

Vol. 10 (1) 2021

ECONOMO SOCIO PHYSICS &

other

**Multidisciplinary
Sciences
Journal**

(ESMSJ)



Econophysics, Sociophysics & Other Multidisciplinary Sciences Journal (ESMSJ) provides a resource of the most important developments in the rapidly evolving area of Econophysics, Sociophysics & other new multidisciplinary sciences. The journal contains articles from Physics, Econophysics, Sociophysics, Demographysics, Socioeconomics, Quantum Economics, Econo-operations Research, or many other transdisciplinary, multidisciplinary and modern sciences and related fundamental methods and concepts.

Econophysics, Sociophysics & Other Multidisciplinary Sciences Journal (ESMSJ) Staff

University of Pitești
Address: Str. Târgul din Vale, Nr.1, Pitești 110040, Argeș, Romania
Phone: +40348453102; Fax: +40349453123

Editor-in-chief
Gheorghe Săvoiu

Managing editor
Marian Țaicu

On - line edition <http://www.esmsj.upit.ro/>
Denis Negrea

Founders

Gheorghe Săvoiu
Mircea Gligor
Ion Iorga Simăn
Constantin Andronache
Constantin Manea for English version

Editors

English version and harmonization of the scientific language
Georgiana Mindreci
Assistant Editors
Mihaela Gâdoiu
Mariana Banuță

Editorial Board

Benedict Oprescu
Ciprian-Ionel Turturean
Ivana Mijatović
Jelena Minović
Maria - Daniela Bondoc
Matei Sandra
Milica Jovanović
Mircea Bărbuceanu
Slađana Barjaktarović Rakočević
Slavica Cicvarić Kostić
Vesna Tornjanski

Scientific Board

Aretina David Pearson
Doru Pogoreanu
Hans Schjær-Jacobsen
Mladen Čudanov
Muhittin Acar
Libb Thims
Ondrej Jaško
Radu Chișleag
Ram Poudel
Sant Sharan Mishra
Shinichi Tokuno
Shunji Mitsuyoshi
Ung-il Chung/Yuichi Tei
Wolfgang Ecker-Lala

SUBMIT AN ARTICLE to E-mail: gsavoiu@yahoo.com

CONTACT: +40745047085;

University of Pitesti, Adress: Str. Targul din Vale, Nr.1, Pitesti 110040, Arges,
Phone: +40 348-453100; Fax: +40 348-453123
Gheorghe Săvoiu Phone: +40745047085; E-mail: gsavoiu@yahoo.com

CONTENTS

	Page
Gheorghe Săvoiu Does Multidisciplinarity Mean more than Inter-, Cros-, and Transdisciplinarity, but without Being Equal with Holistic Approach in Modern Applied Scientific Research?.....	3
Shervin Skaria, Varghese Jacob, Sreelatha. K S and K Babu Joseph Chaos in GDP Growth Rate of G20 Countries	8
Gazal Gupta, Binod Sinha, Vimal Bhatt Study of Consumer Buying Behaviour Towards Titan Wrist Watches with Special Reference to Pune	18
Aleksandra Cvetković, Mladen Čudanov, Gheorghe Săvoiu Benefits and Problems of Telework during the Covid-19 Pandemic: Factors of Age, Gender and Telework Intensity	23
Anu Singh, Shruti Kanga, Suraj Kumar Singh, Sudhanshu Property Tax Evaluation and Management Using Geospatial Technology	30

DOES MULTIDISCIPLINARITY MEAN MORE THAN INTER-, CROS-, AND TRANSDISCIPLINARITY, BUT WITHOUT BEING EQUAL WITH HOLISTIC APPROACH IN MODERN APPLIED SCIENTIFIC RESEARCH?

Gheorghe Săvoiu

Romanian Statistical Society, Bucharest, e-mail: gsavoiu@yahoo.com

Abstract. *Abstract. Mathematics as the scientific discipline together with its mathematical signs as language can offer a good starting point in an attempt to find reasonable answers to such a difficult question or to such a long paper's title. Some assumptions, hierarchies and levels of importance generate in Mathematics the most realistic solutions for the beginnings of scientific knowledge and the rational dialogue. Other voices believe more in Logic. This aspect is not so important for this paper, but it can be maybe for a future volume of ESMSJ. The article tries to find a valid response and to motivate it, to the general question like the following: Does multidisciplinary mean more than inter-, cross-, and transdisciplinarity, but without being equal with a holistic approach in modern applied scientific research? And if this paper offers a false answer or not, only the readers can say to the end of this changing words into new significances and concepts...*

Keywords: *interdisciplinarity, crossdisciplinarity, transdisciplinarity, multidisciplinarity, holistic approach, scientific language, scientific research, Mathematics, Statistics...*

Keywords: *interdisciplinarity, crossdisciplinarity, transdisciplinarity, multidisciplinarity, holistic approach, scientific language, scientific research, Mathematics, Statistics.*

1. INTRODUCTION

A researcher can say that Mathematics is not a science, but certainly, he must admit the most used and validated language of many other sciences is the mathematical one. Or even more tragic, a great majority of mathematicians can believe sciences are not real outside the frontiers of their mathematical scientific language.

And above all of these aspects, there still exist some young or old researchers who have some major reasons to think this is not relative truth. If one tries harder, he really can find some justified reasons to arrive at this specific way of thinking: i) the mathematical language is alive even today, and not dead (i.e. the live Mathematical language versus the dead Latin language); ii) the alphabet of Mathematics enlarges or expands its dimensions day by day; iii) the significance of each mathematical sign is more and more developed, multiplying its nuances; iv) the past apparent limits of some classic mathematical operators or operations seem to disappear in the present or, in the worst case, in the very next future; v) the sciences without mathematical validation are difficult to believe, etc. One logician can say that only logical language can realize all of these things, etc.

Let us consider together these distinct aspects as a futile or indubitable demonstration of the superiority of mathematical language, and, finally, one researcher will not use any other language at all, and thus will forgive

soon everything else even his scientific or native language. Could this idea be an entirely false hypothesis for a mathematician?

On the other hand, an increasing interest in multidisciplinary analyses has been registered during the last decades, particularly due to their potential unbounded area for scientific applications. Indeed, the inter-, cross-, or transdisciplinary concepts are frequently met in all scientific research areas, covering day by day too many fields, spanning from computer science to medicine and social psychology. Moreover, apparently and specific concepts and methods prove to be a reliable bridge between the natural and social sciences, so the recent interest in the inter-, cross-, or transdisciplinary field can be considered anytime fully justified (i.e. based on the strong methodological experience of the statistical methods and mathematical calculus and theory, new applied multidisciplinary papers are published each year, mainly focused on the dynamical, structural and territorial evolutions of populations of any kind, from all the science. A new way of thinking called DoE - demography of everything – can be considered also a new tendency in statistical and mathematical common researches.

The remarkable extension of scientific research started from the concept of *(mono) disciplinarity*, as specific captivity of isolated reasoning, generated by standardized and obsolete concepts (cognitive biases), but also by the captivity of outdated classical theories or by some canonical methods and practically unusable (methodological biases) or even by some traditional models that have already acquired increasing residual errors (modelling biases) [1-3], and developed to:

- a) *interdisciplinarity*, as permanently and extensively (re)drawing the contour of knowledge and imposing cohabitation in the interstitium between different disciplines in scientific knowledge, being also a disaggregated expression at the beginnings or in the process of delimiting the common area, to finalize the aggregative nuances in case of completely different scientific research area [4-5] or to
- b) *crossdisciplinarity*, which manifests itself in the alternative forms of
 - b₁) *simple crossdisciplinarity*, where a method specific to one science is applied in the body of another science, concerning the source of origin or
 - b₂) *complex crossdisciplinarity*, when several methods are aggregated and capitalized analogously [6-7] and even to

- c) **transdisciplinarity**, as a superior form of inter-, and crossdisciplinarity that involves concepts, methodology and language tending to become together more universal and stable, transdisciplinarity generated dynamically, through the action of multiple levels of reality (information theory, scientific modelling theory, systems theory etc.) [8-9].

All of these new variants of research allow the development of **multidisciplinarity** as a complex theoretical solution to approach the knowledge by reality, the most efficient investigation or the best way of modern research to bring together many individual sciences as Logic, Mathematics, Physics, Statistics, Chemistry, Philosophy, Medical Sciences, Sciences of communications, Biology, Economics, Social sciences etc.

Statistical Physics provided the most interesting model of interdisciplinarity, as soon as possible transformed into multidisciplinarity. The real cause of this transformation consists of its capacity as the first form of differentiated and generalized physical thinking, but the further development from the initial first rank of interdisciplinarity to multidisciplinary approach was discontinued in its natural evolution by the general scientific immaturity of the same XX century. It is the specific thinking way of Statistical Physics that lies the first argument of the evolution of statistical thinking in contact with other disciplines such as Physics to others like Economics or Sociology, which were less likely to generalize or maximize the coverage of their specific meditation in immediate reality. [10]

This argument represents the exceptional contribution made by Josiah Willard Gibbs (1839-1903), who was also called the “*father of Statistical Physics*”; he authored the book *Elementary Principles in Statistical Mechanics*, published by Yale University in 1902. It was also Josiah Willard Gibbs who simplified, as only a pragmatic, inimitable and thus genius-like thinker could, the way of thinking and working of the physicist, although at that time there were fewer than 1000 physics university graduates worldwide.

“Introducing a geometrical representation in the character of substitution of the experimental referential, which later became the famous *Gibbs space*, which reduced the macroscopic world to the microscopic one, the “*father of Statistical Physics*” transformed the finite world of a very large number of particles ($n \cong 10^{23}$ particles) located in a real space, into a single elementary particle (a point), placed in an area of $2n$ dimensions. The Gibbs space resulted from turning the $2n$ coordinates and generalized impulses (p_i and q_i) into the coordinates of a single point located in the $2n$ dimensions space, which was also called the *phase space*, starting from the fact that the $2n$ coordinates and generalized impulses determined the microscopic state of the system, or the representative point in the $2n$ -dimensional space, or a microscopic state, or a phase of the system...

Thus, using Statistical Physics, for the first time the macroscopic properties of equilibrium of the systems could be explained, based on microscopic structure, and, again for the first time, both state equations and the dependence of material constants on microscopic

parameters were deduced, in a circular manner. Statistical Physics would, later on, find that, starting from the fact that between the description of macroscopic states and microscopic states there is no bi-univocal correspondence, i.e. knowledge of a microscopic state univocally leads to the knowledge of the macroscopic state, while the knowledge of the macroscopic state can lead to a lot of compatible microscopic states, reaching a very important conclusion in the research of statistical populations: knowing or fixing the macroscopic state through macroscopic system indicators (parameters such as pressure and temperature in Physics, the character in Psychology, price or wage in Economics, population density in demography) can never allow knowing a certain microscopic state (since a huge variety of microscopic states are compatible with the values of the parameters of the system).

What Statistical Physics, however, found almost instantly was that for a given macroscopic state of equilibrium, any of the microscopic states are realized with probabilities completely determined by the values of the macroscopic parameters. The macroscopic state does not determine, separately, microscopic states of the system, but rather probabilities with which these states are realized in the macroscopic system.” [10].

The essential role was assumed by the *probability density on the Gibbs space, or the space of the phases*, a density able to fully describe a new type of state, called *statistical state or assembly state* (and the logical refinement thus became evident).

Knowledge of macroscopic parameters was suddenly possible with the definition of probability density. To better understand the intrinsic connections between the modes of thought that had to be integrated into the statistical thinking to modernize its scientific “*meditation*” belonging to the scientific type, it would be useful to remind that Irving Fisher (1867-1947), the father of American neoclassical economics, the statistician who authored the ideal index, and also the trainer and moulder of the new generations of statisticians who developed the thinking that shaped statistics by founding econometrics (at once with establishing the famous Econometric Society along with Ragnar Frisch, Charles Roos, Harold Hotelling, Carl Snyder, Ladislaus von Bortkiewicz, Arthur Bowley, Joseph Schumpeter, Norbert Wiener and others) was a student of Josiah Willard Gibbs, and, perhaps the most important aspect, his doctoral student. [10]

At the beginning of the XX century, the statistical thinking from real scientific research benefited only partially from the original thinking of Statistical Physics, that is the comparatively little that could be taken over from Josiah Willard Gibbs’s thought as that moment (in fact, nearly half a century was to pass before Ettore Majorana applied it for the first time to economic statistics, for example).

Post-paradigmatic and variational statistical thinking, though already incorporating inter-, and multidisciplinarity in the theory of probability and survey, would have evolved in a limited manner, without the support provided by generalized fuzzy logic, remaining a mere and partial application of Statistical Physics. Statistical Physics and the fascinating synthesis of Josiah Willard Gibbs’s space

were discontinued in their natural evolution, very much like a long-expected interdisciplinary to multidisciplinary invasion, by the overall scientific immaturity of the time, since Statistics failed, after its first phase of modernization, to make the methodical inferencing, providing modelling towards Economics, Psychology and Sociology, while Economic Statistics did not understand its long-term impact, etc.

“The modus ponens in the classical type of logic and mathematics gradually becomes a modus componens, dominated by Gestalt (system or whole), oriented towards an integrative and holistic thinking, the more flexible and more rigorous type of thinking of modern statistics in its final phase of development to Statistical Physics” [10]

Even the field of the possible applications of the multidisciplinary seems today to be unbounded, multidisciplinary research becoming a reunion of the way of thinking of a large variety of disciplines engaged in a certain line of specific inquiries or investigations to a problem, a timeline, a region, a structure, a system, etc. Thus, the individual results of the (mono) disciplinarity is better compared with any of the specific concepts techniques, methods of any of the distinct or isolated disciplines only because these disciplines are brought together in an aggregate. Modern research and knowledge, therefore, tend to be frequently multidisciplinary in nature, models and results.

According to the modern trends in the creative application of multidisciplinary in various scientific researches, and validation of new models of investigations in the existential space of other types of scientific knowledge concerning those multidisciplinary concepts, techniques, and methods that generated them, modern researches supplement investigation by its psychological communication inside the multidisciplinary teams and projects. Holism or holistic approach can identify ideally with the *to-the-extreme* form of complex multidisciplinary, defined as educational (academic) purposefulness, in the explosive sense of an ample dissolution of all disciplines or sciences into one, a complex fusion into a huge scientific universe (epistemological multiverse) [10].

2. WHAT A HOLISTIC APPROACH MEANS IN MODERN RESEARCH?

A lot of differences appear between *holism* and *holistic approach* from the point of view of dictionaries significances or definitions. *Oxford English Dictionary* defines **holism** as *“the tendency in nature to form wholes, which are greater than the sum of its parts, through creative evolution”*. [11] The major aim of a **holistic approach** in medical researches represents a promising evolution in the model of the investigation and a stable solution that can be extrapolated and used in the future based on the opinions of many experts (researchers) from as many scientific disciplines as possible for the moment [12].

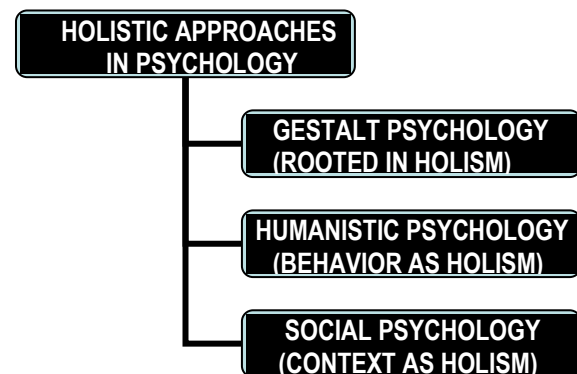
Joshua Freeman offered an expressive and elegant difference between the definitions of holism and holistic approach, based on health researches and medical sciences: “the very concept of holism as a single ‘*holistic*

therapy’ is oxymoronic; at best there can be a holistic approach, combining, when needed, a variety of therapies.” [13] Rather than looking at individual sciences and experts (researchers) and their approach matters separately, a **holistic approach** integrates parts of each vision and scientific theory into the general program of investigation [14-16].

In Psychology, the idea of a **holistic approach** is focused on understanding the human mind and behaviour, looking at all known things as a whole. In any holistic approach, it is important not only to view the research, from object or domain to results, as a unit, rather than trying to break it down into its isolated parts, *but also to believe that it is more important to look at how all the disciplines work together in a common scientific research* [17].

To a better understanding how researchers think, in any holistic approach, one needs to do more than simply focus on how each component functions in isolation, the key phrase summarizing the key idea behind the holistic approach being similar to holism major significance in any dictionary *“the whole is more than the sum of its parts”* in any gestalt phenomenon. [18-19]

The final appeal of holism offers to any researcher the chance to validate or not his abilities to incorporate all of the elements that make populations who real individuals are, more or less. Either population or the individuals are infinitely complex and varied, and many times only a holistic approach is able indeed to address the external and internal factors that influence not only past, but also present, and especially future. [12]



Source: Realized by the author from [20-21].

Fig.1. Some examples of the holistic approach in the major branches of Psychology

A holistic approach of any domain of knowledge can establish the essentiality of real holism and is rooted in holism indeed, materialized in social context, communication and behaviour as in Psychology’s example (Fig. 1). The process of holistic approach includes two permanent elements: model and data discovery using input/output matching.

The process of a holistic approach has been supported and consists of two main principles:

i) holism and holistic approach are defined by *the inclusion of all the necessary disciplines, parts, all the different connections and associations, all the various aspects or parameters versus multidisciplinary, which is*

the partial integration of some common disciplines, theories, methods, models and data, concepts, defining completely different the initial and final spectrum of the same research;

ii) holism and a holistic approach must be *completely and systematically organized* versus multidisciplinary, where researchers' questions of major interest in are to evaluate how can be extracted the essential aspects, *organizing* observed data into meaningful phenomena [22-23].

These are only two major differences based on specific principles and characteristics only, and holistic approach remains always the final stage or destination of any specific or distinct evolution in multidisciplinary. By looking at phenomena holistically, researchers can provide or even can address all of the many factors that might affect reality, including different populations, and especially the environment.

Using multidisciplinary any scientific research can obtain not only a better image of reality, compared or confronted with the unidisciplinary research but also a profound and intense investigation. Multidisciplinary remains just the way of research, while a holistic approach is always the destination or endpoint of any complex scientific research, in general.

