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EDITORIAL

Dimitar Nikoloski

Southeast European Review of Business and Economics (SERBE) is a peer reviewed academic journal published by the Faculty of Economics-Prilep, University "St. Kliment Ohridski"-Bitola, Macedonia. It has been founded on the rich academic and publishing heritage, including the Yearbook of the Faculty of Economics-Prilep and Proceedings from a number of international conferences. Based on this tradition, our intention is to publish original papers, which have not been previously published or submitted for reviewing to other journals.

The process of transition and the subsequent post-transitional development in Southeast Europe have engendered peculiar socio-economic phenomena that deserve comprehensive and systematic analysis. In addition, the global recession and its consequences has brought into question the validity of the existing paradigm and imposed need for applying alternative methodological approaches. In this context, the economics and other social sciences have faced challenging task for exploring the newly created complex social reality. The motivation for this journal arises from the necessity of solutions to actual business and economic problems by upgrading the existing theoretical framework and using a wide arsenal of alternative research techniques.

The aim of the journal is to provide opportunities for researchers to present their findings in the areas of business and economics and to assist in creation of alternative approaches for treatment of actual economic problems. Hence, we encourage experienced scholars, business practitioners as well as young researchers to submit their original work on various problems in the areas of business and economics.

In this first number of Southeast European Review of Business and Economics (SERBE) are presented selected papers from the XI International Conference "Digital transformation of the economy and society: Shaping the future" held on October 19-20, 2019 at the Faculty of Economics-Prilep.

STOCK-AND-FLOW SIMULATION MODELING FOR ASSESSING BASIC SUPPLY CHAIN OPERATIONS

Ilija Hristoski, Ramona Markoska, Tome Dimovski, Nikola Rendevski, Željko Stojanov

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ABSTRACT

The supply chain is a backbone of business operations, an indispensable part of every organization, whether small or large. Effective supply chain management (SCM) is one of the most important aspects of running a successful and profitable business, leading to maximizing customer value and achieving a sustainable competitive advantage over the competitors. In the era of omnipresent digitalization, SCM is subject to intensive ICT support that transforms supply chain operations in a profound manner. The aim of the paper is to propose a basic simulation modeling framework suitable for carrying out various analyses *vis-à-vis* supply chain operations, based on the utilization of continuous stock-and-flow simulations. The resulting simulation model allows one to run various scenarios, making a plethora of 'what-if' analyses regarding a number of adjustable input variables. As an example of how digital transformation affects traditional supply chains, it provides a solid basis for further enhancements and inclusion of additional input and output parameters for forecasting purposes.

Keywords: supply chain, modeling, stock-and-flow simulation, web-based simulation, InsightMaker®

1. INTRODUCTION

According to the process view, a supply chain represents a sequence of processes (e.g. decision making, execution) and flows (e.g. material, information, money) that aims "to meet final customer requirements and take place within and between different supply chain stages" (Van der Vorst, 2004, p. 2).Besides the manufacturer and its suppliers, supply chains may also include transporters, warehouses, retailers, and consumers, depending on logistics flows. It includes, but is not limited to, new product development, marketing, operations, distribution, finance, and customer service (Chopra & Meindl, 2012). A generic supply chain within the context of the total supply chain network is depicted in Figure 1. Each firm (e.g. manufacturer) belongs to at least one supply chain, i.e. it usually has multiple suppliers, distributors, retailers, and consumers.

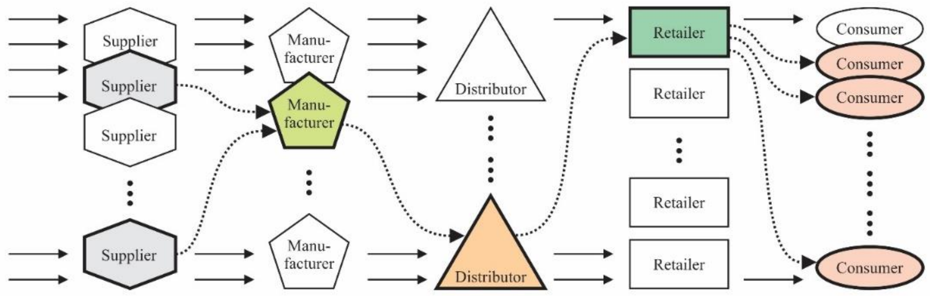

Figure 1.Schematic representation of a single supply chain (represented with dotted lines) within a total supply chain network

On the other hand, supply chain management (SCM) is "the active management of supply chain activities to maximize customer value and achieve sustainable competitive advantage. It represents a conscious effort by the supply chain firms to develop and run supply chains in the most effective & efficient ways possible" (NCSU, 2017).

In today's globalized markets, managing the entire supply chain in an efficient manner becomes a key factor that underpins the success of businesses. In contemporary highly competitive markets, each actor in a given supply chain copes with challenges of reducing time deadlines, inventory costs, transportation costs, and resource consumption to minimum on all levels. However, due to the conflicts/inconsistencies that exist among particular organization objectives, their decision-making processes, non-integration of their vital processes, and poor relationships/synchronization with other actors belonging to the same supply chain, a Bullwhip effect can easily emerge with an unpredictable and devastating impact on the whole supply chain. Since computer simulation permits an evaluation of the operating performance prior to the execution of a given plan, the development of simulation models for supply chain management has become a necessity (Chang & Makatsoris, 2001).

Having minded the previous definitions, the aim of the paper is to propose a stock-and-flow simulation model that would capture the basic supply chain operations among the last three actors depicted in Figure 1 (i.e. the consumers of a single retailer and one of its distributors), based on the principles of the system dynamics approach.

The rest of the paper is organized as follows. Section 2 briefly presents a literature review related to computer simulation of supply chains and the application of the system dynamics approach in building simulation models of supply chains, in the last decade. Section 3 elaborates the common supply chain simulation approaches and focuses on the details of system dynamics. Section 4 describes the problem to be dealt with by describing the underlying causal loop diagram and formulating the corresponding SD model implemented in InsightMaker®. Section 5 evaluates the results obtained. Finally, Section 6 provides conclusions, research limitations, and future research lines.

2. RELATED RESEARCH

Due to its increased significance in recent years, computer simulation of supply chains has been put in the focus of methodologies for their analysis and assessment. The research being made in this area and being covered in this section can be roughly divided into two subcategories: (a) papers dealing with the application of computer simulation in SCM (in general) and (b) papers focused solely on the application of the system dynamics (SD) approach in modeling and simulation of supply chains. What follows is a brief overview of some of the research endeavors done in this field during the last decade.

The subsequent three pieces of research belong to the first subcategory:

Hossain & Ouzrout (2012) attempted to model the trust in SCM for using Agent Modeling Language (AML) by proposing a Multi-Agent System (MAS) SCM model of trust in supply chain management. The proposed model is implemented using the Java Agent Development Environment (JADE) and the simulation results demonstrated the impact of trust in the supply chain along with the evolution of trust.

Ingalls (2014) elaborates the reasons for using simulation as an analysis methodology to evaluate supply chains, its advantages and disadvantages compared to other analysis methodologies, and points out some business scenarios where simulation can help in obtaining cost reductions that other methodologies would miss.

Sánchez-Ramírez *et al*. (2016) develop a simulation model to improve the performance of an automotive supply chain and using sensitivity analysis, they find the values that allow the supply chain to improve its order fulfillment indicator by modification of specific variables in the model such as Cycle Time, Production Adjustment Time, Delivery Time, Raw Material Inventory, and Finished Good Inventory.

What follows are some of the most prominent researches that belong to the second subcategory:

Wai & Chooi-Leng (2011) utilize system dynamics approach and the iThink® software to better understand the supply chain system of an actual semiconductor company and to find out better solutions through experimentations with a few key variables. The results of their research revealed that a company could achieve up to 25% reduction in inventory cost using computer simulations.

Feng (2012) used the method of system dynamics (SD) to model supply chain information sharing, in order to demonstrate its importance in SCM.

Mula *et al*. (2013) propose a simulation approach based on system dynamics for operational procurement and transport planning in a two-level, multi-product and multi-period automobile supply chain. They used the Vensim® simulation tool to highlight the potential of system dynamics for supply chain simulation. The effectiveness of the proposed model was validated through the comparison of the results provided by spreadsheet-based simulation, fuzzy multi-objective programming, and system dynamics-based simulation models. The simulation results indicated a reduction in inventory cost by about 10%.

Sundarakani *et al*. (2014) analyzed the environmental implications of the rapidly growing construction industry in the UAE using the system dynamics approach. By quantitative modeling of the construction industry supply chain, which helps to measure the dynamic interaction among various factors under multiple realistic scenarios, their study provides an analytical decision framework to assess emissions of all stages applicable to the construction industry supply chain.

Hoque & Khan (2016) attempted to provide a review of the best practices and performance measuring frameworks on supply chain performance measurement in order to control and improve operational efficiency and effectiveness, as well as on the system dynamics modeling solely in the field of SCM. According to their research, despite the fact that the dynamic complexity of supply chains can be handled through SD modeling, articles that provide best practices for measuring supply chain performance using the SD approach are quite rare.

There are also a rising number of Ph. D. theses that focus on the application of SD approach to supply chains in different areas, like Li (2016), who focused on risk modeling and simulation of chemical supply chains, and Botha (2017), whoused SD simulation for strategic inventory management in the automotive industry of South Africa.

Ghadge *et al*. (2018) assessed the impact of additive manufacturing implementation on aircraft supply chain networks, using a system dynamics simulation approach that revealed significant and valuable insights into the supply chain performance.

In their research based on the use of agro-straw as a typical agro-waste, Liu *et al*. (2018) utilize a hybrid approach, built on multi-objective optimization and system dynamics simulation, intended for optimizing the structure of straw-to-electricity supply chain and designing motivational mechanisms to enhance its sustainability.

Abidi *et al*. (2018) present a system dynamics simulation inventory management modeling for a multi-echelon multi-product pharmaceutical supply chain that aims to support selecting optimal operational service levels regarding the total inventory cost.

3. SUPPLY CHAIN SIMULATION

As one of the several methodologies available for supply chain analysis, simulation has distinct advantages and disadvantages when compared to other analysis methodologies. Since the objective of any simulation is performance evaluation, supply chain simulation enables effective strategic planning and decision making. Customers, products, sites, and transportation modes can be defined using supply chain specific modeling constructs. Customized business logic, objects, and rules can be defined to capture the dynamics and real-world supply chain behavior. Business policies for inventory, sourcing, transportation, and production processes can be modeled, as well. Applications include: (a) supply chain network design; (b) demand planning; (c) production capacity planning; (d) inventory optimization; (e) transportation modeling; and (f) modeling of warehouse operations.

Some of the most prominent benefits/features of performing supply chain simulations may include (PMC, –):

Creation of realistic supply chain models capturing system dynamics, resource constraints, and risk;

Simulation of existing (as-is) and improved (to-be) supply chain network designs;

Analysis of the performance metrics such as service level, cost, inventory level, and cycle time;

Visualization of the supply chain in action;

Evaluation of routing strategies and testing new strategies to predict actual costs and service levels;

Optimization of supply chain performances.

It should be notified that supply chain simulations can be carried out by using common or dedicated/specialized commercially available software packages such as Arena®, AutoMod®, ExtendSim®, ProModel®, Supply Chain Guru®, Simul8®, Solvoyo®, Tecnomatix Plant Simulation®, and Witness®. In general, supply chain simulations can be also carried out by developing and running a suitable simulation model using a general-purpose programming language (e.g. Python/SimPy).

The main approaches encompass either Discrete-Event Simulation (DES) methods or continuous simulations (e.g. stock-and-flow simulations).

A discrete-event simulation (DES) models the operation of a given system as a (discrete) sequence of events in time. Each event occurs at a particular instant in time and marks a change of state in the system. Between any two consecutive events, no change in the system is assumed to occur; thus the simulation time can directly jump to the occurrence time of the next event (Robinson, 2014).Contrary to this, with continuous simulations, the system state is changed continuously over time on the basis of a set of differential equations defining the relationships for the rates of change of state variables. In trivial cases, those systems of differential equations can be solved analytically, otherwise, they are solved numerically, by using a computer and a corresponding software, either general-purpose or dedicated one (Duivesteijn, 2006; Thierry *et al*., 2008, pp. 12–13).

System Dynamics (SD) is a methodology and a mathematical modeling and simulation technique for framing, understanding, and discussing complex issues and problems. As an approach to understanding the dynamic behavior of complex systems over time and an important aspect of the systems thinking theory, SD uses internal feedback loops, time delays, as well as stocks and flows to model the entire system. In fact, stocks and flows are the main building blocks of SD models (Ford, 1999, pp. 14–24). Contrary to Discrete-Event Simulation (DES), SD uses a quite different approach. SD is essentially deterministic by nature. It models the observed system as a series of stocks and flows, whilst state changes are continuous, resembling a motion of a fluid at a given rate, flowing through a system of reservoirs or tanks (stocks), mutually connected by pipes (flows). Stocks are variables presenting the level of accumulation. Flows go in and/or out of the stocks, thus increasing or decreasing their values with a certain rate. In essence, SD deals with the interaction of different elements of a system in time and captures the dynamic aspect by incorporating concepts such as stock, flows, feedback and delays, and thus offers an insight into the dynamic behavior of a system over time (Tang & Vijay, 2001).

Because of its great flexibility, along with its ability to combine together both qualitative and quantitative aspects of the modeled system, as well as its tendency to model and simulate the dynamics of a system at a higher, yet more strategic level in order to gain a holistic insight into the dynamic interrelations among the different parts of a complex system, SD has been applied in many different fields of study so far, including project management, system analysis, health care, supply chain management, logistics, sustainability, environmental science, etc.The SD approach has become popular in SCM during the last two decades, although it was initially introduced by Jay Forrester in 1961.

Given the accuracy of this modeling method that permits building formal computer simulations of complex systems and their use to design more effective policies, in this paper, we revert to continuous simulations based on the SD principles. Using general-purpose Web-based software in a SaaS manner, we develop a simplified simulation model capturing the basic supply chain operations.

4. STOCK-AND-FLOW SIMULATION MODEL

Contemporary software solutions that support integrated supply chain operations cover a number of operations related to the cost, quality, delivery, and flexibility that arise from the very first suppliers to the end consumers. For instance, retailers do not make explicit purchases from distributors anymore; instead, retailers' information systems automatically generate and send purchases, based on the defined minimum levels of products in their internal warehouses, and distributors automatically initiate the transportation of ordered products to retailers, based on their available resources. This is the essence of the proposed supply chain simulation model.

The underlying logic behind the proposed SD simulation model and its boundaries are concisely described with the causal loop diagram, shown in Figure 2.

Causal loop diagrams are a technique to portray the information feedback at work in the observed system. The word 'causal' refers to cause-and-effect relationships, whilst the word 'loop' refers to any closed chain of cause and effect (Ford, 1999, pp. 69–87). Causal loop diagrams are an essential tool used by the SD approach, allowing one to focus on the structure and the dynamic behavior of a given system over time. It portrays the interrelations that exist among different input and output variables, mutually connected by influence arcs that end with arrows (i.e. directed arcs), forming the causal chains and loops. Each arc has two important features: a direction and a sign. The direction of arcs actually shows the effect of a causal chain, whilst the sign denotes the nature of a change between two variables: when the sign is positive (+), the variables on both sides of the influence arc change in the same direction (e.g. an increase of the value of the variable from which the arc originates implies an increase of the variable to which the arc sinks and vice-versa), otherwise (–) they behave in the opposite manner.

The causal loop diagram depicted in Figure 2 clearly points out the inclusion of three main actors in the SD model, which are a constituent part of any supply chain: the consumers, a retailer, and one of its distributors:

Consumers: the consumer arrival rate (λ), the probability of buying a certain product (π), the mean quantity bought (μ), and the standard deviation of the quantity bought (σ) have all a positive impact on the total quantity bought in a particular retailer's store;

Retailer: the increased quantity bought leads to decreasing the quantity of a product on the retailer's store shelves. After reaching the defined minimum level on store shelves, an internal transfer of a certain quantity of the same product is being initiated from the retailer's store warehouse to store shelves. Each internal transfer of products decreases the number of products in the retailer's store warehouse. After reaching the minimum level in the store warehouse, a certain quantity of the product is being ordered automatically from one of the retailer's distributors;

Distributor: based on the maximum number of available transportation vehicles, the distributor assigns a certain number of these to transport (a part of) the ordered quantity of the product, based on vehicles' storage capacity. The more assigned vehicles and/or the larger the vehicles' storage capacity, the more the quantity delivered to a retailer's store warehouse. The increase of the quantity delivered to a retailer's store warehouse imposes an increase of the quantity in the retailer's store warehouse while decreasing the quantity of a product in a distributor's warehouse.

