around 40% of the persons that worked in such an environment were affected. [1] On the other hand when analysing the "tech superheroes", as per [2], such as Google, Apple, Facebook and so on, it is remarkable how their revenues grew. Big Tech has evolved tremendously. As [3] affirms, "In a dramatic change from only weeks before, news about Big Tech has been a bright spot at a time of great fear — and, increasingly, of grief". When thinking about concrete changes that came up once these challenges took place it is observable that various market sectors were seriously impacted and therefore, as solutions, innovations appeared.

The automotive industry had to lower its production level, due to both a decrease of orders and their employee's health. The focus right now within this market branch are the online upgrades and online shopping even of car options, such as heated seats, autonomous driving etc.

The hotel and restaurants field has been extremely affected, as the accommodations, indoor and sometimes also the outdoor serving were forbidden, therefore new delivery options

appeared via drones, delivery companies, contactless delivery, online and wireless, NFC, payments and so on. Moreover, other sectors, such as the financial, economic ones, changed the decision-making processes to intelligent and digital systems.
As [4] says, "Risk-management teams are running hard to catch up with cascades of credit risk, among other challenges". Digitalization is the key element that offered continuity worldwide. Big Data, AI (artificial intelligence, ML (machine learning), edge computing and so on are modern technological tools used worldwide.
They all play crucial roles, both individually and together, in the frames of digital transformation processes. A great solution delivered by these has been the research and application of great data volumes. [5] This paper aims to identify to what extent does big data serve data analytics during the Covid-19 crisis within a digitalized modern world.

2. COVID-19 CRISIS AND ITS INFLUENCE ON DATA ANALYTICS

The Covid-19 pandemic started as an uncertainty for the whole globe and continued until it led to major losses in almost all the fields and industries. This huge problem occurred all over the world, so helping was at first not an option, as every country and every branch fought for itself.
Many people were jobless, many children lost contact to education and many people got ill. All these tragic events led to worldwide problems with the economy and therefore everyone started to be, more or less, affected by the Covid-19 pandemic.
There were companies that either suffered or took advantage of the brand-new challenges. [6] Technology became one of the most successful areas of interest during the pandemic, as it offered continuity.
This means that once its power was discovered many things changed: new jobs appeared, some of the normal jobs were restarted and restructured, education continued with the help of alternatives and medicine was partially reinvented. One of the technological discoveries and one of the heroes was big data analytics. As per [7] it can be used for processing massive data loads, either for descriptive analysis, tracking or prediction. In parallel to the big data analytics science, the AI, artificial intelligence, contributes to the technological evolution and is a major help for the economical continuity. [8] Also considers, that "While the battle against the pandemic is far from over, we have at least gained more understanding of the coronavirus and its impact across all industries.
Technology, particularly big data and artificial intelligence, plays a huge role in this." An interesting purpose of the big data analytics is the fact that it can be an instrument to quickly detect anomalies and then find possible patterns. It also plays an important role concerning prediction of changes and improvements in different fields, such as finance, society and economics and so on.

3. DATA ANALYTICS

"Data" is the word that leads our minds to information, various events, actions, objects and so on, each with different purposes, while "analytics" frames the concept of analysing, finding root causes, solutions and measures. Their intersection within "data analytics" creates the science focused on analysing raw data through different tools, processes and techniques.
Nowadays it is used to an even higher level, more specifically for automation of both algorithms and mechanical processes, according to [9]. Its main purpose is to investigate the data deeply and not lose results due to huge quantity of information, but quite the opposite, to find out trends and metrics in order to deliver improvement possibilities.
There are four popular types of data analytics: descriptive, prescriptive, predictive, and diagnostic. The descriptive type analyses data gathered from events that took place in the past with the goal of highlighting some conclusions. However, this way of performing data analytics is not clear enough for further possible improvements.
Furthermore, in comparison with the previous type, the prescriptive analytics is more than

useful. Its target is to analyze the past and foresee the future events, in order to correctly control all actions, such as avoiding threats and taking advantage of opportunities. Moreover, it is keen on advanced technology, such as machine learning, artificial intelligence, various algorithms etc.

The combination of descriptive and diagnostic analysis creates the predictive analysis, whose purpose is to foresee future tendencies and events. A quite different type of analysis is the diagnostic one. It is meant to select and classify data from the past and compare it to other events in order to establish root causes, reasons and so on. It is used to deeply analyze events. [10]

This science has brought many advantages to distinctive industries in terms of efficiency and effectiveness. [10] presents four major pro points: effective and efficient marketing and operations, improved customer support and developed ways of decision-making.

