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Time Management and Performance in Organizations

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Abstract:
Research Question (RQ): Is time management an effective strategy to improve organizational performance?
Purpose: The purpose of the article was to examine research evidence on time management and job and organizational performance. examining past and existent research on time management and its association with job performance and organizational performance.
Method: Using theorizing method of search, I examined secondary data from several readings and analysis of previous research studies and literature on the topic of this article. I reviewed past and existing literature with empirical evidence on the time management impact on job and organizational performance using search engines such as: DOAJ, Google Scholar, Public Med, Elsevier, SAGE, and other databases that contained the themes according to keywords: time management, job performance and organizational performance. To test associations between time management and job and organizational performance and to provide arguments for it, I used Pyramid principle method developed by Pinto (2002).
Results: We tested the association between time management and job and organizational performance. Findings reveal that time management influences personal time behavior, job performance and organizational performance: 1) time management is panacea and not placebo, 2) time management successfully uses organizational resources and implements organization goals 3) time management requires the setting of distinctive time behaviors to impact job and organizational performance.
Organization and society: The awareness of the positive role of time management in the process of improving job and organizational effectiveness, help the management of organization to understand, promote and support time behavior of employees, which results in better performance.
Originality: The research aims at promoting time management is an important factor in following the organization success and helps to provide new evidence on already scarce research on the topic of time management.
Limitations / further research: The research is limited due to scarcity of empirical evidence on the topics and due to limited research articles reviewed available in the contents of search engines used. Research is based on indirect associations and not on correlations, so more rational and quantitative method should be used in future research.

Keywords: notion, time, management, job, effectiveness, behavior, performance, performativity.

1 Introduction

The ability to effectively use time in all endeavors in our personal corporate and institutional life, is a source of personal and organizational effectiveness and productivity. Time management is past two decades at the core of interest of managers, scholars and practitioners. Many research articles and books deal with the topics trying to explain the

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benefits of time management. For example:" Getting Things Done: A radical new approach to managing time and achieving more at work" (Black, 1988), "Essential Management Checklists" (Davidson, 1986), "The Manager's Handbook: The Practical Guide to Successful management" (Young, 1987); "The Art of Doing Twice the Work in Half a Time" (Sutherland, 2014); "The Organized Mind: Thinking Straight in the Age of Information Overload" (Levitin, 2014), are only a few of many books written on this topic.

Surprisingly there is a scarce empirical evidence on research of the impact of time management on job performance and organizational performance. Time management is often viewed as a fad and researchers avoid it. However, the review of literature shows that companies spend a great deal of money to train employees in time management. Macan (1994) argues that possible causes lie in the untested belief that poor allocation of time causes stress and impairs performance.

Researchers often report lack of clarity of the impact of time management on critical outcomes such as job performance and organizational effectiveness (Aeon & Aguinis, 2017). The aim of this article is to identify the influence of individual time management behaviors and its impact on job and organization pealrformance through the empirical research studies on time management, job performance, and organizational effectiveness.

2 Theoretical framework

Claessens (2007) argues that in the last three decades there has been great interest in researching the effect of time in organizational contexts. However, most studies of time in management and organization theory take time for granted. Conversely, there are several studies that address time in organization, but they are primarily unsystematic and dispersed (Lee and Liebenau, 1999).

Chappell et al (2016, p.1) argue that a proper description of time remains a key unsolved problem. They developed the definition of time as independent property of nature: "Time is a scalar component and can be viewed as intrinsic geometric property of three-dimensional space without the need for the specific addition of a fourth dimension".

Newton (2003) developed universal concept of time, which is unique, indefinitely dividable and represents the most objective definition of time. Through the common definition, time can be perceived as 'clock time': linear, homogenous, quantifiable, independent, irreversible and free of contingencies. The need to measure time corresponds with the need to interact with other people in a society. Social time differentiates from the common notion of time in a social group. It corresponds to the differences in beliefs and habits of a social group. (Sorokin and Merton, 1937; Fulmer, Crosby and Gelfand, 2014) Hofstede (1980) argues that time has a cultural background. Culture impacts cognition, motivation, emotions and behavior of the individuals. According to Markus and Kitayama (1991) psychological processes are primarily culturally conditioned as well as concepts and time experiences. Social time is not a

continuous time, it is interrupted by critical events and dates (Sorokin and Merton, 1937). Furthermore, time is closely related to motion, and motion is not possible without time category. According to Lewis and Weigert (1981) social time is connected to meaning that people develop in interactive process, which is framed with physical reality of organism and with natural structure of institutions and organizations in a society, but institutional time is dominant over interaction time.

For Giddens (1984) all social structures arise in particular time and space. Furthermore, Giddens (1984) determines that we can understand the dynamics of a society and its organizations and institutions if we put in the context of particular time and space. Differently, Weick in Quinn (1999) associate organizational changes with sequences of particular events in time. For example, Gomez da Silva and Wetzel (2007) study findings indicate that individual establish a reference to central events to make sense of time changes and to adapt to a new situation. They argue that organizational changes take place in universal time. Ermarth (2010) argues that it is essential to find, which time is in consideration before we study it. At micro level of organizational endeavor, we observe time as time behavior patterns, which are the result of managing time in organizational context. Claessens (2007) classifies time management behaviors in three types: time assessment behavior, planning behavior and monitoring behavior. Ahmad et al (2012, p.938) define time management as: "Act or process of planning and exercising conscious control over the amount of time spent on specific activities, especially to increase effectiveness, efficiency and productivity". Lay and Schouwenburg (1993, p. 648) define time management on the level of personal endeavor as: "Clusters of behaviors that are deemed to facilitate productivity and alleviate stress".

Melville (2019) associates time management with the concept of personal performativity, which is seen as new mode of self-organization in organizational context. Performativity as a form of self - organization, impacts working conditions and includes heavier workloads, increased surveillance and feelings of job insecurity. Ball (2003) argues that performativity requires individuals to organize themselves in relation to their goals, indicators, and measurements. Furthermore, it influences self-concept of a new performative employee as 'diverse self' (Regovec, 2014). Ainsworth and Hardy, (2008) define it as an ideal 'enterprising self' with a passion for excellence. Ball (2003) argues performative notion of self is for some people a chance and opportunity to be successful and for others means inner conflicts, artificiality, and resistance.

Melville (2019) states that performativity as a time management concept reduces workers to producers of performances, which are regularly compared, evaluated, and impoverished. For example, Jex and Elacqua (1999) found out in their research that the use of time management behaviors was negatively associated with strain. Respondents reported that their sense of control over time was associated with time management behaviors and strain. Van Eerde (2003) research results suggest that time management training is helpful in lessening worry and procrastination, decrease in perceived stress and increase in perceived control of time (Häfner and Stock, 2010). However, Lincoln et al (2007) study results indicate that no

significant improvement in time and organizational management skills took place. Furthermore, Adams and Blair's (2019) research reveal that cumulative grade point average was significantly correlated with perceived control of time and that time management behavior did not significantly differ across gender, age, entry qualification, and time spent in the program. Kearns and Gardiner (2007) utilized university staff and students to investigate the relationship between time management related behaviors, perceived effectiveness, and work-related morale and distress. Findings reveal that a clear sense of purpose was the most important for perceived effectiveness at work, followed by planning and prioritizing. Twehues (2013, p.2) study reports that students, who are more involved on-campus with academics, extracurricular activities and employment opportunities achieve greater success in college because they develop more efficient time management skills.

Michelatoyoshiy and Kienen (2018) analytic-behavioral interpretation on phenomenon of time management relevantly contributes to clarity of the types of behavior: a) Self-control, b) Self-knowledge, c) Decision making, and d) Problem solving and components of time management behaviors: a) Application of techniques or resources, b) Planning, c) Productivity and health, d) Academic performance, and e) Organization, required for the effective and autonomous individual time management. Similar study of Jackson (2009) defines another set of key steps to successful time management: 1) set realistic goals, 2) get organized, 3) delegate, 4) relax, 5) stop feeling guilty and points out that there are two stumbling time management blocks: procrastination and perfectionism. For example, Ziapour et al (2015) research findings show effective time management of nurse managers behaviors and factors that comprise these behaviors: setting of objectives, task prioritization, and mechanics of time. Results differ significantly on gender, age, education, job experience, and managerial experience. Furthermore, Lakein (1973) conducted two studies between Thai and Chinese students. Results of the Thai study show behavior strategies: managing time, setting goals, and sequencing tasks. Chinese participants utilized behaviors related to work organization, to work environment and to better time control. Additionally, Harahsheh (2019) and Jackson (2009) study reveals five-time management strategies: fulfilment obligations strategy, time planning strategy, utilization of the resources, time organizing strategy and priorities status strategy of resources. Porta, Anderson, and Steele (2013) found out that time use techniques are effective. According to Chase et al (2013), firm dedication and commitment to building and maintaining a productive program of research is based on effective time management planning. Dimitrova and Mancheva (1918) confirm that planning and time management is a tool to improve the effective use of time. Bahadori et al (2015) research findings show that among time management strategies goal setting has the highest priority. Moreover, Peng and Kamil (2017) found out that time management tools: procrastination and prioritization are of utmost importance to academic performance of students. Harahsheh (2019) research findings on Yarmouk Water Company in Jordan managers show that time management strategies: fulfillment obligations strategy, time planning strategy, utilization of the resources, time organizing strategy and priorities status strategy of resources, have positive impact on employee performance. Al hila et al (2017)

research findings on time behavior show that time behaviors are ranked: time management, time control, time planning, and organization of time.

Findings of various research studies show the effect of time management behavior on various factors that improve performativity, personal effectiveness, and job performance. Eshaghieh and Eslami (2015) research findings reveal a positive and significant relationship between personal, environmental, organizational and time management factors and employee productivity. Using time management behavior increases employee productivity. Ahmad et al (2012) research findings indicate that the employees job performance in the organization were affected by their time management in completing the tasks during an event. Ball (2003) Fenner and Renn (2010) research findings show that time management as setting goals and priorities, moderated between work-to-family conflict and technology-assisted supplemental work reduced work-to-family conflict. Elsabay et al (2015) research study reveals that head nurses attending time waster post program report a significant relationship between time management and job satisfaction. Miqdadi et al (2014) showed similar results stating that time management is highly related to academic performance. Chanie (2020) found out that satisfaction with organizational policies, performance appraisals, compensation and benefits and planning were significantly associated with time management practices. Abduljabbr (2012) university research study reveal that positive relationship between time planning and time attitude and job performance, and inverse relationship between time wasters and job performance. Similarly, Awan et al (2020) study acknowledges significant impact of performance management system and work engagement on task and contextual performance of employees. Moreover, Kamaruddin et al (2017) research study among female workforce in Malaysia reports that time management and motivation have a significant, positive relationship with job performance.

Organizational effectiveness is a concept how effective an organization is in achieving its goals. Georgopoulos (1957) defines the concept of organizational effectiveness as ‘success’ or ‘worth’ or how well an organization is doing. He assumes that all organizations attempt to achieve certain objectives and develop products and services through the proper manipulation of given animate or inanimate facilities.

Many studies deliver research data on organizational effectiveness. Studies reveal the core mission of organization to fulfill its mission and fulfill its goals through organizational effectiveness. In this process organizational effectiveness refers to processes and tools that increase efficiency and productivity (Ziekye, 2016). Cunningham (1997) presents seven alternative strategies for assessing organizational effectiveness: rational goals, system resources, managerial process, organizational development, bargaining, and structural functions.

Organizational performance is another tool how well is organization doing. It is considered to be multidimensional phenomenon and is closely related to organizational effectiveness. Moreover, it is a sub-factor of organizational effectiveness, which is broader and linked to

other internal performance outcomes and external economic factors such as corporate social responsibility. Gond et al (2015) argue that the 'performance' company is a widely used metaphor denoting efficiency or profitability using the Lyotard (1984) in The Postmodern Condition links definition of performativity through the measurement of efficiency as a result of input/output ratio. According to Melville (2019) performativity is a system of classification and numeration in relation to knowledge and performance. This system is used to compare, judge measure and categorise the organization members performance. Performativity is symbolic of 'performing – self' in organization and the transformation of learning from personal space to organizational performance. Furthermore, performativity is associated with presenteeism phenomenon that defines modern workplace and refers to employees who work long working hours (Macfarlane, 2015; Cooper, 1998; Kowalski & Loretto, 2017). Furthermore, Richard et al (2009) argue that definition of organizational performance is an open question because structure and definition of it are rarely explicitly stated. According to Richard et al (2009) organizational performance covers three organizational outcomes: financial performance, product market performance and stakeholder return. March and Sutton (1997) link organizational performance to rational success factors, because they aggregate it from accounting, sales, financial reports and stories of organizational history. Han et al (1998) argue about the fourth outcome which is organization innovation. Suhag et al (2017) results of a research study in the telecommunication industry shows that product innovation, process innovation and organizational innovation are linked to organizational performance.

Daniel and Santeli (2020) study reveal that there is a positive relationship between the organizational performance and effective time management. Sutharshini et al (2019) demonstrated in their study that there is a link between effective time management and organizational performance mediated by personal performance. The research results of Wahbeh et al (2016) show that time management supports the effectiveness of performance dimensions of the organization such as internal business processes, learning, growth and the sustainability. Ojokuku and Kehinde (2011) reveal existence between time management and organizational performance stating that time management is effective if set at the beginning of organizational activities. Rapp et al (2013) built and tested theory focusing on the moderating role of time management skill in the nonmonotonic relationship between organizational citizenship behaviour and task performance. Results indicate that the curvilinear association between OCB and task performance is significantly moderated by employees' time management skill. Mohammad (2016) conducted research to predict managers' organizational productivity with regard to managerial talent and time management of school managers. Findings reveal that managerial talent and time management significantly relate to organizational productivity. Ziekye (2016) states that the more efficiently organization use time, the more productive and effective it becomes. The author emphasizes responsibility and discipline as factors that enable organizational effectiveness. Contrary, Claessens, et al (2007) findings demonstrate that the impact of time management behaviors on work and academic performance is not clear.

At the beginning of our research, I stated this statement: Time management is effective strategy to improve performance, following by key question:

Proposition1: Do time behavior strategies of employees improve performance?
and followed by sub- propositions:

- **Proposition 1a:** Personal time management strategies improve the effectiveness of an employee.
- **Proposition 1b:** Personal time management strategies improve job performance.
- **Proposition 1c:** Personal time management strategies improve performance of an organization.

3 Method

Fort the assessment of the associations between time management, job performance and organizational performance in a Time management and performance model (*Figure 1*) I used Pyramid principle method developed by Minto (2002). Pyramid method is based on:

- the stating the problem of a research,
- developing the key question and statement of a research,
- through pyramid or hierarchical classification of arguments finding the answer to key question (Minto, 116).

In the process of theorizing, I focused on issues in articles and books that can provide answers on key question and sub-questions of the research study (Hammond, 2018).

The findings in the present paper are based on secondary data from several readings and analysis of previous research studies and literature. I primarily used accessible research search engines such as: DOAJ, Google Scholar, Public Med, Elsevier, SAGE, and other databases that contained the topics according to keywords. I reviewed all the extracted articles using keywords as a criterion for inclusion of the research articles in a study regardless of the publishing date:

- Time management,
- Job performance,
- Organizational effectiveness,
- Organizational performance.

My research findings show that important issues on:

- Notion of time was found in13 articles,
- Notion of time behavior was found in16 articles,
- Notion of time management was found in 13 articles, notion of job performance was found in 10 articles,
- And notion of organizational effectiveness and performance was found in 21 articles.

These keywords were used to gather information to confirm Proposition 1, Proposition 1a, Proposition 1b, and Proposition 1c in a Time management and performance model (Figure 1).

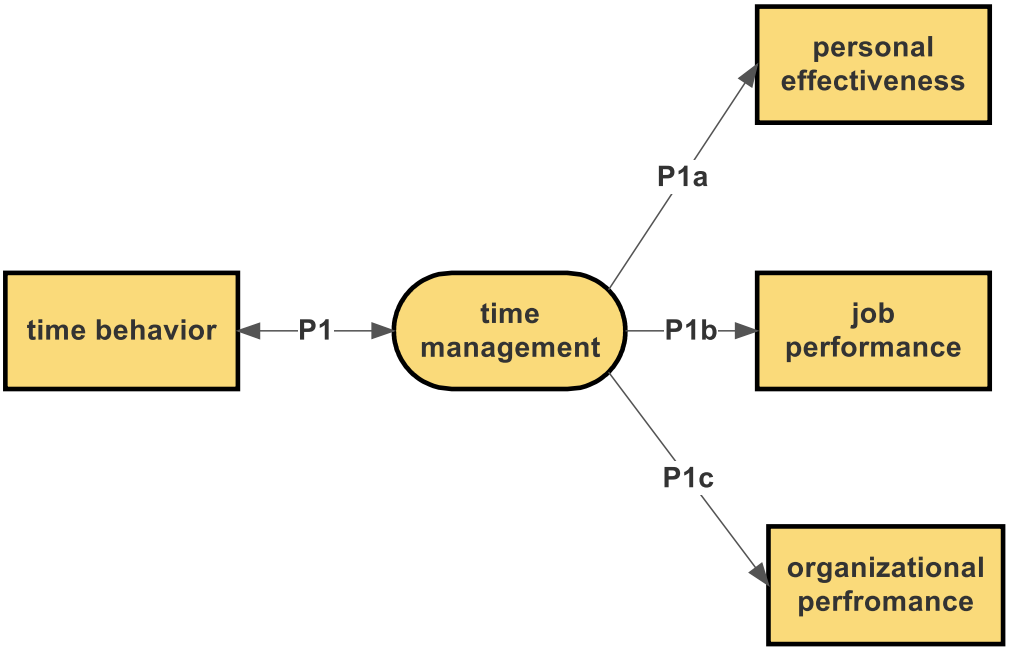

Figure1. Time management and performance model

Figure 1 presents the time management and performance model that is based on the effective use of time. Model shows that time behavior (P1) is in interaction with the time management activities that influence personal (P1a), job (P2a), and organizational performance or effectiveness (P3a).