Figure 2 indicates the existence of two balancing loops, which reflect circular causality in the modeled system: the first one encompasses the processes included in the internal transportation of a product from retailer's warehouse to retailer's store shelves, whilst the second one refers to processes encompassing the transportation of a product from distributor's warehouse to retailer's warehouse. In general, a feedback loop exists when information, originating from some action, travels through a system and eventually returns in some form to its point of origin. Feedback is said to be negative (i.e. balancing) when the change fosters other components to respond by counteracting that modification. Feedback is considered positive (i.e. reinforcing) when the original change leads to modifications that reinforce the process. Negative feedback loops are likely to counteract the disturbance and guide the systems back to equilibrium or steady state. On the other hand, positive feedback loops tend to intensify any disturbance and lead the system away from equilibrium.

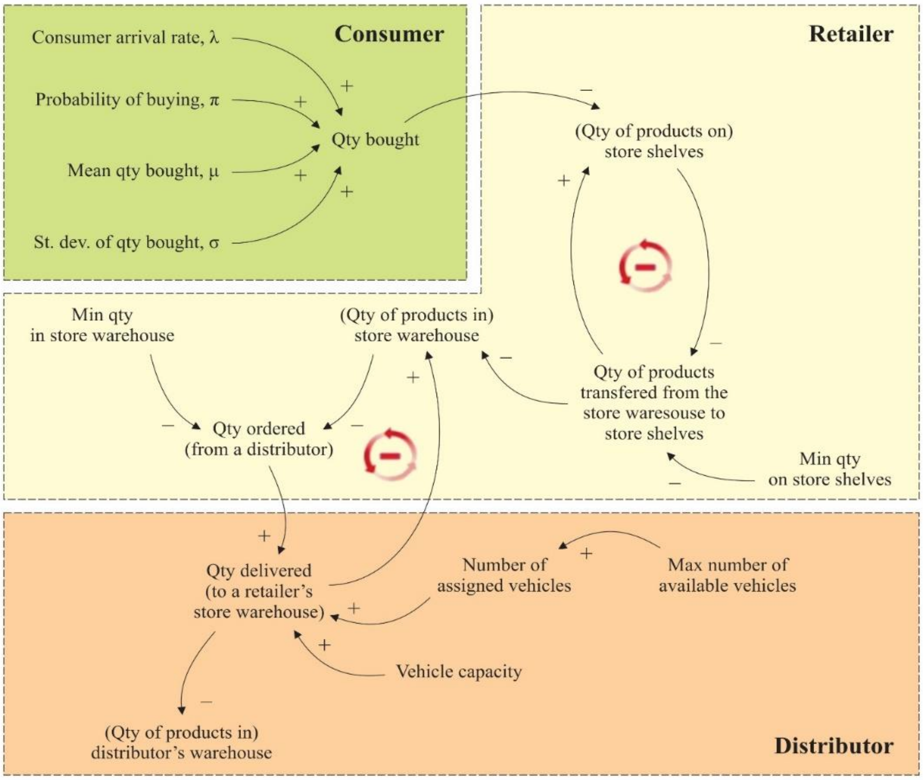

Figure 2. Causal loop diagram depicting the logic and the boundaries of the proposed simulation model

The proposed simulation model (Figure 3) has been completely developed from the causal loop diagram using InsightMaker®,an innovative, Web 2.0-based, multi-user, general-purpose, online modeling and simulation environment, completely implemented in JavaScript, which promotes online sharing and collaborative working in a SaaS manner (Fortmann-Roe, 2014).

In Figure 3, stocks are presented with rectangles, flows with bold directed arrows, variables with ovals, whilst dotted lines, connecting two primitives, represent links, which transfer information between them.

The specifications of variables, stocks, and flows are given in Table 1, Table 2, and Table 3, respectively.

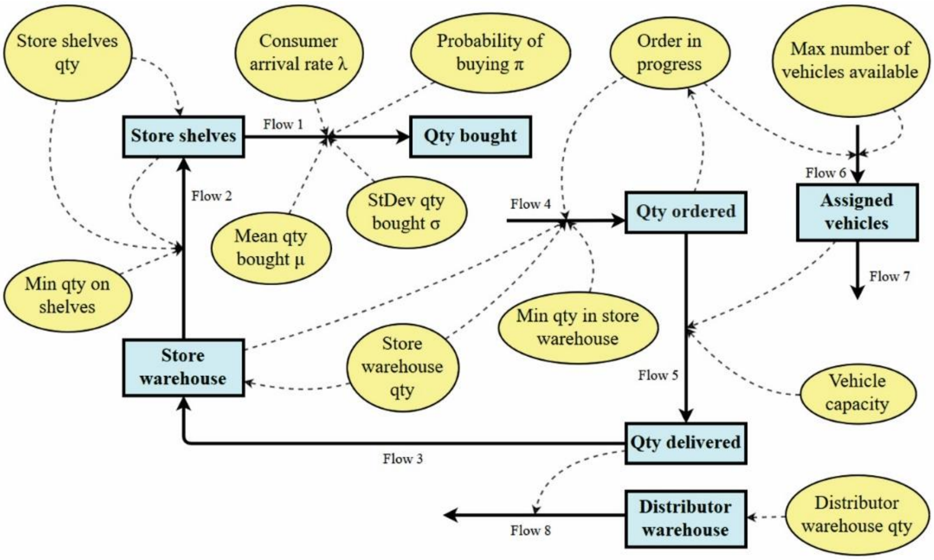

Figure 3. Stock-and-Flow simulation model of basic supply chain operations

Table 1. Specification of variables in the SD model

Object (variable)	Unit	Initial value	Adjustable ?	Min value	Max value	Step
Consumer arrival rate λ	consumers per day	200	Yes	0	1,000	5
Probability of buying π	///	0.05	Yes	0.00	1.00	0.05
Mean qty bought μ	pcs	1	Yes	0	50	1
StDev qty bought σ	pcs	0.75	Yes	0.00	1.00	0.05
Store shelves qty	pcs	50	Yes	0	100	5
Min qty on shelves	pcs	5	Yes	0	25	5
Store warehouse qty	pcs	5,000	Yes	0	10,000	100
Min qty in store warehouse	pcs	500	Yes	0	2,500	100
Order in progress	///	Prog. code	No	///	///	///
Max number of vehicles available	pcs	5	Yes	1	10	1
Vehicle capacity	pcs	25	Yes	10	100	5
Distributor warehouse qty	pcs	500,000	Yes	0	1,000,000	1,000

From Table 1, it is obvious that all variables in the SD model are adjustable, except the variable [Order in progress], which is an internal control variable; it takes its value depending on the output of the following programming code:

If [Qty ordered] > 0 Then 1 Else 0 End If

This variable performs as a semaphore: 0 = there is no ongoing purchase; 1 = a purchase is being serviced.

Table 2. Specification of stocks in the SD model

Object (stock)	Initial value	Meaning
Qty bought	0	Quantity of products being bought from retailer's store shelves by consumers at each time instance
Store shelves	[Store shelves qty]	Total quantity of products on the retailer's store shelves over time
Store warehouse	[Store warehouse qty]	Total quantity of products found in the retailer's warehouse over time
Qty ordered	0	Total quantity of products being ordered by the retailer from the distributor within a single purchase
Qty delivered	0	Quantity of products being delivered at each time instance by the distributor to the retailer within a single purchase
Assigned vehicles	0	Number of distributor's vehicles at each time instance, assigned for transporting the ordered products
Distributor warehouse	[Distributor warehouse qty]	Total quantity of products found in the distributor's warehouse over time

1. SIMULATION RESULTS

Given that the time unit used in simulations is set to 'day', the maximum simulated time length was set up to 1,500 [days].What follows is a step-by-step verification of the proposed SD model by presenting a series of simulation outputs that portray the dynamics of certain parts of the supply chain over time, thus proving that the modeled system complies with the general idea/specification.

Figure 4 depicts the dynamics within the retailer's store. Due to [Flow 1], which represents the quantity of products being bought from store shelves on a daily basis, there is a continuous decrease of the product's quantity on the shelves from its initial value to the minimum allowed one over time. Once the level of the variable [Store shelves] reaches the value of the variable [Min qty on shelves], an internal flow of products, [Flow 2], activates from retailer's warehouse to retailer's shelves, filling up instantly the quantity of products to the value of [Store shelves qty].

Table 3. Specification of flows in the SD model

Object (flow)	Expression
Flow 1	= Round(RandPoisson([Consumer arrival rate λ])*[Probability of buying π] * RandNormal([Mean qty bought μ], [StDev qty bought σ]))
Flow 2	= If [Store shelves]<=[Min qty on shelves] Then [Store shelves qty]-[Store shelves] Else 0 End If
Flow 3	= [Qty delivered]
Flow 4	= If [Order in progress] = 0 Then If [Store warehouse] <= [Min qty in store warehouse] Then [Store warehouse qty] - [Store warehouse] Else 0 End If End If
Flow 5	= If [Qty ordered] - [Assigned vehicles] * [Vehicle capacity] > 0 Then [Assigned vehicles]*[Vehicle capacity] Else If [Qty ordered] - [Assigned vehicles] * [Vehicle capacity] < 0 Then [Qty ordered] Else 0 End If End If
Flow 6	= If [Order in progress] = 1 Then Round(Rand(0, 1) * [Max number of vehicles available]) Else 0 End If
Flow 7	= [Assigned vehicles]
Flow 8	= [Qty delivered]

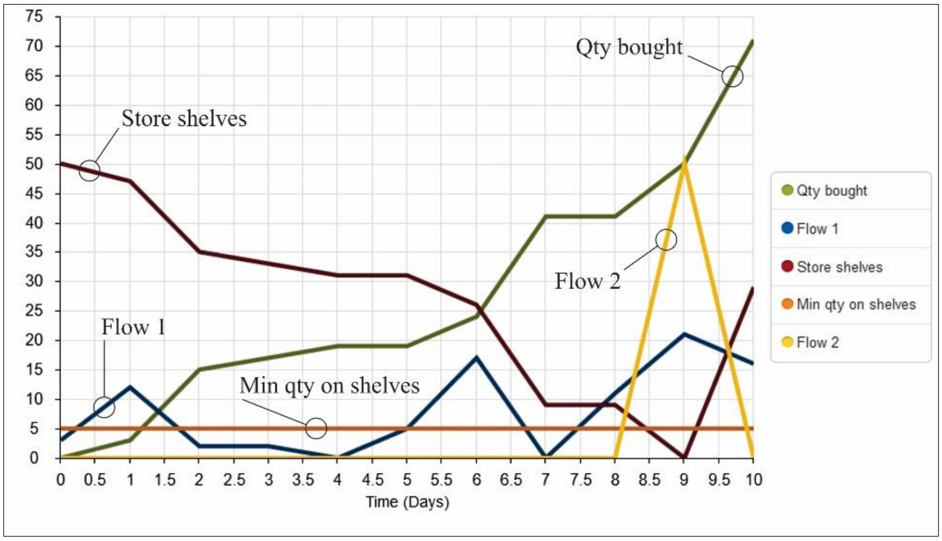

Figure 4.The dynamics with the retailer's store

Consecutive activations of [Flow 2] impose the level of the product in the store warehouse, [Store warehouse], to decrease slowly over time (Figure 5). In Figure 5, the primary axis represents the levels of product's quantities in the retailer's store warehouse over time, whilst the secondary axis represents the amounts of the product transferred from the retailer's store warehouse to retailer's store shelves at particular time instances, due to [Flow 2].

Once the current level of the product in the store warehouse, [Store warehouse], reaches the specified minimum, [Min qty in store warehouse], an order is being automatically generated and sent to retailer's distributor, which complements the product's quantity in the store warehouse up to [Store warehouse qty]. This behavior is repeating over time, as long as there are quantities of the product in the distributor's warehouse (Figure 6).

Figure 7 explains the role of the control variable [Order in progress]. It takes a value of 1 at the moment when a purchase to supply additional quantities of the product from the distributor is made by the retailer, and takes a value of 0 when the purchased quantities are completely transferred. In the same context, Figure 8 illustrates the role of the control variable regarding to the dynamics of assigned vehicles at each time instance, intended to transfer the ordered quantities of the product from distributor's warehouse to retailer's store.

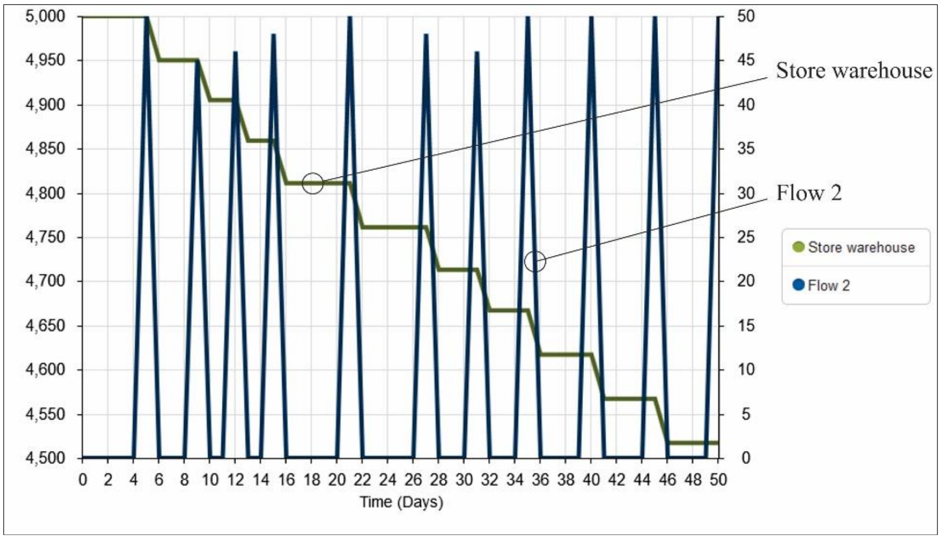

Figure 5.Decrease of product's quantities in the retailer's warehouse as a result of many consecutive transfers of products to retailer's store shelves

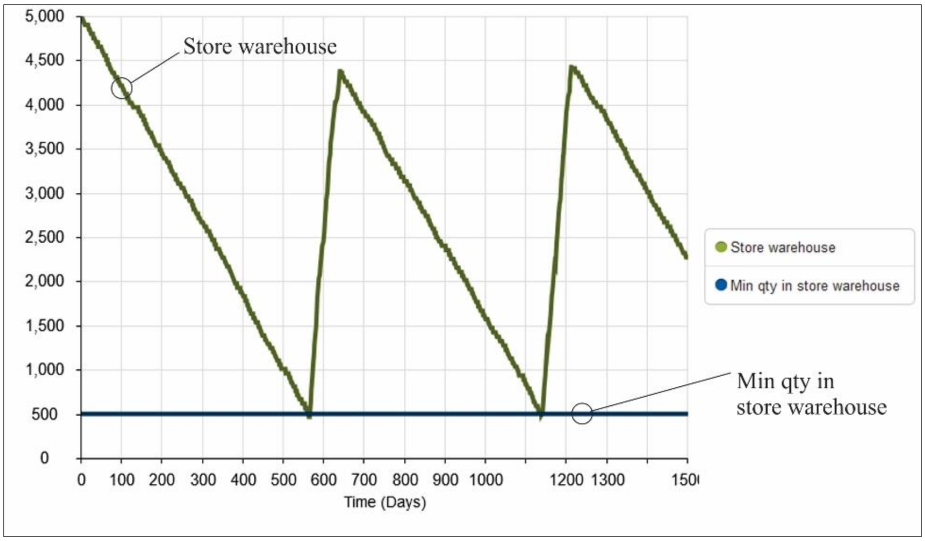

Figure 6.Cycliccomplementing product's quantities in the retailer's store warehouse over time, as a result of reaching the specified minimum