By "efficient operations", it is meant to understand within this constellation that the data analytics are supposed to support the operational part of a business. It will help identify cost-cutting procedures, will help improve processes and will target the main interests of the clients and of the involved third parties.

Marketing is supposed to become more effective as the main focus nowadays is understanding and interacting with the customers, followed by creating and offering exactly what they need, maybe even personalized on their character, needs, likes and dislikes and so on. Data analytics play an important role in this context because it helps people achieve what they want when they aim to ideal outcomes. It is highly being used via technology.

The customer, the customer service, the customer support and the customer satisfaction are the most common rules within each enterprise. The customer is always the most important, he is number one and he is, theoretically, always right.

This area of interest also got better via data analytics once it allowed a deeper identification and recognition of the customer's needs and priorities. Their preferences are, hand in hand with marketing, slowly, more and more customized and personalized. The tendency right now it to uniqueness and full satisfaction. Decision-making and its followers such as improved, developed and intelligent decision-making that use data analytics are surely going to get great results, make great choices and amazing further steps. It picks up information, analyses it, creates new data out of it, offers a complete perspective on the clients and totally supports them.

The whole digitalization and innovation burst due to the Covid-19 pandemic has led to the creations of new tools and technologies, as well as to generating a trends list. Some of the top are, according to [11]: data analytics as a core business function, engineering decision intelligence, data and analytics at the edge, from big and small to wide data, composable data analytics, smarter, responsible, scalable AI, XOps, graphs as they relate everything, the creation of the augmented consumer and the last, but not least, data fabric as the foundation. As [12] affirmed, "Using wide data, organizations attain a richer, more complete situational awareness or 360-degree view, enabling them to apply analytics for better decision making." The composable data and analytics tools refer to the cloud migration while trying to build agile, low-code and no-code applications.

The XOps has already been used for the past years within many IT enterprises; however, the outbreak happened due to the current crisis. There are several types of concerned operations, such as data, model, machine learning, platform and so on, all of them on a DevOps level with the main purpose of achieving efficiency and implementing automations.

4. BIG DATA

Big Data as part of data analytics refers, as the naming says, to huge amounts of information. Moreover, as presented in the frames of the [13] it is supposed to use "advanced analytic techniques" and to contain different kinds of data, such as semi-, un- and structured. Its volume of data storage is much bigger than any other type of storages used before, between terabytes to zettabytes.

All the information that is being saved, analysed, furthermore used and so on can inbound from various sources, such as sensors, files, networks, logs etc. Furthermore, beyond its big volume of storage another advantage is that it also includes high speed.
Another important aim that comes once using big data is the contribution to better, faster, smarter and relevant decision-making. [13] recommends various tools for data solutions in big companies that prefer open-source software, such as Apache Spark and Hadoop, while [14] mentions SAP Big Data Analytics, [15] talks about Qlikview, Qliksense and Tableau and [16] highlights Atlas. SAP big data analytics was created as in "in-memory computing platform" well known as SAP HANA 2.
Its purpose is to contribute to increasing the performance of the business processes and IT structures and fields. [14] It is based on micro services on cloud; hence, it plays a great role to the intelligent decision-making processes. Tableau focuses on the visual and is available in cloud. It offers embedded analytics capabilities and it is built out of three main components, such as server, desktop and online. [15]

5. INTELLIGENT DECISION-MAKING DURING CRISIS

Intelligent decision-making is a modern deviation from the humanly and traditional decision-making. It is based on support systems that have the ability to change decisions by combining software engineering, IT (information technology) and AI (artificial intelligence).
The purpose is to extract and to analyse big loads of data from the past and furthermore to foresee, prevent and so on. JIT (just in time) and real time processing are some of the great advantages of the intelligent decision-making systems. [17]
Decision-making has been spited into phases and furthermore into steps in order to frame it as an easy-to-follow process. The intelligent decision-making systems start from this general template and add information and details from the digitalized research.
The phases are: intelligence, design, choice, implementation and learning. The first one, intelligence, refers to root cause and problem identification and afterwards to relevant information picking. The "design" phase is about creating a specific model and analyzing it. Moreover, by "choice", the main reference is to appraisal, interpretation and selection. The last phase, the learning one, concerns the outcome process analysis and synthesis. [18]
The concrete combination of all the factors that create the intelligent decision-making support systems (i-DMSS) is the incorporation of intelligent behaviour techniques and decision-making. [19] In comparison to the classic decision-making, the i-DMSS work very well with new data, deliver quick responses, are able to deal with complex situations, use results from previous analysis and do not need any kind of input from humans. [18]
Crisis management is a very important topic nowadays. Lots of new methods, ideas and innovations stepped forwards in the past years. A popular solution has been the implementation of intelligent decision-making support systems, i-DMSS.
It has been proved that during a crisis big data plays an important role and has the purpose to provide doable and real results, information and actions. It seems like digitalization took over crisis management and currently the artificial intelligence, big data and therefore the smart reporting and intelligent systems are actively involved in the management of crisis situations, especially right now in the frames of the Covid-19 crisis [20] .