4 Results

To be successful and to do well in severe competitive environment, modern organization must adopt performative and effective organizational behavior, linked to effective time management to excel in productivity. Time is universal (Newton, 2003). Chappell et al (2016) argue that time is independent property of nature, and only people, institutions and organizations produce different notions and meaning of time. Social notion of time in the form of institutional time prevails and dominates all human and institutional activities (Lewis & Weigert, 1981).

The need to measure time corresponds with the need to interact with other people in a society. From the organizational and time management point of view, linear notion of time or 'clock time' homogenous, quantifiable, independent, irreversible, and free of contingencies is measured on fixed scales in the form of seconds, minutes, days, weeks, and years (Lewis and Weigert, 1981). Of particular importance is the social time, or institutional time (Sorokin and Merton, 1937), which can be measured as a set of critical events or dates or as a sequential time (Weick & Quinn, 1981; Gomez da Silva & Wetzel, 2007). Furthermore, time behavior is affected by cultural notion of time through values, norms, and beliefs (Hofstede, 1980) and by

time and space of institutions (Giddens, 1991). Ermarth (2010) points out that the selection of the appropriate notion of time, affects the perception of time in organizational setting. On the individual level, organizational time presents itself as a self-organization in the form of performativity (Melville, 2019). Ball (2003) argues that performativity requires that individuals organize themselves in relation to their goals, indicators, and measurements.

Porta, Anderson, and Steele (2013) confirms that time use techniques are effective. Harahsheh (2019) and Jackson (2009) findings associate time management behavior with obligations strategy, time planning strategy, utilization of resources, time organizing strategy and priorities status strategy of resources. Claessens (2007) understands time as a behavior, which functions as an assessment, planning and monitoring behavior. Ahmad et al (2012), Michelatoyoshiy and Kienen (2018), Jackson (2009) Ziapour et al (2015) Lakein et al (1973) (Chase et al (2013), and Dimitrova and Mancheva (1918) see it as work and activity organization and managing time, process of planning procrastination, prioritization, and sequencing tasks.

Peng and Kamil (2017) understand it as a setting of realistic goals. Bahadori et al (2015), define it as delegating, and exercising conscious control of time. Moreover, Al hila et al (2017); Häfner and Stock (2010), and Adams and Blair (2019) link it to increased personal and organizational effectiveness, efficiency, and productivity. Further, Lay and Schouwenburg (1993), Jex and Elacqua (1999), and Van Erde (2003) time behavior explain as clusters of behavior that facilitates productivity and alleviate stress and reduce strain.

Findings of various research studies confirm the effect of time management behavior on various factors that improve performativity, personal effectiveness, and job performance. Eshaghieh and Eslami (2015) state that using time management behavior increases employee productivity through personal, environmental, and organizational factors. Ahmad et al (2012) research findings show more precisely the relation between the employee's job performance and the use of event time management to complete the task. Miqdadi et al (2014) and Abduljabbr (2012) demonstrate similar results stating that time management in the form of time planning, time attitude and job performance is highly related to academic performance. Abduljabbr (2012) even found out inverse relationship between time wasters and job performance. Similarly, Awan et al (2020) and Kamaruddin et al, (2017) studies acknowledge significant impact of performance management system and work engagement on task, contextual performance, and motivation of employees. For example, Chanie (2020) research study results show that satisfaction with organizational policies, performance appraisals, compensation, benefits, and planning, are the result of time usage practices. Several other research study results show that time management practices and technology – assisted work reduced work-to-family conflict and job satisfaction (Ball, 2003; Fenner and Renn, 2010; Elsabay et al, 2015).

Georgopoulos (1957) defines the concept of organizational effectiveness as 'success' or 'worth' or how well an organization is doing. According to Ziekye (2016), and Cunningham

(1997), organizational effectiveness refers to processes and tools that increase efficiency and productivity through various time behavior strategies: rational goals, system resources, managerial process, organizational development, bargaining, and structural functions.

Gond et al (2015) argue that the 'performance' company is a widely used metaphor denoting efficiency or profitability through the measurement of performativity as a result of input/output ratio, as a system used to compare, judge measure and categorise the organization members performance. Lyotard (1984); Melville (2019); Macfarlane, (2015); Cooper (1998); Kowalski and Loretto (2017), and Richard et al (2009) argue that definition of organizational performance is an open question because structure and definition of it are rarely explicitly stated. According to March and Sutton (1997) organizational performance is linked to rational success factors: financial factors, product performance, and stakeholder return. Han et al (1998), added the fourth innovation factor, which includes: product innovation, process innovation and organizational innovation that are linked to organizational performance.

Daniel and Santeli (2020) and Ojokuku and Kehinde (2011) and Rapp et al (2013) studies reveal that there is a positive relationship between the organizational performance and effective time management. Moreover, Sutharshini et al (2019) argue that personal performance mediates relationship between effective time management and organizational performance. Additionally, time management supports internal business processes, learning, and growth and sustainability. (Wahbeh et al, 2016) Further, Mohammad (2016) and Ziekye (2016) related managerial talent and time management to organizational productivity.

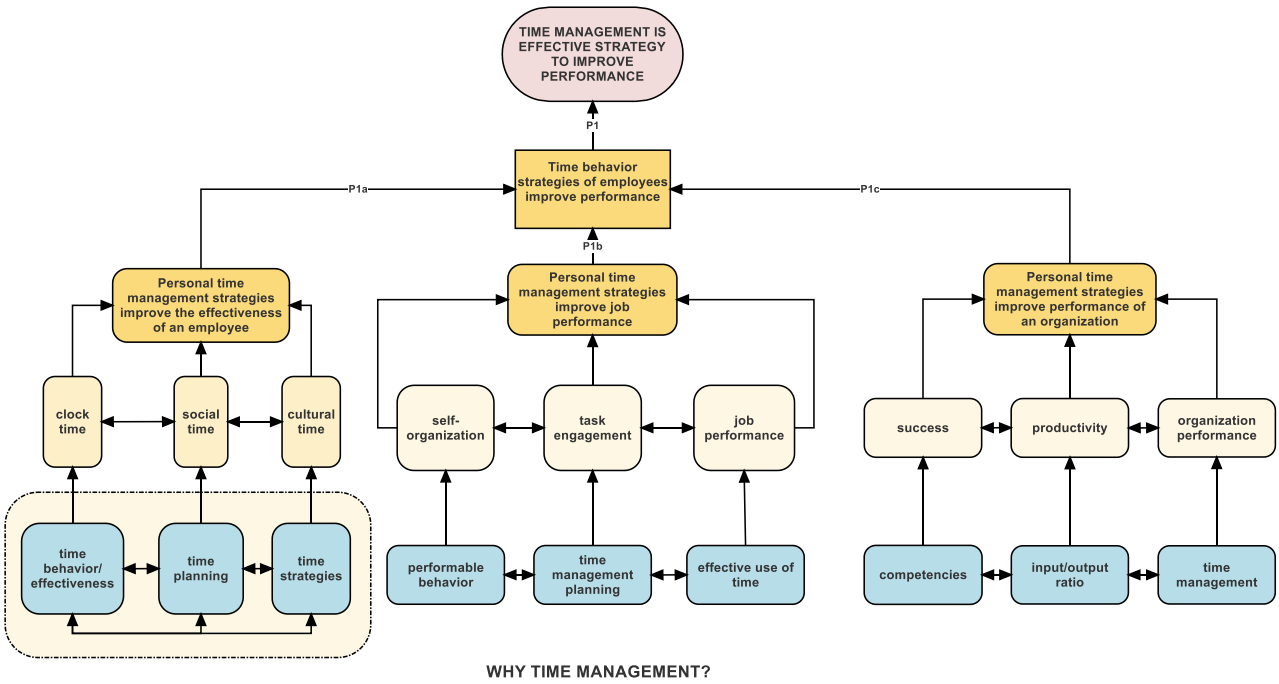

Figure 2. Effective time management and performance model

5 Discussion

According to the research findings in the literature on personal effectiveness, proposition 1a can be accepted: 'Personal time management strategies improve the effectiveness of an employee'. Research findings confirm that linear of time, social time resulting in events time, and cultural time set the time notion basis for the measurement of personal performable behavior, and job and organizational performance. Research findings with one exception show that there is an association between behavior strategies, resulting in time planning activities, and personal effectiveness or performativity.

Furthermore, research findings on association between personal performativity and job performance, give enough evidence to accept the proposition 1b: 'Personal time management strategies improve job performance'. The answer is positive, as such, we can confirm proposition 1b. Research evidence on job performance confirms that performable behavior and time management planning of task execution led to effective use of time, and performable behavior leads to self-organization. Self-organization of a job motivates task engagement and increases job performance. Time planning strengthens motivation to perform the task, positively influences the job satisfaction, reduces conflicts in the working team and improves the quality of personal life.

Research findings on the association between personal time management and organizational performance show that personal time planning in an opportunity to learn new competencies that result in higher input/output ratio of the organization and strengthens the management engagement in implementing time management strategies. New competencies lead to more successful coping with environment and to improved usage of available resources of an organization that lead to higher productivity and consequently to improved organizational performance. Evidence on association between personal time management and performance lead us to the acceptance of the 1c proposition: 'Personal time management strategies improve performance of an organization'.

6 Conclusion

To summarize, I explored the role of time behaviors and time management in the relationship to job and organization performance.

Firstly, I confirmed that time management is panacea and not placebo because it is the product of linear, social, cultural and performable time.

Secondly, I confirmed, that time management is one of the essential and vital components for successful implementation of organization goals and effective use of organization resources in delivering superior job and organizational performance.

Thirdly, I confirmed that time management requires setting time behaviors that result as: setting of a mission of organization, goals and priority setting, work and activity organization, planning of procrastination and prioritization, sequencing tasks, conscious control of time and

monitoring. This requires the engagement of disciplined and responsible time behaviors and systematic time management of all members of organization.

Furthermore, time management improves employee's competence in performing the job and implicitly the performance of organization. The article argues that time behaviors that form time management based organizational culture, are essential to development of effective time management on all levels of organization.

Present research study has limited generalizations. Available research articles due to selective availability do not reflect the whole body of research on time management and performance in organizations. Furthermore, research findings do not reflect correlations, but only associations that can be concluded on the non-comparable research findings. It is proposed to use structural equation model as a method in a future research to address all possible correlations between variables of time management, job performance and organizational performance.

Research evidence of the impact of time management on personal, job, and organizational performance is often unsystematic and unclear. Further research endeavour should address rational, emotional, cultural, and situational factors to reveal broader scope of time management factors that influence performance on all levels of organization.

References

1. Abduljabbr, N.A., Mahdi, O.R., Almsafir, M. K. (2012). Relationship between Time Management and Job performance: Empirical Study in Malaysia Privet University. *Journal of Advanced Social Research,2*(10), 427-438..
2. Aeon, B., Aguinis, H. (2017). It's about time: New Perspectives and Insights on Time Management. *Academy of Management Perspectives*, *31*(4), 309–330.
3. Ahmad, N. L., Ahmad N. M. Y., Diyana Mohamed Shobri, N. D. M., Wahab, S. (2012). The Relationship between Time Management and Job Performance in Event Management. *International Social and Behavior Sciences, 65*, 937-941.
4. Al Hila, A., Mazen A. l., Shobaki, N. S. A., Naser, S. A., Amuna, Y. A. (2017). The Reality of the Effectiveness of Time Management from the Perspective of the Employees of the Beauty Clinic of Dentistry. *International Journal of Engineering and Information Systems (IJEAIS) 1* (6), 137 – 156.
5. Adams, R. V., Blair, E. (2019). Impact of Time Management Behaviors on Undergraduate Engineering Students' SAGE Open, 1-11, DOI: 10.1177/2158244018824506 journals.sagepub.com/home/sgo
6. Awan, S. H., Habib, N., Akhtar, C. S., and Navee, S. (2020). Effectiveness of Performance Management System for Employee Performance Through Engagement. *SAGE Open*, 1-15.
7. Ball, S. (2003). The teacher's soul and the terrors of performativity. *Journal of Education Policy*, *18*, 215–228.
8. Bahadori, M., Salesi, M., Ravangard, R., Hosseini, S. M., Raadabadi, M., Dana, A. H., Ameryoun, A. (2015). Prioritization of Factors Affecting Time Management among Health Managers. *IntJ Travel Med Glob Health. 3(4), 159-164.*

9. Chanie, M.G., Amsalu E.T., Ewunetie, G. E. (2020). Assessment of time management practice and associated factors among primary hospitals employees in north Gondar, northwest Ethiopia. PLoS ONE 15(1).
10. Chase, JA, D., Topp, R. V., Smith, C. E., Cohen, Z.M., Fahrenwald, N., Zerwic, J., Benefield, L. E., Anderson, C. M. (2013). Time Management Strategies for Research Productivity. *Western Journal of Nursing Research*, *35*(2),155-176.
11. Chappell, J.M., Hartnett, J. G., Ianella, N., Iqbal, A. Abbott, D. (2016). Time as a Geometric Property of Space *Front. Phys.,17.*
12. Chen, N., Rau, P. and Suriyalaksh, P. (2017) How Thai and Chinese Young Adults Manage Time? *Psychology*, *8*, 717-727.
13. Claessens, B., van Erde, W., Rutte, C. G., Roe, R. A. (2007). A review of the time management Literature *Personnel Review*, *36*(2), 255-276.
14. Cooper, C. L. (1998). The changing nature of work. Community, *Work and Family*, *1*(3), 313–317.
15. Cunningham, J. B. (1997). Approaches to the Evaluation of Organizational Effectiveness. *Academy of Management Review*, 463-474.
16. Daniel. C. O., Santeli, J. N. (2020). Effective time on employee performance of Northern Nigeria noodle company ltd *International Journal of Research Science & Management 7*(1),72-81.
17. Dimitrova, V., Mancheva-Ali, O. (2018). Planning and time management. International Conference Knowledge-based organization, XXIV (1).
18. Elsabahy, H. E. Sleem, W. F., Hala Gaber El Atroush, H. G. (2015). Effect of Time Management Program on Job Satisfaction for Head Nurses. *Journal of Education and Practice 6*(32), 36-44.
19. Evangelopoulos, N. (2011). Citing Taylor: Tracing Taylorism's Technical and Sociotechnical Duality through Latent Semantic Analysis. *Journal of Business and Management*, *17*(1), 57-74.
20. Ermarth, E. D. (2010) Time is finite: The implications for history, Rethinking History, *14*(3), 321-341.
21. Eshaghieh A. E., Saeed Eslami, S. (2015). The Effect of Time Management on Human Resources' Productivity Social Security Organization of Yazd. *J. Appl. Environ. Biol. Sci., 5*(11), 69-79.
22. Fenner, G. H., Renn, R. W. (2010). Technology-assisted supplemental work and work-to-family conflict: The role of instrumentality beliefs, organizational expectations and time management. *Human relations,63*(1). 63-82.
23. Giddens, A. (1984). *The Constitution of Society*. Cambridge: Polity.
24. Georgopoulos, B. S. (1957). The study of organizational Annual Conference of the American Association for Public Opinion Research, Washington D.C.
25. Gomez da Silva, J. R., Wetzel, U. (2000). Organizational Change and the Meaning of Time. *Brazilian Administration Review*, *4*(3) 16-30.
26. Gond, J. P., L. Cabantous, N., Harding and M. Learmonth (2015). What do we mean by performativity in organizational and management theory? The uses and abuses of performativity. International Journal of Management Reviews, 18(5), 440-463.
27. Hammond, M. (2018). An interesting paper but not sufficiently theoretical: What does theorize in social research look like? *Methodological Innovations*, 1-10.
28. Han, Jin K.; Kim, Namwoon; and Srivastava, R. K. (1998). Market Orientation and Organizational Performance: Is Innovation a Missing Link? *Journal of Marketing*. *62*(4), 30-45. Research Collection Lee Kong Chian School of Business. Available at:
29. Harahsheh, F. (2019). The effects of time management strategies on employee's performance efficiency: Evidence from Jordanian firms. *Management Science Letters 9,* 1669–1674.
30. Häfner, A., and Stock, A. (2010). Time Management Training and Perceived Control of Time at Work. *The Journal of Psychology*, *144*(5), 429–447.