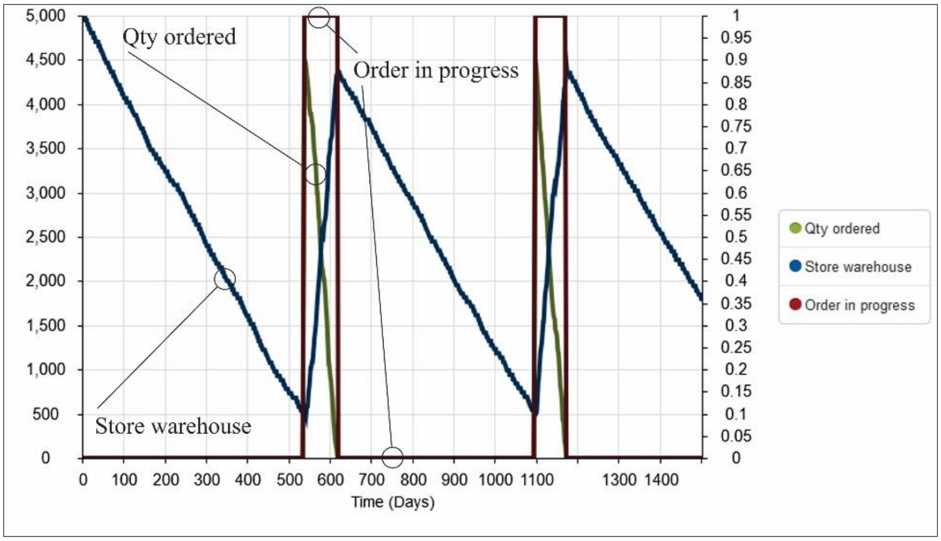

Figure 7.Illustration of the variable [Order in progress] vis-à-vis the timing of placing and fulfilling purchases

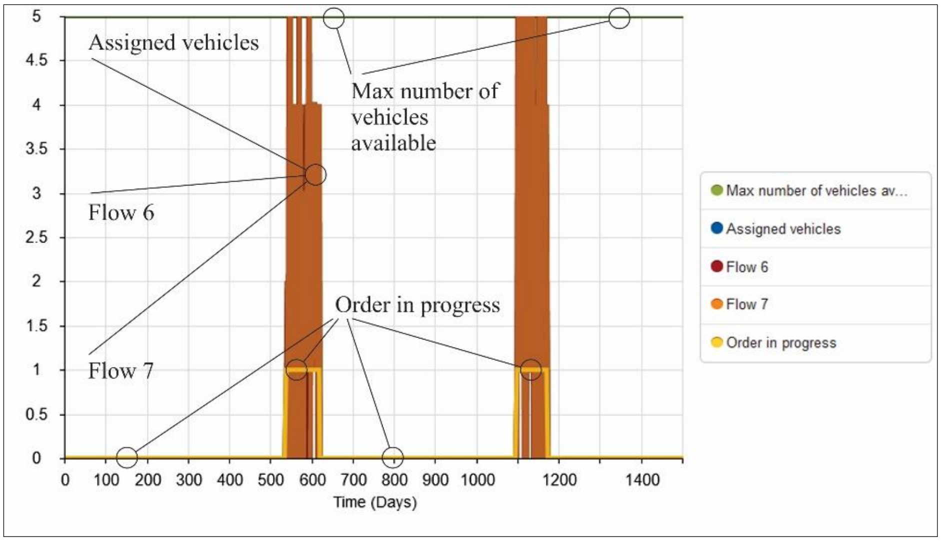

Figure 8. Illustration of the variable [Order in progress] vis-à-vis the number of assigned vehicles

Finally, Figure 9 shows the decrease of product quantities in the distributor's warehouse over time (primary axis), as a result of [Flow 8], representing the transfer of purchased quantities to retailer's store warehouse at particular time instances (secondary axis).

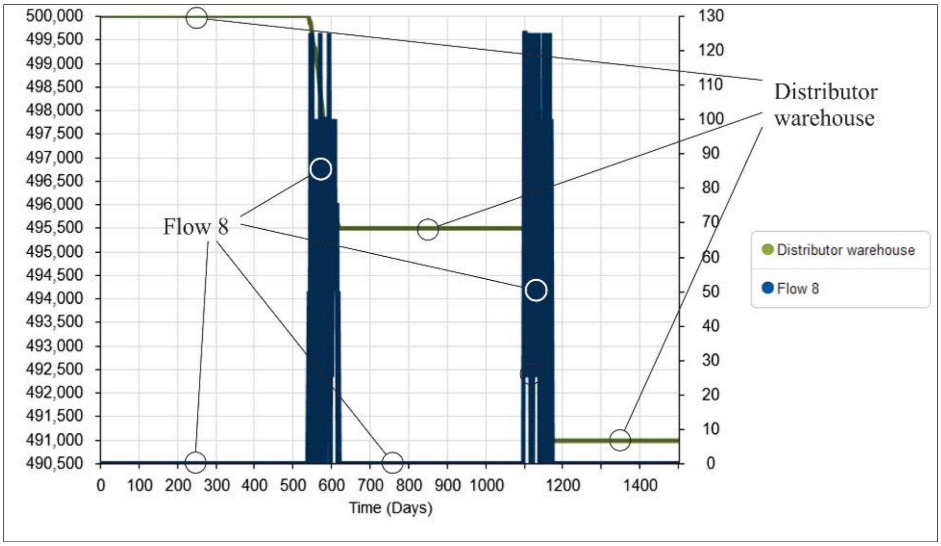

Figure 9.Decrease of product quantities in the distributor's warehouse [Distributor warehouse] over time, as a result of [Flow 8]

2. CONCLUSION

Simulation enables the design of a supply chain and evaluation of SCM prior to the implementation of the real system, which allows one to perform 'what-if' analyses leading to 'the best' (i.e. the optimal) decision/solution. As such, simulation of supply chains can be used to support supply chain design decisions or evaluation of supply chain policies.

The power of simulation as a methodology for analysis shows up whenever the observed supply chain is complex, dynamic, and has transient (i.e. time-dependent) performance problems. In general, simulating a supply chain can be extremely complex, because the underlying model must capture well a number of crucial business processes, including the basic material requirements planning (MRP) process, planning, and scheduling, capital acquisition, labor policies, allocation of constrained resources, etc. However, if a supply chain is modeled correctly, a supply chain simulation can show ways to increase revenues, profitability, and service levels to the customer. This can translate into large financial advantages to the company.

The proposed generic SD model allows making thorough insights into the dynamics of the modeled supply chain. Since it captures solely the basic operations among the last three actors in a supply chain (i.e. 'the last mile'), it has a number of limitations, including the following ones: (a) The supply chain refers to a single product, a single retailer store, and a single distributor; (b) The distributor uses transportation vehicles all having a same storage capacity; (c) In order to restrict the model to only three actors (i.e. consumers, retailer, and distributor), the distributor warehouse capacity is theoretically infinite (i.e. sufficiently large in practice).Contrary to verification, which was carried out as an internal process, validation of the modeled system, which is the process of assuring that it meets the needs of a customer and other identified stakeholders (i.e. its end users), was not possible to be carried out at this point, due to the fact that the proposed simulation model is generic and in an early stage of development. Yet, the model is quite flexible in two ways: (a) the 11 adjustable parameters offer a plethora of possibilities to run various 'what-if' analyses and test various simulation scenarios; (b)the SD model can be easily upgraded by including additional variables to assess various categories of interest, like costs related to human resources, transportation, storage of products, etc.

REFERENCES

Abidi, M., Lattouf, A., Altarazi, S. (2018). A system dynamics simulation modeling for managing the inventory in multi-echelon multi-product pharmaceutical supply chain. *Proceedings of the Annual Simulation Symposium* (ANSS '18), Baltimore, MD, USA.

Botha, A. (2017). *A System Dynamics Simulation for Strategic Inventory Management in the South African Automotive Industry*. Ph. D. thesis, University of Pretoria, Pretoria, South

Africa.https://repository.up.ac.za/bitstream/handle/2263/66223/Botha_System_2018.pdf (accessed 16.09.2019)

Chang, Y. &Makatsoris, H. (2001). Supply Chain Modeling Using Simulation. *International Journal of Simulation: Systems, Science and Technology*, Vol. 2, No. 1, pp. 24–30.

Chopra, S. &Meindl, P. (2012). *Supply Chain Management: Strategy, Planning, and Operation*, 5th Edition. Upper Saddle River, NJ, US: Pearson/Prentice Hall

Duivesteijn, W. (2006). *Continuous Simulation*. Utrecht University, the Netherlands. http://www.cs.uu.nl/docs/vakken/sim/continuous.pdf (accessed 06.09.2019)

Feng, Y. (2012). System Dynamics Modeling for Supply Chain Information Sharing.*Physics Procedia*, Vol. 25 (2012), pp. 1463–1469.

Ford, A. (1999). *Modeling the Environment:An Introduction to System Dynamics Modeling of Environmental Systems*. Washington, DC, US: Island Press.

Fortmann-Roe, S. (2014). Insight Maker: A General-Purpose Tool for Web-based Modeling & Simulation. *Simulation Modelling Practice and Theory*, Vol. 47, pp. 28–45.

Ghadge, A., Karantoni, G., Chaudhuri, A., Srinivasan, A. (2018). Impact of Additive Manufacturing on Aircraft Supply Chain Performance: A System Dynamics Approach. *Journal of Manufacturing Technology Management*, Vol. 29, Issue 5, pp. 846–865.

Hoque, M. A. & Khan, Q. K. (2016). Supply Chain Performance and System Dynamics Modeling: A Literature Review. *British Journal of Business Design & Education*, Vol. 9, No. 2.

Hossain, S. A. &Ouzrout, Y. (2012). Trust Model Simulation for Supply Chain Management. *Proceedings of the 15th International Conference on Computer and Information Technology* (ICCIT 2012), Chittagong, Bangladesh, pp. 376–383.

Ingalls, R. G. (2014). Introduction to supply chain simulation. In: Tolk, A., Diallo, S. Y., Ryzhov, I. O., Yilmaz, L., Buckley, S., and Miller, J. A. (Eds.), *Proceedings of the 2014 Winter Simulation Conference* (WSC ’14), Savannah, GA, USA, pp. 36–50.

Li, C. (2016). *Risk Modelling and Simulation of Chemical Supply Chains using a System Dynamics Approach*. Ph. D. thesis, John Moores University, Liverpool, UK.http://researchonline.ljmu.ac.uk/id/eprint/4254/1/2016chaoyuliphd.pdf (accessed 16.09.2019)

Liu, Y., Zhao, R., Wu, K.-J., Huang, T., Chiu, A. S. F., Cai, C. (2018). A Hybrid of Multi-Objective Optimization and System Dynamics Simulation for Straw-to-

Electricity Supply Chain Management under the Belt and Road Initiatives. *Sustainability*, Vol. 10, No. 3:868, pp. 1–17.

Mula, J., Campuzano-Bolarin, F., Díaz-Madroñero, M., Carpio, K. M. (2013). A System Dynamics Model for the Supply Chain Procurement Transport Problem: Comparing Spreadsheets, Fuzzy Programming and Simulation Approaches. *International Journal of Production Research*, Vol. 51, Issue 13, pp. 4087–4104.

NCSU (2017). What is Supply Chain Management (SCM)? North Carolina State University, Raleigh, NC, USA.https://scm.ncsu.edu/scm-articles/article/what-is-supply-chain-management-scm (accessed 17.09.2019)

PMC (–). Supply Chain Simulation. Production Modeling Corporation (PMC), Dearborn, MI, USA. https://www.pmcorp.com/Products/Simulation/SupplyChainSimulation.aspx (accessed 06.09.2019)

Robinson, S. (2014). *Simulation: The practice of model development and use*. 2nd Edition. London, UK: Red Globe Press

Sánchez-Ramírez, C., López, D. R. M., Hernández, G. A., Alcaraz, J. L. G., Mendoza, D. A. T. (2016). Simulation Software as a Tool for Supply Chain Analysis and Improvement. *Computer Science and Information Systems*, Vol. 13, No. 3, pp. 983–998.

Tang, V. & Vijay, S. (2001). System Dynamics: Origins, Development, and Future Prospects of a Method. ESD.83, Research Seminar in Engineering Systems. Massachusetts Institute of Technology, Cambridge, MA, US.http://web.mit.edu/esd.83/www/ notebook/System%20Dynamics%20final.doc (accessed 24.09.2019)

Thierry, C., Thomas, A., Bel, G. (Eds.) (2008). *Simulation for Supply Chain Management*.1st Edition. London, UK: Wiley-ISTE

Van der Vorst, J. (2004). Supply Chain Management: Theory and Practices. In: Camps, T., Diederen, P., Hofstede, G. J., Vos, B. (Eds.), *The Emerging World of Chains & Networks: Bridging Theory and Practice*, Amsterdam, the Netherlands: Reed Business Information

Wai, C. K. & Chooi-Leng, A. (2011). Supply Chain Management: A System Dynamics Approach to Improve Visibility and Performance. *Journal of ICT*, Vol. 10, pp. 117–135.

APPLICATION OF ELASTICITY IN COST CONTROL

Nina Petković, Sanja Stojanović, Miljan Jeremić

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ABSTRACT

This paper provides an analysis of a company's costs using mathematical methods, having in mind that in addition to the increased revenue intensity and increased production, the reduction, or control of costs, is an important indicator of business performance. The emphasis is placed on one mathematical measure, i.e. elasticity, as an indicator of how a change in the production volume affects the change in costs. On a specific empirical example of approximated cost function, we have shown what the functions of total costs look like, as well as the functions of marginal costs, being the most important for the management of a company, and what the functions of average costs look like; we have also shown how the elasticity of these functions indicates the production volume that is profitable. In this way, we have shown that costs can be monitored in a safe and exact way and that along with their reduction, the profits will increase, which is the ultimate goal of management. All the above listed procedures will be accompanied by appropriate mathematical software.

Keywords: Total costs, marginal and average costs, approximated cost function, elasticity of function

1. INTRODUCTION

Modern business conditions raise increasingly demanding questions for the management of a company. Increased competition in the market, which has to be accompanied with adequate product prices on the one hand, indicates that, in addition to the ambition to increase and preserve profits, it is necessary to pay attention to control, primarily, and to cost reduction as much as it is possible. Therefore, the central problem we are dealing with is precisely the costs of a company. The interest in costs itself dates back to the early 20th century in terms of post-World War I research. Namely, a great number of scientific papers have emerged since the 1930s, which can be considered as the beginning of the development of the Theory of Costs. Over time, it has become more interesting because it is precisely the success of a company that is measured by its revenues at minimal costs. Economic theory recognizes various classifications of costs, which we will not discuss on this occasion, but will look at them from a mathematical perspective as certain functional dependencies.

The central question we will address in this paper will be: To what extent can the volume of production be increased providing that the cost increase is realistic and cost-effective? In practice, the plans and desires can sometimes be unmanageable in terms of greatly increased costs that cannot be covered. In order to get a sure answer to this question at the stage of planning a sustainable volume of production, the answer that will be methodologically justified, not intuitive, we will use a measure of the elasticity of the cost function. It will point to an elasticity interval that depends on the volume of production, where we can expect as much profit as possible with reasonable costs. So, we can get an answer to the question: does it make sense to increase production from some value given in advance and to what extent?

To this end, in this paper we will carry out a complete analysis of the practical problem, i.e. with certain values of the observed costs depending on the number of products in one company, we will first approximate the total cost function, the marginal cost function and the average cost function. Based on that dependency, we will be able to predict the cost for any value of the number of products in advance. In addition, we will introduce a measure of elasticity of a function, and by calculating the elasticity interval, the aim of this paper will be justified. We will get the answer to the question whether increasing the desired and planned production makes sense and to what extent.

In the continuation of this paper, we outline basic mathematical concepts of costs, which are exact and exist in mathematical theory and the listed references will be used on this occasion.