3. CONCLUSIONS

In this paper, I have tried to underline the major changes of the dimensions of the scientific territory and the methodological structures of new applied multidisciplinary knowledge and research and how these can be "connected" to the whole system of the scientific knowledge and scientific research, known together as the holistic approach.

The most important conclusion is drawn in the vitality of the new multidisciplinary tending to the holistic approach, but only after emphasizing the main gains of inter-, trans- and crossdisciplinarity together in any possible scientific domain or even into science formalism. This major conclusion means identifying new characteristics of advanced or complex multidisciplinary (A&CM), from an increasing explanatory power to an unlimited intuitive understanding, coupled with the possibility of using new analytical methods, in addition to the ones existing in the actual scientific literature. The best example is coming from the field of holistic medicine, which "*focuses on treating all aspects of a person's health including physical symptoms, psychological factors, and societal influences*". [22]

If one team of researchers find the possibility to transform advanced or complex multidisciplinary (A&CM) into holism or holistic approach, this difficult action will generate a great number of key advantages, coming from a new way of understanding why people do the things they do and think the way they think:

- 1) holism or holistic approach as the limit of A&CM proposes that it is necessary to look at the entire person;
- 2) holism or holistic approach as the limit of A&CM renounce to focus on just one aspect of the reality,

understanding that is necessary indeed to recognize that different and expected factors interact and influence permanently each other;

- 3) emergent properties underline the profile of the parts inside the whole reality (population), but cannot be observed by looking only at the individual pieces (individuals);
- 4) beyond the parts, segments or variables from the reality even the factors in the holistic approach as the limit of A&CM model interact and influence one another;
- 5) holism or holistic approach as the limit of A&CM remains a bit more focused;
- 6) holism or holistic approach as the limit of A&CM allows researchers to assess multiple factors that might contribute to a difficult change in the entire reality (rather than simply focusing on one small part of an issue, researchers can instead look at all of the elements that may play a role based on holism or holistic approach as the limit of A&CM), etc.

Just like the reductionist approach to Psychology or Sociology, holism or holistic approach as the limit of A&CM has both advantages and disadvantages. [22]. Holism or holistic approach as the limit of A&CM can be helpful at times when trying to understand the big picture allows the researchers to see things they might have otherwise missed, or in other cases, however, focusing on the whole reality might cause them to overlook some of the finer details.

In the case of any multidisciplinary research of a really *big* project, where *big* means the maximum number of disciplines implied in the investigation, reductionism will still exist and tends to focus solely on the trees, but holism or holistic approach as the limit of A&CM allow researchers to view the entire forest. This can be the final truth of both the research results of the two different ways of thinking and research.

There are also some important disadvantages of holism or holistic approach as the limit of A&CM to consider. In pragmatic problems, it is often important to focus on a particular aspect of the issue to come up with a more adequate precision and a prompter solution. Holism or holistic approach as the limit of A&CM tends to be the most generalized variant of research, which can sometimes make precision more difficult. Any team of researchers must be able to focus all of their activities on very well defined variables, parameters and hypotheses, tests and methods of validation etc.

As a final remarque holism or holistic approach as the limit of A&CM really incorporates many variables, offering the image of the big picture (reality) or the opportunity to view the entire forest, but in a lot of investigations holism or holistic approach as the limit of A&CM tends to be non-specific or non-adequate or it can be even overly complex being too much opened or too all-inclusive.

6. REFERENCES

- [1] Kahneman, D., Slovic, P., Tversky, A., 1982. *Judgment under Uncertainty: Heuristics and Biases*. Cambridge:

- Cambridge University Press
- [2] Kahneman, D., Tversky, A., 2000. *Choices, Values and Frames*. Cambridge: Cambridge University Press.
- [3] Kahneman, D., Sibony, O., Sunstein, C.R. 2021. *Noise: A Flaw in Human Judgment*. London: William Collins.
- [4] Savoiu, G. (coord.) 2021. *Metode statistice și interdisciplinaritate*. DOI: 10.5682/9786062810733. București: Editura Universitară, p. 7.
- [5] Savoiu, G. (coord.) 2021. *Metode statistice și interdisciplinaritate*. DOI: 10.5682/9786062810733. București: Editura Universitară, p.179
- [6] Săvoiu, G. (coord.) 2020. *Metode statistice și crosdisciplinaritate*. București: Editura Universitară, DOI: 10.5682/9786062807771. p.
- [7] Weinberg, S. 2017. *Lumea explicată: descoperirea științei moderne*, București: Editura Humanitas.
- [8] Săvoiu, G. 2015. *Statistical thinking. The contribution of its research methods and models to modern trans-, inter- and multidisciplinary*. Bucharest: Editura Universitară.
- [9] Săvoiu, G. (coord.). 2011. *Multidisciplinaritatea și educația academică: dialoguri argumentate* București: Editura Universitară, p. 52.
- [10] Săvoiu, G. 2015. *Statistical Thinking. The Contribution of its Research Methods and Models to Modern Trans-, Inter-, and Multi- Disciplinary*. DOI: 10.5682/9786062802752, Ist Ed., Bucharest: (Publisher House) Editura Universitară.
- [11] Smuts, J.C. 1926. *Holism and evolution*. New York: Macmillan.
- [12] Vorobeychik, G., Black, D, Cooper, P., Cox, A.2020. Multiple sclerosis and related challenges to young women's health: Canadian expert review [published May 6, 2020]. *Neurodegener Dis Manag*. doi:10.2217/nmt-2020-0010.
- [13] Freeman, J. 2005. Towards a definition of holism. *The British journal of general practice: the journal of the Royal College of General Practitioners*, vol. 55(511), pp. 154–155.
- [14] Choi, B.C., Pak, A.W. 2006. Multidisciplinarity, interdisciplinarity and transdisciplinarity in health research, services, education and policy: 1. Definitions, objectives, and evidence of effectiveness. *Clin Invest Med*. Vol. 29(6), pp. 351-364. PMID: 17330451.
- [15] Choi, B.C., Pak, A.W. 2007. Multidisciplinarity, interdisciplinarity, and transdisciplinarity in health research, services, education and policy: 2. Promotors, barriers, and strategies of enhancement. *Clin Invest Med*. Vol. 30(6), pp. 224-232. doi: 10.25011/cim.v30i6.2950. PMID: 18053389.
- [16] Choi, B.C., Pak, A.W. 2008. Multidisciplinarity, interdisciplinarity, and transdisciplinarity in health research, services, education and policy: 3. Discipline, inter-discipline distance, and selection of discipline. *Clin Invest Med*. Vol. 31(1):pp. 41-48. doi: 10.25011/cim.v31i1.3140. PMID: 18312747.
- [17] Strandberg, E.L., Ovhed, I., Borgquist, L. *et al.* 2007. The perceived meaning of a (w)holistic view among general practitioners and district nurses in Swedish primary care: a qualitative study. *BMC Fam Pract*. vol. 8, p.8 Available online at: <https://bmcfampract.biomedcentral.com/articles/10.1186/1471-2296-8-8#citeas> Accessed on August 15, 2021.
- [18] Van Velden, E. 2020. *Gestalt Psychology*. Available online at: <https://www.toolshero.com/psychology/gestalt-psychology/> Accessed on August 15, 2021.
- [19] Köhler, W. 2015. *The task of Gestalt psychology*. New Jersey: Princeton University Press.
- [20] Michaelson, V, Pickett, W., King, N., Davison, C., 2016. Testing the theory of holism: A study of family systems and adolescent health. *Prev Med Rep*, vol. 4, pp. 313–319.
- [21] Freeman, J. 2005. Towards a definition of holism. *Br J Gen Pract*. Vol. 55(511), pp. 154–155.
- [22] Cherry, K., 2020. *How psychologists use holism to understand behavior*, Available online at: <https://www.verywellmind.com/what-is-holism-4685432>, Accessed on August 14, 2021.
- [23] Săvoiu, Gheorghe (coord.) 2012. *Econophysics: Background and Applications in Economics, Finance, and Sociophysics*. London: Academic Press.

CHAOS IN GDP GROWTH RATE OF G20 COUNTRIES

Shervin Skaria¹, Varghese Jacob², Sreelatha. K S^{1,3} and K Babu Joseph⁴

¹Department of Physics Government College Kottayam, Kerala, India shervinskaria@gmail.com

²Department of Mathematics, Government College Kottayam, Kerala, India. drvarghesejacob@gmail.com

³Government Polytechnic College Palakkad, Kerala, India. drsreelathaks@gmail.com

⁴Department of Physics, Cochin University of Science and Technology, Kochi, Kerala India, bb.jsph@gmail.com

Abstract. *This paper analyse the chaos in GDP growth rate of G20 countries specifically as these countries holds specific interest in the world's economic stability. Observation of deterministic chaos in the GDP growth rate helps to predict the nature of economy of a country for coming 5 to 10 years. We considered the data of real GDP growth of these countries from World Bank sited during the years 1961 to 2018. We use techniques such as time series plot, Phase portraits, Hurst exponent determination, Embedding dimension, Detrended fluctuation Analysis (DFA), Fractal dimension, and Lyapunov exponent for the analysis of the data. We have also conducted 0-1 test for deterministic chaos. Our study reveals a chaotic nature for the economic growth rate for most of the countries.*

Keywords: *Hurst exponent, Chaos, Lyapunov exponent, Fractal dimension, DFA Analysis, GDP*

PACS numbers: 89.65.Gh, 89.75.Fb, 05.45.Tp

1. INTRODUCTION

The growth or decline in Gross Domestic Product (GDP) rate of a country has always been treated as a topic of study by many researchers. GDP is considered to be a very powerful measure to gauge the economic health of any country, since it reects the sum total of the production of the country [1, 2, 3]. The increase in GDP growth rate of a country depends on many factors such as industrialization and advances in technology, land and underground resources, capital formation, human resources etc. [4]. Many researchers investigate the impact of liberalization on the growth rate of GDP of various developing countries [5, 6]. Their studies reveal that for most of the developing countries, liberalization has a positive effect on domestic economic growth. But also found that growth itself has a negative impact on trade balance for a majority of countries.

The use of chaos theory in the analysis of economics problems has become an important area of research during the last few years [7, 8]. Applications of chaos theory in economics include topics such as explaining business cycles and forecasting movements in stock markets. Most of the studies involve the analysis of time series using nonlinear techniques [9, 10]. The application of the Lorenz attractor to model economic forecasting was studied by Michaela Simionescu in 2018 [11] and found that when specific values are given to the parameters in the Lorenz system, there is a tendency of increase in world economic growth on the horizon 2015-2019. Radko Kriz studied the presence of chaos in the GDP growth

rate time series of seven European countries and established the existence of chaos in their GDP growth rate [7].

GDP growth rate is generally considered as a powerful indicator by most of the governments and economic decision-makers for planning and policy formulation. The GDP concept was first introduced by Simon Kuznets in a US Congress report in 1934 [12]. An unsteady growth of GDP per capita of a country may lead to increase of poverty, reduction in social health and education, increase in crime and eventually reduces the economic growth. The geometric annual growth rate in GDP over a period of time between first and last year is known as **rate of economic growth**. This rate ignores any fluctuations in the trend in the average level of GDP over the period. Various surveys report that liberalization alone has positive impact on GDP growth in a short span of time but combined with income terms of trade yields a negative overall impact on trade balance to GDP percentages [7, 13] in the case of developing countries

Even though various formal governmental organizations and international groups that have been formed to discuss the global financial stability, the Group of Twenty (G20), founded in 1999, allows a forum to discuss global economic growth, as well as regulations concerning financial markets. After the acceptance of Paris Climate Agreement in 2015, issues of global significance are also included in their objectives. Almost two-thirds of the world's total population is represented by G20 countries and they indicate 85 percent of the total global gross domestic product and more than 75 percent of the global trade. That is why we select GDP growth rate of G20 countries for our study. In this study, we try to investigate the relationship between liberalization and GDP growth rates of G20 countries in a long time span and hence try to predict the global economic stability.

In this paper, we investigate the presence of chaos in the GDP growth rate of the G20 countries during the period 1961–2018 using various analysis techniques. We started with time series analysis, then constructed phase portraits and calculated fractal dimension, time delay, embedding dimension and estimated Hurst exponent. These are needed for the determination of Lyapunov exponent. We have also carried out the Detrended Fluctuation Analysis (DFA). Lyapunov

exponent is considered as an important parameter for the identification of chaotic nature of a dynamical system. Hurst exponent is viewed as a numerical estimate of predictability of time series. We have conducted 0–1 test for deterministic chaos with time series of the GDP growth data as input. The general trend we found is an inverse dependence of GDP rate on the Lyapunov exponent. A detailed account of the methods of analysis and results are given in the following sections. In the concluding section, we point out an economy with a positive Lyapunov exponent as chaotic, whereas that with a negative value is subjected to control. The inverse relation obtained between growth rate and Lyapunov exponent is rather an unexpected one. Since the real GDP accounts for changes in market value, it narrows the difference between output figures from year to year. The existence of deterministic chaos in a GDP growth rate allows us to predict the future behavior of the economic state of a country based on the previous policies based on liberalization, global economy and other factors adopted by the government, to some extent.

2. METHODS OF ANALYSIS

For analyzing the behaviour of the GDP growth rate of G20 countries, we have employed various nonlinear methods. These techniques help us to investigate the chaotic nature of GDP growth of these countries. The techniques used for nonlinear analysis are described below.

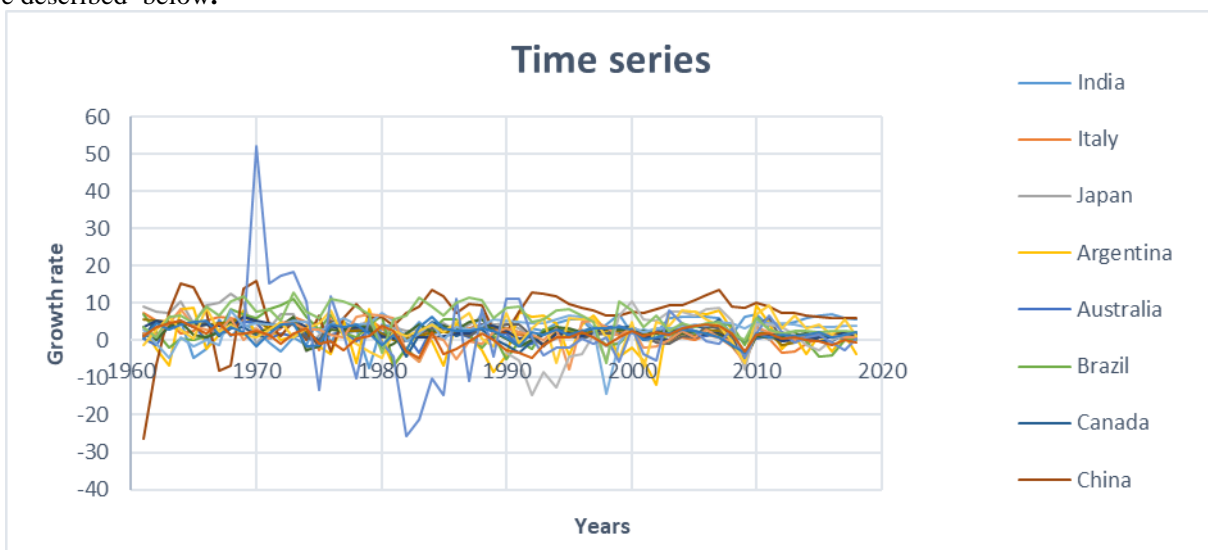


Fig 1: Timeseries of G20 countries

2.2 Reconstruction of Phase Space

To understand the behavior of G-20 countries from the time series data, it is very important to reconstruct the phase space. Reconstruction of phase space leads to the representation of complete dynamics using a single time series. For a proper reconstruction, it is very essential to know the optimum time delay (τ) and the embedding dimension (m).

2.1 Time series analysis

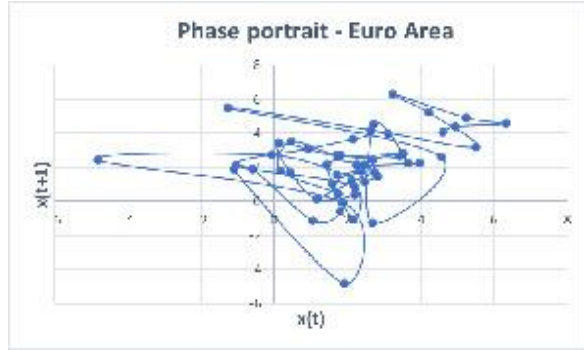
A set of observations or a sequence of data recorded over regular intervals of time is known as time series. Time series data can be used for analyzing the trend, seasonal fluctuations and residual variations for various types of data. Since time is a physical concept, the parameters and other characteristics in the mathematical models for time series can have real world interpretations. Depending on the field of application, time series analysis has many different objectives. Here we use the real GDP annual growth rate data taken from the World Bank Site [14] for creating time series of G20 countries. We considered the real GDP annual growth rate during the period 1961 – 2018 for all countries except Germany, Russia and Saudi Arabia. For Germany we considered the data during 1971 – 2018, for Russia it is during 1990 – 2018 and for Saudi Arabia we took data during 1969 – 2018 for our analysis since only data during these time period are available. The consolidated time series plot of all the G20 countries is shown in (Figure 1).

For a dynamical system, whole information about the variable is present in the univariate time series. Each point of phase space represents a state of the system, while a trajectory in the phase space represents the time evolution of the system, according to different initial conditions [10, 12, 15, 16, 17].

A phase space can be created from a one-dimensional time series using Takens time delay embedding theorem [12]. For a chaotic system with scalar time series $T_t =$

$\{N_1, N_2, N_3, \dots\}$ the reconstruction is possible with the phase space vectors $X(t)$ expressed as : $X(t) = [x(t), x(t + \tau), \dots, x(t + (m - 1)\tau)]$ where $t = 1, 2, \dots, M$; $M = N - (m - 1)\tau$ where τ is the time delay, m embedding dimension of Phase space reconstruction, and M is the number of phase points of reconstructed phase space. Since we are estimating τ for nonlinear time series we use average mutual information (AMI) in the present work. The first local minimum of AMI is chosen as the optimum time delay.