31. Jackson, V.P. (2009). Time management: A Realistic Approach. *J Am Coll Radiology. (6)*, 434-436.
32. Jex, S. M., Elacqua, T. C. (1999). Time management as a moderator of relations between stressors and employee strain. *Work & stress*, *13*(2), 2182-191.
33. Kamaruddin, S. N., Omar, K., Muda, M. H., Saputra, J., Siti, A. I. (2017). Motivation, time management and work performance among female workers in Malaysia, *International Journal of Advanced and Applied Sciences.4*(12), 273-280.
34. Kearns, H., Gardiner, M. (2007). Is it time well spent? The relationship between time management behaviours, perceived effectiveness and work-related morale and distress in a university context *Higher Education Research & Developmen, 26*(2), 235–247.
35. Kowalski, T. H. P., & Wendy Loretto, W. (2017). Well-being and HRM in the changing workplace, *The International Journal of Human Resource Management*, *28*(16), 2229-2255.
36. Harahsheh, F. (2015). The effects of time management strategies on employee's performance efficiency: Evidence from Jordanian firms *Management Science Letters,9,* 1669–167.
37. Lay, C. H., Schouwenburg, H. C. (1993). Trait Procrastination, Time management, and Academic Behavior. *Journal of Social Behavior and Personality 8*(4), 647-647.
38. Lee, C. Y. (1988). Time management strategy, job satisfaction, research productivity, and life satisfaction of university faculty. Retrospective Theses and Dissertations. 9766. https://lib.dr.iastate.edu/rtd/9766
39. Lee H, Liebenau J. (1999). Time in Organizational Studies: Towards a New Research Direction. *Organization Studies*. *20*(6):1035-1058.
40. Lewis, J. D., & Weigert, A. J. (1981). The structures and meanings of social time. *Social Forces, 60*(2), 432-462.
41. Macan, T. H. (1994). Time Management: Test of a Process Model. *Journal of Applied Psychology*, *79*(3). 381-391.
42. Lincoln, M. Barbara J. Adamson & Covic, T. (2004). Teaching time and organizational management skills to first year health science students: does training make a difference? *Journal of Further and Higher Education, 2*8(3), 261-276.
43. Macfarlane, B. (2015). Student performativity in higher education: converting learning as a private space into a public performance. *Higher Education Research & Development, 34*(2), 338–350.
44. March, J. G., Sutton, R. I. (1997). Crossroads - Organizational Performance as a Dependent Variable. *Organization Science,8*(6), 698-706.
45. Melville, P. (2019). Review of Stephen Ball's article The teacher's soul and the terrors of performativity. The Open University UK.
46. Michelatoyoshiy, S., Kienen, N. (2018). Time management: a behavior analysis interpretation. Psicol. educ. [online]. 47, 67-77. ISSN 1414-6975. http://dx.doi.org/10.5935/2175-3520.20180019.
47. Miqdadi, F. Z., Abdulla F., ALMomani, M. T., Masharqa, S., and Nabil M. Elmousel, N. M. (2014). The Relationship between Time Management and the Academic Performance of Students from the Petroleum Institute in Abu Dhabi, the UAE ASEE Zone I Conference, University of Bridgeport, USA, 1-5.
48. Mohammad, H. P., Pourshanbe, H., Marziyeh, A. Nazari, A. (2016). Predicting Managers' Organizational Productivity with Regard to Managerial Talent and Time Management 7(2), 107-115.
49. Dimitrova, V., Mancheva, O. (2018). Planning and time management. International Conference Knowledge-based organization Vol. XXIV No 1.
50. Newton, T. (2003). Crossing the great divide: time, nature and the social. *Sociology, 37*(3), 433-457.

51. Ojokuku, R., M. Obasan Kehinde, A. (2011). Time Management and Organizational Performance:
52. A Causal Analysis *Pakistan Journal of Business and Economic View*, *2*(1), 60-74.
53. Peng, T. Z., Kamil, B. A. M. (2017). Time management, procrastination and prioritization: a framework for service-based learning module. *E-Academia Journal*, *6*(2), 60-70.
54. Minto, B. (2002). *The Pyramid Principle*. Prentice Hall.
55. Porta, C. R., Anderson, M. R., and Steele, S. R., (2013). Effective Time Management: Surgery, Research, Service, Travel, Fitness, and Family *Clin Colon Rectal Surg*. *26*(4), 239–243.
56. Rapp, A. A., Bacrach, D. G., Rapp, T. (2013). The Influence of Time Management Skill on the Curvilinear Relationship Between Organizational Citizenship Behavior and Task Performance. *Journal of Applied Psychology American Psychological Association, 98*(4), 668–677.
57. Richard, P. J., Devinney, T. M., Yip, G. S., Johnson, G. (2009). Measuring Organizational Performance: Towards Methodological Best Practice. *Journal of Management 35*, 718 -804.
58. Regovec, M. (2014). Is promiscuity a neurotic activity or was Freud right? Differences between the sexes? *Anthropos 3-4*, 71-83.
59. Sorokin, P. A., & Merton, R. K. (1937). Social time: a methodological and functional analysis. *The American Journal of Sociology, 42*(5), 615-629.
60. Suhag, A. K., Shafique Rahman Solangi, S. R., Raja Sohail Ahmed Larik, R. S. Muhammad Kamil Lakh, M. K., and Altaf Hussain Tagar, A. H. (2017). The relationship of innovation with organizational performance. *International Journal of Research - Granthaalayah*, *5*(2), 292-306. https://doi.org/10.5281/zenodo.345736
61. Twehues, A. (2013). Success and the Balance of Commitment and Time: Effects of Perceived Time Management Control on College Student Performance. Honors Theses. 130.
62. Wahbeh, N., Mohammed, H., Al Daher, O., Al shatter, A. (2016). The Mediating Effect of Time Management on the Relationship between Knowledge Management and Organization Performance Comparison Between local and the International NGOs, *Arabian J Bus Manag Review*, *S3,* 1-10.
63. Wendy, F. N., Olori, W. O. (2017). Time management and organizational effectiveness: a study of manufacturing companies in port harcourt, nigeria. *International Journal of Advanced Academic Research* Social *& Management Sciences*, *3*(4), 31-46.
64. Van Eerde, W. (2003). Procrastination at Work and Time Management Training, *The Journal of Psychology*, Vol. *137*(5), 421- 434.
65. Wendelien Van Eerde (2003). Procrastination at Work and Time Management
66. Training, The Journal of Psychology, *137*(5), 421-434, DOI: 10.1080/00223980309600625
67. Ziapour A., Khatony, A., Jafari, F., Neda Kianipour, N. (2015). Evaluation of Time Management Behaviors and Its Related Factors in the Senior Nurse Managers, Kermanshah-Iran. *Global Journal of Health Science*; *7*(2) ISSN 1916-9736 E-ISSN 1916-9744, 366-373.
68. Ziekye, J. (2016). Impact of Time Management on Organizational Effectiveness. *South American Journal of Management*, 1-9.

Povzetek:
Upravljanje s časom in organizacijska učinkovitost

Raziskovalno vprašanje (RV): Ali je upravljanje s časom prava strategija za doseganje organizacijske učinkovitosti?
Namen: Namen in cilj tega članka raziskati povezavo med upravljanjem s časom, zmogljivostjo delovne naloge in organizacijsko učinkovitostjo.
Metoda: Raziskovalno temo smo razvili s pomočjo teoretiziranja. Pregledali in analizirali smo sekundarne podatke v literaturi in v raziskavah iz tematskega področja članka. Pri tem smo uporabili indeksirane baze podatkov: DOAJ, Google Scholar, Public Med, Elsevier, SAGE in druge baze in vire. Za preverjanje asocijacij med upravljanjem s časom, zmogljivostjo naloge I organizacijsko učinkovitostjo smo uporabili piramidno načelo (Pinot, 2002), s katerim smo induktivno dokazovali raziskovalno vprašanje po metodi od spodaj navzgor.
Rezultati: S pomočjo piramidne metode smo ugotovili, da je upravljanje s časom povezano z zmogljivostjo pri delovni nalogi in z organizacijsko učinkovitostjo: 1. upravljanje s časom je panaceja in ne placebo, 2. upravljanje s časom je učinkovit način izrabe virov pri doseganju zmogljivosti delovne naloge in organizacijske učinkovitosti, 3. upravljanje s časom izhaja iz ustreznega organizacijskega vedenja, ki se izraža v zmogljivosti pri delovni nalogi in v organizacijski učinkovitosti.
Organizacija: Zavedanje, da upravljanje s časom pozitivno vpliva na izrabo virov v organizaciji in s tem na zmogljivost zaposlenih in organizacije kot celote, je v pomoč menedžerjem pri snovanju učinkovite organiziranosti sistemov in procesov po načelih upravljanja s časom.
in družbenih inštitucijah, da spodbudijo in podprejo časovno učinkovito vedenje, ki se izraža v višji zmogljivosti in produktivnosti posameznika, organizacije in družbe.
Družba: Članek predstavlja način, kako časovno učinkovito vedenje, ki se izraža v višji zmogljivosti in produktivnosti posameznika, organizacije in družbe, uporabiti za doseganje višje učinkovitosti pri izrabi virov ter pri doseganju višje produktivnost. Upravljanje s časom prispeva k bolj učinkovitemu proizvajanju, varčevanju z energijo v družbenih inštitucijah in organizacijah in tako prispeva k trajnostnemu razvoju.
Originalnost: Raziskava prispeva k pojasnjevanju vloge časovnega upravljanja pri doseganju višje produktivnosti in učinkovitosti na osebni in na organizacijski ravni. Raziskava prispeva izviren pogled na časovno upravljanje virov, ki je zelo redko prisotno v organizacijskih raziskavah.
Omejitve/nadaljnje raziskovanje: Raziskava ima nekatere omejitve, ki so povezane z dostopnostjo raziskava upravljanja s časom. Poleg tega raziskava izhaja iz posrednih povezav med upravljanjem s časom in zmogljivostjo, ki bi jih bilo treba v nadaljevanju preveriti s kvantitativnimi metodami raziskovanja.

Ključne besede: pojem, čas, upravljanje, naloga, učinkovitost, vedenje, zmogljivost, per formativnost.

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Technology Diffusion as Therapeutic Prescription for Improved Performance in the Ailing Nigerian Insurance Industry

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Abstract:

Purpose and Originality: The study aims to appraise how technology diffusion can improve the performance of the insurance companies in Nigeria. The originality of the research stems from the inclusion of artificial intelligence as a distinct technology that is relatively unknown in the Nigerian insurance industry.

Method: A cross-sectional survey strategy was adopted, and questionnaires were administered to 235 respondents. Data were analysed using multiple regression analysis. The theoretical underpinning was The Diffusion of Technology Theory.

Results: The two predictor variables (artificial intelligence and other information technology infrastructure) have a positive and significant relationship with improved performance of the insurance industry in Nigeria ($R = .17$; $p < .05$). However, the amount of variation in the dependent variable explained by the two predictor variables ($R^2 = .0028$) was relatively low which is an indication that the insurance industry in Nigeria has not embraced artificial intelligence and even the adoption of other forms of technology is very low.

Society: The impact of this research on the Nigerian society is that if the insurance industry improves its performance, it can render its risk mitigation function better by hedging risks associated with business ventures which can encourage more entrepreneurs to venture into business. With this, more employment will be generated and contribution to GDP and government tax revenues will increase. In addition, a prosperous insurance industry will be able to carry out more functions of corporate social responsibility.

Limitations / further research: This research is not without some limitations and as such, the findings should be interpreted with some caution because the data was obtained at a single point even though common error bias was minimised. We suggest that a longitudinal design or a different method of data analysis might yield a more robust result**.**

Keywords: diffusion, competition, artificial intelligence, strategy, technology.

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1 Introduction

The performance of the Nigerian insurance industry is abysmally poor. The sector lags behind other major sectors of the economy due largely to its inability to key into the digital economy that is capable of improving customer acquisition and retention as well as driving costs downwards. The Nigerian insurance industry contributes less than 0.12% to Nigeria's gross domestic product [GDP], (Daniel, 2014) and has insurance penetration rate of 0.3 % (Statistica, 2016). Nigeria ranks 34th in Africa in terms of insurance penetration coming behind such countries as South Africa with a penetration rate of 16.99 %; Namibia, 6. 69 %; Lesotho, 4.76 %; Mauritius, 4.1 %; Zimbabwe, 4.09 % and Kenya, 2.83 % (Statistica, 2016).

Nigeria also ranks low in terms of insurance density (a measure of gross premium written per capital) with $6.2 compared to South Africa with $762.5; Kenya, $40.5; Angola, $30.5; and Egypt, $22.8 (Augusto & Co, 2019). The total amount of premium written in Nigeria in 2015 amounted to about $1420 million consisting of $974 million for non-life and $446 million for life insurance compared to South Africa that had $46 billion in the same year (Soares, 2017). For a country with a population exceeding 200 million (NBS, 2019), Nigeria presents a viable market for insurance business to thrive if only the right strategies are crafted to develop and distribute products that match the lifestyle of the teeming population. The highly uncontested market of microinsurance, which can address the insurance needs of the rural majority and the urban poor has not been developed and hardly available in the Nigerian insurance market.

Due to poor capitalisation and technical deficiencies, most lucrative insurance businesses are ceded to foreign insurers, mostly American and European companies. For instance, Czartoryski (2019) avers that the total insurance industry capitalisation in Nigeria is N300billion (Three hundred billion Naira) which is a paltry $830 million. This amount of money is hardly adequate to underwrite risks in multi-billion oil and gas businesses hence only 30 % of oil and gas insurance is locally covered by Nigerian insurers thus leading to capital flight (Agboola, 2019). Similarly, the Aviation Refuelling Liability Insurance of II Plc (Former Mobil Nig. Plc) with an insurance value of $1billion has 10.03 % local cover while 89.97 % of the total sum is insured abroad. The Dangote Oil Refinery, which is near completion stage with an insured value of $6.8 billion will likely lose 72 % of insurance business to foreign insurers (Agboola, 2019).

The insurance industry in Nigeria, perhaps, has not keyed into the digital world and thus lags behind its peers in some other countries in the adoption of modern technology. For example, artificial intelligence has become the new game-changer in almost every industry globally, including insurance, but this ubiquitous technology is relatively unknown to the insurance industry in Nigeria. In order to become competitive and be globally relevant, business managers are investing vast amounts of money on artificial intelligence as it is capable of doing several things, handles a large amount of data and proffer solutions to business problems faster, more accurately and cheaper than humans can (Deloitte, 2017; Scor, 2018; Shabbir & Anwer, 2015). The business value derivable from information technology that

culminates in gaining competitive advantage is well documented in the literature as no modern organisation can thrive without embracing information technology (Bruque-Camara, Moyano-Fuentes, Hernandez-Ortiz, & Vargas-Sanchez, 2014; Cakmak & Tas, 2012; Obradovic, Ebersold & Obradovic, 2015; Powell & Dent-Micallef, 1997; Singhal, 2014). It is, perhaps, also a well-known reality among insurance practitioners in Nigeria that it has not done much in acquiring and deploying modern information technology in its business operations (Ujunwa & Modebe, 2011).

Aim and Objectives of the Study

The main aim of this research is to appraise technology diffusion as a therapeutic prescription for the ailing Nigerian insurance industry. Specifically, the study will attempt to:

- Examine if artificial intelligence can be used to improve the performance of the Nigerian insurance industry;
- Analyse the extent to which the adoption of other forms of information technology infrastructure can boost insurance industry performance in Nigeria.
- Determine how the combined effect of artificial intelligence and other forms of information technology can improve the performance of insurance companies.

As such, the following research questions were developed:

- To what extent can artificial intelligence enhance the performance of the insurance industry in Nigeria?
- To what extent can the other information technology infrastructure improve the performance of insurance companies in Nigeria?
- Can a combination of artificial intelligence and other information technology infrastructure improve the performance of insurance companies in Nigeria?

with the corresponding null and alternative hypotheses

H_o1: Artificial intelligence will not significantly improve the performance of insurance companies in Nigeria;

H_A1: Artificial intelligence will significantly improve the performance of insurance companies in Nigeria

H_o2: Other forms of information technology infrastructure will not significantly improve the performance of insurance companies in Nigeria.

H_A2: Other forms of information technology will significantly improve the performance of insurance companies in Nigeria.

H_o3: A combination of artificial intelligence and other forms of information technology will not significantly improve the performance of insurance companies.

H_A3: A combination of artificial intelligence and other forms of information technology will significantly improve the performance of insurance companies in Nigeria.

2 Theoretical framework

2.1 Theoretical Underpinning: Diffusion of Innovations Theory

Diffusion of innovations theory can be credited to the works of Evereth Rogers in 1962. Rogers postulates that diffusion is how an innovation is passed to, and disseminated among a group of people in a given social system. Rogers (1962) believes that four quintessential elements help in spreading any new idea and these include the strength and relevance of the innovation itself, the channels of communication, time as well as the nature of the social system where the innovation is to take place. The entire process, according to Rogers, depends largely on the quality of human capital asset charged with the responsibility of implementing the innovation.

The diffusion of innovations theory attempts to explain how, why and to what extent a new idea or technology can spread. Rogers further avers that the various categories of adopters are the innovators who embrace any new idea as soon as it is popularised, early adopters who follow next, early majority and lastly, the laggards adopt a wait and see attitude to see and observe the impact of the innovation on others before slowly introducing it evolutionarily. Technological innovation involves information about the idea of new technology and options are weighed before a decision is reached. Consequently, when it is eventually adopted, it helps to minimise doubt and uncertainty. The diffusion of innovations theory is found relevant to this research as the insurance industry in Nigeria is yet to adopt such modern technological innovations as artificial intelligence, machine learning and internet of things (IoT) in their operations.

2.2 Conceptual Review

2.2.1 Technology in as a means of improving organisational performance

Technology can be conceptualised as the application of scientific discoveries in practical ways. The skilful deployment of machines, tools, knowledge, skills, information resources, expertise and equipment perhaps makes the difference between high performing organisations and those waiting on the edge. Singhai (2014) opines that as technological advancement is fuelling the pace of globalisation, increasing rivalry among firms and changing customer requirements are placing more demands on firms to seek ways to create competitive advantage. With businesses now depending increasingly on information technology, firms that want to survive and remain competitive cannot ignore the pivotal role of technology in their daily operations (Cakmak & Tas, 2012). Information technology (IT) has been found to be instrumental in creating distinctive competitive advantage, help a firm in long-term value creation and enhance the relationship between employees and customers (Dehning & Stratopoulos, 2003; Strebinger & Trailmaier, 2006; Tabb, 2006). It has been noted that the

advantages that firms derive from the application of technologies that culminate in productivity improvement is contingent upon how well these technologies are adopted by the entire company (Gagnon & Dragon, 2002). Obradovic, Ebersold and Obradovic (2015) describe technology as one of the major stimulants of global market formation through integration of markets. The researchers also conclude that there is a 'direct proportionality between the extent of technological advancement and the growth of international trade'. For the purpose of this study, the two aspects of technology that will be focused upon are artificial intelligence and information technology.

2.2.2 Artificial Intelligence (AI)

To disambiguate the phrase 'artificial intelligence', it is necessary to break the phrase into its parts of 'artificial' and 'intelligence'. Artificial is something fake, imitated, unreal, unnatural and synthetic (Honby, 2001). Intelligence refers to being able to learn, acquire, reason and apply different knowledge and skills in solving problems (Shabbir, 2015).