2. TOTAL, MARGINAL AND AVERAGE COSTS

We will denote the total costs of production by T_u, as a functional dependence on the volume of production x, i.e.

$$T_u = T_u(x) \qquad \ldots(1)$$

Since a business can manufacture more sets of products, this function may be shown depending on more variables, as:

$$T_u = T_u(x_1, x_2, \ldots x_n) \qquad \ldots (2)$$

In each case, the analytic expression of the function is obtained on the basis of empirical data and approximation performed. In the case of one variable, i.e. of a single product, the total cost function is most often expressed as a linear, quadratic, exponential or degree function.

For further analysis, function (1) will be used, and quite similarly, everything can be generalized to function (2). The domain of definition of cost function is the interval $[a,b] \subseteq R^+$, i.e. a set of non-negative real numbers. At this interval, function T_u is differentiable and since increase in production volume x, leads to an increase in costs, for the function T_u, is valid:

$$(\forall x \in [a,b])(T_u(x) > 0 \wedge T_u'(x) > 0) \qquad \ldots (3)$$

The marked function $T_u^{'}(x)$ is a functional derivative and it is clear that it is a positive number as the function $T_u(x)$ grows. This function is of particular importance for economic analysis as it will be a marginal costs function. Namely, the function of total costs itself is sometimes not a sufficient indicator because it does not show the change in costs that is caused by the change in production volume, and therefore it is not sufficient in assessing whether the increase in production volume is cost-effective. In cost theory, marginal costs function is defined as follows (Barnett, Ziegler & Byleen, 2003):

Definition: Marginal costs of function $T_u(x)$ at point $x_0 \in (a,b)$, marked as $T_g(x_0)$, is the marginal value

$$T_g(x_0) = \lim_{\Delta x_0 \to 0} \frac{\Delta T_u(x_0)}{\Delta x_0} = \lim_{\Delta x_o \to 0} \frac{T_u(x_0 + \Delta x_0) - T_u(x_0)}{\Delta x_0} \qquad \ldots (4)$$

if it exists and if it is finite.

The difference $T_u(x_0 + \Delta x_0) - T_u(x_0)$ denotes a change in costs, if the volume of production changes from level x_0 by Δx_0. Marginal costs themselves show the rate of cost change at point x_0.

For $\Delta x_0 \neq 0$, the approximate value of marginal costs is:

$$T_g(x_0) \approx \frac{T_u(x_0 + \Delta x_0) - T_u(x_0)}{\Delta x_0} \qquad \ldots (5)$$

for $\Delta x_0 = 1$, $T_g(x_0) \approx T_u(x_0 + 1) - T_u(x_0)$ … (6)

Since $T_u(x_0 + 1) - T_u(x_0)$, is the exact cost for ($x_0 + 1$)th product, marginal costs function can be used to approximate the exact cost and thus look ahead, i.e. estimate costs for subsequent product and thus estimate how cost-effective an increase in production volume is.

In monitoring the costs of a company, in addition to the total and marginal costs, very often average costs are monitored, i.e. costs per unit of product. We denote average costs function by $\overline{T}(x)$ and it is calculated as a quotient of total costs of production and physical volume of production, i.e. it is given as:

$$\overline{T}(x) = \frac{T_u(x)}{x} \qquad \ldots (7)$$

for each $x \in [a,b]$ and $x \neq 0$.

As an important link between marginal costs function and average costs function, we provide the following theorem without proof.

Theorem 1.1: Marginal costs equal average costs at the level of production x_0 at which minimum average cost is met. (Božinović and Stojanović, 2005).

3. ELASTICITY OF COST FUNCTION

For a more accurate analysis of cost function, as well as an assessment of the extent to which an increase in production volume influences an increase in costs, a measure called cost elasticity can be used. To begin with, we will define the term elasticity, for an arbitrary function $y = f(x)$, which depends on an independently variable quantity x.

If the independently variable quantity x_0 changes by Δx_0, then we gave a change in the function $\Delta y_0 = f(x_0 + \Delta x_0) - f(x_0)$.

Definition: Elasticity of function $y = f(x)$ at point $x_0 \in (a,b)$, at mark E_{y,x_0}, is marginal value:

$$E_{y,x_0} = \lim_{\Delta x_0 \to 0} \frac{\frac{\Delta y_0}{y_0}}{\frac{\Delta x_0}{x_0}} = \frac{x_0}{y_0} \lim_{\Delta x_0 \to 0} \frac{\Delta y_0}{\Delta x_0} = \frac{x_0}{y_0} y'(x_0) \qquad \dots (8)$$

if it exists.

If this marginal value exists at every interval point (a,b) for the function $y = f(x)$, then we can talk about the coefficient of elasticity in the mark:

$$E_{y,x} = \frac{x}{y} y'(x) \qquad \dots (9)$$

In case when:

1. $|E_{y,x}| < 1$, function $y = f(x)$ is inelastic;

2. $|E_{y,x}| > 1$, function $y = f(x)$ is elastic;

3. $|E_{y,x}| = 1$, function $y = f(x)$ has a unit elasticity.

The function is more elastic if its reaction to changes of another quantity is larger. In the case of unit elasticity, changing the argument x, does not affect the change in function.

Specially, if we consider the function of total costs $T_u(x)$, depending on the physical volume of production, we can analyze elasticity coefficient of the total costs function in the mark:

$$E_{T_u,x} = \frac{x}{T_u(x)} \cdot T'(x) = \frac{T_g(x)}{\overline{T}(x)} \qquad \dots (10)$$

since $\overline{T}(x) = \frac{T_u(x)}{x}$, and $T_g(x) = T'(x)$.

So, cost elasticity is the ratio of marginal and average costs. Since: $x > 0, T > 0, T' > 0,$ it follows that $E_{T_u,x} > 0$. Therefore, for the elasticity coefficient of total costs, the following is valid:

1. If $E_{T_u,x} \in (0,1)$, total costs are inelastic, i.e. $\frac{T_g(x)}{\overline{T}(x)} < 1$, then $T_g(x) < \overline{T}(x)$, which means that making a decision on increasing the existing production volume makes sense.

2. If $E_{T_u,x} > 1$, total costs are elastic, then $T_g(x) > \overline{T}(x)$, so that making a decision on increasing the existing production volume is not justified.

3. If $E_{T_u,x} = 1$, then $T_g(x) = \overline{T}(x)$, i.e. minimum average costs are achieved according to Theorem 1.1.

Elasticity coefficient is of great importance for economic cost analysis and can serve to control costs. Its economic interpretation is that if $E_{T_u,x} = k$, this means that an increase in production volume by 1% leads to an increase in costs by k%, if $k > 0$, or a decrease in costs by k%, if $k < 0$ (Barnett, Ziegler & Byleen, 2003).

4. PRACTICAL APPLICATION OF ELASTICITY

In the continuation of the paper, the above mathematical theory of costs, as well as the theory of the elasticity of total costs, will be practically confirmed on the example of one function of costs approximated on the basis of real empirical data.

Namely, a survey was carried out at the Measuring Transformers Factory in Zaječar, which has been operating since 1969 and is engaged in the production of electrical equipment. From a wide range of products, we have monitored costs of producing medium voltage transformers which are delivered in large batches (on a monthly basis) and depend on the number of produced transformers *x*. According to the information available from the accounting department of the factory, which employs no more than 100 workers, fixed costs are approximately EUR 50000, and total costs are increased by the number of products manufactured. This growth is certainly not linear as the components are mostly produced in serial production. According to the empirical data showing costs depending on the physical volume of production of a single product, the cost function is approximated in the form of a quadratic function $y = ax^2 + bx + c$.

So, based on the data collected from the Measuring Transformers Factory, we have come up with a contingency table, Table 1. It shows values of the independent variable *X* (number of transformers produced on a monthly basis) and the dependent variable $Y=T_u(X)$ (value of production costs (in euros) for a given number of transformers). Also, scatter diagram in Figure 1shows the dependence of production costs on the number of transformers produced.

Table 1. Input data and contingency table

X number transf.	Y=Tu (X) (000 euro)		X	Y	X^2	X^3	X^4	XY	X^2Y	Y^2	$\hat{y}$
50	78		50	78	2500	125000	6250000	3900	195000	6084	77.94740854
70	88		70	88	4900	343000	24010000	6160	431200	7744	88.09878717
100	102		100	102	10000	1000000	100000000	10200	1020000	10404	102.2152606
130	115		130	115	16900	2197000	285610000	14950	1943500	13225	114.9990206
150	123		150	123	22500	3375000	506250000	18450	2767500	15129	122.781131
170	130		170	130	28900	4913000	835210000	22100	3757000	16900	129.9709242
200	140		200	140	40000	8000000	1600000000	28000	5600000	19600	139.6450196
225	147		225	147	50625	11390625	2562890625	33075	7441875	21609	146.6887208
240	150		240	150	57600	13824000	3317760000	36000	8640000	22500	150.4707037
275	158		275	158	75625	20796875	5719140625	43450	11948750	24964	157.9996369
300	297		300	162	90000	27000000	8100000000	48600	14580000	26244	162.2668519
320	165		320	165	102400	32768000	10485760000	52800	16896000	27225	165.0142671
340	167		340	167	115600	39304000	13363360000	56780	19305200	27889	167.1693653
365	169		365	169	133225	48627125	17748900625	61685	22515025	28561	169.0302921
380	170		380	170	144400	54872000	20851360000	64600	24548000	28900	169.7026104
		Σ	**3315**	**2064**	**895175**	**268535625**	**85506501875**	**500750**	**141589050**	**296978**	

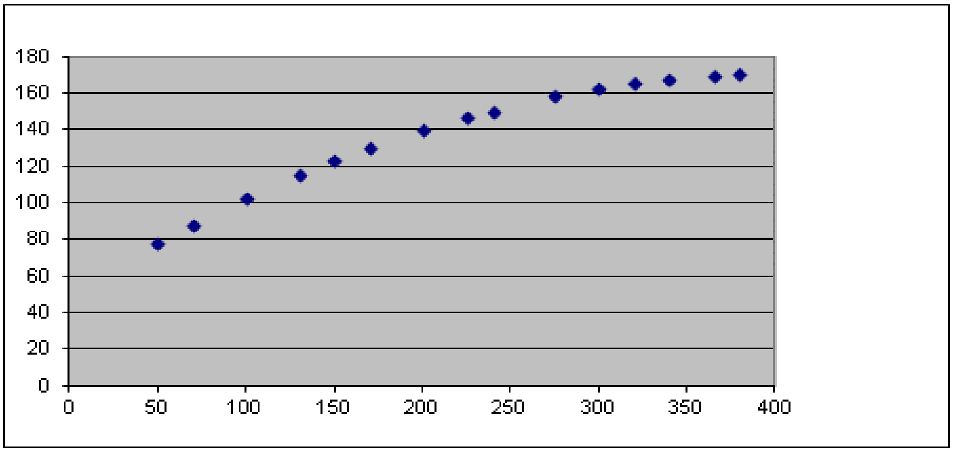

Figure 1. Graphic representation of input data

As can be seen from the scatterplot (Figure 1), it is a quadratic dependence of the observed variables. By applying the least squares method to find quadratic regression function that best approximates given points, i.e. by solving the system of equations (the least squares method)(Milton and Arnold, 2002):

$$\begin{aligned} \sum y &= na + b\sum x + c\sum x^2 \\ \sum xy &= a\sum x + b\sum x^2 + c\sum x^3 \\ \sum x^2 y &= a\sum x^2 + b\sum x^3 + c\sum x^4 \end{aligned} \quad \ldots (11)$$

that is,

$$\begin{aligned}2064 &= 15b + 3315b + 895175c\\ 500750 &= 3315a + 895175b + 268535625c\\ 141589050 &= 895175a + 268535625b + 85506501875c\end{aligned}$$

we obtain the values of the coefficients a= 49.9775748, b= 0.596416492 andc= -0.0007404, which by rounding and multiplying by 1000, since the data is given in 000 units of product manufactured, is: a= 50000, b= 600 and c= -0,75.

The whole data processing in this part of the paper were carried out in statistical software SPSS and Excel.

Based on the procedure previously performed, we conclude that the approximate total cost function by the quadratic regression function based on the initial empirical data, takes the following form:

$$T_u(x) = -0{,}75x^2 + 600x + 50000 \qquad \dots (12)$$

and describes the costs in euros.

It is understood that $x > 0$ as the volume of production, that is, the number of pieces of a product. In any other problem, of course, it can be the amount of a product expressed in any measure depending on the situation. Also, $T_u(x) > 0$, from where we get $x \in (0{,}1076)$.

On the other hand, by differentiating equation (12), we obtain *marginal cost function*:

$$T_g(x) = -0{,}75x \cdot 2x + 600 = -1{,}5x + 600 \qquad \dots (13)$$

The total cost function increases with increasing production volume x, which means $T'(x) = T_g(x) > 0$, i.e. $-1{,}5x + 600 > 0$, where $x < 400$. As the intersection of both intervals of the definition of these functions, we obtain $x \in (0{,}400)$.

In the further analysis, we also use *the average cost function*, which is obtained by (7) and equals:

$$\overline{T}(x) = -0{,}75x + 600 + \frac{50000}{x} \qquad \dots (14)$$

In Figure 2. that follows, we see the previous three functions. The data were processed and graphically illustrated using mathematical software MathLab.

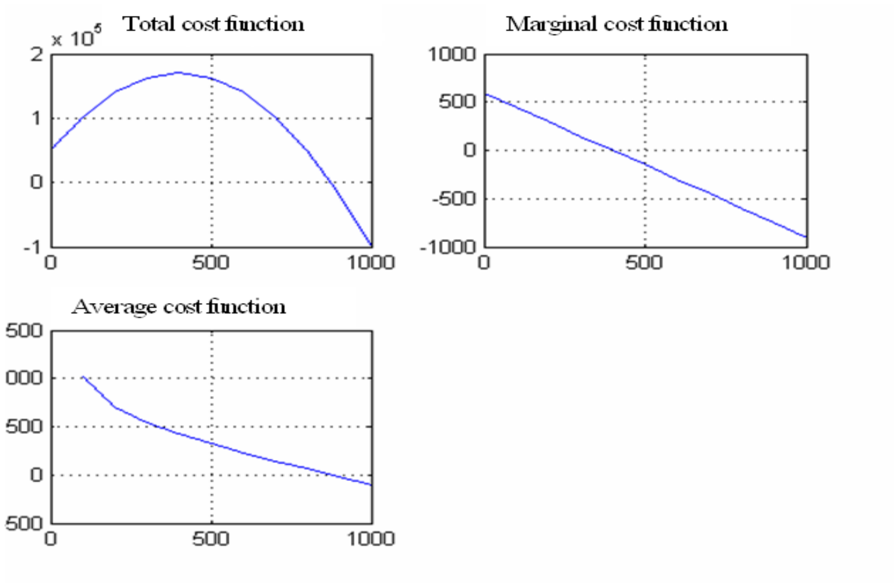

Figure 2. Total cost function, marginal cost function and average cost function (illustrated in Mathlab)

When all these functions are known, we can obtain information on the value of total, marginal or average costs for any value of production volume within the permitted domain $x \in (0{,}400)$. We understand that increasing volume increases costs, but at some point in time, the following realistic questions are posed to the management of a company:

1. How much would total costs be increased if the volume of production were increased to a certain extent and would making a decision to increase production make sense?

2. What is the exact cost of producing each subsequent product?

The answers to these questions are given by the example below, which can be implemented for any other specific situation and thus make the right decision whether to increase production with cost control that ensures sustainable development of both small businesses and large companies.

In our example, we ask the question: How much will the costs increase if the volume of production increases from the level $x = 200$ products.

We get total costs for 200 products, when in equation (12), we substitute for $x = 200$, i.e.

$$T_u(200) = -0{,}75 \cdot 200^2 + 600 \cdot 200 + 50000 = 140000 \text{ €}$$

If the production increases to $x = 201$, the total costs would be:

$$T_u(201) = -0{,}75 \cdot 201^2 + 600 \cdot 201 + 50000 = 140299{,}25 \text{€}.$$

It is clear that the difference $T_u(201)-T_u(200)=140299{,}25-140000=299{,}25\,€$, represents the exact cost for producing 201st product.