As an example, the Phase portrait constructed for Euro Union and India are given in (Figures 2a and 2b).



Fig, 2(a) Phase portrait of Euro Union

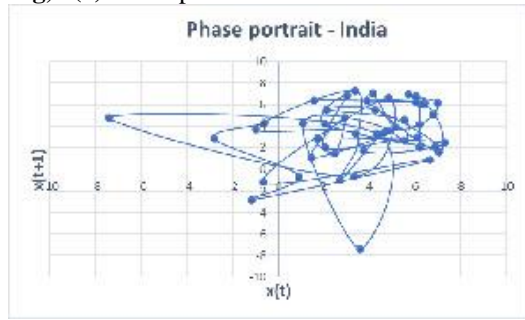


Fig 2b. Phase Portrait of India

2.3 Embedding Dimension

In this investigation we adopted a practical method to determine the minimum embedding dimension from a scalar time series using Takens theorem [18]. Four basic methods that are used to find the minimum embedding dimension: computing some invariant on the attractor, singular value decomposition, the method of false neighbors [17], and Cao's method [19]. We use Cao's method to determine the embedding dimension. Using this method, we can distinguish deterministic signals from stochastic signals. It does not depend on how many data points are available. There are two quantities $E1$ and $E2$, where $E1$ gives the embedding dimension required for the reconstruction and $E2$ helps to distinguish deterministic signals from stochastic signals. For random signals, the value of $E2 = 1$, for every value of m .

2.4 Pearson Correlation Coefficient

The Pearson correlation coefficient is a measure of linear relationship between two data variables X and Y having the values in the range between -1 and $+1$. When $r = 0$, it indicates that there is no relationship between two variables such that the change in magnitude of one variable is independent of that in the other variable. When $r > 0$, it is said to be positively correlated, and there is a direct relationship between the two variables. As the magnitude of the one variable increases the other also increases. Similarly, if the magnitude in one variable increases and that in the other decreases, the relationship between two variables is said to be negatively correlated and this is for $r < 0$. The mathematical formula for calculating the Pearson correlation coefficient [20, 18, 21, 22] is

$$r = \frac{\sum (X_i - \bar{X})(Y_i - \bar{Y})}{\sqrt{\sum (X_i - \bar{X})^2 \sum (Y_i - \bar{Y})^2}} \quad (1)$$

Ranges from -1 (a perfect negative correlation) to $+1$ (a perfect positive correlation). When $r = 0$ no correlation exists.

2.5 HURST EXPONENT (HE)

The Hurst exponent provides a measure of autocorrelation [23, 24, 25]. The value of the Hurst exponent (H) ranges between 0 and 1. For random time series data or white noise the value of H is 0.5, antipersistent or no correlation ($H < 0.5$) and persistent or correlation ($H > 0.5$). The relation between Hurst exponent H and fractal dimension D_f is given by, $D_f = 2 - H$, which measures the intensity of long-range dependence in a time series. In this method, a time series of length of L is divided into d subseries of length n . For each subseries $m = 1, \dots, d$, find the mean (E_m) and standard deviation (S_m); Then after normalizing the data, a cumulative time series is created as

$$Y_{i,m} = \sum_{j=1}^i x_{j,m} \quad i=1,2,3,\dots,m \quad (2)$$

and also the range $R_m = \max(Y_{1,m}, \dots, Y_{n,m}) - \min(Y_{1,m}, \dots, Y_{n,m})$. Then rescale the range R_m/S_m . The mean value of the rescaled range for all subseries of length n can be calculated as ;

$$\left(\frac{R}{S}\right)_n = \frac{1}{d} \sum_{m=1}^d \frac{R_m}{S_m} \quad (3)$$

The ratio (R/S) asymptotically follow the relation [26]

$$\left(\frac{R}{S}\right)_n \approx cn^H \quad (4)$$

It follows that,

$$\log\left(\frac{R}{S}\right)_n = H \log n + \log c \quad (5)$$

Or

$$H = \frac{\log\left(\frac{R}{S}\right)_n - \log c}{\log n} \quad (6)$$

2.6 Fractals and Dimension (FD)

Infinitely complex patterns that have self-similar structures across different scales are called fractals. In mathematics, fractals are considered as a class of complex geometric shapes that have a fractional dimension called *fractal dimension* (FD). In 1918, this concept was first introduced by the mathematician Felix Hausdorff [27]. The index for characterizing fractal patterns or sets and can be calculated by quantifying their complexity as a ratio of the change in detail to the change in scale. It gives a measure of the complexity of the phase portrait of the time series which indicates how many independent variables are needed to simulate the time series. The number of independent variables required is calculated from the fractal dimension by rounding it up to the next integer.

2.7 Detrended Fluctuation Analysis (DFA)

The complex temporal structure of ongoing oscillations is generally scale free and characterized by long-range temporal correlations. Detrended fluctuation analysis (DFA) is very effective in measuring the persistency (or antipersistency) of data series with non-stationarities [11]. Hence it can be analyzed using DFA which lead to differences in the scale-free amplitude modulation of oscillations. For a given time series data $B(i)$, the average value, B_{avg}

$$B_{avg} = \frac{1}{N} \sum_{i=1}^N B(i) \quad (7)$$

The cumulative sum of $B(i)$ obtained by considering time series of the total length N is integrated

$$y(k) = \sum_{i=1}^k (B(i) - B_{avg}) \quad (8)$$

This integration steps maps the original time series to a self-similar process. Fluctuation $F(n)$ employed in the DFA obtained by dividing the integrated time series into small equal parts of width n and then the time series $y(k)$ is detrended by subtracting the local trend $y_n(k)$ in each n . For a given size n , the characteristic size of fluctuation for this integrated and detrended time series is calculated by

$$F(n) = \sqrt{\frac{1}{N} \sum_{k=1}^N [y(k) - y_n(k)]^2} \quad (9)$$

where n is the window size and $y(k)$ is the linear function which approximated by the least squares method for each window. The fluctuation $F(n)$ is proportional to the power of n , $\Rightarrow F(n) \propto n^\alpha$, where α is known as the scaling exponent and is utilized to characterize the fluctuation as shown in (Table 1).

We use DFA method to analyze the long-range correlation and scaling properties of annual GDP growth rate. The slope of the line relating $\log F(n)$ versus $\log n$ graph determines the scaling exponent (self-similarity factor).

Table 1: Classification of α value

α Value	Classification
$\alpha < 0.5$	Anticorrelated
$\alpha = 0.5$	Uncorrelated, White noise
$1 < \alpha < 0.5$	Correlated
$\alpha = 1$	Pink noise
$1 < \alpha < 1.5$	Random walk
$\alpha = 1.5$	Brownian noise

2.8 Lyapunov Exponent

In a dynamical system the Lyapunov exponent characterizes the rate of separation of infinitesimally close trajectories. The instability in chaotic systems is usually characterized by the spectrum of Lyapunov Exponents. Lyapunov exponents (λ) are considered as a reliable measurement to predict the nature of a dynamical system since they are invariant under smooth transformations and hence are independent of the measurement function or the embedding procedure. If $F^t(x_0 + s)$ and $F^t(x_0)$ are two close trajectories, then

$$F^t(x_0 + \varepsilon) - F^t(x_0) \approx \varepsilon e^{\lambda t} \quad (10)$$

Here λ is called Lyapunov exponent. When $\lambda > 0$, small distances grow indefinitely over time, which is an indicator of the onset of chaos. Also when $\lambda < 0$, the system settles down into a periodic trajectory eventually.

In this study, we use the algorithm of Rosenstein [26] to evaluate Lyapunov exponent by considering the reconstructed phase space. In the reconstructed phase space, the nearest neighbour (X_i) of each point on the trajectory is located by looking for the point which has minimum distance from the reference point (X_j)

$$d_j(0) = \min_i |X_i - X_j| \quad (11)$$

where $d_j(0)$ is the initial distances from i^{th} point to its neighbour. Similarly nearest neighbour is found for other points also by repeating this process. The distance between reference point and nearest point after i iterations may be denoted by $d_j(i)$. Then

$$y(i) = \frac{\langle \ln(d_j(i)) \rangle}{i \nabla t} \quad (12)$$

where Δt is the sampling period of time series data. The largest Lyapunov exponent is the slope of the log $\langle \text{divergence} \rangle$ vs $\text{time}(s)$ graph in increasing part

2.9 The 0-1 Test for Chaos

Another test to study the onset of chaos was developed by Gottwald and Melbourne [28] to distinguish between the periodic (regular or quasi-periodic) and chaotic behavior from a discrete and continuous dynamical system. This test measures directly from the one-dimensional scalar time series and does not require any reconstruction of phase space which is necessary for calculating Lyapunov exponent. The output of this test gives a scalar value in between 0 and 1 where the value of '0' indicates a periodic dynamics and the value of '1' indicates a chaotic dynamics. The algorithm of 0-1 test is as follows :

Step 1: From a given one dimensional scalar time series $\phi(n)$ for $n = 1, 2, \dots, N$, a new two-dimensional coordinate system is obtained by $P(n)$ and $q(n)$ as

$$P(n) = \sum_{i=1}^n \phi(i) \cos(ic); \quad q(n) = \sum_{i=1}^n \phi(i) \sin(ic) \quad (13)$$

where c is a random number which is fixed in the range

$$c \in \left(\frac{\pi}{5}, \frac{4\pi}{5} \right)$$

Step 2: Define the Mean square displacement $M(n)$ as,

$$M(n) = \lim_{N \rightarrow \infty} \frac{1}{N} \sum_{i=1}^N \left((p(i+N) - p(i))^2 + (q(i+n) - q(i))^2 \right) \quad (14)$$

$$\text{for } n \in \left(1, \frac{N}{10} \right)$$

Step 3: Define the modified Mean square displacement $D(n)$ as

$$D(n) = M(n) = \left(\lim_{N \rightarrow \infty} \sum_{i=1}^N \phi(i) \right)^2 \frac{1 - \cos nc}{1 - \cos c} \quad (15)$$

where $\alpha = 1, 2, 3, \dots, N/10$ and $\delta = D(1), D(2), \dots, D(N/10)$

Step 4 Estimate the correlation coefficient of the linear growth rate as

$$R = \frac{\text{cov}(\alpha, \delta)}{\sqrt{\text{var}(\alpha) \text{var}(\delta)}} \in (-1, 1) \quad (16)$$

where $\alpha = 1, 2, \dots, (N/10)$ and $\delta = D(1), D(2), \dots, D(N/10)$. Then $K = \text{median}(R)$

Table 2. Consolidated result of nonlinear Analysis

Sl. No.	Country	Total years	Correlation coeft.	Hurst Exponet	DFA	Fractal Dimension	0-1 Test
1	Argetina	58	0.114	0.47	0.82	1.53	0.99
2	Australia	58	0.168	0.58	0.86	1.42	0.99
3	Brazil	58	0.475	0.68	1.11	1.33	0.99
4	Canada	58	0.279	0.67	0.91	1.33	0.99
5	China	58	0.507	0.55	0.95	1.45	0.97
6	Euro Area	58	0.562	0.57	1.11	1.43	0.98
7	France	58	0.587	0.34	1.18	1.66	0.97
8	Germany	58	0.142	0.69	1.04	1.31	0.99
9	India	58	0.174	0.32	0.81	1.68	0.99
10	Indonesia	58	0.344	0.63	1.13	1.37	0.98
11	Italy	58	0.500	0.29	0.97	1.71	0.99
12	Japan	58	0.578	0.63	0.85	1.37	0.99
13	Korea	58	0.335	0.35	0.80	1.65	0.99
14	Mexico	58	0.240	0.59	0.99	1.41	0.99
15	Russia	28	0.653	0.77	1.24	1.23	0.89
16	Saudi Arabia	49	0.298	0.43	1.01	1.58	0.99
17	South Africa	58	0.512	0.62	1.05	1.38	0.66
18	Turkey	58	-0.009	0.47	0.89	1.53	0.97
19	UK	58	0.347	0.45	1.01	1.55	0.97
20	US	58	0.288	0.63	0.94	1.37	0.99

3.RESULT ANALYSIS OF GDP TIME SERIES DATA OF G20 COUNTRIES

The annual real GDP growth rate data obtained from the World Bank site for G20 countries are analysed using the parameters described above, and the results are consolidated in (Table 2). There are deterministic systems whose time evolution has a very strong dependence on initial conditions and they are familiarized as chaotic systems and can predict a deterministic chaos [29]. This is because, these models will always produce the same output from a given

starting condition or initial state. But a random or stochastic process depends on a collection of random variables, representing the evolution of some system for random values over time.

The phase portraits and fractal dimension indicate a chaotic nature of GDP growth rate for all the G20 countries. The 0–1 test confirms this result. But the Lyapunov analysis and Hurst exponent values indicate that some of the countries like Australia, India, Russia, UK, USA and Euro Union have a deterministic nature while the some other countries shows stochastic nature.

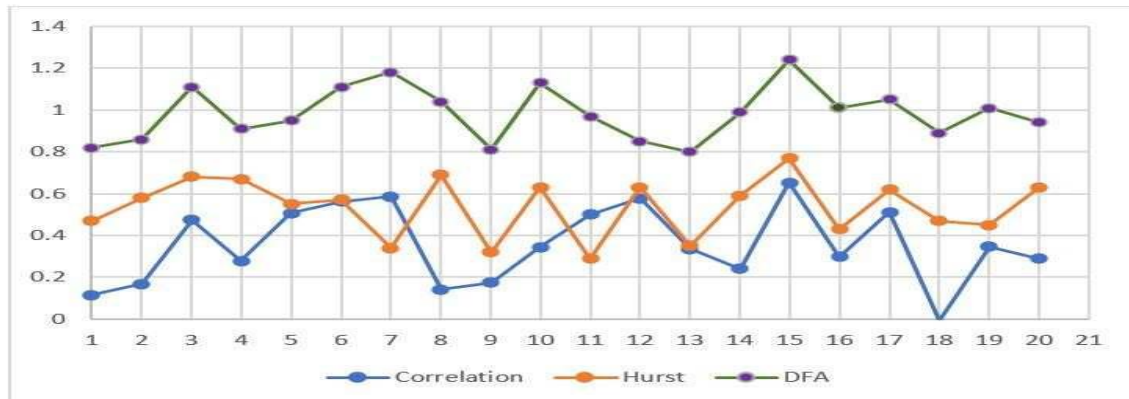


Fig.3: Comparison of Correlation coefficient, Hurst Exponent and DFA values

A plot with correlation, Hurst exponent and DFA values on Y axis and the G20 countries from 1 to 20 on X axis is given in (Figure 3) for a comparison. The behaviour of these values for certain countries shows a trend towards stable economy, while for certain other countries shows a random behavior.

Generally we need to have a large number data for analysing chaos in GDP in a deep sense. But the annual GDP data available is only from 1961 to 2018 with only 58 data points. Eventhough the analysis of such short time series may be questionable, we donot have other choice than to analyse the chaotic behaviour of GDP growth rate of time series. Hence the results we present are only approximations. We try to estimate the trend only from which future trend also can be predicted provided the initial conditions remains same. The plot of Lyapunov

exponent of plotted for all the G20 countries based on the 58 points is shown in Figure 4. We have also compared the Lyapunov exponent slope and rate of economic growth slope for these countries from 1961 to 2018. In this case we could find an inverse relation between Lyapunov exponent and economic growth rate for most of the countries during this time span. Few of the countries show a random nature. When consider short time span of two or three years, there are uctuations in these values from the average value, still with a reverse relation. To get a closer inference, we consider the slope of Lyapunov exponent and GDP growth for the time span 2010- 2018. A detailed analysis on the slope of the economic growth rate and the average of Lyapunov exponent slope is given in the next section.



Fig. 4: Lyapunov exponents of G20 countries consolidat

3.1 SLOPE ESTIMATION FROM 2010 TO 2018

A histogram showing the consolidated contribution of slope in percentage of all G20 countries is shown in (Figure 5).

Twelve out of the twenty countries shows an inverse relation between economic growth rate and Lyapunov exponent and this result is tabulated in (Table 3). The sign of Lyapunov exponent is very important in understanding

the dynamics of the system, whether the system leads to a chaotic state or not.

Detailed analysis of the data shows that, out of the twelve countries, Australia, Euro Union, India, Italy, UK and USA shows a negative Lyapunov exponent value with a positive trend for the economic growth rate during 2010 to 2018.

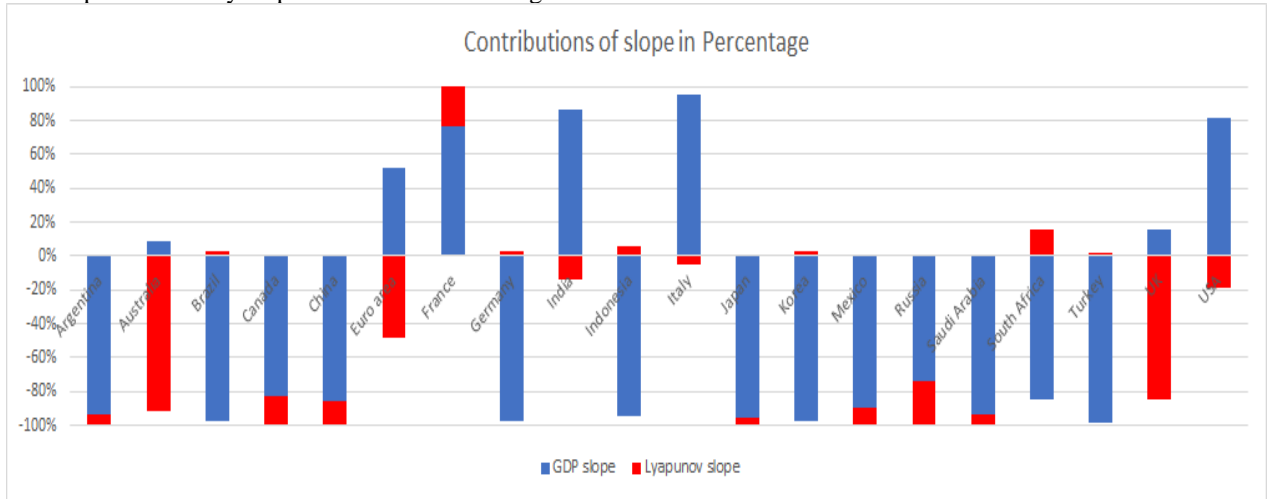


Fig. 5: Contributions of slope in percentage

This result gives a confirmation to our assumption that liberalization in economy, along with other factors, has a major role in controlling the growth of GDP in the long run. This result also indicate that the government policies also have a role in the GDP growth since usually one government continues for 4 to 5 years in most of these countries. Here the important result is that, among these six countries, five are developed countries and India is the only developing country. Even though there are

fluctuations in GDP growth rate for short span of time line (two or three years), the lower end of the fluctuation shows a positive growth trend when we consider the economic growth rate of eight or ten years with a deterministic nature for its economy. India after liberalization shows a continuous growth on an average GDP growth rate especially from 1999, accepting the fact that in certain years there are variations from the average value.