Artificial intelligence is simply 'intelligence' exhibited by machines (Scor, 2018). Artificial intelligence (AI) can be viewed as using machines, computer programmes and systems to execute the intellectual and imaginative roles of humans (Shabbir & Anwer, 2015). AI, big data, and internet of things (IoT) are creeping steadily into every facet of human lives as business executives are equally experiencing this transformation.

AI is a ubiquitous tool that can be used for several different things that the human mind can conjure. AI may be divided into two groups of Narrow AI and General AI. The popular AI in use today is the Narrow Artificial Intelligence which can be deployed or programmed to perform specific tasks as required by the programmer. Health (2018) opines that narrow AI can be recognised as it is used in cases like *Siri*, the Apple iPhones' virtual assistant with speech and language recognition capabilities; the vision recognition systems of self-driving cars; in product development and procurement decisions, and customer service delivery systems among several other uses. The general AI is still at its developmental stages and may become fully operational around 2075 (Health, 2018).

2.2.3. Benefits for the Insurance Industry can Derive from Artificial Intelligence

Artificial intelligence has gained popularity is numerous fields of human endeavour, including manufacturing, agriculture, the auto and aviation industries, pharmaceutical, finance and marketing (Scor, 2018). The insurance industry is perhaps, a late adopter of this ubiquitous technology which poses two fundamental challenges: Firstly is the reality of new forms of risks which can now come to the fore as a result of AI which has to be fully assessed, calculated, computed and mitigated against through insuring. The poser here is that when an insurance company insures a self-driving vehicle and it is involved in an accident, who would be answerable? The end-user, the manufacturer, or the developer of the software behind the AI technology? This becomes a difficult question for the insurer to handle. The second challenge is how insurance firms can leverage the potential of AI for insuring against different

types of risks associated with recent technological developments in cyberspace and AI technologies.

In today's global economy, artificial intelligence, big data, data science and internet of things (IoT) are becoming part of every aspect of human existence, and corporate leaders are equally experiencing this transformation (Dickson, 2020). In most developed economies of the world, insurance executives are redirecting their investments on acquisition and deployment of artificial intelligence and related technologies to assist agents, brokers and the workers to improve end-user experience with personalised services, prompt claims settlement and individual risk-based underwriting processes (Accenture, 2017). AI algorithm has contributed immensely to cost savings, increased efficiency, and it is revolutionising customer experience. Dickson (2020) opines that improvements in edge hardware, cloud computing and internet of things (IoT) have made information about objects, people and business enterprises a lot easier to obtain in the digital world and data processing is readily and easily achieved by machine learning algorithm.

Lloyds (2018) observes that internet of things (IoT) is capable of transforming the entire society and that worldwide connectivity will attain 25 billion devices to the web by 2020 and this could more than quadruple to 125 billion by 2030. The report further notes that internet of things can assist insurance companies to appreciate and obtain a clear understanding of their risk exposures especially in marine, digital homes, water, and agricultural sectors with implications for new product development and better risk pricing capabilities. On a similar note, Dickson (2020) opines that the motor vehicle insurance will benefit from the use of sensors such as 'telematics' to collect real-time data from motor vehicles and their drivers unlike what previously obtains by relying on historical data to develop motor vehicle insurance policies. The machine learning algorithm can be applied to analyse telematics data to obtain driving habits and other useful information. The same data can assist analysts to reconstruct accident scenes which will provide useful information for claims processing and eventual settlement.

Health insurance can equally benefit from AI models as they can easily be applied to collate claims data, prior authorisation, determination of eligibility for cover, policy information or engagement data and healthcare utilisation data in order to create a complete profile of all the candidates applying for cover. Fraud prevention and control is another remarkable benefit that can be derived from AI through its machine learning algorithm as it can easily and readily glean existing patterns from separating legitimate claims from fraudulent ones. Advances in Natural Language Processing (NLP) has also helped in ushering in an array of chatbots that enhance customer experience and has also led to reduced time for claims processing. More recently, improvements in Convolutional Neural Networks (CNN) have made significant progress in image recognition and classification of data with unprecedented accuracy. Insurance companies are now capable of using an image recognition algorithm to automate former manual processes in accident case processing and can obtain results within a few seconds (Dickson, 2020).

There have always been two parties to every insurance contract, which are the insurer and the insured. Both parties have always had asymmetrical information which is quite significant to understanding insurance economics. For the insurer, the company attempts to gather information by using questionnaires, observation and other statistical methods to predict the behaviour of the insured. On the other hand, the insured person would like to underplay the risk, take advantage of the value of the claim and influence the price for his/her benefit. Kessler (2018) observes that this information asymmetry could lead to adverse selection and moral hazard. However, recent developments in AI technology and big data collection will eradicate this information irregularity and bring comprehensive and observable transparency into the insurance transaction. Kessler (2018) further notes that AI and big data are capable of imparting the way insurance business is conducted globally on both the demand and supply sides.

Deloitte (2017) observes that artificial intelligence is capable of transforming the entire insurance industry in such a way that all parties in the insurance ecosystem including brokers, underwriters, reinsurance companies, and even customers will adopt AI tools and methodologies. This will involve improved efficiencies in customer experiences, risk analysis, underwriting, claims management, and new product development. Shabbir and Anwer (2015) opine that artificial intelligence will definitely transform how companies compete around the entire globe and will ultimately culminate in driving corporate performance and profitability.

2.2.4 Other Forms of Information Technology (IT)

The business value of information technology (IT) is, perhaps, clearly appreciated in virtually every business operation and has consequently become a major differentiating factor for firms jockeying for market share and competitive advantage. O'Brien (2003) posits that information technology is a system that makes use of computer hardware, software, and communication networks to retrieve and process data in order to produce information for individuals and businesses. Obradovic et al. (2015) argue that much of the increase in global productivity in the last decade can be attributed to improvements in information and communications technology. Several studies have been carried out to establish the strategic advantages of information technology usage in business firms. For example, Cakmak and Tas (2012) believe that information technology can help an organisation to decrease costs and increase revenues and therefore, a veritable avenue of attaining the desired level of competitive advantage. It significantly improves operational efficiency and transforms the strategy a business may adopt to compete (McFarlan, 1984); information technology can also be incorporated into the major activities of a company's value chain to create or improve sustainable competitive advantage (Porter & Millar, 1985; Singhal, 2014).

O'Brien (2003) posits that information technology is capable of altering the strategies companies may adopt to compete by deploying information technology strategically as a vehicle of organisational renewal, and an investment that galvanises an organisation to

formulate strategies and business processes that will enable it to reengineer or reinvent itself to compete favourably in the marketplace. On the strength of this, information technology can be applied to achieve considerable cost leadership, differentiation, sustainable growth, innovation and strategic alliance.

2.2.5 Organisational Performance

Every organisation is expected to meet some performance expectations of the stakeholders. The organisations that score high in meeting these performance expectations are regarded as high performers while those that score low on the scorecard are regarded as low performers (Antony & Bhattacharyya, 2010). Peterson, Gijsbers, and Wilks (2003) define organisational performance as a firm's capability to utilise its scarce resources in an efficient manner in producing end-user requirements in line with corporate mission and objectives. Slater and Narver (1994) see organisational performance as a firm's market and financial performance that are closely related to the firm's economic value. Langerak, Hultink, and Robben (2004) posit that the market performance perspective is viewed in competitive terms and this may relate to the firm's market share, creating customer value, product performance, new product development and product innovation capabilities. Kaplan and Norton (1992) argue that firms have paid too much attention to financial measures of performance, which they say, are inherently backwards-looking.

2.3 Conceptual Model

The model depicts the individual and combined relationship between the independent variables which are artificial intelligence and other information technology resources which can be deployed by a firm for improved performance (dependent variable) as well as the components of both the dependent and the independent variables.

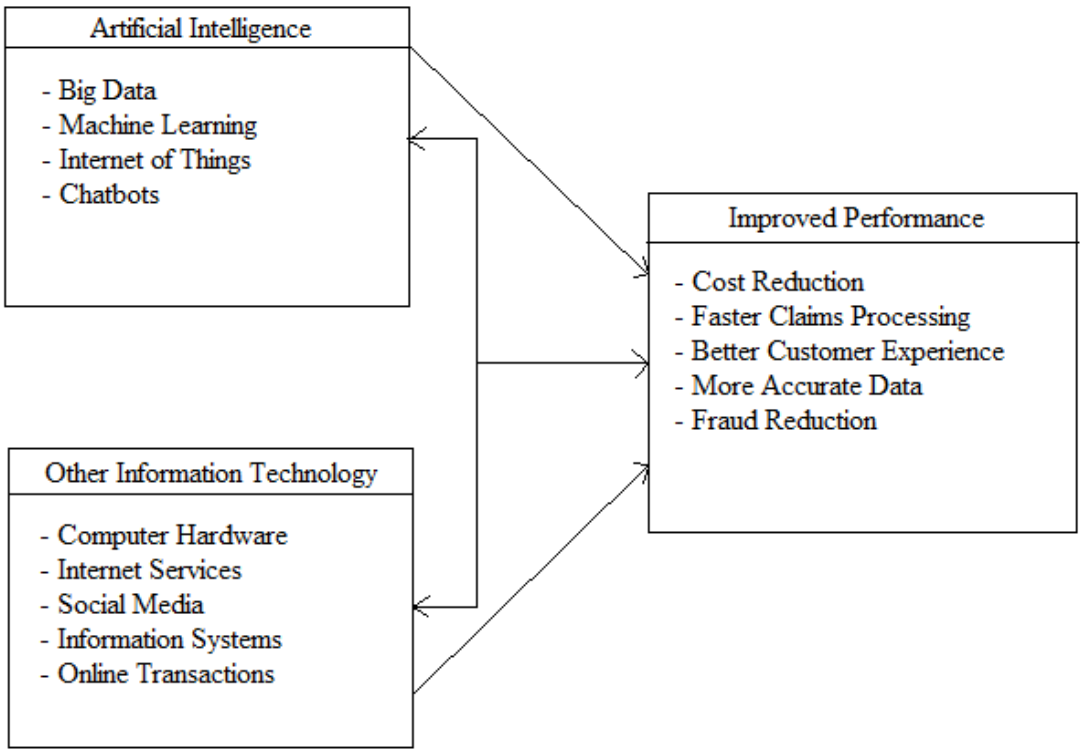

Figure 1. Conceptual Model

3 Method

The study utilises a quantitative research design based on a cross-sectional survey strategy and rooted in the positivist research philosophy and an ontological orientation of objectivism.

Fifteen insurance companies from the 56 registered underwriting firms in Nigeria were included in the study using the stratified sampling technique to obtain samples that included four life insurance companies, eight non-life insurance firms and three composite insurance companies. A questionnaire divided into three parts with items to measure knowledge, adoption and investment in artificial intelligence makes up the first section. The second part consists of items measuring knowledge, adoption and usage of other forms of information technology while the third part consists of items measuring organisational performance. A total of 300 questionnaires were administered to senior staff of these companies out of which 235 were returned and found usable. Reliability of the instrument was tested using Cronbach Alpha with the three major sections of the questionnaire having 0.9, 0.7 and 0.8, respectively. Validity was obtained through the test re-test method and the opinion and suggestions by experts on the content of the instrument.

The variables of interest in this study are one dependent (Organizational Performance) and two independent variables consisting of artificial intelligence and other forms of information technology.

The analysis that was found useful for this study is the ordinary least squares (OLS) method of multiple regression. Data obtained from the research instrument was subjected to statistical analysis using the Statistical Package for the Social Sciences (SPSS V. 22).

The multiple regression applied in this research assumes the form of a linear combination of variables as expressed in the regression model.

$Y= \alpha+\beta_1X_1 +\beta_2X_2+ e$…… (1)

α = intercept which predicts the value of Y if X=0;

β_1 and β_2 represent the regression coefficients of the relative weights of the predictors;

X_1 = Artificial Intelligence;

X_2 = Other forms of Information Technology

e = is the error term or the part of Y not explained by X.

4 Results

This section deals with the analysis and findings based on the output of SPSS that is applied for data analysis.

Table 1 shows the mean and standard deviations of organisational performance, artificial intelligence, and other information technology infrastructure.

Table 1. Descriptive Statistics and Correlations for Study Variables

Variable	n	M	SD	1	2	3	4	5
Org Perf	235	5.172	4.34	-				
AI	235	4.83	1.07	.122**	-			
Infotech	235	5.26	1.07	.163*	.565*	-		

$p \leq .05$** $p \leq .01$*

Org Perf = Organisational performance; AI = Artificial intelligence; Infotech = Information technology

Table 1 also depicts the correlation coefficients of the independent variables and their degrees of significance. Thus, artificial intelligence has a positive and significant relationship with organisational performance r = .12, p<.05; while other forms of information equally have a positive and significant relationship with organisational performance r = .16, p = .00.

Table 2. Model Summary for the Regression Analysis

Model	R	R Square	Adjusted R	Standard Error	Durbin-Watson Square of the Estimate
1	.167	.028	.020	4.3016	2.014

a. Predictors: (Constant), Other Information Technology, Artificial intelligence
b. Dependent Variable: Organisational performance

Table 2 depicts the regression analysis of the study. It shows that the two predictor variables have a positive effect on the performance of insurance firms in Nigeria at R= .17. However, a low R^2 of .028 indicates that less than 3 % of the variability in the dependent variable is explained by artificial intelligence and other information technology infrastructure. The model shows a very good fit with Durbin Watson at 2.0, indicating the complete absence of independent errors.

Table 3. ANOVA of the Variables

Model 1	Sum of Squares	DF	Mean Square	F	Sig
Regression	123.391	2	61.695	3.334	.034
Residual	4292.938	232	18.504		
Total	4416.329	234			

a. Dependent Variable: Organisational performance

b. Predictors: (Constant), Other Information Technology, Artificial intelligence

Table 3 shows the ANOVA of the variables, which confirms the model fit with an F-ratio of 3.3 and an overall significance level of $p < .05$ thus making the study variables highly significant.

Table 4. Showing the Unstandardized Coefficients of the Study Variables

Effect	Estimate	SE	95% CI		P
			LL	UL	
Fixed Effects					
Intercept	1,297	1.556	-1.791	4.385	.409
AI	.188	.336	-4.474	.849	.577
Infotech	.564	.320	-.066	1.194	.079

Note: CI = Confidence Interval; LL = Lower Limit; UL = Upper Limit

Table 4 shows the coefficients of the study variables using the unstandardised coefficients because the constant (beta zero) is included. These b-values indicate whether a relationship exists between the predictors and the dependent variables. A positive b-values shows that a relationship exists whereas a negative b-value indicates an absence of a relationship. Artificial intelligence has $\beta = .19$, $p > .05$ which invalidates H_o1 (Null hypothesis), and therefore, H_o1 is accepted. Other forms of information technology has $\beta = .56$, $p > .05$, which also invalidates H_o2, and therefore, H_o2 or the null hypothesis is accepted. However, a combined regression coefficient of .17, and $p < .05$ shows that when artificial intelligence is combined with other forms of information technology, organisational performance can improve; therefore, H_o3, or the null hypothesis is rejected while the alternative hypothesis is accepted.

5 Discussion

Findings from this study reveal that the Nigerian insurance industry is yet to appreciate that artificial intelligence has become the new game-changer in every business, including insurance. There appears to be very shallow knowledge of what the AI technology is all about and how it can improve the fortunes of the industry. Deloitte (2017) provides financial estimates of global insurance industry investment in artificial intelligence but Nigeria was not in the list of countries that are doing so. The researchers observe that AI holds the future for the insurance industry and the earlier companies key into it, the better. From the data collected and analysed for this study, it is abundantly clear that even basic information technology infrastructure is lacking in many Nigerian insurance companies as top management only pays lip service to investment in information technology. With a paltry 0.028 or 2.8 % of the performance of the insurance industry accounted for by artificial intelligence and information technology, it can be reasonably deduced that the sector has not received much attention from the management of these companies. Furthermore, the remaining 97.2 % of industry performance that is unaccounted for by this study comes mostly from other areas not included in this research. Artificial intelligence has a $\beta = .19$, $p > .05$ which indicates its non-significance in the performance of insurance industry in Nigeria. However, other forms of information technology with $\beta = .56$, $p = .07$ shows a better

contribution to performance though significance level slightly exceeds the threshold of $p \leq .05$. Therefore, it is not surprising that Nigerian insurers cannot compete on the global arena as they are bedevilled with a myriad of problems that have curtailed their access to most lucrative sectors of insuring (e.g., oil and gas, aviation, and nuclear liability insurance), as well, as the vast market potential of a large population, that is waiting to be exploited in the country.

6 Conclusion

The study was conducted to ascertain how technology diffusion can be used as therapeutic prescription for the ailing insurance industry in Nigeria. That the insurance sector in the country is performing poorly can, perhaps, be deduced from its low contribution to GDP (0.12 %) or insurance penetration rate of 0.3 %. A total number of 15 insurance companies comprising of 4 life, 8 non-life and 3 composite companies were sampled for the study. A total of 235 questionnaires were retrieved and analysed, and findings from the study revealed that artificial intelligence and other forms of information technology are poorly deployed in the Nigerian insurance industry. While artificial intelligence has a weak and insignificant relationship with organisational performance, the other information technology infrastructure has a stronger relationship with performance though above acceptable threshold in *p*-value. In conclusion, this study shows that the two predictor variables, namely: artificial intelligence and other forms of information technology, have not contributed significantly to the performance of the Nigerian insurance industry.

It is recommended that operators of the insurance industry in Nigeria should brace up to embrace artificial intelligence as it is the new game-changer in the insurance industry worldwide. They should try and train their staff on AI and IT generally and also improve on their current level of budgetary commitment to information technology to remain relevant and become competitive in an increasingly globalised world.