6. BIG DATA TOOLS USED FOR I-DMSS DURING THE PANDEMIC IN TECH-COMPANIES

The crises require unique approaches, such as thinking of and delivering urgent solutions, embracing the overcoming the uncertainties and offering support to the ones concerned. The decision-making process during a crisis can be really difficult and overwhelming. [21]
Enterprises started to adopt big data techniques in various industries, as both human-knowledge and infrastructures ease the implementation of

new technologies. Big data is currently highly being used in the IT sectors, related for example to the engineering, processing and analyses of data fields. Its purpose is to enhance processes, productions and so on; therefore, it simplifies the decision-making in important and big sectors. [22] Companies that use data-driven decision-making methods have and provide various economic advantages, both on the short run and on the long run.
They are more likely to succeed in the post-pandemic world rather than those who do not want to reorient themselves. Strategies are key actions during the pandemic in order to keep everything under control.
They must be built upon facts and real actions, as the exclusive use of management background and involvement are not enough. The organizations that decided to digitalize their business as much as possible showed much more flexibility, which helped them stand in top positions within the market.
They are expected to recover the fastest from the Covid-19 crisis and maybe even be more successful than before. The well-known "normal" will never be the same. Organizations help themselves by technology and try to gain competitive advantages, because they are always prepared to take the greatest decisions. Big companies are definitely favored concerning the performance of their tech infrastructures and financial power; however, no matter the maturity level of the business, an "insight-driven approach" might be a solution during this crisis. [23]
Furthermore, it is important to establish exactly who should be delegated to make decisions, the front-liners or the higher management. However, in "turbulent environments" this responsibility is hard to teach, therefore the intelligent decision-making systems, i-DMSS, save the situations. [24]

7. EMPIRICAL RESEARCH

Every theory, method and theorem is two-faced. Why? Because it looks one-way on the sheet and differently when put in practice. This is however the beauty of literature and of written information. After performing a thorough literature review, the next step should be the application of the gained knowledge within empirical researches. Therefore, some interesting and critical elements have been studied: which are the top sources and data types for big data during the current pandemic, which are some of the most successful big data applications right now, how can enterprises align the analytics part with their business practices during the Covid-19 crisis and last, but not least, the response of data analytics to the challenges nowadays in tech-companies.

7.1. Information sources for data analytics during the covid-19 crisis

The current pandemic keeps causing serious damages and its end can hardly be foreseen. One of the biggest problems is the fact that nowadays, due to digitalization and power of speak, information can easily be transmitted all over the globe.
This has nowadays both advantages and disadvantages. Of course, on one hand, the good part is that the official and important information gets to be rapidly and efficiently transmitted almost effortless and whenever it is necessary.
On the other hand, this can also have a negative impact on the population, as anyone has access to various communication channels. Misinformation is right now a serious problem.
Compared to the ability to gather information from the last decade nowadays we enjoy variety and diversity.
As mentioned before, this can have both positive and negative effects, both short- and long-term. Figure 1 exemplifies these both aspects. The bright side is that mass analyses can easily performed due to many sources, such as social media, travel data, education, medical records and mobile and sensor data. All these and probably many other help the current crisis to keep track of the events on going and to predict the future ones. The difficult part is that through these positive channels of information gathering misinformation subtly appears. It can also be found in social media, travel, education, mobile, sensors as much as in each person's civil sense.