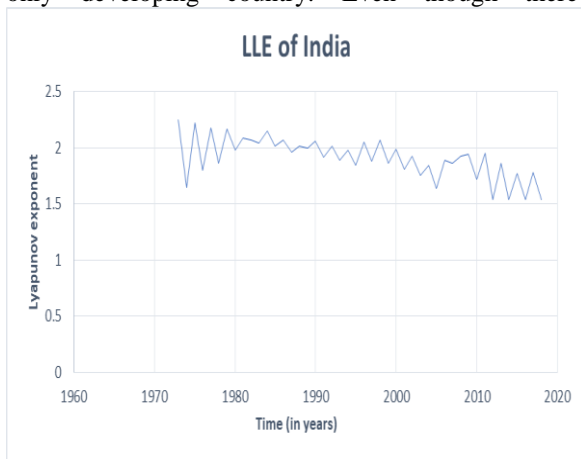


Fig 6. (a) Lyapunov exponent: India

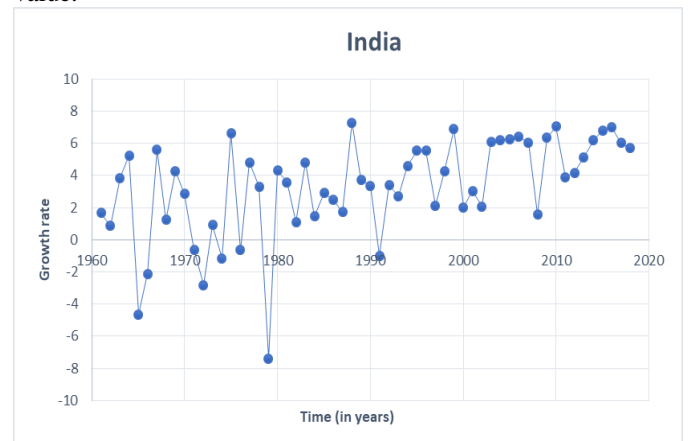


Fig. 6(b) Annual Real GDP growth rate of India from 1961 to 2018

Table 3. Inverse Relation between economic growth rate and Lyapunov exponent

Country	Economic growth rate	Lyapuniv Exponent
Australia	Positive	Negative
Euro area	Positive	Negative
India	Positive	Negative
Italy	Positive	Negative
UK	Positive	Negative
USA	Positive	Negative
Brazil	Negative	Positive
Germany	Negative	Positive
Indonesia	Negative	Positive
Korea	Negative	Positive
South Africa	Negative	Positive
Turkey	Negative	Positive

Euro Union has been considered as the second largest economic power after US. Also it is the only non state member in G20 group. Our analysis of Euro Union gives almost same magnitude for GDP growth rate and Lyapunov exponent with opposite signs (Figure 3 and figure 7). The time series analysis during 2010-2018 gives a negative Lyapunov exponent value with a positive economic growth rate as expected. This indicate that they are growing towards a stable economy, may be due to the importance they given to the constitutional law as a source for global governance guidance, the diversity of approaches they took and the environmental action they considered, respecting the G20 observations and decisions after each summit.



Fig. 7(a) Lyapunov exponent-Euro Union

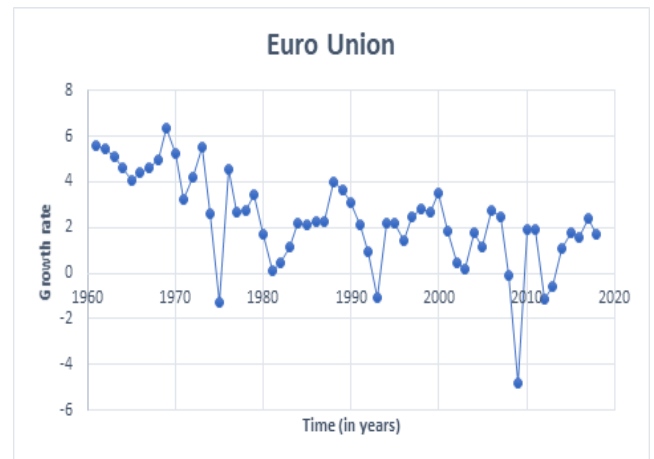


Fig. 7(b) Annual Real GDP growth rate of Euro Union from 1961 to 2018

For the other six countries among the twelve - which include Brazil, Germany, Indonesia, Korea, South Africa and Turkey - the Lyapunov exponent give positive values and shows a decrease in GDP growth rate. Positive value of Lyapunov exponent is an indicator of the onset of chaos. Hence economy of these countries may lead to a chaotic state. The chaotic nature of their economy is confirmed using 0-1 test. Other eight countries shows negative values for both GDP growth rate and Lyapunov exponent except France. France shows a positive value for both GDP Growth rate and Lyapunov exponent. All these countries shows a random nature in their economy as seen from the most of the analysis results.

4. CONCLUSION

The study of economic growth theory itself is a complex process since it depends on many direct factors such as human resources, natural resources, technological advances and indirect factors such as efficiency of financial system, fiscal and budgetary policies, liberalization in economy and the efficiency of the government. Economic growth of a country is measured by the variation of annual GDP growth rate of that country but it is very difficult to determine the factors causing the variation. The analysis of chaos in GDP data for all the G20 countries is very difficult to carry out because all these countries have independent government policies, climate conditions and economic policies. Still we are trying to and similarities in their economy because all these countries have some common objectives towards keeping global economic stability. We considered various nonlinear techniques such as time series, phase portraits, fractal dimension, correlation dimension, Lyapunov exponent, Hurst exponent and DFA and the analysis results are given in (Table 2) and (Figures 1, 2a, 2b, 3, 4 and 5). All the techniques shows a chaotic behaviour for most of the countries. But for few countries, the Hurst exponent, DFA, correlation function and Lyapunov exponent give a random or stochastic nature which is clear from (Figures 1, 2a and 2b). We have conducted 0-1 test for chaos using the time series of the GDP growth rate values. All the countries shows a chaotic nature. We considered the slope

estimation of economic growth rate and Lyapunov exponent during 2010 to 2018 and the result is shown in figure 3. A close observation of the slope of their average GDP growth rate and slope of the average of Lyapunov exponent from 1961 to 2018 shows that these average values during a period of time (may be four or five years) depends on the previous value with the same period which showing a deterministic chaotic nature.

Summerizing, we observed that as the Lyapunov exponent increases from negative to positive value, the GDP growth rate decreases. It appears that although liberalization promotes growth in the short term, the growth rate can be sustained only by introducing some form of consultation among the state holders with the government. In other words, some degree of planning based on the nonlinear analysis may be helpful in achieving high economic goals and a sustained GDP growth rate. This is only an observation which has to be substantiated by a consideration of the economic history of the analysing country.

5. ACKNOWLEDGMENT

The authors wish to express their sincere thanks to Dr. Sunil Kumar M. J., Dr. Joby Jose, Associate Professor, Department of Economics, Government College Kottayam (GCK) for their help in understanding various terms in Economics and also for their valuable suggestions and guidance throughout this work. Authors also wish to acknowledge Prof. C. Vinayachandran, Associate Professor of Statistics (GCK), for their valuable suggestions and support in realizing this work.

6. REFERENCES

- [1] Simon Kuznets. National income, 1929-1932. *National Bureau of Economic Research*, 49:1-12, 1934.
- [2] H E Hurst. Long-term storage capacity of reservoirs. *Transactions of the American Society of Civil Engineers*, 116(1):770-808, 1951.
- [3] Gazi Mainul Hassan and Shamim Shakur. *Nonlinear effects of remittances on per capita gdp growth in Bangladesh. Economies*, 5(3):1-11, 2017.
- [4] Florin Teodor Boldeanu and Liliana Constantinescu. The main determinants affecting economic growth. *Bulletin of the Transilvania University of Brasov Series*, 8(57):329-338, 2015.
- [5] Ashok Parikh and Corneliu Stirbu. *Relationship between trade liberalisation, economic growth and trade balance: An econometric investigation*. Hamburgisches Welt-Wirtschafts-Archiv (HWWA) Hamburg Institute of International Economics discussion paper, (282), 2004.
- [6] Giovanni Andrea Cornia. The impact of liberalisation and globalisation on income inequality in developing and transitional economies. *Center for Economic Studies and ifo Institute (CESifo)*, Munich, 5(843), 2003.
- [7] Radko Kriz and Radka Knezackova. The presence of chaos in the gdp growth rate time series. *Chaotic Modeling and Simulation*, 2:199-206, 2014.
- [8] Radko Kriz. Finding chaos in Finnish gdp. *International Journal of Automation and Computing*, 11(3):231-240, 2014.
- [9] Karen Dynan and Louise Sheiner. Gdp as a measure of economic well being. *Hutchins Center on Fiscal and Monetary Policy, The Brookings Institution*, 43:1-52, 2008.
- [10] Mathew B Kennel, Reggie Brown, Henry D, and I Abarbanel. *Determining embedding dimension for phase space reconstruction using a geometrical construction*. *Physical Review A*, 45(6):3403-3411, 1992.
- [11] Jianhai Yue, Xiaojun Zhao, and Pengjian Shang. *Effect of trends on detrended uctuation analysis of precipitation series*. *Mathematical Problems in Engineering*, 2010.
- [12] Floris Takens. Detecting strange attractors in turbulence. In Young LS.Rand D., editor, *Dynamical Systems and Turbulence, Warwick 1980- Lecture Notes in Mathematics*, vol 898, pages 366-381. Springer Nature, 1981
- [13] Ashok Kotwal, Bharat Ramaswami, and Wilima Wadhwa. *Economic liberalization and Indian economic growth: What's the evidence?* *Journal of Economic Literature*, 49(4), 1152-1199, 2011
- [14] World Bank. World bank open data <https://data.worldbank.org>.
- [15] Syed Ahsin Ali Shah, Wajid Aziz, Maliksajjad Ahmed Nadeem, Majid Almarashi, Seong O Shim, and Turki M Habeebullah. *A novel phase space reconstruction - (psr-) based predictive algorithm to forecast atmospheric particulate matter concentration*. *Scientific Programming*, 2019.
- [16] Liangyue Cao. Practical method for determining the minimum embedding dimension of a scalar time series. *Physica D*, 110, 43-50, 1997.
- [17] Andrew M Fraser and Harry L Swinney. *Independent coordinates for strange attractors from mutual information*. *Physical Review A*, 33(2), 1134-1140, 1986.
- [18] Richard Taylor. *Interpretation of the correlation coefficient: A basic review*. *Journal of Diagnostic Medical Sonography*, 6(1):35-39, 1990.
- [19] K Hema Divya and V Rama Devi. *A study on predictors of gdp: Early signals*. *Procedia Economics and Finance*, 11:375-382, 2014.
- [20] Richard Hardstone, Simon-Shlomo Poil, Richard Hardstone, Simon- Shlomo Poil, Giuseppina Schiavone, Rick Jansen, Vadim V Nikulin, Huibert D Mansvelder, and Klaus Linkenkaer-Hansen. *Detrended fluctuation analysis : A scale-free view on neuronal oscillations*. *Frontiers in Physiology*, 3(450), 2012.
- [21] Joseph Lee Rodgers and W Alan Nicewander. *Thirteen ways to look at the correlation coefficient*. *The American Statistician*, 42(1), 59-66, 1988.
- [22] Patrick Schober, Christa Boer, and Lothar A Schwarte. *Correlation coefficients: Appropriate use and interpretation*. *Anesthesia & Analgesia*, 126(5):1763{1768, 2018.
- [23] H E Hurst. *A suggested statistical model of some time series which occur in nature*. *Nature*, 180:494-495, 1957.
- [24] Rafa Weron. *Estimating long-range dependence: finite sample properties and confidence intervals*. *Physica A : Statistical Mechanics and its Applications*, 312(1-2), 285-299, 2002.

- [25] H E Hurst. *Problem of long term storage in reservoirs*. *International Association of Scientific Hydrology. Bulletin*, 1(3):13-27, 1956.
- [26] Michael T Rosenstein, James J Collins, and Carlo J De Luca. *A practical method for calculating largest lyapunov exponents from small data sets*. *Physica D: Nonlinear Phenomena*, 65(1-2), 117-134, 1993.
- [27] John E Hutchinson. *Fractals and self similarity*. *Indiana University Mathematics Journal*, 30(5), 713-747, 1981.
- [28] Georg A Gottwald and Ian Melbourne. *A new test for chaos in deterministic systems*. *Proceedings of The Royal Society A Mathematical Physical and Engineering Sciences*, 460(2042), 603-611, 2004.
- [29] Mauro Cattani, Ibero Luiz Caldas¹, Silvio Luiz de Souza, and Kelly Cristiane Iarosz¹. *Deterministic chaos theory : Basic concepts*. *Revista Brasileira de Ensino de Fisica*, 39(1), 2017.

STUDY OF CONSUMER BUYING BEHAVIOUR TOWARDS TITAN WRIST WATCHES WITH SPECIAL REFERENCE TO PUNE

Gazal Gupta¹, Dr. Binod Sinha², Dr. Vimal Bhatt³

¹Balaji Institute of Modern Management, Sri Balaji University, Pune, Maharashtra-411033

²Professor, Balaji Institute of Modern Management, Sri Balaji University, Pune, Maharashtra

³Associate Professor, Symbiosis Institute of Business Management (SIBM), Symbiosis International (Deemed University) (SIU), Pune, Maharashtra -412115

Abstract. *This research paper has been written in order to understand the consumer buying behaviour towards Titan wrist watches in Pune. The objectives of this research is to study the factors affecting choice of type of Titan wrist watches, to measure the customer satisfaction towards Titan wrist watches, to find out the desired platform for buying of watches and to find out the type of strap material preferred for wrist watches. Descriptive research design and non-probability (convenience) sampling technique has been used in order to conduct this research. In order to collect the primary data, questionnaire is used and telephonic interview is conducted. Chi-square test and ANOVA is used to test the hypotheses. Data is analysed using SPSS. The results of the study revealed useful information about the consumers buying behaviour which might be of great value to the marketers and the manufacturers of Titan wrist watches.*

Keywords: *Buying Behaviour, Customer Satisfaction, Titan Wrist Watch, Strap Materials, Preference.*

1. INTRODUCTION

Watches have turn out to be nearly a need for human beings, irrespective of the economic class they belong to. The watch industry in the modern state of affairs is booming and achieving a rapid growth in India. With the advent of latest technology, a revolutionary change has occurred in the watch market of India. Many new brands with latest technology have entered the market leading to rising competitiveness in the industry.

Titan Company Ltd. (earlier referred to as Titan Industries Ltd.) is an Indian consumer good company that manufactures fashion add-ons which include watches, jewellery, eyewear, etc. It is a joint venture of Tata Group and TIDCO (Tamil Nadu Industrial Development Corporation) & is taken into consideration Tata group's largest consumer company. Later it kept on launching more variety of products and started touching more segments.

Titan is also having its city specific edition for Mumbai and Kolkata.

2. RESEARCH PROBLEM

This study has been set out in order to identify:

1. The demographic factors responsible for the choice of type of Titan wrist watches.
2. The type of strap material preferred for wrist watches.
3. The desired platform for purchase of wrist watches.
4. The satisfaction level of customers towards the various aspects of brand.

3. RESEARCH OBJECTIVES

Primary objective-

1. To study the demographic factors affecting choice of type of Titan wrist watches.
2. To study the difference between the satisfaction levels of customers with respect to various aspects of Titan wrist watches.

Secondary objectives-

1. To measure the customer satisfaction towards Titan wrist watches.
2. To find out the desired platform for buying of watches.
3. To find out the preferred strap material for wrist watches.

4. HYPOTHESES

1. Null Hypothesis (H_0) - There is no significant relationship between various demographic factors (income, age, gender) and the choice of type of Titan wrist watch.

Alternate Hypothesis (H_1) - There is a significant relationship between various demographic factors (income, age, gender) and the choice of type of Titan wrist watch.

2. Null Hypothesis (H_0) - There is no significant difference between the satisfaction level of customers of various occupation with respect to various aspects (quality, design, warranty period) of Titan wrist watches.

Alternate Hypothesis (H_1) - There is a significant difference between the satisfactions level of customers of various occupation with respect to various aspects (quality, design, warranty period) of Titan wrist watches

5. LITERATURE REVIEW

Dhevika, Lathasri and Karthik (2014) have studied in their research the loyalty of the college students towards the particular brand of wrist watch. Loyalty is one of the factors which proves to be very fruitful for the Brand. The study brings out that the loyal customer base brings more revenue for the company than the new customer base. In this study

it has been concluded that Brand trust is the most important factor contributing towards brand loyalty, followed by the product quality and brand effect, which shows that most of the people stick to the brand because of the trust they have in the brand, the quality offered by the brand, etc. [1]

Shanmugapriya and Kavya (2018) tried to find out the preference and buying behaviour of the customers towards the branded watches, role that brand image plays on their usage pattern, and the factors that are considered before the purchase of the branded watches. The study showed that customers consider a variety of factors like price, quality, design, before purchasing a particular brand of watch [2].

In the research paper of Gurusamy *et al.* (2018), authors studied the Quality of the wrist watches offered, finding out whether they are able to meet the demand of the people in the market, difference between the expectation and the reality in terms of the quality offered [3].