This research is not without limitations and the findings should be interpreted with some caution. The data were obtained at a single point even though common error bias was minimised. It is suggested that a longitudinal design or a different method of data analysis might yield a more robust result. Also, the insurance companies that were not captured in the sample could also be used for future research to validate or repudiate the findings of this study.

References

1. Accenture (2017). Artificial intelligence set to transform the insurance industry but integration challenges remain. Retrieved from http://www.accenture.com.
2. Agboola, P. (2019, August 6). Nigeria insurers may lose 72 % of Dangote Refinery's risk, others. *ThisDay Newspapers*

3. Anthony, J.P & Bhattacharyya, S. (2010). Measuring organisational performance and organisational excellence of S.M.Es- Part 1: A conceptual framework. *Measuring Business Excellence, 14*(2), 3-11.
4. Bello, O.B. & Abayomi, O.A. (2018). Organisational learning, organisational innovation and organisational performance: Empirical evidence among selected manufacturing companies in Lagos metropolis, Nigeria. *Journal of Economics and Management*, *33*(3), 25-38.
5. Bruque-Camara, S., Moyeno-fuentes, J., Hernandez-Ortiz, M., & Vargas-Sanchez, A. (2014). Information technology and competitive advantage: The role of ownership structure. Retrieved from https//www.researchgate.net/publication/221409160
6. Cakmak, P. I. & Tas, C. (2012). The use of information technology on gaining competitive advantage in Turkish contractor firms. *World Applied Sciences Journal, 18*(2), 274–285.
7. Czartoryski, J. (2019). Micro insurance, tech, key to deepening Nigerian insurance sector. Retrieved from https//www.proshareng.com/micro-insurance-tech-key-to-deepening-Nigeria's-insurance-sector/
8. Daniel, F. (2014). Contribution of insurance to GDP in Nigeria. Retrieved from http://www.movebacktonigeria.com/rebased_economy_nigeria_insurance_industry_contr
9. Dehning, B. & Stratopoulos, T. (2003). Determinants of a sustainable competitive advantage due to an IT-enabled strategy. *Journal of Strategic Information Systems, 12*(1), 7-28.
10. Deloitte (2017). From mystery to mastery: Unlocking the business value of artificial intelligence in the insurance industry. *Deloitte Digital*, Retrieved from https://www2.deloitte.com
11. Dickson, B. (2020). 3 ways AI is transforming the insurance industry. Retrieved from https//thenextweb.com
12. Gagnon, Y.C. & Dragon, J. (2002). The impact of technology on organisational performance. *The Journal of Public Sector Management, 28*(1), 19-31.
13. Health, N. (2018). What is AI? Everything you need to know about artificial intelligence. Retrieved from https//www.Zdnet.com/article/what-is-ai-everything-you-need-to-know-about-artificial-intelligence/
14. Honby, A.S. (2001). *Oxford advanced learner's dictionary of current English.* (6th ed.), Oxford University Press: Oxford, England.
15. Kaplan, R. & Norton, D. (1992). The balanced score card: Measures that drive performance. *Harvard Business Review* (January – February) *4*, 71-79.
16. Kessler, D. (2018). How artificial intelligence will impact the (re)insurance industry. Retrieved from https//www.scor.com
17. Langerak, F., Hultink, E. J. & Robben, H. (2004). The impact of market orientation, product advantage, and launch proficiency on new product performance and organisational performance. *Production Innovation Management*, *21*, 79-94.
18. Lloyds (2018). Networked world: Emerging risk report. Retrieved from https//www.lloyds.com
19. McFarlan, F. (1984). Information technology changes the way you compete. *Harvard Business Review, 62*(3), 98-103.
20. NAICOM (2018). Insurance industry balance. Retrieved from https:www.naicom.gov.ng/docs/publications/BALANCE%20SHEET%20Life%20Nn-lifepdf
21. NBS (2018). Nigerian population estimate. Retrieved from www.nigerianstat.gov.ng
22. Obradovic, D., Ebersold, Z. & Obradovic, D. (2015). The role of technology strategy in competitive increasing. *Economic Annals-XXI*, *1-2*(1), 32-35.
23. O'Brien, J.A. (2003). *Introduction to information systems: Essential for the e-business enterprise.* 11thEd. New York: McGraw-Hill Higher Education.

24. O'Reilly, C.A. & Pfeffer, J. (2000). *Hidden value: How great companies achieve extraordinary results with ordinary people.* Boston: Harvard Business School Press.
25. Peterson, W., Gijsbers, G. & Wilks, M. (2003). An organisational performance assessment system for agricultural research organisations: Concepts, methods and procedures. Retrieved from https//books.google.com.
26. Porter, M.E. & Millar, V. (1985). How information gives you competitive advantage. *Harvard Business Review, 65*(4), 149-160.
27. Powell, T.C. & Dent-Micallef (1997). Information technology as competitive advantage: The human, business, and technology resources. *Strategic Management Journal*, *8*(5), 375-405.
28. Rogers, E. M. (1962). Diffusion of innovation theory. (1st ed). New York: Free Press of Glencoe.
29. Scor (2018). The impact of artificial intelligence on the (re)insurance sector. Retrieved from http://www.scor.com
30. Shabbir, J. & Anwer, T. (2015). Artificial intelligence and its role in near future. *Journal of Latex Class Files, 14*(8), 1-11.
31. Singhal, T. K. (2014). Information technology for competitive advantage through innovation and differentiation. *Amity Business Review*, *15(*2), 37-44.
32. Slater, S.F. & Naver, J.C. (1994). Does competitive environment moderate the market orientation performance relationship? *Journal of Marketing*, 58(1), 46-55.
33. Soare, P. (2017). 44th Africa Insurance Organization (AIO) Conference in Kampala, Uganda. Retrieved from https://www.vanguardngr.com/2017/05/nigeria-emerges-fifth-largest-insurance-market-africa/
34. Statistica (2016). Insurance penetration rates in Sub-Saharan Africa. Retrieved from https://www.statistica.com/statistics/727403/insurance-penetration-in-sub-saharan-africa-by-country.
35. Strebinger, A. & Traiblmaier, H. (2006). The impact of business to consumer e-commerce on organisational structure, brand architecture, IT structure and their interrelation. *Schmalenbach Business Review, 56*(1), 81-113.
36. Tabb, L. (2006). Who said technology is not important? *Wall Street and Technology, 24*(10), 54.
37. Ujunwa, A. & Modebe, J. (2011). Repositioning the insurance industry for operational efficiency: The Nigerian case. *Journal of Applied Finance and Banking*, *1*(3), 15-32.

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Povzetek:
Tehnološka difuzija kot terapevtski recept za izboljšanje uspešnosti v bolniški nigerijski zavarovalniški industriji

Namen in izvirnost: Cilj študije je oceniti, kako lahko difuzija tehnologije izboljša uspešnost zavarovalnic v Nigeriji. Izvirnost raziskave izhaja iz vključitve umetne inteligence kot posebne tehnologije, ki je v nigerijski zavarovalniški industriji razmeroma neznana.
Metoda: Sprejeta je bila strategija presečne raziskave, vprašalniki pa so bili izpolnjeni za 235 anketirancev. Podatki so bili analizirani z večkratno regresijsko analizo. Teoretična podlaga je bila teorija difuzije tehnologije.
Rezultati: Dve spremenljivki (umetna inteligenca in druga infrastruktura informacijske tehnologije) imata pozitiven in pomemben odnos do izboljšane uspešnosti zavarovalniške industrije v Nigeriji ($R = .17$; $p < .05$). Vendar je bila količina sprememb odvisne spremenljivke, ki sta jo pojasnili spremenljivki ($R2 = .0028$), razmeroma nizka, kar kaže na to, da zavarovalniška industrija v Nigeriji ni sprejela umetne inteligence in je sprejemanje drugih oblik tehnologije ocenila celo kot zelo nizko.
Družba: Vpliv te raziskave na nigerijsko družbo je, da lahko zavarovalnica, če izboljša svojo uspešnost, izboljša svojo funkcijo zmanjševanja tveganj z varovanjem tveganj, povezanih s poslovnimi podvigi, kar lahko spodbudi več podjetnikov, da se podajo v posel. S tem se bo ustvarilo več delovnih mest in povečal prispevek k BDP ter prihodki od državnih davkov. Poleg tega bo uspešna zavarovalnica lahko opravljala več funkcij družbene odgovornosti podjetij.
Omejitve / nadaljnje raziskave: Ta raziskava ni brez nekaterih omejitev, zato je treba ugotovitve razlagati previdno, ker so bili podatki pridobljeni na eni točki, čeprav je bila pristranskost pogostih napak čim manjša. Predvidevamo, da bi dolgoročna zasnova ali drugačna metoda analize podatkov lahko dala močnejši rezultat.

Ključne besede: difuzija, konkurenca, umetna inteligenca, strategija, tehnologija.

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The Impact of Internal Logistics on the Performance of Manufacturing Companies - A Review Article

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Abstract:
Research Question (RQ): What is the impact of quality implementation of internal logistics processes on production performance?
Purpose: Determine which organization of internal logistics is best suited to production success and what approaches improve the quality of organization of internal logistics processes.
Method: Results will be sought by reviewing articles and existing literature from the past few years. We will focus primarily on the latest literature because the review article describes the changes that began in the 4.0 industry era.
Results: The organization and investment in the processes of internal logistics in production affects the quality of production and thus, the competitiveness of companies. The results are intended to illustrate options that help us improve our internal logistics processes.
Organization: The results contribute to make the right decisions in the organization of logistics processes within production and to make the right inputs from management into improvements and advanced technologies for the implementation of logistics processes.
Society: The lower costs that is achieved with the proper organization of internal logistics in production represent a great competitive advantage for the organization, at the same time, we are burdening our employees with the introduction of advanced technologies.
Originality: A comprehensive review of existing recent literature on the impact of proper planning, organization, and manner of performing internal logistics on production performance in companies.
Limitations / further research: The analysis will still be limited due to the limited number of literature and articles.

Keywords: internal logistics, production, performance, improvements, technology.

1 Introduction

"The logistics function in a company is usually only treated as a support function, and its impact on overall business performance is not fully recognized. In order to successfully improve internal logistics activities, we need to change the way we look at this area and its operation." (Granlund & Wiktorsson, 2014, p. 550)

Logistics has a significant impact on the competitiveness and economy of manufacturing companies. Changes, market development, globalization and many other factors increase the demands for the implementation of logistics processes. This also applies to the field of internal logistics in production, which must ensure a successful flow of materials and

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information. Internal logistics is a key element of an organizations' success. Industry 4.0 brings a great del of significant changes in production with an emphasis on the interaction of machines and people, which will result in a faster and more efficient production system (Fusko, Rakyta, & Manlig, 2017, p. 213–214).

Internal logistics includes activities within the physical framework of manufacturing companies. It is about planning, organizing, and controlling all activities of moving goods and warehousing within companies, in order to optimize production. The elements of internal logistics are workforce, internal transport, transport routes, means of transport and equipment, warehouses and warehousing, and all logistics services that bring significant added value. We can emphasize the importance of appropriate means of transport and equipment in the service of internal transport, where it is important to organize internal transport properly, storage and handling operations (loading, unloading, moving, palletizing, containerization, packaging, unpacking). The basic principle of internal logistics is to make the best use of space and shorten the routes and time of material flow (Jakomin & Veselko, 2004, p. 19–21).

The purpose and goal of the research were to determine how the correct organization of internal logistics affects the success of the production process and what are some suitable approaches that would benefit internal logistics processes. By reviewing the literature, we will learn how to improve the organization of internal logistics and what are the main factors that bring success in manufacturing companies. We will focus mainly on approaches that improve the performance of manufacturing companies through the proper implementation of internal logistics processes. The result showed the possibilities for improving processes in internal logistics, which could reduce costs, improve flow and respond faster to market changes, thereby affecting the performance and competitiveness of manufacturing companies. The results could be useful for improving internal logistics procedures and thus the performance of manufacturing companies.

2 Theoretical framework

Internal logistics as a science and as an activity is based on the development of logistics processes, and logistics phenomena that are important for efficient and successful implementation within the tasks of individual business functions. The field of internal logistics is limited, and the logistics phenomena it deals with can be placed among the phenomena related to its internal resources, potentials and capabilities. Internal logistics emphasizes the flow of materials, energy, capital, information and people within the company. These are based on the integration and suboptimization of internal logistics subsystems or other subsystems of the organization and contribute to optimizing the organization's operations and efficiency. The concept of internal logistics is focused on the dynamics and goals of the company as a whole, so the systematic approach contributes to the implementation of synergy measures to reduce total costs (Zelenika & Pupovac, 2001, p. 354–378).

Internal logistics represents all activities aimed to control the flow of material in the production process. Emde and Boysen (2012, p. 393–402) break it down into the following activities: production planning, inventory management, supply, material handling, and providing transitional information.

Production logistics is the most complete corporate logistics system; materials and production tools required for production processes, the harmony of the production process and its sub-processes, and the flow of materials and related information flow processes are necessary to ensure that consumers get products from production. As the competition on the market grows, companies can only hope to maintain their market position by seizing opportunities for integration in-between production management and logistics. The efficient functioning of logistically integrated production management also means an integrated information system. Logistically integrated production management takes into account the level of stocks of finished products, manages data from product design and production technology, and process planning (i.e., the order of activities and technical data, technological equipment for activity), determines material demand and production capacity needs. A further step in production planning is planning, which also takes into account inventory levels and logistics capacity. Production planning as a whole also reveals that in addition to production resources, logistics resources are also taken into account and optimized. The purpose of logistics-oriented production processes is to create a structure of production organization that will solve logistics principles as comprehensively as possible and thus significantly increase an organization's competitiveness. Proper management of production logistics processes is vital for the cost-effective operation of companies, as it can affect an organization's business performance and customer satisfaction. (Nagy, Illés, & Bányai, 2018, p. 4–6).

Kartning, Grösel, and Zrnic (2012, p. 193–194) say that the history of internal logistics dates back to the post-war period when economic and industrial development was mainly driven by production. Transport in the factories was initially carried out with the assistance of simple equipment such as sack trolleys, other handcarts, and overhead cranes. The goods were stored at ground level, as storage on the floors was useless due to poor visibility and accessibility. This situation began to change in the early 1950s under the influence of newly developed modes of transportation in the United States. New items were introduced, such as pallets as universal loading units and forklifts, which enabled the U.S. military to effectively conduct logistics operations between the two world wars and the Korean War. The introduction of standardized loading units in the form of containers and pallets has stimulated the development of forklifts and elevators. Pallet storage racks helped save space and make it easier to access stored goods. Standardization of the 800x1200 mm pallet is introduced, which is the key to further standardization of logistics equipment and systems. The 1960s were a period of strong economic growth, production expanded rapidly, as did distribution and international trade. The economic boom is increasing labour costs, which management is aware of and is looking for ways to operate the whole businesses efficiently, not just production processes. There is a need to rationalize storage facilities, which must represent an

efficient space between the various stages of production and flexibility with the final market. The 1960s thus marked a period of rapid progress in storage technology. The first automated twenty-meter-high warehouse was built in 1962 in Germany, which encouraged the automation of transfers and processes for computer storage and thus resulted in lower storage costs. In the 1970s, production and distribution were shaped by the consumer with demands for quality products and a more comprehensive range of products at reasonable prices. Demand has become more complicated, so organizations have increasingly invested in automated warehouses, equipment for performing production processes, development of distribution centres and new technologies such as AGV (Automatic Guided Vehicle) and new approaches in the field of electronics and information technology. The economic situation in the early 1980s triggered the need for flexible production modelled on Japanese methods, which lead to factory leaders to begin to view production as a unit of internal and external processes. The just in time (JIT) philosophy was introduced, which depended mainly on appropriate information systems and communication technologies, and internal logistics marked by the introduction of bar code systems. Since the mid-1980s, computer systems and later lean production have played a significant role, while organizations were striving to introduce the use of lighter, more efficient, and faster cargo handling devices into logistics systems. Technologies based on wireless communication are introduced into the processes and in internal logistics, mainly in the field of AGV use, while radio frequency identification (RFID) technology is becoming increasingly important, which enabled information support of goods and devices and significantly overtook the set of barcode functions.

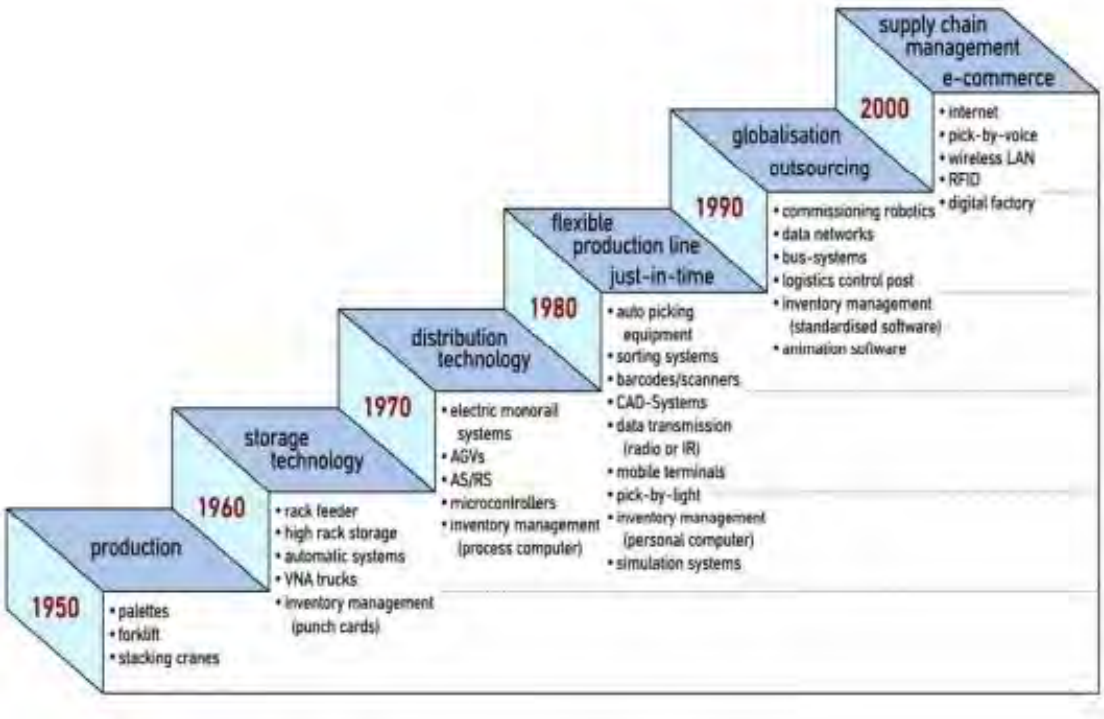

Figure 1. History of internal logistics. Adapted from *"Past, State-of-the-Art and Future of Intralogistics in Relation to Mega-trends",* by G. Kartning, B. Grösel, and N. Zrnic, 2012*, FME Transactions 40*(4), p. 193. Copyright 2012 by Georg Kartning, Faculty of Mechanical Engineering, Belgrade.