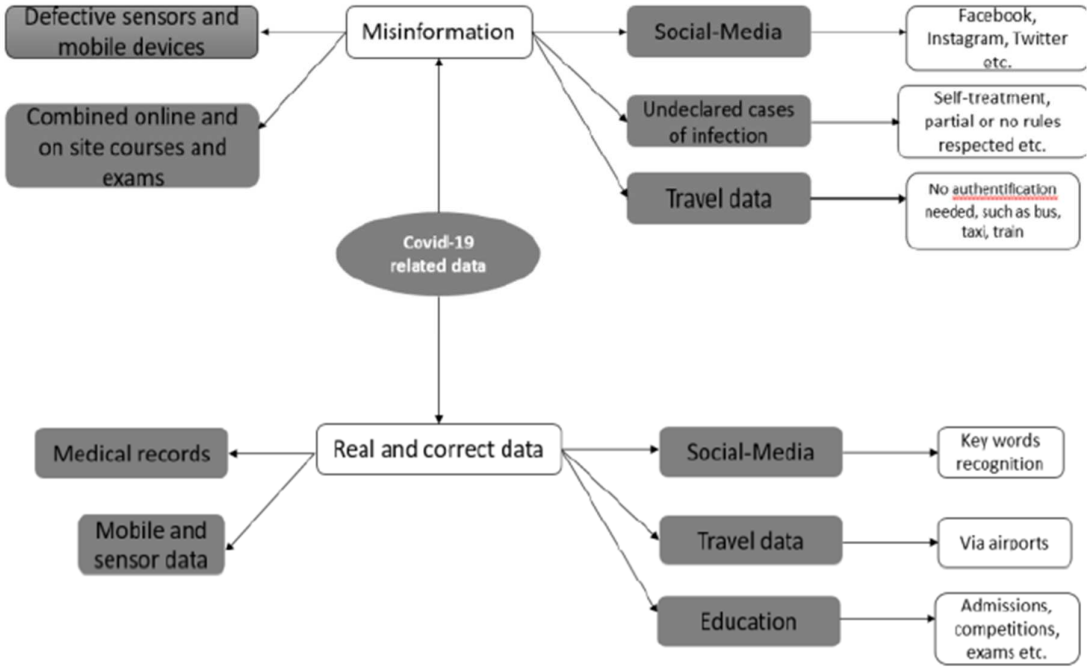

Fig. 1. Examples of valid and false data sources for big data analytics during the coronavirus pandemic. Author's experience and observations inspired by *[25]*

7.2. Big data apps developed and used during the pandemic

The continuity of life offers incremental amounts of knowledge that server for a better future. Information has always been a lot, due to decades of important events. However right now to world suffers some serious transformation regarding data. Digitalization together with the global mobility to overcome the pandemic generated, as [26] mentioned, "huge and varied amount of data that is increasing continuously." All these are highly being used in order to control the situation, to follow its course, to foresee future events, to avoid risks and so on. For this, tech-orientated companies began to receive new requirements from clients concerning development of new, innovative and modern applications based on big data analytics.

Table 1

Innovative applications created to support big data analytics.
Author's experience and observations inspired by [25]

Application	Description
Sensors	-Hardware and software -Ex. Temperature measurement
Apps that analyze symptoms	-Software -Ex. Tracking of infection symptoms before declaring it, during the outburst and during the recovery
National platforms of the governments	-Software -Ex. Registration of infected persons by sanitary national forces, tracking of their health and well-being, prioritizing the critical cases, finding possible root causes, such as locations or other infected people
Bio-Tech applications	-Hardware and software -Ex. Continuous research and development, tests, results, trials, medicine, vaccines, risk tracking, risk and crisis management etc.

In order to successfully overcome the pandemic and all the changes it brought to the whole world the human kind had to be creative, smart and always one-step ahead. Once people observed that digitalization might play the key role during these times they started to focus their work on

the high-tech field. Their innovations helped millions of persons worldwide, therefore they continued developing and implementing.
Both hardware and software were highly impacted by all these challenges. Table 1 exemplifies some big data apps developed lately for the greater use and for overcoming the challenges everyone is facing nowadays.

7.3. Business focus and analytics balance

The effects of the current crisis do not stop to appear. Enterprises used to adopt different strategies for the analytics part of the business and for the corporate focus.
Right now big organizations use data analytics much more than before. Moreover, they combine the corporate strategies with the analytic strategies in order to achieve an overview of the past, present and the future. [26]

Table 2
Methods of aligning the analytics and the corporate strategy practiced in tech-companies nowadays. Author's experience and observations inspired by [24]