Kumaravel and Poornima (2015) analysed the Eco-friendly technologies adopted by the Titan watches. Titan has launched a range of watches that can be recharged from diffused and indirect light sources like mobile screen and candle light. Apart from this they have also launched the solar powered watches. These watches get charged whenever they come in contact with the light sources. This study revealed that advertisement is the major source of their brand awareness [4].

In his study Halamata (2013) offered basically a research about the extent to which the customers are aware about the brand, their attitude towards it, and the marketing channels. Titan has the global market and is considered to be the most reliable brand when it comes to the quality and the performance. It has never failed to meet the expectations of its customers. It is also concluded from this research that there is equal contribution of friends and relatives in choosing this brand [5].

Mini Tejaswi (2019) brought out that now-a-days watches are not only considered as an object or device which tells us time but it has also become an accessory with multiple features and designs, and is considered as a status symbol [6].

6. RESEARCH METHODOLOGY

This study is undertaken to study the buying behaviour of the consumers. Descriptive research design and non-probability (convenience sampling) has been used in this research. In order to conduct the research both primary and secondary data is used. Primary data is collected through questionnaire and telephonic interview. The questionnaire was divided into two parts, one dealt with the demographic factors and the other with consumer buying behaviour. The secondary data is collected through various journals, articles, and websites. The sample size that has been studied is of 150 respondents. Chi-square test and ANOVA is used to test the hypotheses. Data is analysed using SPSS.

7. DATA ANALYSIS AND INTERPRETATION

Hypothesis Testing

1. Null Hypothesis (H_0) - There is no significant relationship between various demographic factors

(income, age, gender) and the choice of type of Titan wrist watch.

Alternate Hypothesis (H_1) - There is a significant relationship between various demographic factors (income, age, gender) and the choice of type of Titan wrist watch.

Table 1: Relationship between gender and type of Titan wrist watch

Variables			Type of wrist watch				Total
			Analog	Digital	Hybrid	Touch screen	
Gender	Male	Count	28	7	23	10	68
		E.C.*	38.5	7.3	15.9	6.3	68
	Female	Count	57	9	12	4	82
		E.C.*	46.5	8.7	19.1	7.7	82
Total		Count	85	16	35	14	150
		E.C.*	85	16	35	14	150

Source: Table realized by authors E.C.* = Expected Count

Table 2: Chi-Square Tests

Values from tests	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	14.997 ^a	3	0.002
Likelihood Ratio	15.211	3	0.002
Linear-by-Linear Association	14.469	1	0
N of Valid Cases	150		

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 6.35.

Source: Table realized by authors

P-value= 0.002, since p value is less than 0.05, Reject null hypothesis. Inference: There is a significant relationship between gender and the type of Titan wrist watch.

Interpretation: Males prefer more of Hybrid type of watches whereas females prefer more of Analog watches.

Table 3: Relationship between age and type of Titan wrist watch

Variables			Type of wrist watch				Total	
			Analog	Digital	Hybrid	Touch screen		
Age	13-24	Count	50	9	7	4	70	
		E.C.*	39.7	7.5	16.3	6.5	70	
	25-34	Count	16	2	12	4	34	
		E.C.*	19.3	3.6	7.9	3.2	34	
	35-44	Count	13	4	10	5	32	
		E.C.*	18.1	3.4	7.5	3	32	
	45-60	Count	5	1	6	1	13	
		E.C.*	7.4	1.4	3	1.2	13	
	Above 60	Count	1	0	0	0	1	
		E.C.*	0.6	0.1	0.2	0.1	1	
	Total		Count	85	16	35	14	150
			E.C.*	85	16	35	14	150

Source: Table realized by authors E.C.* = Expected Count

Table 4: Chi-Square Tests

Values from tests	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	21.248 ^a	12	0.047	0.056	
Likelihood Ratio	22.201	12	0.035	0.032	
Fisher's Exact Test	23.345			0.011	
Linear-by-Linear Association	10.128 ^b	1	0.001	0.001	0.001
N of Valid Cases	150				
a. 11 cells (55.0%) have expected count less than 5. The minimum expected count is .09.					
b. The standardized statistic is 3.182.					

Source: Table realized by authors

Since 11 cells (55.0%) have expected count less than 5, the assumption for chi-square is violated, hence we will look for Fisher's exact test value.

P-value= 0.011, since p value is less than 0.05, Reject null hypothesis. Inference: There is a significant relationship between age and the type of Titan wrist watch.

Interpretation: Younger people prefer all type of watches whereas older people prefer more of Analog and hybrid watches.

Table 5: Relationship between income and type of type of Titan wrist watch

Variables		Type of wrist watch				Total	
		Analog	Digital	Hybrid	Touch screen		
Income	Less than 20000	Count	64	10	12	5	91
		E.C.*	51.6	9.7	21.2	8.5	91
	21000-50000	Count	13	3	15	5	36
		E.C.*	20.4	3.8	8.4	3.4	36
	51000-100000	Count	6	3	6	2	17
		E.C.*	9.6	1.8	4	1.6	17
Above 100000	Count	2	0	2	2	6	
	E.C.*	3.4	0.6	1.4	0.6	6	
Total	Count	85	16	35	14	150	
	E.C.*	85	16	35	14	150	

Source: Table realized by authors E.C.* = Expected Count

Table 6: Chi-Square Tests

Values from tests	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	25.786 ^a	9	0.002	0.004	
Likelihood Ratio	25.05	9	0.003	0.004	
Fisher's Exact Test	25.407			0.001	
Linear-by-Linear Association	16.349 ^b	1	0	0	0
N of Valid Cases	150				
a. 9 cells (56.3%) have expected count less than 5. The minimum expected count is .56.					
b. The standardized statistic is 4.043.					

Source: Table realized by authors

P-value= 0.001, since p value is less than 0.05, Reject null hypothesis. Inference: There is a significant relationship between income and the type of Titan wrist watch

Interpretation: People with lower income prefer all type of watches whereas people with higher income prefer more of Analog and hybrid watches.

1. Null Hypothesis (H₀) - There is no significant difference between the satisfaction levels of customers of various occupation with respect to various aspects (quality, design, warranty period) of Titan wrist watches.

Alternate Hypothesis (H₁) - There is a significant difference between the satisfaction levels of customers of various occupation with respect to various aspects (quality, design, warranty period) of Titan wrist watches.

Table 7: Difference between the satisfaction levels of customers of various occupation with respect to quality of Titan wrist watches

ANOVA					
Level of Satisfaction towards Quality					
Values	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	6.65	4	1.66	6.017	0.00
Within Groups	40.05	145	0.28		
Total	46.69	149			

Source: Table realized by authors

P-value= 0.000, since p value is less than 0.05, Reject null hypothesis

Inference: There is a significant difference between the satisfaction level of customers of various occupation in relation to quality of Titan wrist watches.

Interpretation: Respondents of various occupation have difference in the satisfaction level with respect to quality of Titan wrist watches.

Table 8: Difference between the satisfaction levels of customers of various occupation with respect to design of Titan wrist watches

ANOVA					
Level of satisfaction towards design					
Values	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	9.379	4	2.345	5.671	0
Within Groups	59.954	145	0.413		
Total	69.333	149			

Source: Table realized by authors

P-value= 0.000, since p value is less than 0.05, Reject null hypothesis. Inference: There is a significant difference between the satisfaction levels of customers of various occupation in relation to design of Titan wrist watches.

Interpretation: Respondents of various occupation have difference in the satisfaction level with respect to design of Titan wrist watches.

Table 9: Difference between the satisfaction levels of customers of various occupation with respect to warranty period of Titan wrist watch

ANOVA					
Level of satisfaction towards warranty period					
Values	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	3.336	4	0.834	2.77	0.03
Within Groups	43.657	145	0.301		
Total	46.993	149			

Source: Table realized by authors

P-value= 0.030, since p value is less than 0.05, Reject null hypothesis. Inference: There is a significant difference between the satisfaction levels of customers of various occupation in relation to warranty period of Titan wrist watches.

Interpretation: Respondents of various occupation have difference in the satisfaction level with respect to warranty period of Titan wrist watches.

8. ANALYSIS OF OBJECTIVES

O1.To measure the customer satisfaction towards titan wrist watches

FACTORS	C-SAT SCORE (%)
Quality	96.66
Design	89.33
Warranty Period	84.00
Variety	83.33
Return & exchange	76.00

Source: Table realized by authors

Interpretation: Around 96% of respondents are found to be satisfied with the quality of Titan wrist watches while 76% respondents are found to be satisfied with return & exchange.

O2.To find out the preferred strap material for wrist watches

Table 10: Gender * Strap Material Cross tabulation

Variables		Strap Material					Total
		Metal	Leather	Ceramic	Rubber	Others	
Gender	Male	14	38	8	5	3	68
	Female	52	16	5	4	5	82
Total		66	54	13	9	8	150

Source: Table realized by authors

Interpretation: It can be seen in the table that maximum number of males i.e. 38 prefer leather as a strap material and maximum number of females i.e. 52 prefer metal as a strap material. Hence can be interpreted that males generally prefer leather as a strap material and females metal as a strap material.

9. FINDINGS

- i. There is a significant relationship between various demographic factors (income, age, gender) and the selection of type of Titan wrist watch.
- ii. From the research it was found that 13-24 age group is the major contributor towards Titan wrist watch followed by 35-44 age group.
- iii. Out of 150 respondents, it was found that majority (45.3%) of respondents prefer to buy Titan wrist watch from its outlet followed by its website.
- iv. This research also reveals that majority of respondents prefer metal as a strap material followed by leather. It has also been found out that females mostly prefer metal as a strap material because of its ornamental thing and it is unlikely to break or stretch while males mostly prefer leather strap material because of its light weight and can be worn out in any occasion.
- v. 56.7% i.e. 85 respondents prefer analog watches over other type of watches followed by Hybrid, Digital and Touch screen.
- vi. C-sat score reveals that 96.66% of the respondents are satisfied with the quality of Titan wrist watches while there are 76% people who are satisfied with their return & exchange policy.
- vii. 50% of the respondents are found to be brand loyal and are not thinking of switching to another brand.
- viii. There is a significant difference between the satisfaction levels of customers of various occupation with respect to various aspects (quality, design, warranty period) of Titan wrist watches.

8. CONCLUSIONS

This research was conducted in order to find out the consumer's buying behaviour towards Titan wrist watches. Study reveals that metal is the most preferred strap material. Apart from this, Analog watches are considered to be most demanded by the consumers. The study also brings out that most majority of people prefer to shop for Titan watches from its outlet. This study concludes that there is a difference between the satisfaction level of various customers with respect to various aspects quality, design, warranty period, of Titan wrist watches. With the growth of watch industry and more competitors entering this market, it is necessary for Titan to focus on its return & exchange policy and the warranty period of watches.

6. REFERENCES

- [1] Dhevika, V. P. T., Lathasri, O. T. V. and Karthik, M. (2014) 'Brand Loyalty of Wrist Watches among College Students', *International Journal of Research Instinct*, 1(1), pp. 186–198.
- [2] Shanmugapriya, S. and Kavya, D. (2018) 'A Study On Customer Preference And Buying Behaviour Towards Branded Watches In Coimbatore District', *Suraj Punj Journal For Multidisciplinary Research*, 8(12), pp. 285–297.
- [3] Gurusamy, M. *et al.* (2018) 'A Study On Consumers' Behaviour Towards Wrist Watches In Paavai Educational Institutions At Namakkal', *International Journal of Advance Research and Innovative Ideas in Education*, 4(2), pp. 509–517. Available at: www.ijariie.com509 (Accessed: 20 June 2021).
- [4] Kumaravel, V. and Poornima, N. (2015) 'Eco-Friendly Technologies of Titan Company with special reference to Brand Equity and Preference of Titan Watches in Salem City', *Shanlax International Journal of Management*, 2(4), p. 90.
- [5] Halamata, A. N. (2013) 'Consumer Behaviour and Brand Preference of Titan Watches-An empirical study with reference to Haveri District, Karnataka', *IOSR Journal of Business and Management (IOSR-JBM)*, 7(1), pp. 1–07. Available at: www.iosrjournals.orgwww.iosrjournals.org (Accessed: 20 June 2021).
- [6] Mini Tejaswi (2019) "'Time" is up for watches, they are more of a style statement - The Hindu', *The Hindu*. Available at: <https://www.thehindu.com/business/time-is-up-for-watches-they-are-more-of-a-style-statement/article28977817.ece> (Accessed: 20 June 2021).

BENEFITS AND PROBLEMS OF TELEWORK DURING THE COVID-19 PANDEMIC: FACTORS OF AGE, GENDER AND TELEWORK INTENSITY

Aleksandra Cvetković¹, Mladen Čudanov², Gheorghe Săvoiu³

¹University of Belgrade, Faculty of Organizational Sciences, Serbia, E-mail: aleksandra.r.cvetkovic@gmail.com

²University of Belgrade, Faculty of Organizational Sciences, Serbia, E-mail: mladenc@fon.bg.ac.rs

³Romanian Statistical Society, Bucharest, e-mail: gsavoiu@yahoo.com

Abstract: *This paper analyses telework, or remote working in relation to the factors of age, gender and telework intensity. We have surveyed a sample of 191 employees working on-site, in-office or combined. After eliminating dubious responses, 166 answers were analysed using the constructs of perceived benefits and problems of telework. Theoretical concepts of information technology for teleworking, organizational changes and digital transformation of organizations are given and compared to the results. The advantages and disadvantages of teleworking have been examined. Our results show significant differences in perceptions of telework benefits between employees younger and older than 35 years and between those who telework more than four days per week and those who work less. Following those results, we propose possibilities and effects of teleworking in the future.*

Keywords: *remote working, teleworking, organization, technology, pandemic, digital transformation, analysis*

1. INTRODUCTION

Telework practices intensified since the beginning of the year 2020, marked the beginning of the Covid-19 pandemic. The coronavirus has affected all spheres of society. Individuals and business systems have been forced to adapt to the new way of life and work through many changes. This greatly affected on the organization of private and business lives. Systems that did not have the conditions and opportunities for adaptation suffered collapse and closure, and many professions were forced to reduce incomes or remain without them.

Employees in organizations that can be organized remotely have the opportunity to work remotely or hybrid, from home or from the office. Like any change, the transition from office work to working from home required adjustments. Organizations had to react urgently and prepare their business and employees for teleworking, and employees had to adjust their private and business life to work from home and the so-called new normal that is characteristic of the Covid-19 pandemic.

Information technology has enabled radical changes in organizations. Their expansive development almost daily improves operations in all spheres of society, both the individual and the most complex systems. In modern business, it is impossible to do business successfully without adequate use of information technologies.

2. LITERATURE REVIEW

Indeed (www.indeed.com), one of the largest worldwide employment web sites, published six different work

environment types and career roles in its research. Indeed lists the working environments as conventional, enterprising, social, artistic, investigative and realistic [1]. According to Indeed, elements of work environment are: hours typified as fixed working hours or flexible working hours, company culture which is depicted as formal or casual dressing code and committing duties of employers, benefits such as paid leave, motivation for overtime and bonuses, people who have a great role in creating a working atmosphere positively or negatively, career development which some organizations offer to their employees through courses, training and exercises, while others expect employees to take responsibility for training and workspace which can be office or coworking space or teleworking, actually work from home.

Lou Adler, CEO of company Performance-based Hiring Learning Systems, in his research about working categorization, published that there are four types of work: thinkers, that is, knowledge workers who are the main generators of ideas and creative types of people, builders who are realizing ideas and turning them into reality, improvers responsible for improving organization and achieving long term goals and producers who do jobs that keep recurring (Adler, 2017, [2]).

The term teleworking represents a wide range of jobs. The most common words associated with teleworking are online work, remote or telecommuting, home office or work from home. What everyone has in common is independence from the location of the employee who does that type of work. The two basic things needed to do remotely are a computer and Internet access. Remote working can be: fully remote, which means teleworking in its entirety, flexible job which presents hybrid work that allows an employee to work both from home and from the office, freelance or part-time work, nowadays with a popular name "online workers" who look for employment instead of are dependent on one organization, online business which is a combination of part-time and teleworking with the option of starting own business and side hustles where workers work remotely along the way and this is not their primary source of income. (Workplaceless, 2021, [3]).

Like any job, remote working has principles that should be followed for success. GitLab, a company that publicly shares research based on data from global companies, publishes a nine-point remote manifesto on its website (GitLab, [4]):

1. *Hiring and working from all over the world instead of from a central location.*
2. *Flexible working hours over set working hours.*
3. *Writing down and recording knowledge over verbal explanations.*

4. *Written down processes over on-the-job training.*

6. *Opening every document for editing by anyone over top-down control of documents.*

7. *Asynchronous communication over synchronous communication.*

8. *The results of work over the hours put in.*

9. *Formal communication channels over informal communication channels."*

Before the Covid-19 pandemic, many organizations considered remote work is impossible. However, when the pandemic broke out, social distance was mandatory. All jobs that could be performed remotely had to be switched to remote access. Organizations that thought they had all the necessary tools and opportunities to enable their employees to work smoothly from home were faced with many obstacles, from lack of equipment and software to training employees on what to do and how to work remotely and how to meet workers' demands working remotely (Brown, 2020, [5]).

Employees who thought working from home was ideal encountered many obstacles and problems in work and private life. Since the beginning of the pandemic, many authors and researchers have studied the field of remote work and how it changes over time.

Lina Vyas and Nantapong Butakhieo from Hong Kong university analyzed the impact of working from home during Covid-19 on work and life in Hong Kong. Research has shown that working from home, although previously thought to be a benefit and motivation for the workers, is extremely unfavourable for the most workforce in Hong Kong. It turned out that the organizations were not ready for the permanent transition from office to remote work, and employees did not have a clear view of how to organize work from home. (Vyas, & Butakhieo, 2020, [6]).

Santa Berzina, head of the macroeconomic analysis division of the monetary policy department in Latvia, dealt with whether remote work was a forced experiment during the Covid-19 era or a lasting value. She concluded that teleworking increases productivity under normal circumstances, helps to balance work and life, contributes to social security during the corona virus pandemic, that its organization differs from country to country, is not accessible to all and that social interaction and weak IT skills are obstacles to working remotely (Berzina, 2021, [7]).