Kartning, Grösel, and Zrnic (2012, p. 196–200) argue that the most critical mega-trends that will have a significant impact on internal logistics are: globalization, urbanization, individualization, demographic change, climate change and environmental impacts, and ubiquitous intelligence, they relate mainly to reducing production costs and increasing the speed and use of advanced management, information and communication technology.

As stated by Fusko, Rakyta, and Manlig (2017, p. 214–215), Industry 4.0 represents a period of higher productivity, production growth and a 'pull' production system in which planning is subordinated to actual sales, while processes are based on customer demand. The interaction between machines and people will enable production systems to be up to 30% faster and 25% more efficient, and it also is estimated that Industry 4.0 will change production factories beyond recognition. The transformation will result in smart factories, where smart devices will takeover all manual and operational activities and organize efficient production operations together with control systems.

The interconnection of systems promoted by Industry 4.0, based mainly on the availability of real-time digital process information (e.g., the position of goods throughout the facility), has paved the way for the increasing acceptance of service robots into the logistics sector. In 2013, approximately 1,900 logistics systems were installed, which is 37% more than in 2012, which represented 9% of the total sales of robots for professional services. Approximately 1,300 automated guided vehicles in production environments generated a nearly 70% increase in sales for automated guided vehicles in 2012. The market for AGVs in manufacturing is expected to grow sharply in the coming years as essential preconditions for AGV investments are increasingly being met, such as:

- Digitization of factory floors. AGVs depend on digital data for their guidance and missions.
- Increasing the capacity and flexibility of fully autonomous navigation without the need to install markers or beacons.
- Improving energy storage technology (batteries, supercapacitors) increases the lifetime with shorter charging cycles.
- Increasing the positive reputation of AGV use, the ease of it throughout the manufacturing and logistics industry.

Between 2014 and 2017, more than 10,200 logistics systems will be sold, of which approximately 9,200 are AGVs. (IFR, 2019, p. 11).

The potential for the robotization of internal logistics is still vast. On the one hand, the growth of the logistics sector, reflected in the boom in e-commerce, requires the automation of more than just transport (i.e., AGV). On the other hand, advances in the perception, decision-making, and capabilities of robots technically make it possible to automate the handling and manipulation processes for a variety of objects. However, the advantages of using robotics to automate the handling of materials in internal logistics do not always justify the cost of a robotic solution. The need for efficient automatization of some manual internal logistics

processes remains unfulfilled. On the one hand, potential users, who are looking to automate some currently manual internal logistics processes, prefer to buy more flexible technologies, as the capacity of flexible systems can be utilized better in for a shorter payback period. On the other hand, technology providers would prefer to design their components in a way that would make them more flexible and can be used in different areas, with different products and processes, as some of their older technologies are struggling to find their way into the market or do not achieve enough sales to justify the costs of their development (Bonini et al. 2018, p. 380–381).

In 2018, Lakner and Winkler (as cited in Winkler & Zinsmeister, 2019, p. 538–539) reviewed the literature on current digital trends in intralogistics, and presented the results according to the number of references in various studies in Table 1 below.

Table 1. Identified internal logistics trends

Trend	Number of mentions in relevant literature
Self-organizing Conveyor Systems	
Automated Guided Vehicles	25
Camera-based Identification Systems	21
Augmented Reality	20
Active Localization indoor – outdoor	19
Collaborative Robotics	15
Smart Container Systems / RFID	14
Wearables	14
Automated Picking Systems / Pick-by-Robot	14
Machine Learning	13
Grid Sorter	12
Real-Time Simulation	11
Virtual Commissioning	11
Crowd-Logistics	11
3D-Shuttle Systems	9
Semantically enriched Data	8
Industrial Data Space	8
Predictive Maintenance	7
Crowd-Sorting	6
Drone Technology	4
Gamification/Employee Motivation	4
Shared-Service Business Models	4

Note: Identified internal logistics trends. Adapted from "Trends in digitalization of intralogistics and the critical success factors of its implementation" by H. Winkler and L. Zinsmeister, 2019, *Brazilian Journal of Operations & Production Management, 16*(3), p. 537-549.

From Table 1, we can see which trends are currently the most important for digitalization in intralogistics. Digitalization is currently one of the biggest intralogistics challenges for the industry. Let's look at the first three common ones: (1) Self-organizing Conveyor Systems, (2) Automated Guided Vehicles, and (3) Camera-based Identification Systems. From these areas, we can see a strong connection to the implementation of Industry 4.0 technologies, while among the most common trends is a strong connection with information technology, which is seen in the trends of (12) Real-Time Simulation, (13) Virtual Commissioning, and

(17) Industrial Data Space. The results of the frequency of trends shown in the table above, set the guidelines for the continuation of our study.

The research aims was to determine how the correct organization of internal logistics affects the success of the production process and what are some suitable approaches that would benefit internal logistics processes In doing so, we formulated two research questions, namely: what are the factors that are crucial for the optimization of internal logistics and in what way they affect the production environment of the company.

3 Method

Data collection was based on the analysis of articles from the last decade (2010–2020), with which we obtained an overview and the data for the research. The analysis is focused on identifying the factors that influence the proper organization of internal logistics and thus, successful production in organizations. There are many articles on the success of production processes in connection with the appropriate internal logistics, so we have limited ourselves to just a few of the latest ones, due to advances in the use of technology over the last decade. All articles were studied in detail so that we could summarize only the most essential data on the proper planning of internal logistics for successful. Most articles contained several factors that are repeated by different authors. The organization of internal logistics or the implementation of internal logistics processes affects the performance of production companies. The efficient implementation of internal logistics processes affects the implementation of efficient production, which leads to the success of manufacturing companies. We decided to explore which factors affect the efficient implementation of internal logistics and consequently, efficient production. After reviewing and collecting the results, we arranged them in a table to determine the key categories.

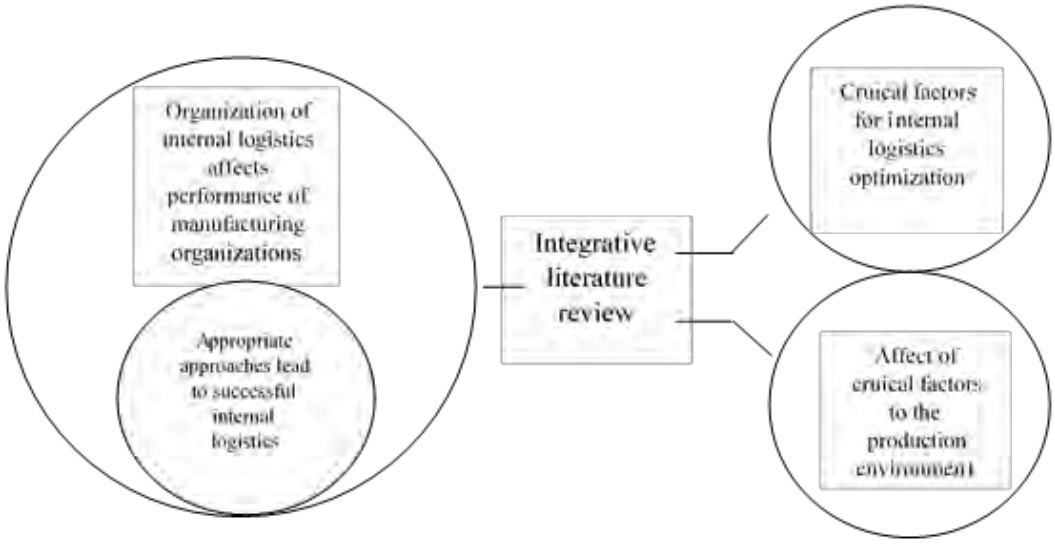

Figure 2. Research model

The research is based on an integrative review (Torraco, 2005, 2016) of the existing scholarly literature in the field of efficient performance based on an appropriate organization of internal logistics processes (see Figure 2). We used the method of a thematic analysis of the academic literature. The framework for the integrative part is based on the author Granlund (2011, p. 52), who notes that the question of the most important success factors for a well-functioning internal logistics system can be described by three areas: (1) performance factors such as delivery accuracy, inventory and delivery times, (2) information factors such as information systems, communication and information accuracy; and (3) flow-related factors and processes, such as good and balanced flow. The aspect of efficiency can be partially considered as a result of the system, but it also refers to internal capacity, as an example we can cite the accuracy of delivery for domestic transport, thus ensuring smooth operation. He also mentions a person as a factor of success, especially in terms of commitment and responsibility and the qualifications of people working in internal logistics systems. Similarly, Schulze and Wűllner (2006, p. 522) state that the internal logistics system with internal logistics activities is presented as a necessary and essential part for the entire operation of organizations in a wide range of operations. In the manufacturing industry, the main task of the internal logistics system is to provide the necessary stocks to the organization's operational units. Failure to flow materials or related information can lead to costly backlogs, which explains the importance of a well-functioning internal logistics system. Our research also led us to similar results. Based on the studied literature, an overview of key impact factors the organization of internal logistics, and thus, the performance of manufacturing organizations is presented. Using research databases (WoS, ScienceDirect, SpringerLink, Google Schoolar) we found articles that meet our requirements. The following inclusion criteria were set: publication of the article between 2010 and 2020 and the availability of the full text of the article in English. We reviewed all extracts of selected hits. In the revision, we included potentially relevant hits and selected those contributions that we used in the review. Articles were found by keywords, which are classified in Table 2. We did not find any original scientific papers in the Slovene language, or they were older than ten years, so we did not include them in the review. We found that many recent articles that would be suitable for our research appear were from various international conferences, and were published only in conference proceedings that have no impact factor, so we excluded them and did not use them in the research analysis.

Table 2. Keywords used in databases

Logistics
Interlogistics
Internal logistics
Manufacturing companies
Production performance
Efficient internal logistics
Modern technologies in internal logistics
Industry 4.0 in logistics processes

After reviewing the titles and abstracts of the articles, 215 articles met the criteria, 121 were excluded by reviewing the data (because they did not meet the inclusion criteria or were duplicates) and 84 due to inadequacies regarding the year of publication, so 10 articles were included in the final analysis. After identifying the topic, collecting, and reviewing the literature, evaluating the suitability and exclusions, selecting the appropriate articles, and identifying the categories, we came to the following findings.

The analysis of the articles showed that factors of internal logistics organization can be divided into three keygroups, namely: (1) the impact of information technology, (2) the use of lean production principles, and (3) the use of Industry 4.0 technologies in internal logistics. Different authors highlight the different factors shown in Table 3.

Table 3. Factors affecting the efficiency of internal logistics

Factor	Author	Impact Factor
1. Information technology	Fusko et al, 2017	0.784
	Jun et al, 2013	0.179
	Strandhagen et al, 2013	2.047
	Barreto et al, 2017	0.855
2. Application of lean production principles	Antunes, et al, 2013	0.283
	Reis et al, 2017	0.758
	Roessler et al, 2013	0.552
3. Industry 4.0 Technologies in Internal Logistics	Strandhagen et al, 2017	2.047
	Barreto et al, 2017	0.855
	Gregor et al, 2017	0.784
	Rocha, et al, 2010	0.552
	Vavrik et al, 2017	0.784
	Sun et al, 2010	1.342

4 Results

An integrative review of the literature showed that most authors emphasize the most important factor, the use of Industry 4.0 technologies in internal logistics processes, which is strongly related to the use of information technology, and both are strongly related to the third

factor, namely the use of lean production principles in internal logistics, especially in the field of efficient material storage and supply systems. The use of modern technologies of industry 4.0 in internal logistics enables the increase of the general competitiveness of organizations. Table 4 presents summaries of individual articles, with special emphasis on the different approaches of a successful organization of internal logistics.

Table 4. Presentation of key findings successful organization of internal logistics

Factor	Author	Key findings
1. Information technology	Fusko et al, 2017	**Reducing the cost of internal logistics** is one of the main ways to achieve a competitive advantage in the market. Traditional approaches to production systems need to be changed to digital. In the article, the authors present a new look at internal logistics with recommended **digitization** practices. The production process encompasses the activities required to convert the input string into results. The set of entries includes human resources, raw materials, components, equipment, energy, money, information, and so on. Market globalization, increasing global competition and more complex products require the use of new production and logistics technologies, methods and business processes. In the future, the production environment will require even more **urgent approaches to integrating information technology (IT)** into the production area. The article examines approaches for reducing costs of internal spare parts logistics by introducing new methods and technologies.
	Jun et al, 2013	**Building logistics computerization** is essential for the **development of manufacturing companies**. By choosing the appropriate method of building logistics computerization, a manufacturing company can save an investment provided that they meet their business requirements. The authors show **the essential ways of computerization of logistics** and explain **the method of building logistics computerization**, and then determine the suitability of individual methods of building logistics computerization for each of the types of companies, as divided in the article.
	Strandhagen et al, 2013	The era of Industry 4.0 is marked by rapid technological development and the need for manufacturing companies to become independent of labour costs. The use of 4.0 applications has been clearly outlined, but their relevance in different production environments is not clear. In this article, the authors identify and research **the industry 4.0 technologies** used in the internal logistics of manufacturing companies and the impact of production environments on their usability. As one of Industry 4.0's applications, they **also present a seamless flow of information**. The

		emphasis is on vertical integration for integrated information management, which can mean **improving internal logistics. The integration of IT systems and the digitization** of production in the context of internal logistics will mean that the tasks needed to direct the flow of materials through the factory are carried out with **the support of IT systems.**
	Barreto et al, 2017	Over the last decade, **the use and development of information and communication technologies in industry** has become completely unavoidable. The advent of the industrial Internet has spurred new challenges in **the field of logistics that require technological change**, such as the great need for transparency and control of the integrity of the right products at the right time, in the right place, the right quantity and at the right cost.
2. Application of lean production principles	Antunes, et al, 2013	Based on a case study of the supply of components on the assembly line of car audio systems, the authors recognize that the **Six Sigma methodology, combined with the principles of lean manufacturing**, represents great potential in **improving internal logistics processes**. The use of continuous improvement methodologies such as Six Sigma and lean principles in the field of internal logistics are key concepts of the article. Variables indicating the quality and performance of internal logistics are grouped into three categories: delivery delays, supply errors and delivery errors. The result of the study is reflected in the proposed improvements to **reduce errors** in the procedures of supply of assembly lines with the necessary components. The lean logistics and Six Sigma methodology are presented as key factors to **reduce non-value added activities and improve the organization's internal logistics.**
	Reis et al, 2017	Managing the internal logistics process is an issue that has currently become crucial to success in a competitive market within any industry and supply chain. Based on an empirical study of **the principles of leanness in the storage** of oil and gas companies, the authors show the importance of **applying the principles of leanness in the production context, especially in the storage industry**. The industrial environment often underestimates internal logistics, which may be due to the fact that it does not create added value. Internal logistics processes in terms of internal storage and material handling often remain intact in terms of improvements. The article offers **solutions in terms of lean techniques in the field of internal logistics operations.**

	Roessler et al, 2013	To manage the growing complexity in **the design of lean machine-internal logistics systems**, a process model is needed to systematize the space for solutions. The authors state that in **the material flow planning phase of lean manufacturing,** key performance indicators for design alternatives, taking into account machine tools and elements of intralogistics, are obtained through simulation. In the case study, three possibilities of designing machine-internal logistics systems were evaluated, taking into account five key performance indicators. **A relative lean corridor can be determined** for each design variant. This paper sees a special emphasis on tool and internal logistics configurations to achieve **optimization and proper planning.**
3. Industry 4.0 Technologies in Internal Logistics	Strandhagen et al, 2017	The era of Industry 4.0 is marked by rapid technological development and the need for manufacturing companies to become independent of labour costs. **The use of 4.0 applications** has been clearly outlined, but their relevance in different production environments is not clear. In this article, the authors identify and research the impacts of **Industry 4.0 technologies used in the internal logistics of manufacturing companies** and the impact of production environments on their usability. Multiple case studies have been conducted and the findings show that the applicability of Industry 4.0 in production logistics depends on the production environment. **Companies with a low recurrence rate see less potential in using 4.0 technology in internal logistics, while companies with very recurring production see more potential.**
	Barreto et al, 2017	In addition to the already mentioned emphasis on the use of information and communication technologies, the authors present other findings on important dimensions that are necessary for the full implementation of **the logistics paradigm 4.0.** Under the requirements of Industry 4.0, Logistics 4.0 also includes a range of **technical components, software and human support.** Logistics 4.0 can be interpreted as optimized logistics systems **designed by a high degree of automation.**
	Gregor et al, 2017	Rapid development not only changes products and their functionality, but also brings a new perspective on the monitoring, control and optimization of logistics activities. The authors present the described changes in the case of a selected company, where a large number of manual operations performed by employees are transformed into an automated, flexible and intelligent form. Smart Connected Logistics concept is highlighted, which brings a significant increase in efficiency. The results are shown as **savings in**

		the use of mobile robotic systems compared to human labour. They find 89-90% cost savings, while also 20-30% performance growth and a significant reduction in errors. Autonomous intelligent solutions represent the future of logistics, both with updated equipment and a changed logistics concept.
	Rocha, et al, 2010	The authors of the article **emphasize the use of automated guided vehicles in material handling systems** and flexible production systems, where production orders are constantly changing. They enable **a significant reduction in time consumption, increase the flexibility of the production process,** which in many production processes still lags behind expectations due to inadequate transport systems. In the case of simulation, the article examines the impact of the use of automated guided vehicles in a selected company, and the result is reflected in **higher system productivity.**
	Vavrik et al, 2017	The article describes the results of the research project, and at the same time presents the method of determining the number of automated guided vehicles and the selection of the optimal internal logistics route of the company. **New technologies are significantly changing internal logistics,** so **internal logistics is gradually becoming more flexible**, which requires changes to the overall concept of future solutions. The research examines **the automated logistics system** of the planned operation of the production of semi-finished products within the process of production of components in the automotive industry. A simulation model of the logistics system is proposed, which contains the required number of automated guided vehicles and vehicle track optimization.
	Sun et al, 2010	Although, an extremely **high level of automation** is achieved within logistics and in production today, human labour is still used for transport by trolleys and forklifts, resulting in high labour costs and a risk of damage. Fixed-mounted conveyors are used in automated warehouses, but they are not flexible in the event that the company's production lines change. As a solution, the article presents a new approach with **a composite group of autonomous robots that perform tasks within logistics.**

We found that the key factors influencing the successful implementation of internal logistics processes are (1) the use of information technology, (2) the use of Industry 4.0 technologies in internal logistics processes and (3) the use of lean manufacturing principles in internal logistics. The text below describes how different authors connect them with the successful organization of internal logistics and also with the success of production organizations.