By using equation (6), an approximate result can be obtained using marginal costs function, which we have seen can approximate the exact cost of producing the next product. Thus, an approximate result can also be obtained using equation (13) as follows:

$$T_g(200)=-1{,}5\cdot 200+600=300\approx 299{,}25$$

With this we have confirmed that marginal cost function can be used as a faster and easier way of obtaining approximate exact costs for the next product.

If we are interested in what these costs are for the 201st product relative to the average cost per unit of product when a total of 200 products are manufactured, then we use the average costs function (14) and obtain:

$$\overline{T}(200)=-0{,}75\cdot 200+600+\frac{50000}{200}=700\,€.$$

Obviously, the costs for the 201st product would be greatly decreased compared to the average costs for the previous 200 products.

In deciding whether to increase production volume, in terms of increasing costs, elasticity coefficient also gives significant results, which in our case, according to (10) is:

$$E_{T_u,x}=\frac{x}{T_u(x)}\cdot T'(x)=\frac{T_g(x)}{\overline{T}(x)}=\frac{T_g(200)}{\overline{T}(200)}=\frac{299{,}25}{700}=0{,}43\%$$

Therefore, $E_{T,200}=0{,}43\%<1$, so in line with the previous theory of total costs elasticity, we obtain that the total costs are elastic, i.e. a decision can be made to increase production. More precisely, if the volume of production increases by 1%, i.e. from 200 to 202 products, the total costs increase to

$$T_u=140000+140000\cdot\frac{0{,}43}{100}=140602\,€.$$

With the results obtained in this way, which in a certain way predicts costs in the future, while increasing the volume of production and having in mind the available finances for investment, the management of any company can make right decisions, while having a safe and accurate control over costs.

5. CONCLUSION

Higher profits and increasing production volume are the most important objective of the management of a company. Sustainable development, which requires control over costs that are inevitable and naturally increase with production volume, transport, sales, use of human and other natural resources, cannot be forgotten. It is impossible to give an absolute exhaustive classification of costs, but regardless of their nature, one thing is indisputable: without daily cost control, there is no successful business. To this end, increased competition in the market requires immediate improvement from the management. In this paper, based on the example of the production of medium voltage transformers in the Measuring Transformers Factory – Zaječar, we started from the empirical data related to the number of units of products (transformers) produced and costs incurred for a period of 15 months and obtained an approximate function of total costs. We further provided a complete mathematical analysis of the total costs and indicated how it is possible to predict, with the help of the measure of elasticity, the extent to which an increase in production volume can influence an increase in costs.Making the right decision by the management is in any case a complex decision, but such an analysis of costs and its elasticity is useful and can help companies to operate more successfully, to generate and save more profit at less costs.

REFERENCES

Barnett, R. A., Ziegler, M. R., Byleen, K. E. (2003) *Applied mathematics for business, economics, life sciences, and social sciences.* Prentice Hall

Božinović M., Stojanović V. (2005). *Matematičkemetodeimodeli u ekonomiji preduzeća.* Univerzitet u Prištini

Bojičić R., Božinović M. (2016). *Operaciona istraživanja.* Univerzitet u Prištini. Ekonomski fakultet

Milton, J.S., Arnold, J.C. (2002). *Introduction to Probability and Statistics: Principles and Applications for Engineering and the Computing Sciences 4th*. McGraw-Hill, Inc. New York, NY, USA

Petković N., Božinović M. (2015). *Maksimizing sales under conditions of nonlinearity.* Factauniversitatis, str.269-278.Vol.12.*N*^{0}4. Niš

Todorović O., Pešić M., Mimović P. (2009). *Operacionaistraživanja.*Ekonomskifakultet, Niš

http://www.yourarticlelibrary.com/economics/cost-theory-introduction-concepts-theories-and-elasticity-economics/28725 (accessed 10.09. 2019)

DOES THE INTERNET PENETRATION HELP REACH MILLENNIUM GOALS: THE CASE OF CENTRAL ASIAN TURKIC REPUBLICS

Rasim Yilmaz, Cuneyt Koyuncu

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ABSTRACT

The Sustainable Development Goals (SDGs) are a collection of measurable and universally-agreed development targets established by UNDP. SDGs are designed at the United Nations Conference on Sustainable Development in Rio de Janeiro in 2012. SDGs include 17 goals build on the Millennium Development Goals which are set at the Millennium Summit of United Nations Conference in New York in 2000.This study investigates whether the diffusion of the internet can help reach millennium goals for Turkic Republics of the former Soviet Union. Three models are constructed to test this hypothesis. Bivariate estimation results indicate strong correlation between the internet and millennium goals of environmental sustainability, human capital development, and improvement in income distribution and human development. Multivariate estimation results are also support the relationship between the internet and millennium goals. Thus, our results suggest government support for the diffusion of information and communication technologies to reach further levels in millennium goals.

Keywords: Internet, Information and Communication Technologies, Millennium Goals, Central Asian Turkic Republics

1. INTRODUCTION

The Sustainable Development Goals (SDGs) are a collection of measurable and universally-agreed development targets established by UNDP. The Sustainable Development Goals (SDGs) are designed at the United Nations Conference on Sustainable Development in Rio de Janeiro in 2012. SDGs include 17 goals build on the Millennium Development Goals which are set at the Millennium Summit of United Nations Conference in New York in 2000. Table 1 presents definition and explanation of the goals.

The 17 Sustainable Development Goals (SDGs) with their 169 targets are intended to be met by the end of 2030. Accordingly, there has been increasing efforts for finding tools to meet the goals.

The goals address the social, economic, and environmental aspects of sustainable development. Apart from its other effects, diffusion of ICT can be the main instrument in achieving most of the Sustainable Development Goals (SDGs) (MDGs). Several case studies support this argument.

Table 1.Definition and explanation of sustainable development goals

Goals	Definition	Explanation
1	No Poverty	End poverty in all its forms everywhere
2	Zero Hunger	End hunger, achieve food security and improved nutrition and promote sustainable agriculture
3	Good Health and Well-Being	Ensure healthy lives and promote well-being for all at all ages
4	Quality Education	Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all
5	Gender Equality	Achieve gender equality and empower all women and girls
6	Clean Water and Sanitation	Ensure availability and sustainable management of water and sanitation for all
7	Affordable and Clean Energy	Ensure access to affordable, reliable, sustainable and modern energy for all
8	Decent Work and Economic Growth	Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all
9	Industry, Innovation and Infrastructure	Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation
10	Reduced Inequality	Reduce inequality within and among countries
11	Sustainable Cities and Communities	Make cities and human settlements inclusive, safe, resilient and sustainable
12	Responsible Consumption and Production	Ensure sustainable consumption and production patterns
13	Climate Action	Take urgent action to combat climate change and its impacts
14	Life Below Water	Conserve and sustainably use the oceans, seas and marine resources for sustainable development
15	Life on Land	Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss
16	Pease, Justice and Strong Institutions	Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels
17	Partnerships for Goals	Strengthen the means of implementation and revitalize the global partnership for sustainable development

*Source:*https://www.undp.org/content/undp/en/home/sustainable-development-goals.html

The internet penetration rate varies among the Central Asian Turkic Republics. As of 2016, Azerbaijan had the highest the internet penetration rate with 78.2%, followed by Kazakhstan with 74.4%. The internet penetration is moderate in Uzbekistan and Kyrgyz Republic with 46.7% and 30.2%, respectively. Tajikistan and Turkmenistan present lower internet diffusion with 20.4% and 17.9%, respectively (see Table 2).

Although the internet penetration rates are similar among the states except Turkmenistan in 2007, Azarbaijan and Kazakhstan displayed higher performance in terms of the internet diffusion after 2007.

Table 2. Percentage of individuals using the internet-Central Asian states

	Azerbaijan	Kazakhstan	Uzbekistan	Kyrgyz Republic	Tajikistan	Turkmenistan
1994	0.001	0.0005	..	..	..	..
1995	0.002	0.0113	0.0015	..	..	..
1996	0.006	0.0318	0.0042	..	..	..
1997	0.025	0.0645	0.0105	..	..	..
1998	0.037	0.1310	0.0207	0.0728	..	..
1999	0.099	0.4642	0.0306	0.2047	0.0327	0.0450
2000	0.147	0.6685	0.4843	1.0414	0.0486	0.1332
2001	0.305	1.0061	0.5975	3.0029	0.0512	0.1752
2002	4.999	1.6747	1.0819	2.9992	0.0554	0.3021
2003	..	2.0004	1.9125	3.9087	0.0645	0.4251
2004	..	2.6503	2.5937	5.0903	0.0774	0.7540
2005	8.030	2.9617	3.3435	10.533	0.2986	0.9972
2006	11.99	3.2683	6.3883	12.306	3.7724	1.3195
2007	14.54	4.02	7.4906	14.03	7.1976	1.4063
2008	17.08	11	9.0801	15.7	8.78	1.75
2009	27.4	18.2	11.9	16	10.07	1.95
2010	46	31.6	15.9	16.3	11.55	3
2011	50	50.6	18.6	17.5	13.03	5
2012	54.2	61.906	23.6	19.8	14.51	7.19
2013	73.00	63.304	26.8	23	16	9.6
2014	75.00	66	35.5	28.3	17.49	12.2
2015	77	70.829	42.8	30.2	18.98	14.99
2016	78.2	74.587	46.791	34.5	20.47	17.99
2017	79	76.426	..	..	..	..

Source: World Telecommunication Database

The aim of this study is to empirically examine the impact of the Internet on the Sustainable Development Goals (SDGs) in the context of Turkic Republics. For this end, three models are developed to address different dimensions of the goals. The next section provides a model addressing environmental aspects of the goals, while section 3 presents models focusing on income inequality and human development dimensions of the goals and section 4 provides a model centering human capital development aspects of the goals. The last section concludes.

2. ICT AND ENVIRONMENTAL SUSTAINABILITY

One of the millennium goals is to ensure environmental sustainability. Information and communication technologies may help reach environmental sustainability for Turkic Republics of the former Soviet Union. In order to test this hypothesis, this part of the study empirically investigates the relationship between diffusion of the internet and forest ownership (deforestation) in the panel data context. Our panel includes 6 countries (Azerbaijan, Kazakhstan, Kyrgyz Republic, Tajikistan, Turkmenistan, and Uzbekistan) and the period between 1990 and 2015.

The following bivariate and multivariate random and fixed time effect models, which is based on the previous studies of Jorgenson and Burns (2007) and De Fries et al. (2010), are estimated:

$$FOREST_{it} = (\alpha + \tau_t) + \beta_1 INTERNET_{it} + u_{it} \quad \ldots (1)$$

$$FOREST_{it} = (\alpha + \tau_t) + \beta_1 INTERNET_{it} + \beta_2 PCR_{it} + \beta_3 RPG_{it} + \beta_4 GDPPC_{it} + u_{it} \quad \ldots (2)$$

and the following bivariate and multivariate random time effect models (REM);

$$FOREST_{it} = \alpha + \beta_1 INTERNET_{it} + (\tau_t + u_{it}) \quad \ldots (3)$$

$$FOREST_{it} = \alpha + \beta_1 INTERNET_{it} + \beta_2 PCL_{it} + \beta_3 RPG_{it} + \beta_4 GDPPC_{it} + (\tau_t + u_{it}) \quad \ldots (4)$$

where*it* subscript stands for the *i-th*country’s observation value at time *t* for the particular variable. α is the intercept term and τ_t represents time-specific effects which affect all countries in the same way (i.e., τ_t is variant across time but not across countries). u_{it} is idiosyncratic error term of the regression model.

Dependent variable of the model is forest area as a percentage of land area. The data comes from World Development Indicators. Our main explanatory variable of interest in this study is INTERNET, which is the percentage of individuals using the internet. The data is taken from World Telecommunication database. The expected relationship between the internet diffusion and forestation in our model is positive as such increase in the internet penetration increases the percentage of forest area.

Three more determinants of forestation, which are suggested by previous studies (Jorgenson and Burns, 2007; De Fries et al., 2010), are introduced to test the robustness of bivariate estimation results: permanent cropland as a percentage of total land area (PCR), rural population growth (RPG), and GDP per capita at constant 2010 USD (GDPPC). The source of those variables is World Development Indicators (WDI).

Bivariate estimation results for forestation model is presented at Table 3 below. The coefficient on the INTERNET variable is negative and statistically significant at 1% level in bivariate model estimation. Bivariate estimation results suggest that there is a strong positive correlation between the internet diffusion and forestation.

Table 3.Bivariate model estimation results (forestation)

	FORESTATION
C	5.8065
Standard Error	1.7818
P-value	0.0015
INTERNET	0.0158
Standard Error	0.0023
P-value	0.0000
Number of Observations	121
Number of Countries	6
R-squared	0.2808
Estimated Model	REM
Hausman-statistics	0.0456

Multivariate estimation results are presented at Table 4. The coefficient on INTERNET variable is positive and statistically significant at the 1% level, which suggests that forestation increasesas the percentage of individuals using the internet increases.

Table 4.Multivariate model estimation results (internet)

	Forestation
C	3.8184
Standard Error	2.0062
P-value	0.0596
INTERNET	0.0109
Standard Error	0.0034
P-value	0.0021
CROPLAND	-0.4870
Standard Error	0.3156
P-value	0.1257
RURPOPGRO	-0.2187
Standard Error	0.0597
P-value	0.0004
GDPGRO	0.3657
Standard Error	0.1695
P-value	0.0331
Number of Observations	115
Number of Countries	6

R-squared	0.4179
Estimated Model	REM
Hausman-statistics	5.8544

In regard to other independent variables, the estimated coefficient of CROPLAND variable is negative and statistically significant at the 1% level in all models. The results indicate that surge in the agricultural land demand leads to deforestation. The coefficient of RURPOPGRO variable statistically significant and have expected sign. The result displays that rural population growth causes deforestation. The coefficients of GDPGRO variable is positive and statistically significant at 5% level which implies that deforestation tends to decrease as nations becomes more developed.

3. ICT, INCOME INEQUALITY AND HUMAN DEVELOPMENT

Millennium goals of reducing child mortality, improving maternal health, combating HIV/AIDS, malaria and other diseases are related to human development while millennium goals of eradicating extreme poverty and hunger and promoting gender equality and empowering women are affiliated to income inequality. Improvements in income equality can indicate decrease in poverty and hunger, improvement in gender equality and women empowerment. Similarly, enhancement in human development can be the sign of reduction in child mortality, improvement in maternal health, decrease in HIV/AIDS, malaria and other diseases.

Information and communication technologies may help reduce income inequality and improve human development for Turkic Republics of the former Soviet Union. In order to test this hypothesis, this part of the study empirically investigates the relationship between diffusion of the internet and income inequality (and human development) in the panel data context. Our panel includes 6 countries (Azerbaijan, Kazakhstan, Kyrgyz Republic, Tajikistan, Turkmenistan, and Uzbekistan) and the period between 1990 and 2015.

The following bivariate and multivariate random and fixed time effect models, which is based on the previous study of Gupta et al. (1998), are estimated:

$$POVERTY_{it} = \beta_{1i} + \beta_2 INTERNET_{it} + u_{it} \quad \ldots (1)$$

$$POVERTY_{it} = \beta_{1i} + \beta_2 INTERNET_{it} + \beta_3 ORERATE_{it} + \beta_4 EDUCATION_{it} + \beta_5 CSTOCK_{it} + u_{it} \quad \ldots (2)$$

and the following bivariate and multivariate random effect models (REM);

$$POVERTY_{it} = \beta_1 + \beta_2 INTERNET_{it} + \varepsilon_i + u_{it} \quad \ldots (3)$$

$$POVERTY_{it} = \beta_1 + \beta_2 INTERNET_{it} + \beta_3 ORERATE_{it} + \beta_4 EDUCATION_{it} + \beta_5 CSTOCK_{it} + \varepsilon_i + u_{it} \quad \ldots (4)$$

where, *it* subscript stands for the *i-th* country's observation value at time *t* for the particular variable. All variables are in logarithmic forms. On the other hand, whenever the observation value of a particular variable takes the value of zero then we add the value of 0.000001 to all observations of that variable in order to be able to take the logarithms. β_{1i} represents country specific factors not considered in the regression, which may differ across countries but not within the country and is time invariant. ε_i is a stochastic term, which is constant through the time and characterizes the country specific factors not considered in the regression. u_{it} is error term of the regression.