Kimberly Mlitz, a research expert covering the IT services industry, published an article about changing remote work trends due to Covid-19 in the United States in 2020. She analyzed the frequency of remote working before and during the pandemic. The result of her research shows that before the corona virus pandemic, seventeen per cent of employees in the United States worked from home five or more days a week, and that percentage increased to forty-four during the pandemic. She also explains that information technologies that support teleworking have increased the demand, and video conferencing companies have increased profits, so organizations had to consider new communication techniques and resources. Kimberly states that many employers see the benefits of remote working, including positive results in employee health surveys and potential office space reductions. Many employees also

5. *Public sharing of information over need-to-know access.*

plan to work from home more often in organizations where it is allowed and feel motivated about it. (Militz, 2021, [8]).

Australian IT Company Traqq published SWOT (Strengths, Weaknesses, Opportunities, Threats) analysis if permanent remote work is sustainable. By identifying strengths, weaknesses, opportunities, and threats to a company offering software products, they provide an answer if a business system like that is ready to work remotely. They conclude that leaders in companies should organize and support telework, that the key to the success of remote work is effective communication between all team members and that they must be motivated and rewarded for successfully completed tasks (Traqq, 2020, [9]).

In an online article, McKinsey lists the activities and occupations that can work from home to better understand teleworking. The potential for telework or work that does not require interpersonal interaction or physical presence in China, France, Germany, India, Japan, Mexico, Spain, the United Kingdom, and the United States was analyzed. More than two thousand tasks in more than eight hundred jobs were analyzed and it was determined which activities and occupations have the greatest potential for teleworking:

"Activities with the highest protentional for remote work include updating knowledge and interacting with computers.

The finance, management, professional services, and information sectors have the highest protentional for remote work.

Labor forces in advanced economies can spend more time working remotely than workforces in emerging economies.

While most of the workforce cannot work remotely, up to one quarter in advanced economies can do so three to five days a week. "

According to McKinsey's article, *"hybrid models of remote work are likely to persist in the wake of pandemic, mostly for a high educated, well paid minority of the workforce"* (McKinsey, 2020, [10]).

Thomas A. Limoncelli, site reliability engineering manager at Stack Overflow Inc., a company working remotely since the beginning, published an article about remote work techniques. He states that forty per cent of the company worked remotely before the Covid-19 pandemic, and one hundred per cent worked remotely during the pandemic. He explains the best practices for remote working:

"Meetings should be one hundred per cent physically or one hundred per cent remotely; no mixed meetings.

Chat status should be away when the person is away and available when the person is available; no fake status.

Conversation should be started to a quick way.

In a videoconference room coworker should be working silently together.

Social events should be created specifically for remote workers." (Limoncelli, 2020, [11]).

Hive (www.hive.com), the platform for remote teams, researched how the pandemic impacted remote work. Surveys says that seventy-two per cent of participants like remote work, sixteen per cent of respondents were indifferent

and twelve per cent of remote workers don't like working from home.

Survey results show top five remote work advantages are:

*"Saving time without a commute – 88%,
Flexible work hours – 66%,
Spending less money – 59%,
Spending more time with family at home – 56%,
Fewer distractions at home – 38%."*

Also, there are top five remote work struggles:

*"Trouble unplugging from work – 63%,
Feeling lonely or socially isolated – 47%,
Feeling pressure to work longer – 33%,
Feel disconnected from organizational goals – 31%,
Trouble staying focused without an office – 30%."*

Hive found that ninety-one per cent of remote workers use video conferencing tools (Hive, 2020, [12]).

Aja Frost, freelance writer, in her book *"Work from Home Hacks"* describes the ways how to be productive and organized and have a balance between life and work during remote working. She states how to (Frost, 2021, [13]):

*"Set up a home office,
Build routines and schedules,
Create new communication habits,
Overcome distraction,
Have meeting remotely,
Manage team remotely,
Maintenance work-life balance."*

Karen Mangia, Vice President of Customer and Market Insights at Salesforce, American software company, in her book *"Working from Home"* writes about possibilities, rituals, routines and boundaries of working from home. Her book is *"the handbook for thriving in the new normal"*. Karen teaches readers how to: create a home office and work productively in it, have personalized time management routines, deal with technologies for remote working, discover how to build great virtual presentations and career impact online. She says that her story *"explains in detail how to turn even the smallest of living spaces into the ideal remote work environment"* (Mangia, 2020, [14]).

M.J. Fievre and Becca Anderson, in their book *"Your Work from Home Life"* write about reorganization and optimization life in non-traditional and remotely working conditions. They state the pros and cons of working remotely. According to them, the pros are the ability to work anywhere, flexible work hours, no commute and savings, better work-life balance and communication skills, and the cons are isolation, loneliness, anxiety, technological and cybersecurity issues (Fievre, & Anderson, 2021, [15]).

GitLab in Remote Work Report 2021 gives an overview of tips and tactics for remote transition. In the survey, eighty-two per cent of remote workers agreed that teleworking is the future of work, and about eighty per cent would recommend working remotely (GitLab, 2021, [16]).

Harvard Business Review Guide to Remote Work in 2021 is about being more productive, setting boundaries, and connecting with coworkers in teleworking. In the survey many authors write about remote work during Covid-19 pandemic. They give an overview and advice on how to: be focused and productive at the home office, work from home when children are near, set limits between personal and work time, handle technology and collaborate

with the virtual team (Harvard Business Review Press, 2021, [17]).

Karin Reed and Joseph Allen, in their book *"Suddenly Virtual"* write about making remote meetings work. They discuss problems and challenges that the new normal brings in the business meeting. They also reveal the best practices for virtual meetings as: *"turn on camera, leverage the right technology tools, be social, safety first"* (Reed, & Allen, 2021, [18]).

"Remote, Inc." by Robert Pozen and Alexandra Samuel is about strategies and tools for making remote work effective and efficient. In the opinion of authors, the critical success factors for remote work are: focusing on outcomes, setting rules for communications in the team, balancing professional aims and personal priorities, creating routines, organizing workspace and using technology in the right way (Pozen, & Samuel, 2021, [19]).

3. RESEARCH METHODS

Data for this research has been collected between July and September of 2021. A questionnaire was developed following the usual methodological guidelines [20]. It had two parts, the first is focused on demographic traits of the respondents, and the second is on their perception of telework. In particular, there were two telework constructs:

Four item scale "Benefits of telework" consisting of items:

- I do not have to travel to work
- I can work from anywhere
- I do not have to see other colleagues
- I have more time for myself and for my family

Seven item scale "Problems of telework" consisting of items:

- Bad internet connection
- Organization of workspace
- Taking care of the children
- Organization of private life
- Feeling anxious
- I do not have all information and documents I could access at the workplace
- I cannot communicate with colleagues as I used to

According to the instructions from the literature, there were several control questions aimed at diminishing measurement error [21]. In total, 197 responses were gathered. The whole questionnaire in Serbian language is available at the given link: <https://forms.gle/qkgK31Tsyj9SuTJe9>.

After the analysis, two of the control questions were used to eliminate inconsistent responses. First, respondents were asked for a number of days working weekly on-site/teleworking, before and after COVID-19 pandemic. New variables were calculated, subtracting the total days worked on-site after and before and after the COVID-19 pandemic; the same was performed for telework. Since the population aimed by this research were full-time workers if after adding those two values result was larger than the absolute one, responses were eliminated as reckless. Differences of -1 or +1 days were tolerated as acceptable

changes in work schedule organization. After that, 166 (86.24%) responses were acknowledged as valid and analysed further.

According to the previous analysis, we have posted three hypotheses:

H1: There are significant differences in perception of benefits and problems of telework between older and younger population

H2: There are significant differences in perception of benefits and problems of telework between different genders

H3: There are significant differences in perception of benefits and problems of telework between mostly remotely engaged employees and employees who still mostly work on site

To measure the scale reliability of our two constructs, we have used Cronbach's Alpha test. Afterwards, we have checked the stated hypotheses by the independent samples t-test, following the given methodological guidelines in business and management research [22,23,24].

4. RESEARCH RESULTS AND DISCUSSION

First analysis has shown the reliability of our scales. Using the Cronbach's Alpha coefficients, according to acceptable value range [25] all constructs in this study have acceptable consistency. As elaborated by the Bland & Altman (1997), as well as in the later analysis by DeVellis (2003) weights between 0.7 and 0.9 are deemed most reliable [26,27]

Table 1. Telework scale reliability

<i>Variable name</i>		<i>Cronbach's Alpha</i>	<i>Items</i>
Benefits of telework	of	0.789	4
Problems of telework	of	0.779	7

In the further text, we will present differences according to participants age, gender and telework intensity.

Table 2. Descriptive statistics for groups differing by participant's age

	Participant's age	N	Mean	Std. Deviation	Std. Error Mean
Benefits of telework	>= 35.0	77	3.1916	1.1319	.129
	< 35.0	89	3.7556	.946	.1009
Problems of telework	>= 35.0	77	2.7012	.9033	.103
	< 35.0	89	2.5490	.9348	.0999

Table 3. Independent samples t-test telework perception differences according to the participant's age

	Levene's Test		t-test for Equality of Means						
	F	Sig. (F)	t	df	2-tailed sig.	Mean Diff.	Std.Err. Diff.	95% Confidence Interval of the Difference	
								Lower	Upper
Benefits of telework	4.419	.037	-3.497	164	.001	-.5641	.16128	-.8825	-.2456
Problems of telework	.136	.713	1.064	164	.289	.1523	.1432	-.1305	.4352

Levene's F statistics suggest equal variances between observed groups for problems of telework variable (F=0.136, P=0.713), while for the benefits of telework variable, equal variances cannot be assumed (F=4.419, p=0.037), so we have an interesting significant difference in variances for this variable, also. Data from our research suggest no statistically significant difference in problems of telework t(164)= -1.064, p=0.289. However, there is a

statistically significant difference in perceived benefits of telework between two groups of participants – older and younger than 35 years. Benefits of telework perceived by those of less than 35 years old (M=3.76, SD=0.95) and participants more than 35 years old (M=3.19, SD=1.13) is larger (mean difference 0.56) and significantly different t(164)= -3.497, p=0.001.

Table 4. Descriptive statistics for groups differing by participant's age

	Participant's gender	N	Mean	Std. Deviation	Std. Error Mean
Benefits of telework	Male	77	3.5357	1.0472	.11934
	Female	89	3.4579	1.0957	.11615
Problems of telework	Male	77	2.6493	.9679	.1103
	Female	89	2.5939	.8824	.0935

Levene's F statistics suggest equal variances between observed groups both of our variables. Data from our research suggest no statistically significant difference in

benefits telework $t(164) = 0.386, p=0.7$, or the problems of telework $t(164) = 0.466, p=0.642$ between different genders of participants, as presented in the table 5.

Table 5. Independent samples t-test telework perception differences according to the participant's gender

	Levene's Test		t-test for Equality of Means						
	F	Sig. (F)	t	df	2-tailed sig.	Mean Diff.	Std.Err. Diff.	95% Confidence Interval of the Difference	
								Lower	Upper
Benefits of telework	.297	.587	.466	164	.642	.0779	.1671	-.25205	.4078
Problems of telework	1.824	.179	.386	164	.700	.0554	.1437	-.2282	.3391

Regarding the intensity of telework, Levene's F statistics suggest equal variances between observed groups for problems of telework variable ($F=0.141, p=0.708$). In contrast, for the benefits of telework variable, equal variances cannot be assumed ($F=5.534, p=0.020$). Data from our research suggest that there is no statistically significant difference in problems of telework $t(164) = -0.345, p=0.73$ between intensive and non-intensive telework group. However, there is a statistically significant

difference in perceived benefits of telework between two groups of participants different by the intensity of telework. Benefits of telework perception by those of who use it intensively (more than four days per week ($M=3.72, SD=0.94$)) is larger than perception of participants who work less than four days per week ($M=3.24, SD=1.15$) (mean difference 0.48) and difference is statistically significant $t(166) = 2.945, p=0.004$.

Table 6. Descriptive statistics for groups differing by participant's age

	Intensity of telework (days per week)	N	Mean	Std. Deviation	Std. Error Mean
Benefits of telework	≥ 4.0	87	3.7241	.93854	.10062
	< 4.0	79	3.2405	1.15362	.12979
Problems of telework	≥ 4.0	87	2.5961	.9496	.1018
	< 4.0	79	2.6456	.893	.1005

Table 7. Independent samples t-test telework perception differences according to the participant's intensity of telework (days per week)

	Levene's Test		t-test for Equality of Means						
	F	Sig. (F)	t	df	2-tailed sig.	Mean Diff.	Std.Err. Diff.	95% Confidence Interval of the Difference	
								Lower	Upper
Benefits of telework	5.534	.020	2.945	150.596	.004	.48363	.16423	.15914	.80812
Problems of telework	.141	.708	-.345	164	.730	-.0495	.1435	-.3328	.2338

According to our results, telework is changing the perception of benefits and problems of work, in line with the constant change of our business environment [28]. Results align with the transformative nature of telework, observed even between its prevalence during the COVID-19 pandemic [29]. These changes can be considered as

broader digital disruption, which has been observed in some industries [30].

While the change of working environment is relatively accepted, existing literature does not agree on the perceptions of telework. Our results partially confirm our H1: There are significant differences in perception of benefits and problems of telework between older and

younger populations. While the younger population is slightly less perceptive of the problems of telework, the differences are not statistically significant. On the other hand, younger employees perceive the benefits of telework on a much higher level, and the differences are statistically significant. Younger employees (less than 35 years of age) perceive benefits of telework 17.55% higher than the older employees. This result is in line with the research in the field stating that younger employees have more appreciation for telework, before [31,32] and after COVID 19 pandemic [33].

Contrary to those results, we can reject the H2: There are significant differences in perception of benefits and problems of telework between different genders. Our results show no significant differences between genders regarding the perception of telework benefits and problems. Compared to the study in Austria, which finds that engagement in telework is still significantly higher for male than for female employees [34], we can argue that our study has roughly engagement between genders.

Our following hypothesis can be of most practical use. We can partially confirm H3 that there are significant differences in perception of benefits and problems of telework between mostly remotely engaged employees and employees who still work in office for more than two days per week. Intensive use of telework (more than four days per week) gives increased perception of benefits, while the problems are perceived relatively equally by both groups. Telework has been perceived beneficial for organizations, but not as much by the decision-makers, as noted in the pre-covid research [35], this finding can encourage its implementation.

5. CONCLUSION

Our research brings new insights into telework perceptions by the employees. While the young employees perceive more benefits of teleworking, there is no difference in the perception of problems of teleworking, between the employees younger and older than 35 years. It might be useful as the motivation factor of young employees, which have been more prone to job-hopping [36]. This points towards the conclusion that problems of teleworking are converging to general issues, not related to the age of employees. No difference between genders can be explained by the limitations of our research sample or by bridging the gap between gender use of telework, which was biased toward male employees. While previous research finds that telework employees are mostly male [34], our sample shows a roughly equal distribution. The final result of our study was that intensive use of telework is associated with a higher perception of its benefits. We can say that there is a learning and adoption curve and that the employees "get used to" telework. Also, observed phenomenon can be explained by the "either / or" nature of benefit manifestation concerning telework intensity. Four or more days per week of teleworking brings a substantial change in the lifestyle and private sphere of employee activity, and it might be observed as a threshold where the perceptions of telework benefits are beginning to take hold substantially. So the companies might consider that while the problems remain at the same perceived level, complete

or near-complete transition to telework will increase the perception of benefits by the employees.

Research limitations are mostly related to the sample, which has been based on the researcher's contact network. Respondents are from Serbia or nearby countries. While it is questionable if it is representative of the general population, it consists mainly of educated professionals and can be considered for inference in Serbian or even similar emerging economic environments. Further research can be aimed at examining separate factors of benefits and problems of telework and the difference in job and life satisfaction related to different aspects and forms of telework.