Information Technology: Fusko (2017, pp. 214–215) says that information and communication systems are on the one hand very well developed, and on the other hand many factories are still not ready to transform from classic technical services to digital technologies. Appropriate information technology in the field of internal logistics reduces the amount of work, which in itself does not bring added value (search in the warehouse, ambiguous labelling, surpluses and shortages of stock in the warehouse, on production lines…). However, the introduction of information systems means significant cost reduction in internal logistics processes. He also states that globalization of the market, increasing global competition and the complexity of modern products necessitate the use of new production and logistics technologies in business processes. The production environment requires the integration of information technologies into its area, both in terms of applications in the right equipment and new methods and technologies that need to be integrated into internal logistics (Fusko, 2017, p. 218). Similarly, Jun et al. (2013, p. 5), state that in the logistics process of manufacturing companies, the use of information has become a key factor in increasing operational efficiency, reducing costs, and improving the quality of customer service.

Industry Technologies 4.0: Strandhagen et al. (2017, p. 344–358) say that automation and the use of robots are important not only in production processes, but also for transportation, the supply of production lines, and handling of materials within companies. AGVs are just one example of material transport systems in manufacturing companies, which from the point of view of autonomy represents an important industry 4.0 system. Technological development, autonomous and automatic systems for transport and handling of materials greatly benefit the organization's internal logistics, and in order to achieve efficient internal logistics, in addition to improving the flow of materials, emphasizes greater use of information technology and control over reducing stocks of raw materials and finished products. Barreto et al (2017, p. 1248) present smart logistics as a logistics system that can increase flexibility, adapt more easily to market changes and bring customers closer to customer needs, based on improved customer service, production optimization and lower costs of storage and production processes. All this is possible only with the use of the latest technologies in the Industry 4.0 period. Also Rocha et al. (2010, p. 248–255) claims that more and more internal logistics processes should be fully aligned with production resources (machines, tools, and operators) and thus support complexity. Internal logistics systems depend on the type of production, the type and quantity of products produced, as well as on customer requirements (production processes where work is done in stock or according to customer orders). He notes that by improving internal logistics processes, we are influencing more efficient distribution and production flows, citing conveyors, automatically controlled

and similar vehicles as solutions, which provide flexibility, reliability, lower labour costs and higher productivity in connection with the development of technology to manage these vehicles. Similarly, Vavrík et al. (2017, p. 923–928) believe that new technologies are changing internal logistics, citing as an example an automated logistics system of production operation with an optimized supply of materials using an appropriate number and appropriate models of automated guided vehicles.

Application of lean production principles: Antunes et al. (2013, p. 414–419) claim that the approach of using Six Sigma in combination with the concepts of lean production represents a great potential that can be successfully used in improving internal logistics processes. Similarly, Reis et al. (2017, p. 342) note that internal logistics management is an issue that has become crucial to success in a competitive market of any industry, emphasizing the application of lean production concepts in manufacturing companies, especially in warehousing. Similarly, Roessler (2013, p. 559–564) presents the use of lean production concepts, which emphasizes the connection between material flows and internal logistics elements for material handling and the development of concepts for appropriate internal logistics solutions and integration into lean material flows.

The automation of individual internal logistics processes should be emphasized. The benefits of automation are great, especially in internal logistics due to the often large amount of repetitive manual work. As an example, Frazelle (2012, p. 22) presented a methodology for the design and transformation of storage systems, where automation is also listed as one of the common denominators of successful warehouse operations. Automation includes computerization and mechanization, where mechanization refers primarily to the automation of the physical flow of goods, and computerization to the flow of information. The level of automation is a concept often used in the discussion of the development of automation. It is often used in assessing the level of automation. The level of automation can be described as a variable that ranges between fully manual and fully automatic control (Frohm, 2008, p. 12–13).

Highly automated product manufacturing is an important way to achieve industry competitiveness, especially in parts of the world where labour costs are relatively high (U.S. and Europe). The development in the 20th century is mainly in the direction of automating the production processes of manufacturing companies and thus increasing efficiency and quality in production. A higher level of automation includes not only the actual manufacturing processes, but also higher automation of support tasks (material handling, transport, and storage). In the 1980s, the emphasis was on full automation in all production units, but systems in manufacturing companies remained semi-automatic, consisting of a combination of automatic and manual tasks. Product customization requirements have increased, production systems have become increasingly complex, but automation has not necessarily led to higher efficiency. As an integral part of the production system, it is also necessary to include a person who must be involved in technical progress and must be qualified to operate machinery and equipment. From this, we can conclude that just like automation and the use of

advanced technologies, efficient production requires an appropriately qualified workforce (Frohm, 2008, p. 2–3).

5 Discussion

Production processes and the technology used have changed dramatically in the last fifty years. Automation has mostly replaced manual process management, which represents a sudden leap for production in terms of both productivity, accuracy and further competitiveness and performance. Despite these facts, the processes of internal logistics, which decisively support production, in many cases still lag behind the development of production itself. Procedures for receiving, storing, and transporting of materials and delivering them to the various production stages remain unchanged, while companies still do not decide to upgrade and continue to use outdated systems. This is partly due to the rapid automation of production. All available resources and assets have been invested in it by production companies in an essential production process, while internal logistics processes have lagged. As another factor for stagnation, we can also consider that until recently, solutions to improve internal logistics processes were often very expensive and inflexible, which is a considerable problem for manufacturing companies. The introduction of changes in terms of modern technologies in internal logistics processes was a risky and challenging investment from a business point of view. Production internal logistics procedures are very inefficient if they are not technically perfect. Production companies with such an unfinished internal logistics system are losing control over the efficient management and control of supplies, which is the basis for successful production processes. For this reason, there is a more significant investment in production equipment and workers who take care of supplies.

The analysis of the articles shows that the success of production companies can be achieved through different approaches to the design of internal logistics processes. The most important is the use of Industry 4.0 modern technologies in the planning of internal logistics processes, which in connection with the transformation of processes from semi-automatic to fully automatic and in close connection with appropriate information technology, significantly contributes to the success of not only the production process but the overall competitiveness. Modern technologies need to be introduced into individual internal logistics processes and thus achieve higher performance, which, in combination with appropriate information technology and lean production concepts, bring critical competitive advantages to manufacturing companies.

Granlund (2011, p. 2–3) points out that the benefits of using automation in internal logistics activities (internal transport, material management) are excellent, as they are often characterized by a large amount of manual work, both time-consuming and physically strenuous. Logistics costs vary according to the degree of automation in logistics processes, and higher automation can also have other advantages, such as increased capacity and improvements in the work environment. Automation is probably a key point in the development and optimization of internal logistics.

A significant factor is the automation of internal logistics processes with the introduction of Industry 4.0 technologies, which answers the research questions that the appropriate organization of internal logistics processes affects the performance of manufacturing companies. Automation is an effective way to achieve the success of manufacturing organizations, also in conjunction with the transformation of internal logistics processes. At the same time, a person is a palliative for difficult and dangerous tasks, but we must not forget that it also has its drawbacks. The company must prepare adequately for the introduction of automation of internal logistics processes, as there may be incompatibilities if organizations do not prepare for automated internal logistics procedures in advance with the correct distribution of functions and tasks between man and automated equipment.

Based on a review of the literature, we can confirm the impact of adequately organized internal logistics on the performance of production processes and thus the competitiveness of manufacturing companies. The internal logistics system includes all activities related to the management of the flow of materials within the organization. We believe that, as a system, it represents an important part that needs to be continuously improved. Automation is a tool that has great potential for improving internal logistics. Despite the high potential and the growing trend of use, automation in the field of internal logistics processes is still not used as often as in other phases of production processes. The use of technology such as automation, therefore, affects competitive advantage and can worsen or improve an organization's competitive position, so it is imperative that it is appropriately used to ensure a positive effect. To achieve this, it is necessary to find both the level and the type of automation that best suits the needs and requirements of the environment in which the automated equipment will be used.

6 Conclusion

With the Industry 4.0, internal logistics in manufacturing companies represents a new dimension. Internal logistics in production contributes to better movement management and inventory control between different production processes, technology, modern software, and automation represent a positive factor needed for optimization. Automation of internal logistics processes creates a competitive advantage by reducing costs, increasing flow, and responding more quickly to changes in demand. Optimization of internal logistics for production companies represents greater efficiency of individual processes, and it is crucial that the company before investing in advanced technologies in terms of automation of internal logistics, assesses the state of the processes and develops a strategy for successful implementation of automation.

The article provided an integrative review of the literature on effective organization of internal logistics processes that shape the performance of manufacturing organizations. By taking into account, the key factors of the optimization of internal logistics, both top management and management of individual production departments can plan more appropriate, efficiently, and more rational internal logistics processes in manufacturing organizations, thus, affecting overall competitiveness. The identified key factors can lead to

critical decisions or at least specific guidelines that can be used by any manufacturing organization in planning of internal logistics processes. The changed processes of internal logistics in production affect and shape the performance of production companies. Many manufacturing organizations still have difficulties in finding and selecting appropriate automation of their internal logistics processes, which can be a starting point for further research. Problems arise mainly due to poor insight into the current state of efficiency of internal logistics, lack of strategic view of internal logistics, which leads to incorrect assessment and decision-making regarding the development of automation. Also, the three factors that influence the organization of internal logistics processes highlighted in the article represent only a part of possible improvements and are indeed subject to further research.

The research is limited both in terms of the number of contributions and the broadness of the topic. For more detailed results, it could be expanded and adapted to different types of manufacturing companies, which would further improve the insight into the key factors for the success of internal logistics processes.

Reference

1. Antunes, D. L., Sousa, S. D., & Nunes, E. (2013). Using project six sigma and lean concepts in internal logistics. *Lecture Notes in Engineering and Computer Science*, *1 LNECS*, 414–419.
2. Barreto, L., Amaral, A., & Pereira, T. (2017). Industry 4.0 implications in logistics: an overview. *Procedia Manufacturing*, *13*, 1245–1252. https://doi.org/10.1016/j.promfg.2017.09.045
3. Bonini, M., Urru, A., Steinau, S., Ceylan, S., Lutz, M., Schuhmacher, J., Andrews, K., Halfar, H., Kunaschk, S., Haque, A., Nair, V., Rollenhagen, M., Shaik, N., Reichert, M., Bartneck, N., Schlegel, C., Hummel, V., & Echelmeyer, W. (2018). *Automation of Intralogistic Processes through Flexibilisation - A Method for the Flexible Configuration and Evaluation of Systems of Systems*. https://doi.org/10.5220/0006878003900398
4. Emde, S., & Boysen, N. (2012). Optimally locating in-house logistics areas to facilitate JIT-supply of mixed-model assembly lines. *International Journal of Production Economics*, *135*(1), 393–402. https://doi.org/10.1016/j.ijpe.2011.07.022
5. Frazelle, E. (2012). Svetovni standardi za logistiko skladišča. Pridobljeno na: https://ozon-st.cdn.ngenix.net/multimedia/1005556088.pdf
6. Frohm, J., Lindström, V., Stahre, J., Winroth, M. (2008). Levels of automation in manufacturing. *Ergonomia - an International journal of ergonomics and human factors,* Vol. 30 Issue 3, 2-13.
7. Fusko, M., Rakyta, M., & Manlig, F. (2017). Reducing of Intralogistics Costs of Spare Parts and Material of Implementation Digitization in Maintenance. *Procedia Engineering*, *192*, 213–218. https://doi.org/10.1016/j.proeng.2017.06.037
8. Granlund, A. (2011). Competitive internal logistics system through automation, 2-3.
9. Granlund, A., & Wiktorsson, M. (2014). Automation in internal logistics: Strategic and operational challenges. *International Journal of Logistics Systems and Management*. https://doi.org/10.1504/IJLSM.2014.063984
10. Gregor, T., Krajčovič, M., & Więcek, D. (2017). Smart Connected Logistics. *Procedia Engineering*, *192*, 265–270. https://doi.org/10.1016/j.proeng.2017.06.046

11. IFR International Federation of Robotics statistics department (2014). *World robotics Service Robots: Statistics, Market Analysis, Forecasts and Case Studies.* Adapted by: https://ifr.org/news/service-robots-logistic-systems-on-the-rise
12. Jakomin, I. & Veselko, G. (2004). Načrtovanje, organiziranje in nadzor vseh aktivnosti. *Logistika in transport,* št. 10, 19-21.
13. Jun, L., Yan, Q., & An, Y. W. (2013). The research on classified construction mode of manufacturing enterprise logistics informatization. *Advanced Materials Research*, *694 697*, 3492–3497. https://doi.org/10.4028/www.scientific.net/AMR.694-697.3492
14. Kartnig, G., & Grösel, B. (2012). *Past , State-of-the-Art and Future of Intralogistics in Relation to Megatrends*. 193–200.
15. Nagy, G., Illés, B., & Bányai. (2018). Impact of Industry 4.0 on production logistics. *IOP Conference Series: Materials Science and Engineering*. https://doi.org/10.1088/1757-899X/448/1/012013
16. Reis, A., Stender, G., & Maruyama, U. (2017). Internal logistics management: Brazilian warehouse best practices based on lean methodology. *International Journal of Logistics Systems and Management*, *26*(3), 329–345. https://doi.org/10.1504/IJLSM.2017.081965
17. Rocha, L. F., Moreira, A. P., & Azevedo, A. (2010). Flexible internal logistics based on AGV system's: A case study. In *IFAC Proceedings Volumes (IFAC-PapersOnline)* (Vol. 43, Issue 17). IFAC. https://doi.org/10.3182/20100908-3-PT-3007.00049
18. Roessler, M. P., Wolff, M., & Abele, E. (2013). Design and simulation based assessment of lean material flows considering imprecision. In *IFAC Proceedings Volumes (IFAC-PapersOnline)* (Vol. 6, Issue PART 1). IFAC. https://doi.org/10.3182/20130911-3-BR-3021.00021
19. Schulze, L., & Wüllner, A. (2006). The approach of automated guided vehicle systems. *2006 IEEE International Conference on Service Operations and Logistics, and Informatics, SOLI 2006*, 522–527. https://doi.org/10.1109/SOLI.2006.236834
20. Strandhagen, J. W., Alfnes, E., Strandhagen, J. O., & Vallandingham, L. R. (2017). The fit of Industry 4.0 applications in manufacturing logistics: a multiple case study. *Advances in Manufacturing*, *5*(4), 344–358. https://doi.org/10.1007/s40436-017-0200-y
21. Sun, D., Kleiner, A., & Schindelhauer, C. (2010). *Decentralized hash tables for mobile robot teams solving intra-logistics tasks*. *2*(Aamas), 923–930.
22. Torraco, R. J. (2005). Writing Integrative Literature Reviews: Guidelines and Examples. *Human Resource Development Review*, *4*(3), 356–367. https://doi.org/10.1177/1534484305278283
23. Torraco, R. J. (2016). Writing Integrative Literature Reviews: Using the Past and Present to Explore the Future. *Human Resource Development Review*, *15*(4), 404–428. https://doi.org/10.1177/1534484316671606
24. Vavrík, V., Gregor, M., & Grznár, P. (2017). Computer Simulation as a Tool for the Optimization of Logistics Using Automated Guided Vehicles. *Procedia Engineering*, *192*, 923–928. https://doi.org/10.1016/j.proeng.2017.06.159
25. Winkler, H., & Zinsmeister, L. (2019). Trends in digitalization of intralogistics and the critical success factors of its implementation. *Brazilian Journal of Operations & Production Management*, *16*(3), 537–549. https://doi.org/10.14488/bjopm.2019.v16.n3.a15
26. Zelenika, R., & Pupovac, D. (2001). Suvremeno promišljanje osnovnih fenomena logističkog sustava. Ekonomski pregled. 354-378

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Povzetek:
Vpliv notranje logistike na uspešnost proizvodnih podjetij – pregledni članek

Raziskovalno vprašanje (RV): Kakšen je vpliv kakovostnega izvajanja notranjih logističnih procesov na uspešnost proizvodnje?
Namen: Ugotavljamo kakšen način organizacije notranje logistike je najprimernejši za uspešnost proizvodnega procesa ter s katerimi pristopi izboljšujemo kakovost organizacije notranjih logističnih procesov.
Metoda: Rezultate bomo iskali s pomočjo pregleda člankov in že obstoječe literature iz obdobja preteklih nekaj let. Osredotočili se bomo na novejšo literaturo, saj se pregledni članek navezuje na spremembe, ki so se začele v obdobju industrije 4.0.
Rezultati: Organiziranost in vlaganje v procese notranje logistike v proizvodnji vpliva na kakovost opravljanja proizvodnje in s tem tudi na konkurenčnost podjetij. Z rezultati želimo prikazati možnosti, s katerimi pripomoremo k izboljšanju procesov notranje logistike.
Organizacija: Prikazani rezultati lahko pripomorejo k sprejemanju pravilnih odločitev pri organizaciji logističnih procesov znotraj proizvodnje ter k pravilnejšim vložkom s strani vodstva v izboljšave in napredne tehnologije za izvajanje logističnih procesov.
Družba: Nižji stroški, ki jih prinaša pravilna organiziranost notranje logistike v proizvodnji predstavlja za organizacijo veliko konkurenčno prednost, hkrati pa z implementacijo naprednih tehnologij razbremenimo tudi delavce.
Originalnost: Celovit pregled obstoječe novejše literature o vplivu pravilnega načrtovanja, organizacije in načina izvajanja notranje logistike na uspešnost proizvodnje v podjetjih.
Omejitve/nadaljnje raziskovanje: Analiza bo še vedno omejena zaradi omejenega števila literature in člankov.