There are two dependent variables and hence two models in this section. Our dependent variables are income inequality (GINI) and human development (HDI). GINI and HDI focus on different dimensions of poverty. GINI is related to income inequality while HDI is associated with human development.

GINI is the Gini index. The Gini coefficient is a measure of inequality between 0 and 1, where 0 corresponds with perfect equality (where everyone has the same income) and 1 corresponds with perfect inequality (where the richest person has all the income and everyone else has zero income). HDI is the Human Development Index and is a proxy for human development. The Human Development Index (HDI) is a summary measure of average achievement in key dimensions of human development: a long and healthy life, being knowledgeable and have a decent standard of living. The HDI is the geometric mean of normalized indices for each of the three dimensions. The HDI was created to emphasize that people and their capabilities should be the ultimate criteria for assessing the development of a country, not economic growth alone.

HDI data is taken from UNDP while GINI data is obtained from the World Bank.

Our main explanatory variable of interest in this study is INTERNET which is the percentage of individuals using the internet. The data is taken from World Telecommunication database. The expected relationship between the internet diffusion and income inequality in our model is negative as such increase in the internet penetration decreases income inequality.

We also introduced three more determinants of income inequality which are suggested by previous study by Gupta et al. (1998) into our analysis to see how robust our finding is: the total natural resources rents as a percentage of GDP (ORERATE), the gross tertiary school enrollment to total enrollment ratio (EDUCATION), and gross fixed capital formation as a percentage of GDP (CSTOCK). The source of those variables is World Development Indicators (WDI).

Table 5 reports bivariate estimation results for regressions where INTERNET is used as an independent variable. All coefficients of INTERNET variable are statistically significant at the 1% level and take the expected signs. The results indicate that surge in the percentage of individuals using the internet is associated with an increase of Human Development Index and decrease in Gini coefficient (i.e. decrease in inequality).

Table 5. Bivariate model estimation results (internet)

	HDI	GINI
C	0.635523	3.291161
Standard Error	0.017469	1.476861
P-value	0.0000	0.0000
INTERNET	0.001733	-0.126095
Standard Error	0.000123	0.036607
P-value	0.0000	0.0012
Number of Observations	101	21
Number of Countries	6	5
R-squared	0.6679	0.2017
Estimated Model	REM	REM
Hausman-statistics	1.3532	0.1040

Table 6 presents multivariate estimation results. All coefficients of INTERNET variable continue to have statistically significant and expected signs, suggesting that the internet diffusion is positively associated with human development index (HDI) while it is negatively correlated with Gini coefficient. Regarding other variables, results indicate that capital stock and natural resource endowment are associated with higher human development index.

Table 6. Multivariate model estimation results

	HDI	GINI
C	0.5772	3.7641
Standard Error	0.0117	2.2318
P-value	0.0000	0.0000
INTERNET	0.0018	-0.0770
Standard Error	0.0001	0.0338
P-value	0.0000	0.0297
ORERATE	0.0018	0.0020
Standard Error	0.0003	0.0637
P-value	0.0000	0.9742
CSTOCK	0.0010	-0.1302
Standard Error	0.0003	0.0963
P-value	0.0068	0.1862
EDUCATION	-0.0002	-0.0575
Standard Error	0.0005	0.0566
P-value	0.5841	0.3174
Number of Observations	78	36
Number of Countries	5	5
R-squared	0.9355	0.4296
Estimated Model	FEM	REM
Hausman-statistics	77.5562	3.9435

4. ICT AND HUMAN CAPITAL DEVELOPMENT

One of the millennium goals is to achieve universal primary education, which is related to human capital development. Information and communication technologies may help improve human capital for Turkic Republics of the former Soviet Union. In order to test this hypothesis, this part of the study empirically investigates the relationship between diffusion of the internet and human capital in the panel data context. Our panel includes 3 countries (Kazakhstan, Kyrgyz Republic, Tajikistan) and the period between 1990 and 2015.

The following bivariate and multivariate fixed time effect panel data models (FEM) implemented by the studies of Binder and Georgiadis (2011) and Shuaibu and Oladayo (2016) are employed to assess the impact of ICT penetration on human capital:

$$HUMANCAPITAL_{it} = (\alpha + \tau_t) + \beta_1 INTERNET_{it} + u_{it} \quad \dots (1)$$

$$HUMANCAPITAL_{it} = (\alpha + \tau_t) + \beta_1 INTERNET_{it} + \beta_2 GDPPCGRT_{it} + u_{it} \quad \dots (2)$$

and the following bivariate and multivariate random time effect models (REM);

$$HUMANCAPITAL_{it} = \alpha + \beta_1 INTERNET_{it} + (\tau_t + u_{it}) \quad \dots (3)$$

$$HUMANCAPITAL_{it} = \alpha + \beta_1 INTERNET_{it} + \beta_2 GDPPCGRT_{it} + (\tau_t + u_{it}) \quad \dots (4)$$

where, *it* subscript stands for the *i-th* country's observation value at time *t* for the particular variable. α is the intercept term and τ_t represents time-specific effects which affect all countries in the same way (i.e., τ_t is variant across time but not across countries). u_{it} is idiosyncratic error term of the regression model. All variables are expressed in logarithmic forms. Since our models are full logarithmic models, parameter in front of each independent variable represents elasticity.

The dependent variable of our model is human capital. Human Capital Index is used as a proxy for human capital development. Human Capital Index is an index of human capital per person based on years of schooling and returns to education. The data is taken from Penn World Tables (PWT).

Our main explanatory variable of interest in this study is INTERNET, which is the percentage of individuals using the internet. The data is taken from World Telecommunication database. The expected relationship between the internet diffusion and human capital development in our model is positive as such increase in the internet penetration enhance human capital development.

Table 7 reports bivariate estimation results. The coefficients on INTERNET variable is statistically significant at the 1% level and take the expected positive sign. The results show that increase in the percentage of individuals using the internet leads to increase in human capital index.

Table 7. Bivariate model estimation results (hci-human capital index)

	HCI
C	3.0267

Standard Error	0.0399
P-value	0.0000
INTERNET	0.0045
Standard Error	0.0012
P-value	0.0009
Number of Observations	57
Number of Countries	3
R-squared	0.1839
Estimated Model	REM
Hausman-statistics	0.7385

As a part of robustness checks, a number of control variables suggested by previous studies (Binder and Georgiadis, 2011; Shuaibu and Oladayo, 2016) are included in the bivariate models in order to test the validity and robustness of the bivariate estimation results. Multivariate estimation results are provided at Table 8. Estimation results indicate that both INTERNET and GDPPCGRT variables are positively associated with Human Capital Index, suggesting that increase in the percentage of individuals using the internet and GDP per capita growth positively affects human capital development.

Table 8.Multivariate model estimation results (hci)

	HCI
C	2.9665
Standard Error	0.0251
P-value	0.0000
INTERNET	0.0040
Standard Error	0.0010
P-value	0.0002
GDPPCGRT	0.0175
Standard Error	0.0037
P-value	0.0000
Number of Observations	56
Number of Countries	3
R-squared	0.3982
Estimated Model	REM
Hausman-statistics	4.5050

5. CONCLUSION

The Sustainable Development Goals (SDGs) agreed on by the United Nations Conference on Sustainable Development in Rio de Janeiro in 2012 consists of 17 goals with their 169 targets for all countries in the world. The goals are intended to be reached by the end of 2030.

Building on three models, this study examines the effect of the internet penetration on The Sustainable Development Goals (SDGs) in the context of Turkic

Republics. The empirical results of the study suggest that promoting the use of Information and Communication Technologies (ICT) in Turkic Republics can help them to reach The Sustainable Development Goals (SDGs) of environmental sustainability, human capital development, and improvement in income distribution and human development.

Thus, our results suggest government support for the diffusion of ICT, especially the internet access, to reach further levels in millennium goals. ICT's success on meeting the goals depends on the accessing ICT equally. The access to ICT is not equal within and among countries. A lack of access to ICT can deteriorate disparity among the society. That is why, governments should focus on increasing the access to ICT by especially economically lower levels of the societies, enhancing the availability and quality of ICT infrastructure, and removing obstacles to training and capacity building.

Without providing education and training, providing ICT tools such as computers, tables and the internet to poor house households will not be enough to reach the goals. It should be noted that all family members of poor households should reach training for ICT tools. Moreover, providing children and parents with supporting software is also as important as providing hardware.

REFERENCES

Binder, M. and Geogiadis, G. (2011). *Determinants of Human Development: Capturing the Role of Institutions*. CESifo Working Paper No. 3397. Munich: Center for Economic Studies and Ifo Institute.

DeFries, R.S., Rudel, T., Uriarte, M. and Hansen, M. (2010). *Deforestation Driven by Urban Population Growth and Agricultural Trade in the Twenty-First Century*. Nature Geoscience, 3: 178-181.

Gupta, S., Davoodi, H., Alonso-Terme, R. (1998). *Does Corruption Affect Income Inequality and Poverty?* IMF Working Paper No. 76, Washington D.C., IMF.

Jorgenson, A.K. and Burns, T.J. (2007). *Effects of Rural and Urban Population Dynamics and National Development on Deforestation in Less-Developed Countries, 1990-2000*. Sociological Inquiry, 77(3): 460-482.

Shuaibu, M. and Oladayo, P.T. (2016). *Determinants of Human Capital in Africa: A Panel Data Analysis*. Oeconomia Copernicana, 7(4): 523-549.

MODEL OF A SOFTWARE SYSTEM FOR BUSINESS WORKFLOW MANAGEMENT BASED ON PETRI NETS

Stoyan Cheresharov, Kremena Stefanova

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ABSTRACT

This paper describes a model of a software system that helps the digital transformation of business models. It can be used as a module in a modular system for rapid application development. It offers consistency, simplicity, functionality reuse, high quality, balance and stability in the architecture and approach for building enterprise applications. The existing business systems don't always offer models based on strong mathematical theory. The proposed model addresses this problem in a new consistent way. The model uses a flexible, reusable workflow engine module, based on the Petri Nets theory. It can be built with different technologies and can use standard dependency managers. The communication can be done using web services. The model is not restricted to use a single SQL or NoSQL database. The problem we tackle is offering a model for building as wide variety of information systems as possible in a standard way, by using an interchangeable module. It allows a graphical and formal mathematical solution for a wide variety of business problems.

Keywords: Business models, Information systems, Workflow management, Petri nets

1. INTRODUCTION

The problem we try to solve is how to create digital models of the existing business processes in the most efficient way. Very often we create software in an attempt to simplify and manage business processes. Each time we have to write different software since the business processes differ from one another. For each different workflow, we have to write different software. The elements of the software are similar, but not exactly the same and we end up rewriting and reinventing the same principles over and over again. With our model of a software modular system, we try to solve this issue, by creating a reusable module that can model and manage different business processes, models and workflows. The model of the module is based on the Petri Nets theory. Since this theory can be used to create models and manage many processes, the module will be able to do the same. This way we will write the code once and reuse the module in different software systems for managing business processes. In fact, the module can be used for managing any kind of process. Such an approach perfectly fits the new trends in software development like server-less service-oriented architecture. Sometimes the existing solutions are too complex and overkill for the small tasks we try to solve. Our goal is to create a relatively simple-to-implement module that solves as many problems as possible, yet as simple as possible. The complexity stays in balance with simplicity. The model should be easy to implement and use. Our contribution is a simple implementation of Petri Net theory, build as an exchangeable module for modeling and managing business processes (a workflow engine). The business process can be represented (modeled) with a clear and simple set of objects and rules. The model of the business process can be created and tested with many available tools for creating Petri Nets. After that, it can be exported as an XML file or another format and used by the module to orchestrate the business process. The proposed model is for building workflow modules for managing business processes that can be standalone as a micro service and follow the modern tendencies of a server-less, service-oriented distributed architecture base in the cloud. The module can exist in the cloud and offer its functionality through Remote Procedure Calls (RPCs), RESTful or GraphQL Application Programming Interfaces (APIs). With such a module it is possible to manage business processes that can be used as a cloud service. We can introduce a new term, Workflow as a Service (WaaS). The mathematical model can be created with a third party tool and deployed to the module to be used. It can be used as a stand-alone service or as a part of a bigger system that has authorization and authentication systems, etc. The proposed model is only for activity-based business processes, answering the question “Who does what, when and how?”. Since there is no standard model for Petri Net implementation, we propose a simplified model.

2. RELATED WORK

Related work has been done with the use of Petri Nets in different domains for managing and creating business processes and models.

Yu *et al*. (2018) are describing methods that can help the designers of software systems to analyze structural security issues of an e-commerce business process. In this case, the Petri Nets theory is used to help analyze a distributed and complex system, using Application Programming Interfaces (APIs) such as Cashier-as-a-Service (CaaS).

An investigation of consistency features in resource perspective by using Petri Nets has been done by Lacheheub *et al*. (2019). The authors apply the Petri Nets theory for optimizing business process construction.

Another effort for creating a formal model that supports the specification and analysis of company requirements has been made (Lacheheub and Maamri, 2016). The authors reveal the fact that the deployment and execution of business processes can be very costly and offer a formal model to detect problems that can be caused by the lack of resources.

All previously mentioned work is done in different domains using the Petri Nets theory.

Van der Aalst and Van Hee (1996) propose a framework for redesigning business processes based on the Petri Nets theory. The framework verifies the correctness of the redesigned business process, but it does not offer management.

Kim *et al*. (2017) provide detailed guidelines on how design analytics can be done for accounting information systems (AIS) using the Petri Nets theory. This research is another attempt to use a unified modeling strategy of business processes.

Business process simulation (BPS) with Petri Nets is a powerful tool for resource allocation (Si *et al*., 2018). The research of Si endeavors to combine the power of genetic algorithms (GAs) and the benefits of the process simulation.

Wang *et al*. (2019) develop a model of a flexible production process based on a Petri Net. A serial optimization approach and a search algorithm are used to solve the problem. A case study is carried out to verify the validity and performance of the methodology.

Clempner (2014) presents a trajectory-tracking approach for verifying the soundness of workflow/Petri nets. The advantage of this approach is to represent the dynamic character of the business process.

“A correct business process model is the key to achieving a business goal through business process management.” (Kang, Yang, and Zhang, 2019). Modeling a business process with a strong mathematical theory such as Petri Nets guarantees the correctness of the model. Kang addresses the verification of behavioral soundness for an artifact-centric process model with synchronizations using Petri Nets.

Mejía *et al*. (2016) present a real-life Petri Net-based framework. It is aimed for use in collaborative project management in the Animation and Videogame industry. The potential of the framework is illustrated with two short case studies. The results and deliverables have been tested by managers of some companies.

The research of the scientific literature reveals that the modeling and managing business processes and their different aspects with Petri Nets theory are a common practice.

Ribas *et al*. (2015) describe a framework for place/transition or Petri net-based multi-criteria decision-making (MCDM) framework to assess a cloud-based service in comparison with a similar on-premises service. The framework helps the managers to make a decision and choose between a cloud-based and on-premises service.

In the interesting research of Saini and Thiry (2017), the combination of functional programming (FP) and Petri Nets is used for Business Process Modeling (BPM). The authors propose a general methodology to model business processes using mathematical functions and higher-order functions. They describe the basic part of Business Process Modeling, behavioral semantics via Petri Nets (PN) and Functional implementation of the models.

Gonsalves and Itoh (2011) deal with performance modeling and the optimization of concurrent service systems. Petri Nets have some limitations, such as lacking in time duration concept, in data collecting mechanism and in conjunctive logic on the preconditions of an event. The authors are introducing the Client/Server Petri Net, which overcomes all these limitations. They demonstrate the effectiveness of the novel Client/Server Petri Net model editor–simulator–optimizer with a practical example of an automobile purchase concurrent service system.

Akshay*et al*. (2016) are working with Time Petri Nets (TPNs). TPNs are a classical extension of Petri Nets. They have time constraints attached to transitions. In the paper, the authors show that the questions of friability and termination are decidable for this class.