Methods	Details
Decision-making	-The process is not completely traditional, conceived and followed by humans -It is based of huge amount of data -Big data helps the effective, correct and efficient decision-making process -Reorientation to intelligent decision-making -Acceptance, implementation and use of i-DMSS (intelligent decision-making systems) -Artificial intelligence and machine learning lower the human effort and create a very contoured past, current and partially future situation -Human involvement might still be necessary at the end in order to decide if the solutions are good or not based of other various subjective elements
Cross-functional teams	-Employees of tech-companies are usually professionals on a specific technology, however their know-how is much brighter due to the fact that technologies work together and are constantly being combined -For a granular approach of a project teams are usually made out of some experts whose focus is exclusively on their tasks -The know-how of the specialists is however much bigger, so big IT-companies decided to adopt the cross-functional teams strategy – shared know-how and involvement -The purpose is to achieve greater results in a much shorter period of time
Trainings	-Companies usually focus on their employee's know-how level and take measures in this regard -The constant professional evolution is required, so continuous knowledge transfer is necessary -Enterprises organize internal or external training for the new technologies

Big enterprises usually have strong strategies and ways of working and acting. They must face difficult times or, on the contrary, great development, in order to open up to strategic and corporate changes.
The coronavirus pandemic forced many organizations to rethink their way of working. Table 2 highlights some new methods implemented in tech-companies because of the new needs and requirements. While the decision-making process used to be classic, from the top to the bottom, the teams were granularly created and their tasks as well, right now these, and many other, things changed.

7.4. Data analytics as a tool against the current crisis challenges

Organizations had to perform risk assessments as soon as the pandemic started. However, as this was a totally new and unknown situation, the key elements kept changing. They were filtered over the time and right now according to [24] the most critical ones are the financial

part, the clients and the projects, the strategies they use and of course the employees

Table 3

Measures taken in the critical fields of enterprises after implementing data analytics and inteliigent decision-making. Author's experience and observations inspired by [24]

Field	Measures
Finance and strategies	-Calculation of the financial situation before and during the crisis -I-DMSS results -New financial tools -New strategies -Global finance tools -Costs, investments, strategies, cash flow etc.
Workforce	-Satisfaction -Empowerment -On site vs. remote work -Medical records and status -Human resources tools that are big data based -Retention of the key employees
Customers	-New strategies of the sales department -Take good care of the worthy customers -Seal new, stable and long-term deals -Personalized offers based on the market needs -Retention of old clients -Targeting a profit growth

8. CONCLUSIONS

Digitalization is the key element for this pandemic that offered continuity in almost all market, academic and even health sectors. It includes various technologies and tools, such as big data, artificial intelligence, machine learning, edge computing, cloud computing etc. Regarding big data, it can be used either by itself or together in various combinations with the other ones.

These are all modern tech innovations and they are all highly used and continuously developed nowadays.

Big data as part of data analytics contributed to overcoming the Covid-19 crisis for both various clients from several sectors and field, as well as for IT-companies themselves. Their intersection brought great results, such as the creation of intelligent decision-making support systems that helped and partially replaced the traditional, humanly, decision-making processes.

The results are great, as right now exists the possibility to analyse huge volumes of data from the past, present and try to foresee the future. Therefore, innovations continued to appear in both terms of hardware and software.

These are very helpful instruments in what crisis management during the pandemic is concerned. Data sources are also various, however they are not always real. Some of them are corrupted. Some of them deliver misinformation.

Even though this is hard to control, there are ways to identify quality information.

Moreover, these changes and challenges affected also the organizational structure of tech-companies.

Many of them were restructured as their core competencies, important clients and valuable employees changed.

The decisions are made differently right now, teams are restructured, and workload is bigger, hence the future is unclear and the crisis is still ongoing.

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Cadrul conceptual privind rolul analizelor Big data în sisteme inteligente de sprijin pentru luarea deciziilor în timpul crizei Covid-19

Rezumat: *Scopul acestei lucrări este de a identifica utilitatea și rolul analizelor big data în cadrele proceselor inteligente de luare a deciziilor. Perioada aleasă pentru această cercetare a fost prezentul și ultimii doi ani, vorbind în mod concret despre pandemia de Covid-19. Studiul a fost realizat dintr-o perspectivă de proiect în cadrul întreprinderilor orientate spre tehnologie. Mai mult, metodologia aplicată a fost crearea unui cadru conceptual prin efectuarea unei recenzii a literaturii de specialitate a analizelor big data și a sistemelor inteligente de luare a deciziilor și prin aplicarea unora dintre observațiile și experiențele autorului în câteva exemple. Se pare că subiectul abordat este un element cheie în timpul crizei actuale și continuă să crească exponențial. Companiile IT (tehnologia informației) lucrează activ pentru a dezvolta noi aplicații conexe și pentru a face față schimbărilor rapide și constante.*

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