Ključne besede: notranja logistika, proizvodnja, uspešnost, izboljšave, tehnologija.

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ESP-NOW communication protocol with ESP32

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Abstract:
Purpose and Originality: The main problem in data acquisition from different sensor nodes is the lack of access to a local wireless network. The purpose of this paper is to present the possibilities offered by the ESP-NOW communication protocol on the development board ESP32 from Espressif (1).
Method: For this paper we used quantitative method. 3 wireless communication modules are used that exchange information from 3 different sensor nodes.
Results: The used system provides data retrieval from sensor nodes in conditions of non-existence of local internet network, with satisfactory communication distance (190m).
Society: This type of devices is especially useful for use in systems for measurement of data acquisition from environmental protection systems.
Limitations / further research: Direction for further research: a system change is recommended in order to increase the achieved distances of Wi-Fi information exchange

Keywords: Data acquisition, Measurement, Development board, MCU, ESP32, ESP-NOW.

1 Introduction

Today's measuring and acquisition systems are in widespread use, for example measuring systems for process control in various production plants, measuring systems for measuring air quality, measuring systems for traffic management…Characteristic problem for all of them is the storage of the measured data, especially when there is a need for real time measurements and display data. Wireless communication offers almost unlimited possibilities for collecting measured data.

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2 Theoretical framework

Espressif Systems (688018.SH) is a public multinational, fabless semiconductor company established in 2008, with offices in China, the Czech Republic, India, Singapore and Brazil, with team of engineers and scientists from all over the world, focused on developing cutting-edge Wi-Fi-and-Bluetooth, low-power, AIoT solutions. They created the popular ESP8266, ESP32 and ESP32-S series of chips, modules and development boards. Published papers covering this area are rare worldwide.

3 Method

For this paper we used quantitative method. 3 wireless communication modules are used that exchange information from 3 different sensor nodes. ESP-NOW is a connectionless Wi-Fi communication protocol that is defined by Espressif [1]. Application data in ESP-NOW is encapsulated in a specific action frame and then transmitted from one Wi-Fi device to another without connection. CTR with CBC-MAC Protocol (CCMP) is used to protect the action frame for security. ESP-NOW supports the following features (2):

- Encrypted and unencrypted unicast communication,
- Mixed encrypted and unencrypted peer devices,
- Up to 250-byte payload can be carried,
- The sending callback function that can be set to inform the application layer of transmission success or failure.

ESP-NOW technology also has the following limitations:

- Broadcast is not supported,
- Limited encrypted peers. 10 encrypted peers at the most are supported in Station mode; 6 at the most in SoftAP or SoftAP + Station mode. Multiple unencrypted peers are supported, however, their total number should be less than 20, including encrypted peers,
- Payload is limited to 250 bytes.

The default ESP-NOW bit rate is 1 Mbps. The format of the vendor-specific action frame is as follows:

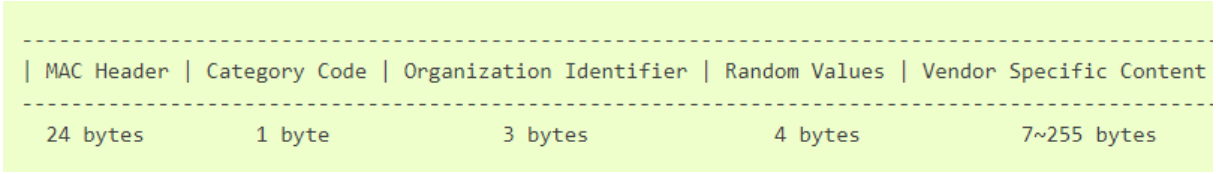

Figure 1. Format of the specific action frame

- Category Code: The Category Code field is set to the value (127) indicating the vendor-specific category.

- Organization Identifier: The Organization Identifier contains a unique identifier (0x18fe34), which is the first three bytes of MAC address applied by Espressif.
- Random Value: The Random Value filed is used to prevents relay attacks.
- Vendor Specific Content: The Vendor Specific Content contains vendor-specific fields as follows:

Element ID	Length	Organization Identifier	Type	Version	Body
1 byte	1 byte	3 bytes	1 byte	1 byte	0~250 bytes

Figure 2. Vendor-specific fields

- Element ID: The Element ID field is set to the value (221), indicating the vendor-specific element.
- Length: The length is the total length of Organization Identifier, Type, Version and Body.
- Organization Identifier: The Organization Identifier contains a unique identifier(0x18fe34), which is the first three bytes of MAC address applied by Espressif.
- Type: The Type field is set to the value (4) indicating ESP-NOW.
- Version: The Version field is set to the version of ESP-NOW.
- Body: The Body contains the ESP-NOW data.

As ESP-NOW is connectionless, the MAC header is a little different from that of standard frames. The FromDS and ToDS bits of FrameControl field are both 0. The first address field is set to the destination address. The second address field is set to the source address. The third address field is set to broadcast address (0xff:0xff:0xff:0xff:0xff:0xff). ESP-NOW uses the CCMP method, which is described in IEEE Std. 802.11-2012, to protect the vendor-specific action frame. The Wi-Fi device maintains a Primary Master Key (PMK) and several Local Master Keys (LMK). The lengths of both PMK and LMk are 16 bytes.
ESP-NOW allows to exchange data between several ESP32 boards programmed with Arduono IDE. Multiple devices can tock to each other in an easy way.

Figure 3. ESP-NOW one-way communication protocol

After pairing a device with each other, the connection is persistent. It very important to know, if suddenly one of your boards loses power or resets, when it restarts, it will automatically connect to its peer to continue the communication.

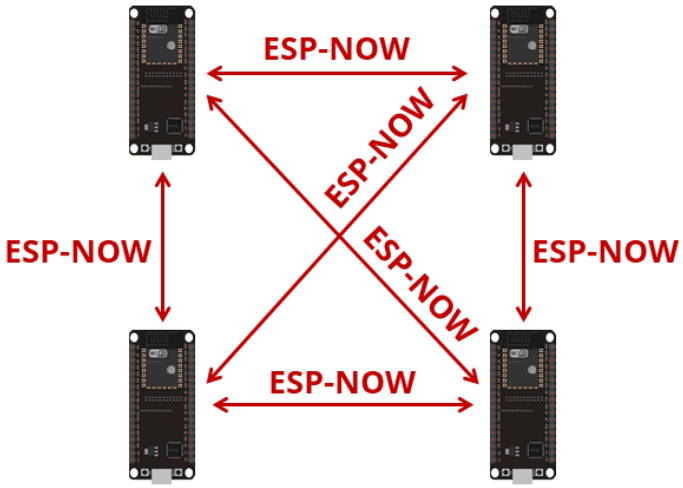

Figure 4. ESP-NOW two-way communication protocol

4 Results

In order to be able to communicate between multiple ESP32 via ESP-NOW, it is essential to know the ESP32 receiver MAC address. In this way it is determined which ESP32 node will receive the data. Each ESP32 board has unique MAC address.

Sender sketch must include:

- Initialize ESP-NOW;
- Register a callback function upon sending data;
- Add a peer device (the receiver with MAC address);
- Send a message to the peer device.

Receiver sketch must include:

- Initialize ESP-NOW;
- Register for a receive callback function.
-

Inside that callback function save the message into a variable to execute any task with that information.

In our case, we test communication range between ESP32 boards, and we have stable communication up to 190 meters in open field.

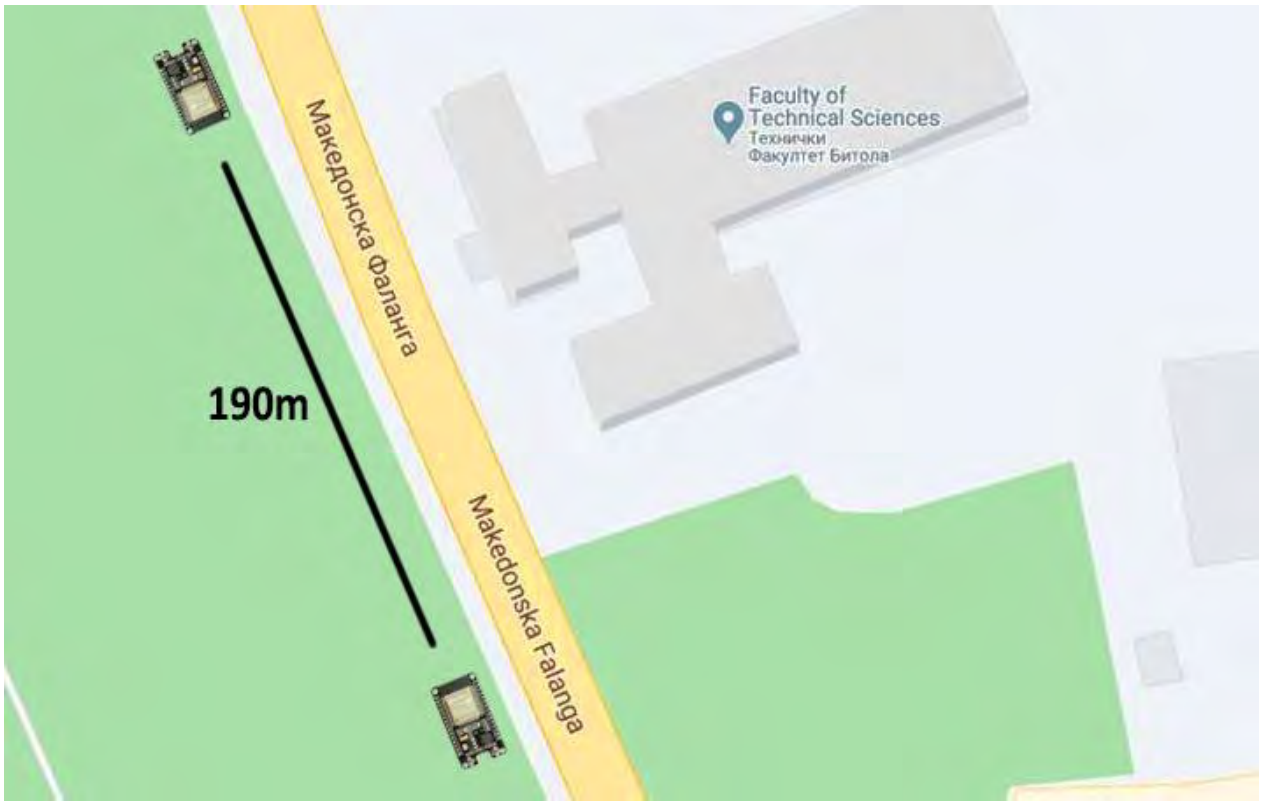

Figure 5. ESP-NOW communication range

5 Discussion

In our case, it has been tested ESP-NOW one-way communication protocol between two senders and one receiver ESP32 boards. Each sender has a combined sensor for measuring temperature and relative humidity based on AM2301.

Figure 6. AM2301 temp/hum sensor

In order to be able to communicate between multiple ESP32 via ESP-NOW, it is essential to know the ESP32 receiver MAC address.

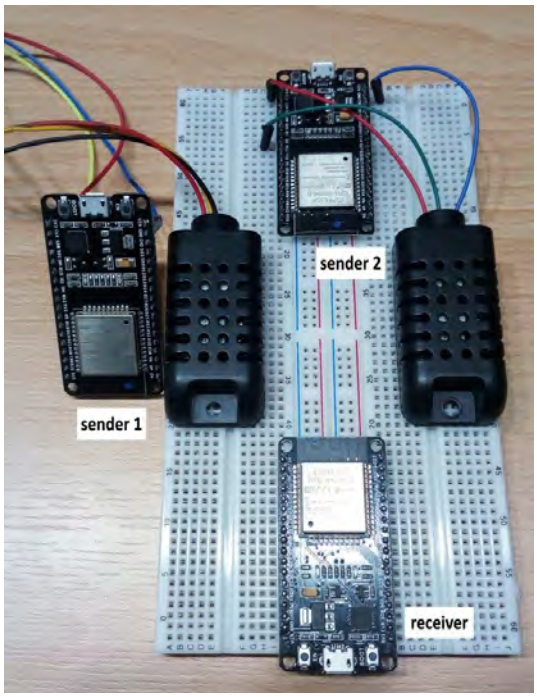

Figure 7. Two senders and on receiver ESP32 boards in one-way ESP-NOW comm. protocol

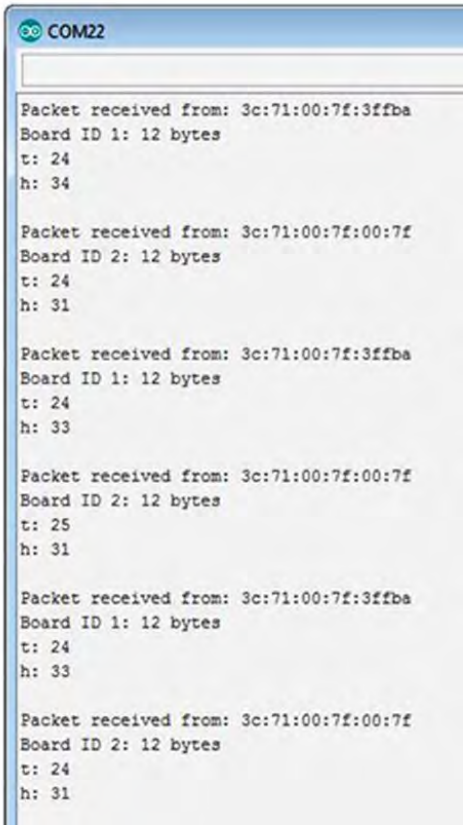

Figure.8. Arduino IDE serial monitor from receiver ESP32 board

6 Conclusion

ESP-NOW communication protocol from Espressif will greatly alleviate the problems of retrieving the measured data from sensor nodes placed in environments where there is no possibility to connect to a local wireless network. Robust design, ultra-low power consuptation, high level of integration and hibrid wifi and bluetooth chip on ESP32 MCU are ideal features of a platform for solving complex problems in real measurement systems and data acquisition from sensor node groups.

References

1. Espressif (homepage). Retrieved from espressif.com/en
2. ESP-IDF Programming Guide - ESP32. *ESP-IDF Programming Guide latest documentation*. Retrieved from https://docs.espressif.com/projects/esp-idf/en/latest/esp32/
3. Getting Started with ESP-NOW (ESP32 with Arduino IDE). *Random Nerd Tutorials.* Retrieved from https://randomnerdtutorials.com/esp-now-esp32-arduino-ide/
4. HM2301 Digital-output humidity and temperature sensor. *Temperature / Humidity module AM2301*. Retrieved from https://mikroshop.ch/pdf/DHT21.pdf
5. Kuzmanov, I., & Pasic, R. (2019). Real impact of the microclima changes to workers wo circulate from hot to cold chambers – a part from an extensive research into industrial entity. *Temel International Journal*, Vol.3., Iss.2.

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Povzetek:
ESP-ZDAJ komunikacijski protokol z ESP32

Namen in izvirnost: Glavna težava pri pridobivanju podatkov iz različnih vozlišč senzorjev je pomanjkanje dostopa do lokalnega brezžičnega omrežja. Namen tega prispevka je predstaviti možnosti, ki jih ponuja komunikacijski protokol ESP-NOW na razvojni plošči ESP32 podjetja Espressif.
Metoda: V prispevku smo uporabili kvantitativno metodo. Uporabljajo se trije brezžični komunikacijski moduli, ki si izmenjujejo informacije iz treh različnih vozlišč senzorjev.
Rezultati: Uporabljeni sistem omogoča pridobivanje podatkov s senzorskih vozlišč v pogojih neobstoja lokalnega internetnega omrežja z zadovoljivo komunikacijsko razdaljo (190 m).

Družba: Ta vrsta naprav je še posebej uporabna za uporabo v sistemih za merjenje pridobivanja podatkov iz sistemov za varstvo okolja.
Omejitve / nadaljnje raziskave: Za povečanje dosežene razdalje izmenjave informacij Wi-Fi je priporočljiva sistemska sprememba.

Ključne besede: zajem podatkov, merjenje, razvojna plošča, MCU, ESP32, ESP-ZDAJ.