Petri Net Markup Language (PNML) allows for creating formal models of the business models and processes. They can be exchanged and shared between the businesses. In (Hsieh and Lin, 2014) the authors demonstrate the capabilities of PNML in the development of applications instead of an industrial interchange format only. A PNML is used to develop context-aware workflow systems. The authors propose a methodology to automatically generate context-aware action lists and control resource allocation. A health care example is suggested to demonstrate the design methodology.

3. METHODS AND MODEL

The methods of the module-oriented, object-oriented and aspect-oriented programming have been used to build a workflow engine module. It plays a key role in modeling and managing business processes. It is a simple implementation of the Petri Nets theory. The architectural principles of the server-less, service-oriented architecture are applied.

The conceptual model of a modular software system for business workflow management is represented in Figure 1. The key role in the modular system plays the workflow module. It manages the processes into the entire system. The rest of the modules can be standard elements of a software system, such as modules for authentication, authorization, ORM, etc. A very important requirement for the system is to have a module or system for events management since the communication between the workflow module and the rest of the system is done with events. This allows the system to be loosely coupled. The modern approaches such as server-less and micro services architecture can be used.

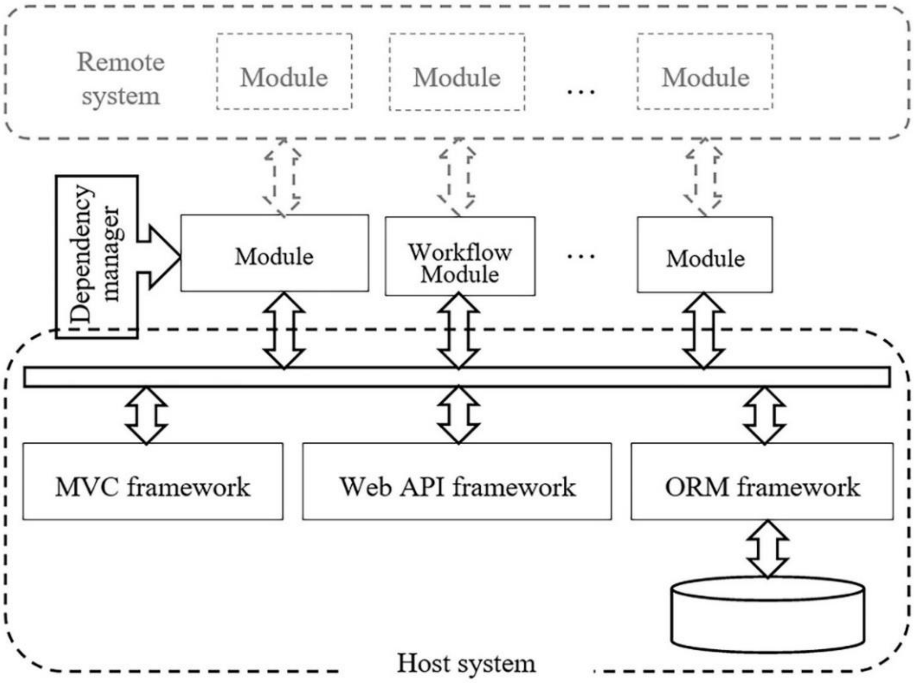

Figure 1. Modular system: Conceptual Model

The modules can communicate between each other and other systems using web services or sockets. This will allow each individual module to be built with different technology. The workflow module offers an extra layer of abstraction and simplification for modeling and managing business processes.

The module is an implementation of the Petri Nets theory. Petri Nets is a formal and graphical language for modeling discrete parallel processes. It is a generalization of the automata theory and follows formal mathematical rules described in the theory. The logic of the module is using the Petri Nets theory objects and rules to create an environment for executing workflows. Each participant has its own role in the workflow. In a workflow management system, each user has a so-called “in-box”. This in-box contains task instances (work items) which can trigger a transition. The model is based on using terms, definitions, and rules borrowed from the Petri Nets theory. The business process (workflow) should be represented (modeled) by objects and rules described below.

The objects in Petri Nets are:

Places – they are passive objects that can play the role of an inbox in a business management system. They are represented with circles in the Petri Net diagram. Every Petri Net has one input and one output place, but an unlimited number of intermediate places.

Transitions – they are active objects and represent the tasks that need to be done. They are represented with rectangles in the diagram.

Arcs – every arc connects one place with one transition. They are represented with arrows in the diagram. “Inward arc” is going out of a place and is sinking into a transition. “Outward arc” is going out of a transition and is sinking into a place.

Tokens – they represent the current state of the business process (workflow). They are represented as black dots in the places of the diagram. A place can hold 0 or more tokens in every moment of time.

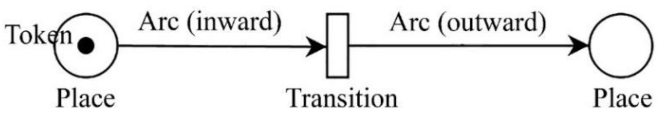

Figure 2. Objects in Petri Nets

The places hold the tokens, which represent the state of the process. A given place can contain 0 or more tokens in every given moment of time. An arch connects one place with one transition. Place P is called:

an input place for transition T, if there is a direct inward arc connecting P with T;

an output place for transition T, if there is a direct outward arc connecting T with P.

When an enabled transition is triggered, it moves tokens from all its input places to all its output places. A transition T is enabled when all input places for T have at least one free token. How an enabled transition is triggered depends on the type of the trigger. When a transition T is triggered, it consumes one token from all its input places P for T and produces one token for every output place P for T.

Every workflow has exactly one starting place. It needs to have at least one inward arc entering a transition. It is possible to have one outward arc coming from a transition for restarting the workflow process.

Every workflow can have only one finishing place. It needs to have at least one outward arc coming from a transition. It is possible to have more than one outward arc coming from transitions. But the finishing place cannot have inward arcs going to a transition.

The moment when a transition becomes enabled and the moment when the transition is triggered are usually different. The event that triggers an enabled transition is called a *trigger*. There are four different types of triggers:

Automatic – the transition is triggered immediately after it becomes enabled.

User – the enabled transition is triggered by the user. In a workflow system, every user has an inbox and there can be found its tasks – work items. The user triggers a transition by clicking a button or another interaction within the task.

Time – an enabled transition can be triggered after a certain amount of time elapses.

Message – external events can trigger an enabled transition. Such external events include receiving an e-mail, a phone call, etc.

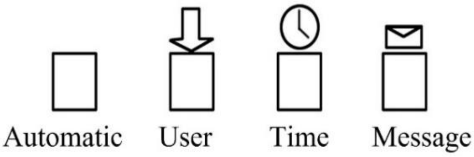

Figure 3. Triggers in Petri Nets

Based on the previously described rules, there are different types of routing in Petri Nets models, represented in Figures 4–7.

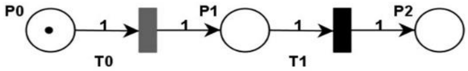

Figure 4. Sequential Routing

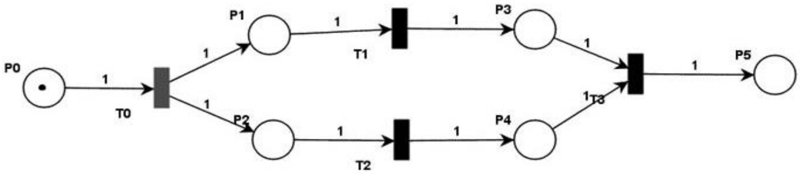

Figure 5. Parallel Routing

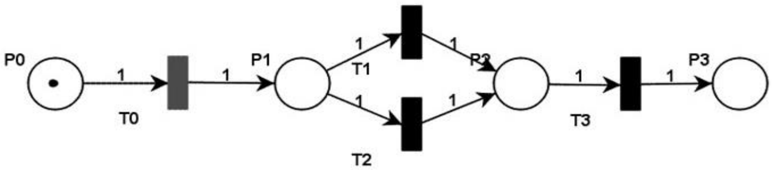

Figure 6. Conditional Routing

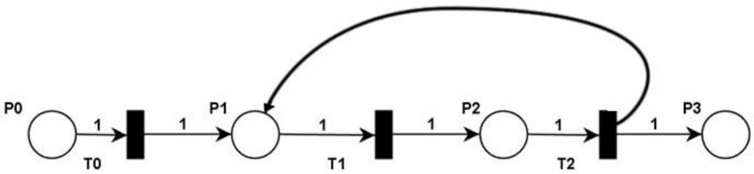

Figure 7. Iterative Routing

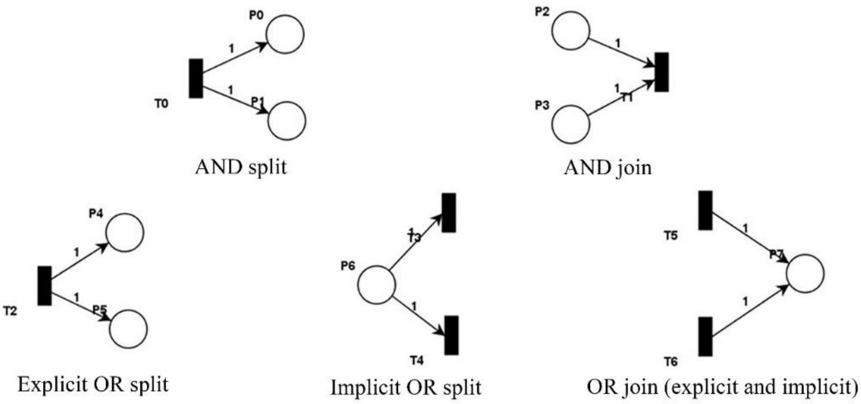

Figure 8. Split and join in Petri Nets

Business processes represented with the previously described rules can be managed by the module. In other words, the business process has to be represented with the set of formal rules. The main objects used in the implementations include Workflow, Place, Transition, Arc, Token, Work item, Workflow Case and User.

The logic of the module unites all objects and offers an environment for the execution of the workflow. Every participant in the workflow has a specific and different role for each workflow and it is determined individually according to the needs. The role of the participant in the workflow does not match the role of the user in the software system. For instance, a given user can have the role of an administrator for the software system, but his role in a given workflow can be different.

The module creates an inbox with tasks (work items) for every participant in the workflow process. An analogy with a very well-known e-mail inbox can be made. Similarly, every task generated by the module for a participant appears in its tasks inbox and looks like an e-mail. After finishing the task, the participant must confirm the completion by interacting with the task in the inbox and after that, the task is removed from the inbox and the module advances the workflow. Another task can be generated for the participant or other participants according to the rules determined by the objects and rules of the workflow.

4. RESULTS

As a result of the research and described model, a prototype of a modular system was built and it proved the concept. The model was used to build a module implementing the described principles. The workflow module and the entire software system proved to be sound and reliable. It was involved in a standard MVC software system shorting the time for modeling and managing the business. It reduced the necessity of writing code for every different business process which needed to be modeled and managed.

The model, its objects and rules were implemented using PHP as a primary programming language. PHP has matured enough as an OOP language, offering a lot of frameworks, which simplify the process of building web applications. The PHP technology was chosen because the language is simple and easy to learn. Developers without experience or students can be involved in the development process.

To set the rules and speed up the development process, frameworks such as Zend (for a primary framework), Doctrine (for ORM) and Apigility (for API) have been used. The modules are using the MVC paradigm. The implementation is based on the MySQL database. The tables in the database perfectly match the entities from the code-first built domain model. The database schema is built and kept in sync with the help of the ORM framework Doctrine.

The domain model of the prototype matches the objects from the Petri Nets theory. Each object is represented by a class. For the abstraction to work, extra classes were created, such as Workflow, Case, Work Item, etc. The actions in the MVC system are responsible for executing the transitions in the workflow system.

The implementation of the workflow module offers two different approaches for building the User Interface (UI). One of them is addressed by using front-end technics based on HTML/CSS/JavaScript. The second approach is addressed by preparing the HTML on the server-side with the help of the controllers and actions of the framework.

The goal was to be able to create a model and manage a business process without writing programming code, just by using the abstraction offered by the Petri Nets theory. For creating the Petri Net model, third party tools were used, such as Platform Independent PetriNet Editor (PIPE) (Figure 9). The workflow module needs, as an input, an XML file that can be produced manually or, even better, by the help of a graphical tool. This approach allows the freedom to use a tool of choice for creating Petri Nets. The Petri Net is a mathematical representation of the business process.

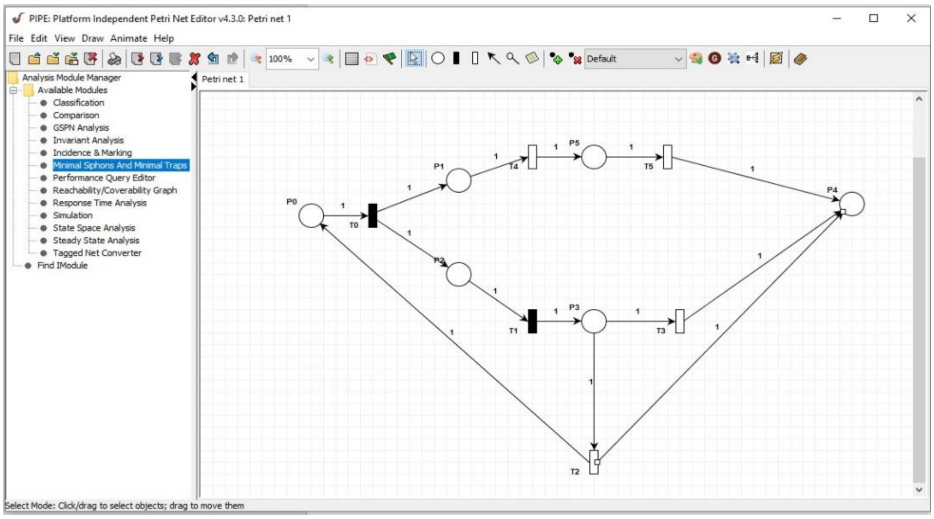

Figure 9. A third-party graphical tool for modeling a process – Platform Independent PetriNet Editor (PIPE)

The goal of the research is to build a workflow engine suitable for processing wide variety of activity based workflows. The workflow is a formal definition of a business process of different kind such as order fulfilment, article publishing etc. The business process used in the results is for proof of a concept purposes only. The used business process is for processing investment applications in the field of finances. It starts with the customer filling an application form (Figure 9, place P0). The customer’s credit card and bank account needs to be verified and charged with the processing fees (transition T0). If the process is unsuccessful the customer is notified and an e-mail is sent for correcting the information (transition T1). The customer can either correct the information or cancel the order (transition T2). If the order is canceled the process comes to its end (place P4). If the information is corrected the process starts again from its starting point (place P0). If there is no customer response after certain predefined amount of time the process is canceled and it finishes (place P4). In a case of successful verification and charge a written contract needs to be prepared and shipped to the customer for signing (transition T4). The customer has to sign and send the contract back (transition T5) which finishes the workflow process (place P4). The workflow engine automates the process of managing the investment applications and answers the questions who does what when and how. Every participant involved in the process receives a task in his/her task box, similar to an e-mail box unaware of the progress of the process. The workflow engine takes care to move forward every instance of the business process.

5. DISCUSSION

Mathematical formalism such as Petri Nets theory offers a unique opportunity to create another level of abstraction and simplification, which speeds up and makes it easy to create a model and manage business workflow processes. The workflow module built by the model allows a standard strict mathematical approach for solving a wide variety of problems for creating and managing business processes. The generalization of the approach for modeling business processes allows for managing wide variety of processes. The formal mathematical approach allows the model to be used not only for managing business, but theoretically any type of activity based processes. The described module built by the model is much simpler compared to similar modules and researches. It has been created with simplicity and agility in mind. Its goal is with minimum resources to achieve maximum results. The model covers only a minimalistic workflow engine without tools for creating and editing Petri Nets . Third party tools like Platform Independent PetriNet Editor (PIPE) have to be used to create the necessary XML file for the engine. The verification and validation of the process has to be done prior XML generation. The model does not include validation and verification of the process. So it relies on third-party tools for creating, editing, validating the Petri Net diagram of the process. The described model can be a part of a bigger system. At the same time the simplicity allows the model to be implemented in wide verity of software projects. The simplicity also contributes to the robustness of the model. The module is built to be a part of a bigger system not to be used as a stand-alone entity like many other projects. It can be used to manage the processes in the host system. The model was tested by managing a business processes of applications processing. It proved to be sound and reliable.