6. REFERENCES

- [1] Indeed (10.06.2021). 6 Different Work Environment Types and Example Career Roles. Retrieved from <https://www.indeed.com/career-advice/finding-a-job/different-work-environment-types>
- [2] Adler L. (18.07.2017). There are Only Four Types of Work in the World. Retrieved from <https://www.linkedin.com/pulse/every-job-mix-only-four-types-work-lou-adler>
- [3] Workplaceless (2021). Types of Remote Work. Retrieved from <https://www.workplaceless.com/blog/types-remote-work>
- [4] GitLab. Remote Manifesto. Retrieved from <https://about.gitlab.com/company/culture/all-remote/>
- [5] Brown C. (16.03.2020). Covid-19's impact on the enterprise and remote work. Retrieved from <https://www.cio.com/article/3532812/covid-19s-impact-on-the-enterprise-and-remote-work.html>
- [6] Vyas L., & Butakhieo N., (23.12.2020). The impact of working from home during COVID-19 on work and life domains: an exploratory study on Hong Kong. Retrieved from <https://www.tandfonline.com/doi/full/10.1080/25741292.2020.1863560>
- [7] Berzina S. (23.03.2021). Remote work – a forced experiment during the Covid-19 era or a lasting value? Retrieved from <https://www.macroconomics.lv/remote-work-forced-experiment-during-covid-19-era-or-lasting-value>
- [8] Miltz K. (09.04.2021). Change in remote work trends due to COVID-19 in the United States in 2020. Retrieved from <https://www.statista.com/statistics/1122987/change-in-remote-work-trends-after-covid-in-usa/>
- [9] Traqq team. (30.07.2020). Permanent Remote Work: Here Is a SWOT Analysis to Decide If It Is Sustainable. Retrieved from <https://traqq.com/blog/permanent-remote-work-here-is-a-swot-analysis-to-decide-if-it-is-sustainable/>
- [10] McKinsey (23.11.2020). What's next for remote work: An analysis of 2,000 tasks, 800 jobs, and nine countries. Retrieved from

- <https://www.mckinsey.com/featured-insights/future-of-work/whats-next-for-remote-work-an-analysis-of-2000-tasks-800-jobs-and-nine-countries#>
- [11] Limoncelli T.A. (2020). Five Nonobvious Remote Work Techniques. doi 10.1145/3411757.3417752
- [12] Hive (03.12.2020). 2020 Remote Work Survey: What We Learned. Retrieved from <https://hive.com/blog/remote-work-survey-2020-hive/>
- [13] Frost A. (2020). Work from Home Hacks
- [14] Mangia K. (2020). Working From Home. ISBN 9781119758938
- [15] Fievre. M.J., & Anderson B. (2021). Your Work from Home Life. ISBN: (p) 978-1-64250-490-3
- [16] GitLab. (2021). The Remote Playbook.
- [17] Harvard Business Review Press. (2021). Remote Work.
- [18] Reed K.M., & Allen J.A. (2021). Suddenly Virtual. ISBN 9781119793694
- [19] Pozen R.C., & Samuel A. (2021). Remote, Inc.
- [20] Saris, W.E. & Gallhofer, I.N. (2014). *Design, evaluation, and analysis of questionnaires for survey research*. 2nd edition. New York, USA: John Wiley & Sons.
- [21] Bagozzi, R.P., Yi, Y. & Phillips, L.W. (1991). Assessing construct validity in organizational research. *Administrative science quarterly*, 36(3) 421-458. DOI: 10.2307/2393203
- [22] Krishnaswamy, K.N., Sivakumar, A.I., & Mathirajan, M. (2004). *Management Research Methodology: Integration of Principles, Methods and Techniques*. New Delhi, India: Dorling Kindersley Ltd.
- [23] Saunders, M., Lewis, P., & Thornhill, A. (2011). *Research methods for business students*, 5th edition. Harlow, UK: Pearson Education.
- [24] Zikmund, W., Babin, B., Carr, J. and Griffin, M. (2012). *Business research methods, 9th edition*. Cincinnati, USA: South-Western College Pub.
- [25] George, D., & Mallery, P. (2003). *SPSS for Windows step by step: A simple guide and reference* (4th ed.). Boston: Allyn & Bacon.
- [26] Bland, J.M., & Altman, D.G. (1997). Cronbach's alpha. *British Medical Journal*, 314(7080), 572-573.
- [27] DeVellis R. (2003). *Scale development: theory and applications*. Thousand Okas: Sage Publications.
- [28] Cudanov, M., Tornjanski, V., & Jasko, O. (2019). "Change equation effectiveness: empirical evidence from South-East Europe". *E&M Economics and Management*, Vol . 22. Iss. 1, pp. 99-114. doi: 10.15240/tul/001/2019-1-007
- [29] Boell, S. K., Campbell, J., Cecez-Kecmanovic, D., & Cheng, J. E. (2013). The transformative nature of telework: A review of the literature.
- [30] Tornjanski, V., Marinković, S., Šavoju, G., & Čudanov, M. (2015). A need for research focus shift: Banking industry in the age of digital disruption. *Econophysics, Sociophysics & Other Multidisciplinary Sciences Journal (ESMSJ)*, 5(3), 11-15.
- [31] Baruch, Y. (2001), "The status of research on teleworking and an agenda for future research", *International Journal of Management Reviews*, 3(2), pp. 113-129.
- [32] Nakrosiene, A., Buciuinienė, I. and Gostautaitė, B. (2019), "Working from home: characteristics and outcomes of telework", *International Journal of Manpower*, 40(1), pp. 87-101. <https://doi.org/10.1108/IJM-07-2017-0172>
- [33] Erjavec, K. (2020). EMPLOYEES' COMMUNICATION DURING COVID-19. *Leadership, Innovation, Management and Economics: Integrated Politics of Research*, 67.
- [34] Beno, M. (2019). Home-based Telework and the Role of Gender-Results of a Study in Austria. In CONF-IRM (p. 12).
- [35] Harker Martin, B., & MacDonnell, R. (2012). Is telework effective for organizations? A meta-analysis of empirical research on perceptions of telework and organizational outcomes. *Management Research Review*, 35, pp. 602–616. doi:10.1108/01409171211238820
- [36] Ivanovic, T., & Ivancevic, S. (2019). Turnover Intentions and Job Hopping among Millennials in Serbia. *Management: Journal Of Sustainable Business And Management Solutions In Emerging Economies*, 24(1), 53-63. doi:10.7595/management.fon.2018.0023.

PROPERTY TAX EVALUATION AND MANAGEMENT USING GEOSPATIAL TECHNOLOGY

Anu Singh¹, Shruti Kanga^{1*}, Suraj Kumar Singh², Sudhanshu¹

¹Centre for Climate Change and Water Research, Suresh Gyan Vihar University, Jaipur, India

²Centre for Sustainable Development, Suresh Gyan Vihar University, Jaipur, India

*Corresponding author: shruti.kanga@mygyanvihar.com

Abstract. *The current property assessment and tax collection system is today under pressure to improve its efficiency. Changes in the counts of floors, land areas, covered areas, type of building, property occupancy, tax categories, property utilization, land usage, etc., are not regularly updated. In addition, there is no regular monitoring and updating of property units which leads to revenue loss. This research intends to examine the application of spatial technology to improve property tax evaluation processes and work efficiency in the tax process. Research would increase consistency and uniformity in the system of property tax management. Comprehensive geo-statistical reporting, visualization, and theme charts will enable governments to estimate the income recovery potential and build the right policy tool. Tax defaulter, hidden property, possible tax recovery, and tax types of property are easily identified through analysis and visualization. Tax assessment variables can be monitored and updated with GIS and Remote Sensing Technologies, such as areas, tax categories, important roadways, and building types. This will make the property tax system more transparent, efficient, updated, and improved government revenues.*

Keywords: *Property Tax, GIS, Technology, Management, Land use/ land cover, Decision support system*

1. INTRODUCTION

In the past, monitoring and document registration were the most popular technique for maintaining the land ownership track. The position and scope of a property in the property mapping are digitized on the ground, and a unique identification number is assigned [1]. An accurate property mapping should reflect the size and shape of each parcel of a town/town. Data from other sources are deficient and outmoded since reliable paper maps, cad maps, and data are not available. Since there was no CAD drawing or analog to update maps when further spatial subdivisions or consolidations are being implemented [7]. The author has created many digital maps for the analysis of property tax for each parcel. It is considered an important aspect for earth feature system modeling and understanding. Land use is defined as any human activity or economic function associated with a specific piece of soil [8].

In contrast, land cover is defined as the sort of feature on the earth's surface. Land cover maps are now being generated at local, regional, and global levels [9]. A basic map contains crucial background information and is generally paired with other map levels that indicate operational information maintained by a local government department and agency. The DGPS geo-referral map has been developed based on new satellite imagery, toposheet, base maps, a current master plan map, and other input maps. This provides information on all significant physical characteristics, including roads, bridges, city roads,

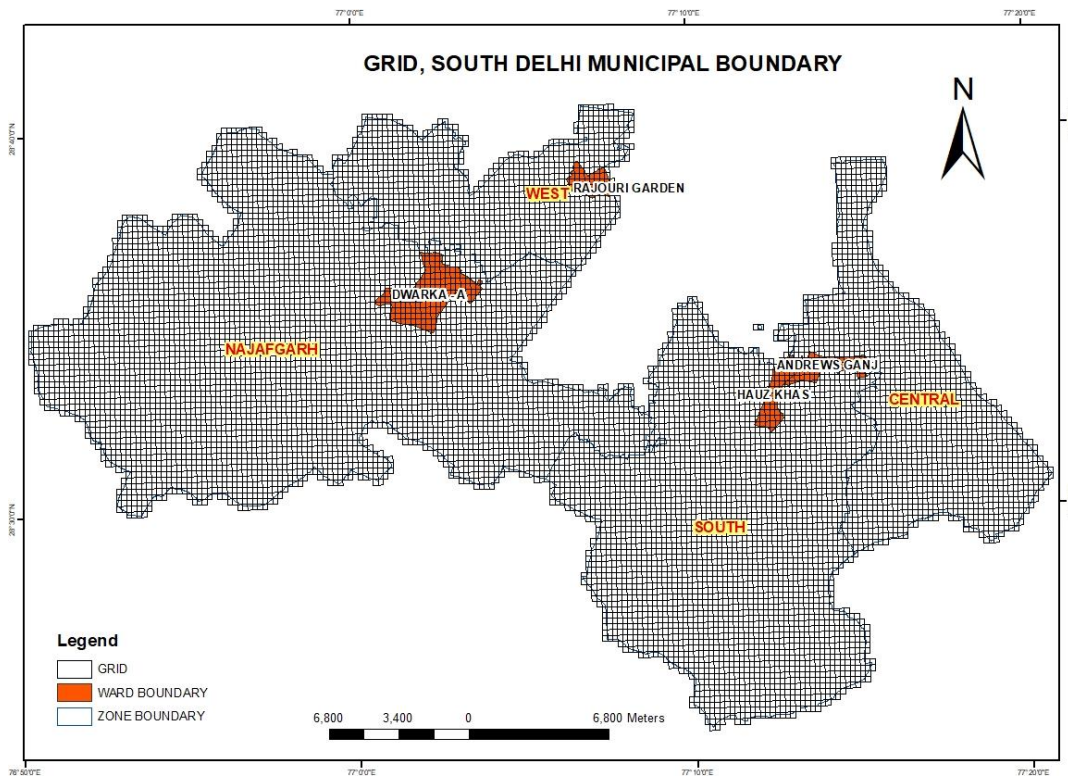
map for the research region, this choice was outdated. In addition, the collecting of corner points using GPS also took time. The raster imagery (satellite imagery) is utilized in the heads-up digitalization as the background image [2]. Regular updates or monitoring are not available in adding or removing distinct units in those revenue sources. For example, in the case of property tax, it is not closely monitored if property taxes are imposed by owners for the addition of homes, floor additions in residences, change of ownership, etc. As a result, towns appear to be losing substantial sums of income [3]. This study shows how the GIS could help monitor this process efficiently and stop revenue loss through effective property tax practices. The property tax is not recognized as high due to poor assessment rates and weaker revenue collection efficiency. Today, the most significant issue for towns and local municipalities is defining improved property valuation procedures, keeping a regular track of income collection, and recording losses due to derogations [4]. An effective GIS can hold correct taxable information and revenue collection that can be visibly monitored. It can periodically send automated notices to taxpayers to inform them of pending duties [5].

Visual representation not just creates a compelling and precise revenue collecting method for the entire property tax system but minimizes the frequency of on-site visits for remedial and other assessment purposes [6]. This would also make all the linked city departments accessible and provide a clear and consistent tax assessment system. The digital tax maps require continuous updates to the corresponding database. This also applies to the necessity

roadways, rails, essential landmarks, watersheds, drains, canals, rivers, etc.

2. STUDY AREA

South Delhi Municipal Corporation (SDMC), which was founded following a division of the erstwhile Delhi Municipal Corporations into three ("trifurcation"), is one of Delhi's municipal corporations. SDMC serves the population of about 56 residents in the Lacs with a responsibility to efficiently monitor, upgrade and expand civic facilities to build a better morning for Delhi citizens. The area is 656,91 km² and is further subdivided into four zones-the Central, South, West, and Najafgarh Zones and contains 104 wards (Fig.1).



Source: Realized by authors

Fig. 1 South Delhi Municipal Boundary

3. MATERIALS AND METHODS

On the system, a unique ID will be established for each property. This database already includes the BUID and PID (Property ID) based on the Grid and Building ID. This unique ID is utilized as a single code for all future reference and identification of the property. But according to the MCD Act, the single ID for a property can be created using a specified formula which can be used to provide citizens and other property reasons. Delhi Municipal Corporation Act (MCDA) deals with the identification code and the way of notification (Property Identification Code Number). The

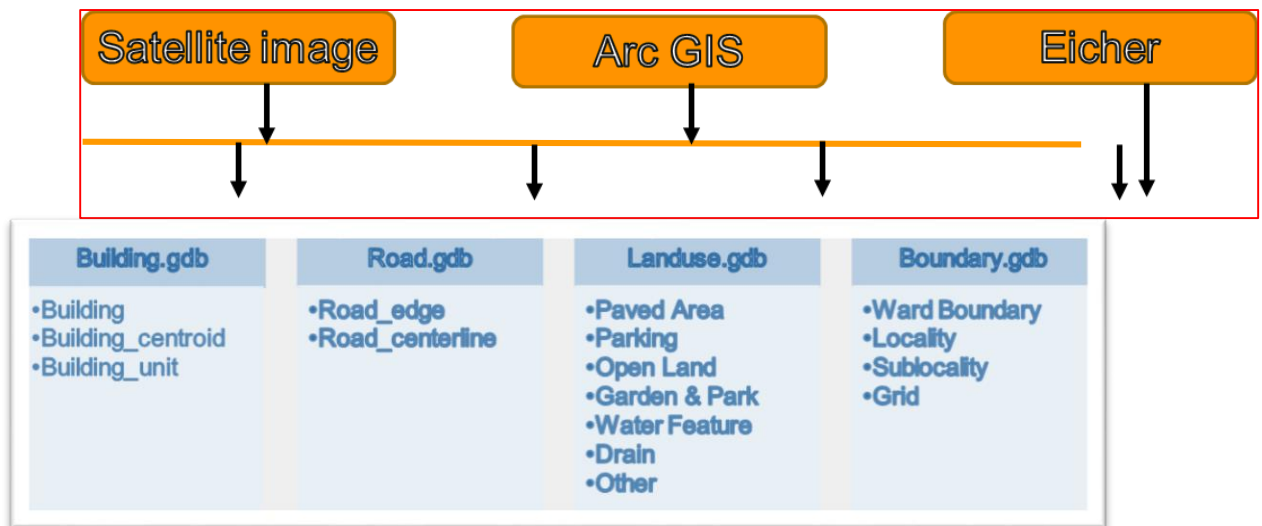
property identification code number by which any procedures in any field within the competence of the company may be known is set as follows:

1. The first three digits shall represent a number of the ward.
2. The following four digits shall show the number of the colony in numerical form.
3. The next six numbers shall show the alphanumeric form of the premises number and
4. The sub-number of numbering premises shall be indicated by the next two digits.

XXX	-	XXXX	-	XXXXXX	-	XX
Ward No.		Colony No.		Premises No.		Sub No.

However, the significant constraint of this frame is that ward boundary of MCD change at least once in

5 to 10 years, based on census data, to equalize population. This means the first 03 digits change once in 10 years at least.



Source: Realized by authors

Fig. 2 Methodology adopted.

Efficient management of real estate taxes relies on reliable, timely, and cost-effective data. The most labor-intensive and expensive property tax administration function is building and maintaining property inventory and attribute databases. Tax mapping is a vital aspect of any integrated property and tax management system. Tax mapping is a classic method for identifying real estate units or “tax plots.” It established the connection between real estate on the spot and property evaluation and tax records of the tax authorities. Tax maps give information about essential real estate for the public. Tax parcel maps are essential for property assessment (evaluation). They enable identifying the property’s location, specify the size and shape of each plot, determine the actual land use, and aid in identifying undeclared properties for taxation. Although tax maps are a general reference to property sites, they do not replace official cadastral survey documents and should not be

utilized in legal disputes over land. They allow the development of a real estate recording system that can be converted to data computing (Fig.2). Digital parcel mapping is the process of digitizing and keeping, and updating tax maps utilizing GIS for local government units based on the paper map (cadastral basis maps, property identification maps). This is usually done in parallel with the installation of a computerized property taxes system. This can take time and cannot be managed sustainably if the process flow and the system’s aim are not thoroughly analyzed from the outset; however, if the advantages for improved property management and higher real estate assessment are numerous based on cautious local wants and requirements analysis. This will significantly expand the local tax base and enhance local authorities’ financial alternatives and freedom to invest in an upgraded social service provision and physical infrastructure. In return, visible efforts will improve local citizens’ “tax morale.”

Usage details:

Grid No.					Survey Sequence No.					
Plot Size/Area (in Sq. mtrs)					Total No. of floors					
(Refer to General Instructions for area conversion)										
Sl No	Floor No.	Type of Property (Refer to Section 2 of Instructions)	Property No.	Property Name	Covered Space (in Sq. mtr)	Type of Occupancy (Uninhabited/ Rented/ Self Occupied)	Type of Structure (Pucca/ Semi-pucca/ Kutcha)	Year of construction	Electricity CA No.	Remarks
1	G	R	1		204	SO	P	1990		
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										

Use Annexure-1, if required.

Floor No. : Basements (B1, B2,...), Mezzanine(M), Stilt/Parking (S), Ground (G), 1st, 2nd....., Terrace (T).

Terrace (check for): Telecom Towers, advertisement hoardings.

Also check for: Advertisement Hoardings / CNG Stations / Petrol Pumps/Storage Tanks/Swimming Pools.

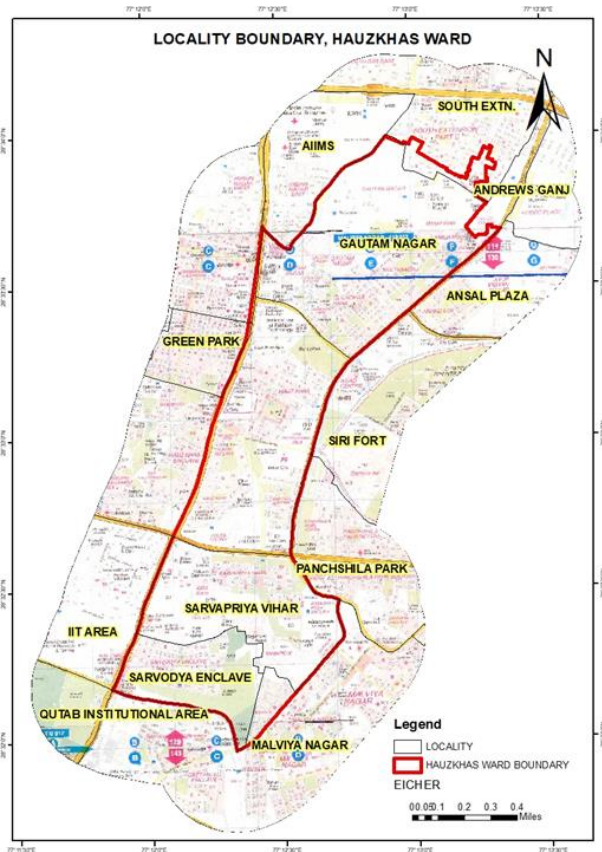
Source: Realized by authors

Table no.1 Survey Form

4. RESULTS AND DISCUSSION

During the administration of the property owner's questionnaire, their property was also evaluated. During the questionnaire delivery, the attribute information or building attributes needed for property assessment not obtained from the photograph were acquired from the field. This comprises the owners' name, house number, address, building type, area, age, usage, tenancy, power supply, and water availability (Table 1). The quality and amount of the data used correlate with the precision of the results of the evaluations, and hence the precision and correctness were ensured [10]. Though the digitalized buildings automatically had a unique identifier to distinguish between the sampled properties and other properties, the GPS coordination locations of the sampled properties were recorded during the sampled property listing. This was done

to facilitate data entry and to allow combined operation for the sampled characteristics. Where the landowners are willing, a photocopy has been gathered from scanning documentation on properties such as a survey plan and approved building plan. The pictures were also taken of the property owners and their properties. These have been scanned and used for HyperText Markup Language (HTML) or linked in the database. This cannot be achieved by the manual property evaluation method due to error or omission, or conduct. The utilization of high-resolution satellite images has solved this difficulty. While it helped attain a 100% coverage essential for tax growth, the classification of property by field research helped to incorporate a taxable property into the tax base. The property owners or their representatives were given a structured questionnaire tailored for the property listing (Fig. 3)



Source:

Realized by authors

Fig.3 Creation of Locality &Sub-Locality Boundary

The utilization of high-resolution satellite images has solved this difficulty. While it helped attain a 100% coverage essential for tax growth, the classification of property by field research helped to incorporate a taxable property into the tax base.

This cannot be achieved by the manual property evaluation method due to error or omission, or conduct [11]. The property owners or their representatives were given a structured questionnaire tailored for the property listing.

During the administration of the property owner's questionnaire, their property was also evaluated. During the questionnaire delivery, the attribute information or building attributes needed for property assessment not obtained from the photograph were acquired from the field. This comprises the owners' name, house number, address, building type, area, age, usage, tenancy, power supply, and water availability. The quality and amount of the data used correlate with the precision of the results of the evaluations, and hence the precision and correctness were ensured [12]. Though the digitalized buildings automatically had a unique identifier to distinguish between the sampled properties and

other properties, the GPS co-ordination locations of the sampled properties were recorded during the sampled property listing (Fig. 4).

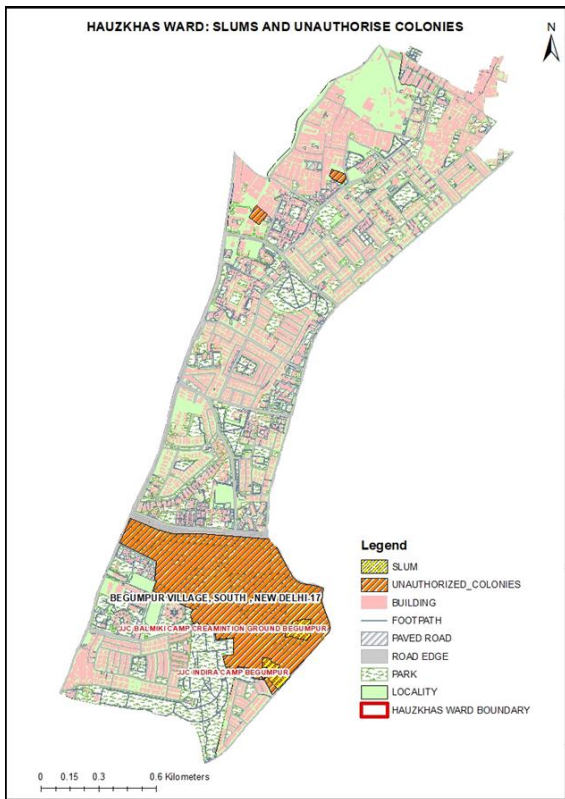


Fig.4a Slum and Unauthorised Colony

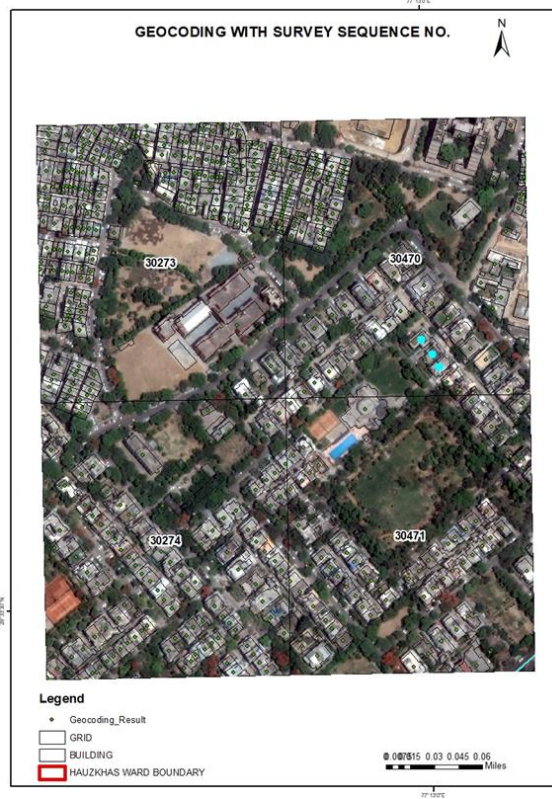
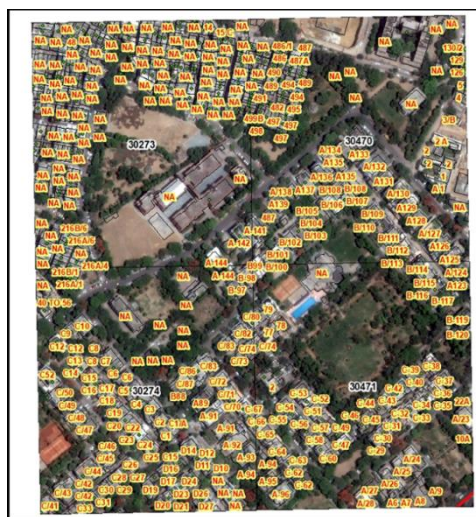
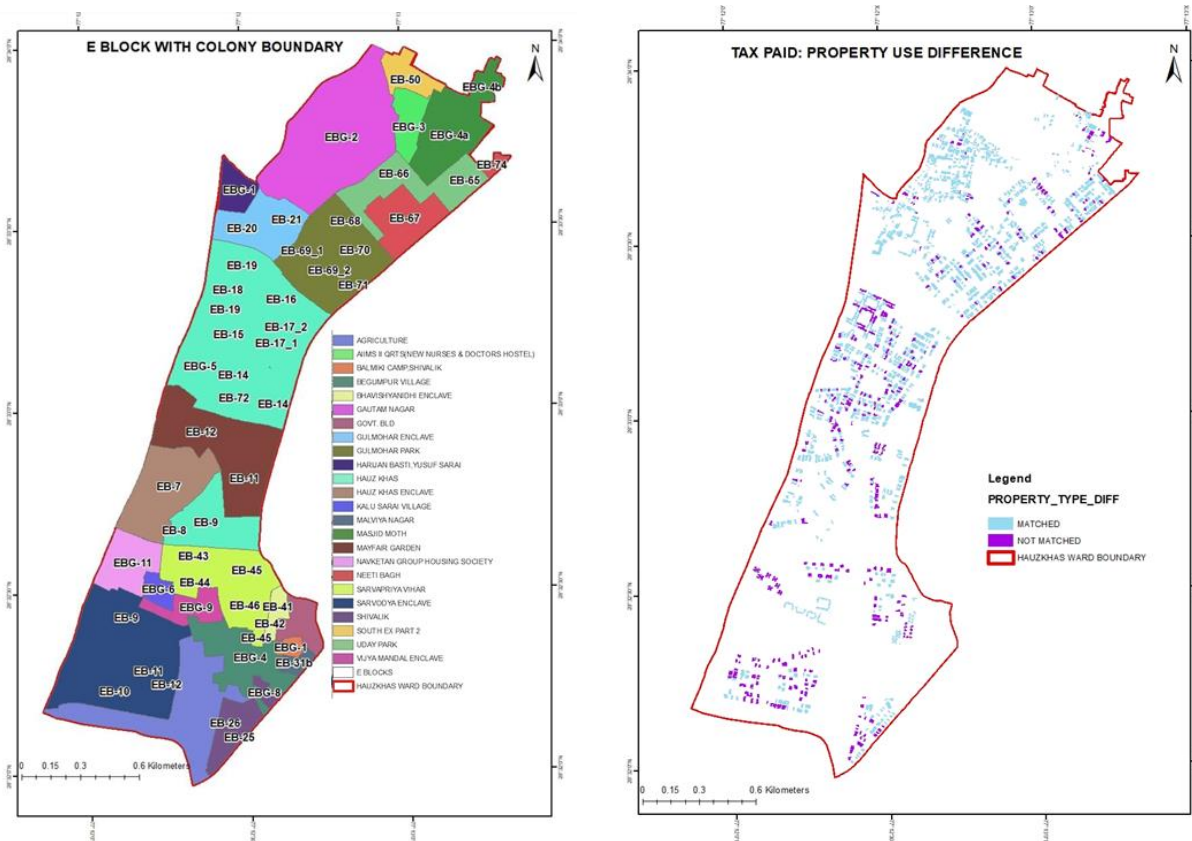


Fig. 4b. Mapping of Survey data



Source: Realized by authors

Fig.5 Creation of Unique No. for Buildings



Source: Realized by authors

Fig. 6 Colony Demarcation and Category Distribution

This was done to facilitate data entry and to allow combined operation for the sampled characteristics. Where the landowners are willing, a photocopy has been gathered from scanning documentation on properties such as a survey plan and approved building plan. The pictures were also taken of the property owners and their properties. These have been scanned and used for HyperText Markup Language (HTML) or linked in the database. The property map has been spatially associated with property attributes to assist in determining property taxes (Fig. 5). The combination of attribute and space data generates the geo-database. The geo-database was linked with the estimator of the fiscal model to offer a simple and effective method of taxation [13]. The evaluation method was used to model an estimate for property tax management. The valuation of property is a complicated task. The assessors always have to provide property owners with easily understandable explanations of how their properties are appreciated. A hyperlink is another convenient approach to identify the property [14]. When you move your cursor over each property, it links the property in the database to the owner's name and displays it on display, as shown. This method can also connect the amount paid or due by the owners of the property. This strategy minimizes search time and simplifies and simplifies the task of property tax managers. Geospatial technology is capable of generating property data in the absence of a cadastral map. It can also be utilized to raise the tax base to 100%, eliminating the delay in property valuation and enhancing property tax revenue collection

[15]. The study also revealed that the GIS-based property tax system could estimate a significant property value in an area in the short term, increasing efficiency, removing valuation delays, achieving effective delivery of services, and reducing operating costs (Fig. 6). While the GIS-based property tax system is recommended, institutional capacity improvement is needed for adequate property tax service providers, notably in remote sensing, GIS, and ICT [16]. Many streets have no name, and many houses are not particularly numerous in the urban development zones. It is advisable to name streets and dwellings as part of creating a GIS property information system.

The success of property tax management depends on the government's political will. Governments are generally interested in programs that create revenues to manage state affairs; consequently, they are most interested in projects which deliver rapid results [17]. Therefore, it calls upon a government with the political will to invest in a long-term project or one willing to invest extensively in a project to complete it within its tenure in office [18]. Given the importance, advantages, and urgency of introducing a GIS-based tax reporting system, the government should have the political will to prioritize the completion of the project to prevent a failure in the mid-term project. Many elements have a role in the economy of land use. Due to its impact locally, property tax has a direct and indirect effect on the economy of land use. Since property tax plays a significant role in land-use decisions, planners should ensure that property tax policies do not meet intended land use goals

and that these goals, if possible, are modelled [19]. There are currently insufficient grounds for adequately discussing many crucial tax/land use linkages. In addition, planners are often not very familiar with tax matters [20]. This study will offer the planner a good understanding of property tax, how it is utilized in other regions to achieve land use aims, and the considerations needed for developing a tax and land use program. Although the general rule is the significant usage of property tax, many localities are considerably less dependent on property tax than others. This is primarily the case in countries that have permitted local governments to charge other taxes, such as sale, income or payroll, and/or given local governments with additional money through grants. Local governments have chosen to use state tax sources to augment local needs with offerings. Finally, it has been established that the real estate component carries the highest taxation burden.

5. CONCLUSIONS

Based on the research and the examination of individual tax plans, various conclusions were formed about land use planning concerning the use of property tax. There are both administrative and substantial concerns with property taxes that affect investment decisions for land use. This influence is, in many situations, negative. The most successful of the reform initiatives enacted so far were those concerning administrative failures. Very little experimentation has been made with substantial reform. As a result, legislation continues to rectify substantive faults in property tax by withdrawing from property tax exemptions. Individualized tax plans had very few ways to assess the efficiency of fiscal measures. Neither case study has disclosed that the local

6. REFERENCES

- [1] Obey, M. & Matikonis, K. 2021. *Small business property tax reductions and job growth*. Small Business Economics - An Entrepreneurship Journal 56, 277–292.
- [2] Koeva, M., Gasuku, O., Lengoiboni, M., Asiama, K., Bennett, R.M., Potel, J. & Zevenbergen, J. 2021. *Remote Sensing for Property Valuation: A Data Source Comparison in Support of Fair Land Taxation in Rwanda*. Remote Sensing 13, 3563.
- [3] Mondal, S., Chakravarty, D., Bandyopadhyay, J. & Kunal, K.M. 2016. *GIS based Land Information System using Cadastral model: A case study of Tirat and Chalbalpur rural region of Raniganj in Bardhaman district*. Modeling Earth Systems and Environment 2, 120.
- [4] McMillen, D. & Singh, R. 2020. *Assessment Regressivity and Property Taxation*. The Journal of Real Estate Finance and Economics 60, 155-169.
- [5] Joy, J., Kanga, S., Singh, S.K. & Sudhanshu. 2021. *Cadastral level Soil and Water conservation Priority Zonation using Geospatial technology*. International Journal of Agriculture System 9(1), 10-26.
- [6] Brueckner, J.K. & Kim, H.A. 2003. *Urban Sprawl and the Property Tax*. International Tax and Public Finance 10, 5-23.
- [7] Cathy, H., Sarah, S., Edward, S. & Pete, W. 2020. *Implementing a land value tax: Considerations on moving from theory to practice*. Land Use Policy 94, 104494.
- [8] Anderson, J. E. 1993. *Use-Value Property Tax Assessment: Effects on Land Development*. Land Economics 69 (3), 263–269.
- [9] Tajani, F., Morano, P., Torre, C.M. & Di Liddo, F. 2017. *An Analysis of the Influence of Property Tax on Housing Prices in the Apulia Region (Italy)*. Buildings 7, 67.
- [10] Che, S., Kumar, R.R. & Stauvermann, P.J. 2021. *Taxation of Land and Economic Growth*. Economies 9, 61.
- [11] Ali, M., Odd-Helge, F. & Lucas, K. (2017). *Property taxation in developing countries*. CMI Brief 16, 1-4.
- [12] Sadhana, J. (2008). *Remote sensing application for property tax evaluation*. International Journal of Applied Earth Observation and Geoinformation 10(1), 109-121.
- [13] Bachofer, F. & Murray S. 2018. *Remote sensing for measuring housing supply in Kigali*. Policy paper, International Growth Centre, London.
- [14] Wyatt, P. 1996. *Using a geographical information system for property valuation*. Journal of Property Valuation and Investment 14 (1), 67-79.

government has undertaken a cost-benefit analysis. In truth, few revenues lost because of the tax subsidy are preserved far lower than the amount due to the tax exemption. In general, many of the tax initiatives have been connected with an overarching development plan or well-defined objectives. It also appears that if they were linked with other regulatory measures, many of the tax schemes would be more effective. The system has been dynamically created to allow the introduction of utilities, despite its capacity to perform property taxation, as data on property water and electricity connections were collected in the database. In addition, organizations have their employment policy and the degree to which systems must be capital-heavy rather than labor-intensive. However, as the property tax information system is related to high technology such as GIS, the application needs to be maintained and maintained according to the information it supports. Since the system has been built to support a continuous program, it must be kept current to achieve its objective because the data will change in due course (update). Precise methods must be developed to preserve and cope with the impact of such developments. The administrative staff must thus produce a strategic strategy and perform thorough research to solve all these problems to ensure that the GIS technology for property tax management is successfully implemented. This solution increases the regular re-inspection of the tax base. It allows users to turn all relevant data sets for a property tax assessment into valuable information without specialization.

- [15] Balaji, L. & Muthukannan, M. 2021. *Investigation into valuation of land using remote sensing and GIS in Madurai, Tamilnadu, India*. European Journal of Remote Sensing 54 (2), 167-175.
- [16] Wyatt, P. 1997. *The development of a GIS-based property information system for real estate valuation*. International Journal of Geographical Information Science 11(5), 435-450.
- [17] Tomar, J.S., Kranjčić, N., Đurin, B., Kanga, S. and Singh, S.K. 2021, *Forest Fire Hazards Vulnerability and Risk Assessment in Sirmaur District Forest of Himachal Pradesh (India): A Geospatial Approach*. ISPRS International Journal of Geo-Information, Vol. 10 No. 7, pp. 447.
- [18] Bera, A., Taloor, A.K., Meraj, G., Kanga, S., Singh, S.K., Đurin, B. & Anand, S. 2021. Climate vulnerability and economic determinants: Linkages and risk reduction in Sagar Island, India; A geospatial approach. Quaternary Science Advances 4, 100038.
- [19] Meraj, G., Singh, S.K., Kanga, S. & Md. Nazrul, I. 2021. *Modeling on comparison of ecosystem services concepts, tools, methods and their ecological-economic implications: a review*. Modeling Earth Systems and Environment. Available online at: <https://doi.org/10.1007/s40808-021-01131-6> Accessed on the 1st of August, 2021
- [20] Kumar, A., Agarwal, V., Pal, L., Chandniha, S.K. & Mishra, V. 2021. *Effect of Land Surface Temperature on Urban Heat Island in Varanasi City, India*. J 4, 420-429.