6. CONCLUSION

Using the model, real-life software systems were built, using the module in the monolithic and distributed architecture. The model is limited to activity-based workflow systems. The weak aspect of the research is the fact that the model implements the basic elements of the Petri Nets theory. It has not been tested with more complex and demanding processes. At the same time the simplicity allows the model to be implemented very easy in a module which is a part of a bigger system. It can even be a central element of a system dedicated to perform only process management. So the simplicity of the approach can be seen as a strong side of the mode. The model should not be limited by the number of the places, transitions and the arcs participating a Petri Net model of a process. For practical use of the model very little requirements should be met. The model can be implemented as a module of a bigger system for managing processes. Modern technologies like C#, Java, Python, JavaScript, Go etc. can be used. For keeping the elements of Petri Net such as places, transitions and arcs, SQL or NoSQL database systems can be used. Exciting research and development of the model can be done by adding abilities for creating, editing, verifying and validating Petri Nets since right now the model relies on third-party tools to do this. In the future, other mathematical formalisms can be used in the model. For instance, Time Petri Nets (TPNs) theory can be used. Another possible way of extensions is creating a workflow module using Generalized Stochastic Petri Nets (GSPNs).

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REFERENCES

Aalst van der, W. M. P., K. M. van Hee. (1996). Business Process Redesign: A Petri-Net-Based Approach. *Computers in Industry*.29 (1–2), pp. 15–26.

Akshay, S., L. Helouet, R. Phawade. (2016). Combining Free Choice and Time in Petri Nets. in*Proceedings of the International Workshop on Temporal Representation and Reasoning*. Vols. 2016-Decem. Elsevier, pp. 120–129.

Clempner, J. (2014). Verifying Soundness of Business Processes: A Decision Process Petri Nets Approach. *Expert Systems with Applications*.41(11), pp. 5030–5040.

Gonsalves, T., K. Itoh. (2011). GA Optimization of Petri Net-Modeled Concurrent Service Systems. *Applied Soft Computing Journal*. 11(5), pp. 3929–3937.

Hsieh, Fu S., J. Bon Lin. (2014). Development of Context-Aware Workflow Systems Based on Petri Net Markup Language. *Computer Standards and Interfaces* 36(3), pp. 672–685.

Kang, G., L. Yang, L. Zhang. (2019). Verification of Behavioral Soundness for Artifact-Centric Business Process Model with Synchronizations. *Future Generation Computer Systems*.98, pp. 503–511.

Kim, R., J. Gangolly, P. Elsas. (2017). A Framework for Analytics and Simulation of Accounting Information Systems: A Petri Net Modeling Primer. *International Journal of Accounting Information Systems*.27, pp. 30–54.

Lacheheub, Mohammed N., N. Hameurlain, R. Maamri. (2019). Resources Consumption Analysis of Business Process Services in Cloud Computing Using Petri Net. *Journal of King Saud University - Computer and Information Sciences*.

Lacheheub, Mohammed N., R. Maamri. (2016). BPRN: A Formal Model of Resources Consumption in Business Process Based on an Extension of Petri-Net and Workflow Model. In *Procedia Computer Science*. Vol. 83. Elsevier, pp. 171–178.

Mejía, G., K. Niño, C. Montoya, M. Angélica Sánchez, J. Palacios, L. Amodeo. (2016). A Petri Net-Based Framework for Realistic Project Management and

Scheduling: An Application in Animation and Videogames. *Computers and Operations Research*. 66, pp.190–198.

Ribas, M., C. G. Furtado, J. Neuman de Souza, G. Cordeiro Barroso, A. Moura, A. S. Lima, F. R. C. Sousa. (2015). A Petri Net-Based Decision-Making Framework for Assessing Cloud Services Adoption: The Use of Spot Instances for Cost Reduction. *Journal of Network and Computer Applications.*57, pp. 102–118.

Saini, A., L. Thiry. (2017). Functional Programming for Business Process Modeling. *IFAC-PapersOnLine*. 50(1), pp. 10526–31.

Si, Yain W., V. Ian Chan, M. Dumas, D. Zhang. (2018). A Petri Nets Based Generic Genetic Algorithm Framework for Resource Optimization in Business Processes." *Simulation Modelling Practice and Theory*, 86, pp. 72–101.

Wang, W., Y. Hu, X. Xiao, Y. Guan. (2019). Joint Optimization of Dynamic Facility Layout and Production Planning Based on Petri Net. in*Procedia CIRP*. Vol. 81. Elsevier, pp. 1207–1212.

Yu, W., Z. Ding, L. Liu, X. Wang, R. David Crossley. (2018). Petri Net-Based Methods for Analyzing Structural Security in e-Commerce Business Processes. *Future Generation Computer Systems*.

DOES ICT INDUSTRY EXPERIENCE JOBLESS GROWTH? EMPIRICAL EVIDENCE FROM OECD ECONOMIES

Selda Gorkey

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ABSTRACT

The role of Information and Communication Technology (ICT) industry is of rising importance, as it highly contributes to technological accumulation, and hence economic growth in economies. Even though the expansion of any industry or economy is expected to generate employment, many studies confirm that economic growth is not always capable of creating employment. Examination of the jobless growth, specifically in the ICT industry is beneficial, as it requires highly skilled labor. This study aims to empirically explore how output growth is successful at creating employment and tests the existence of jobless growth in the ICT industry in OECD economies from 1999 to 2016. The study first distinguishes the reaction of employment to output growth in the ICT industry, the total industry, and the aggregate economy; and then tests the lagged effects on employment. Then, it divides the time-period into two sub-periods: 1999-2007 and 2008-2016 in order to explore the impact of the 2008 Global economic crisis. The findings indicate significant positive, yet quite low output elasticity of labor demand coefficients for the ICT industry and the aggregate economy. The coefficients rose slightly, and the coefficient of the total industry became significant with time lags. The findings emphasize that the impact of output growth on employment was the lowest in the ICT industry, compared to those of other industries. In addition, the findings show that the impact of wages on ICT employment was significant, yet mostly positive, as opposed to the theory; and the impact of ICT exports was statistically insignificant. These results clarify that even though output growth generated some employment in the ICT industry, it was not at sufficient levels and, as expected, it had worsened after the 2008 Crisis.

Keywords: Jobless growth, ICT, employment elasticity, jobless recovery.

1. INTRODUCTION

Information and Communication Technologies (ICT) has been subject to many studies in the last decades, since it highly contributes to economic growth. Due to its importance, the ICT industry attracts high levels of investments in developed economies. Investments in the ICT industry lead to higher production in ICT capital goods (Niebel, 2018; Schreyer, 2000), which results in a rapid expansion of the industry (Nasab & Aghaei, 2009; Niebel, 2018). This process then boosts productivity (Niebel, 2018) in the overall economy, and contributes positively to technological, and economic growth. An expansion of an industry is expected to generate employment even though numerous empirical studies indicate that growth is not always capable of creating employment opportunities. Negative or positive, yet low employment generation of output, i.e. jobless growth may signify the existence of some structural problems for economies. Jobless growth has always attracted attention in growth studies; however, it has come to the fore with studies that examine the recovery period, particularly jobless recovery, following the 2008 Global economic crisis (Blecker, 2016; Martus, 2016). Many factors cause jobless, and these factors differ in economies. Some of the primary reasons can be summarized as labor market rigidities, labor market regulations, tax burden, changing skill structure of employees, and technological change (Abdioglu & Albayrak, 2017; Graetz & Michaels, 2017; Telli, Voyvoda, & Yeldan, 2007).

The topic of jobless growth is examined from different, yet similar perspectives in studies. Some of those (Bhalotra, 1998; Hong, Byun, & Kim, 2016) express that, jobless growth is experienced when output increase is accompanied by a decrease in employment; however some of the studies (Abdioglu & Albayrak, 2017; Graetz & Michaels, 2017; Kannan & Raveendran, 2009; Telli et al., 2007) imply positive but insufficient level of employment creation of output. In addition to this, there are several studies (Akkemik, 2007; Altman, 2003; Hanusch, 2012; Wolnicki, Kwiatkowski, & Piasecki, 2006) which examine the issue by focusing on the inverse relationship between output and unemployment levels, i.e. Okun's law.

The literature of jobless growth is rich in studies that focus on the aggregate economy (Altman, 2003; Hanusch, 2012; Telli et al., 2007; Wolnicki et al., 2006), and on the industry-level (Abdioglu and Albayrak, 2017; Akkemik, 2007; Graetz and Michaels, 2017; Kannan and Raveendran, 2009; Onaran, 2008; Thomas, 2013; Upender, 2006). However, the studies that examine specifically the ICT industry are limited. Hong, et al. (2016) empirically investigated jobless growth in the ICT manufacturing and ICT services in Korea over a time span of 1995-2009. Estimation results of this study indicate that the ICT manufacturing experienced jobless growth, and labor productivity in the ICT industry was estimated low. Graetz and Michaels (2017) examined employment creation of output for a panel of 17 economies and 28 industries and found out a weak relationship between the two. Even though this study did not directly focus on the ICT industry, it aimed to test whether the technological change was a determinant for the jobless recovery. It included the share of ICT in total capital in the empirical analysis, and it found out that technological change was not a reason for the jobless recovery.

The limited numbers of studies that focus on jobless growth specifically in the ICT industry show a literature gap on the matter. However, as ICT contributes substantially to technological change and economic growth; the employment creation capacity of output growth in the industry is worthwhile. Thus, this study aims to examine the jobless growth in the ICT industries of OECD economies over a time span of 1999-2016, in an attempt to contribute to the literature. The study first distinguishes the ICT industry from the aggregate economy and the total industry concerning jobless growth and then examines the impact of the 2008 Global economic crisis on the ICT industry. It aims to estimate the output elasticity of labor demand coefficients, using panel data analysis.

The study seeks answers to the following research questions. First, did the OECD economies experience jobless growth in the ICT industry from 1999 to 2016? Second, was the output elasticity of labor demand different in the ICT industry compared to those in the aggregate economy, and total industry during the period examined? Third, did the 2008 Global economic crisis make any difference in the output-employment relationship in the ICT industry? The rest of this study is organized as follows; section two describes the labor demand model theoretically; section three presents the data, model and variables; section four shows estimation results; and the conclusion concludes.

2. METHODOLOGY

Following Onaran (2008) and Wolnicki et al. (2006), the model in this study is based upon labor demand function, derived from Cobb-Douglas production function:

$$Q = Af(K, L) = AK^{\alpha}L^{\beta} \qquad \dots (1)$$

where, Q is output, A is total factor productivity, K is capital, L is employment; andα and β are output elasticity of capital and labor, respectively.

Marginal productivities with respect to capital and labor are included in Equation (1), and then natural logarithms are taken. Finally, rearranging the terms, labor demand model is derived as follows:

$$lnL = \gamma_0 + \gamma_1 lnY + \gamma_2 lnW \qquad \dots (2)$$

where, W in equation (2) denotes wages. The output is expected to positively, and wage is expected to negatively affect labor demand. γ_1 indicates output elasticity of labor demand or employment elasticity; and it presents the sensitivity of labor demand (employment) to output changes in an economy/industry (Upender, 2006). It shows the percentage increase in labor demand (employment), when output increases by 1 percent (Kannan & Raveendran, 2009). Hence, a negative value of employment elasticity signifies the existence of jobless growth.

This study empirically analyses the existence of jobless growth in the ICT industry in 25 OECD economies[1] from 1999 to 2016 by using panel data analysis. 11 OECD economies[2] are excluded from the study due to a lack of data. The study first examines whether the experience in the ICT industry was different than that of the total industry, and the aggregate economy in OECD economies. It then divides the

[1]Austria, Belgium, Canada, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Netherlands, Norway, Poland, Portugal, Slovak Republic, Slovenia, Spain, Sweden, United Kingdom, and United States.

[2]Australia, Chile, Iceland, Israel, Japan, Korea, Luxembourg, Mexico, New Zealand, Switzerland, and Turkey.

period into two sub-periods – 1999-2007 and 2008-2016 – to examine the impact of the 2008 Global Economic Crisis.

The study uses labor demand model to test jobless growth, following the studies of Onaran (2008), and Wolnicki, et al. (2006). Equation (2) is adjusted for panel data and the model of this study is presented as follows:

$$lnL_{ICT_{it}} = \gamma_0 + \gamma_1 lnY_{ICT_{it}} + \gamma_2 lnW_{ICT_{it}} + \varepsilon_{it} \quad \text{... (3)}$$

where, *L* is employment, *Y* is output, and *W* is wages in the ICT industry[3]. i denotes countries, t denotes time, and ε includes country and time-specific effects and the error term. γ_1 denotes output elasticity of labor demand, and it is expected to be positive. The impact of wages γ_2 on labor demand is expected to be negative. All of the variables are expressed in natural logarithms. Since changes in wages and output may affect the employment level by a time lag, the impact of lagged wages and output on employment up to three lags are also estimated in the study. The impact of ICT exports (*X_ICT*) on ICT employment was also included in equation (3) to estimate its impact.

The existence of jobless growth is also estimated for the total industry, and the aggregate economy, to distinguish ICT from the others concerning jobless growth. The models for industry and, the aggregate economy are presented by equations (4) and (5), respectively:

$$lnL_{IND_{it}} = \gamma_0 + \gamma_1 lnY_{IND_{it}} + \gamma_2 lnW_{IND_{it}} + \varepsilon_{it} \quad \text{... (4)}$$

$$lnL_{AGG_{it}} = \gamma_0 + \gamma_1 lnY_{AGG_{it}} + \gamma_2 lnW_{AGG_{it}} + \varepsilon_{it} \quad \text{... (5)}$$

where, *L*, *Y*, and *W*are employment, output[4], and wages. IND and TOT suffixes of variables represent the total industry[5] and the aggregate economy, respectively. i denotes countries, t denotes time, and ε includes country and time-specific effects and the error term. All variables are expressed in natural logarithms. The impact of output

[3]comprises ICT manufacturing and ICT services industries. According to ISIC Rev.4, the ICT industry is the sum of the following divisions: D26 Manufacture of computer, electronic and optical products; J61 Telecommunications; and J62-63 IT and other information services. (OECD, 2019a).

[4]Y is GDP for total employment.

[5]According to ISIC Rev.4, the total industry is thesum of allthedivisionsfrom 01 to 99. Itincludes: A01-03 Agriculture, hunting, forestryandfishing; B05-09 Mining and quarrying; C10-33 Manufacturing; DE-35-39 Electricity, gas and water supply, sewerage, waste management and remediation activities; F41-43 Construction; GI45-46 Wholesale and retail trade, repair of motor vehicles and motorcycles, transportation and storage, accommodation and food service activities; J58-63 Information and communication; K64-66 Financial and insurance activities; LN68-82 Real estate, renting and business activities; OU84-99 Community, social and personal services (OECD, 2019a).

on labor demand is expected to be positive, whereas the impact of wages is expected to be negative.

3. DATA

Data for all the variables in equation (3) were collected from the OECD (2019b) Database. Employment in ICT (*L_ICT*) data was collected as thousand persons from the dataset, and then it was turned into an index by the author. Output in ICT (*Y_ICT*) and wages in ICT (*W_ICT*) data were collected in monetary value from the dataset. Both were then deflated and expressed as indexes. Data for ICT exports was collected from the OECD (2019c). Database in monetary value. The variable was constructed as percentages of industry exports, which was also collected from the same database as monetary value.

Data for the variables in *Equations (4)* and *(5)*were collected from the OECD Database. Employment in total industry (*L_IND*) was in thousand persons in the dataset (OECD, 2019b), and it was converted to an index by the author. Output in the total industry (*Y_IND*), wages in the total industry (*W_IND*), and industry exports (*X_IND*) were gathered in monetary value from the dataset (OECD, 2019b; OECD, 2019c). After deflating series, each was converted into indexes (2010=1). The data for the aggregate employment (L_AGG) was collected as an employment index with the 2015 base year, and it was converted to the 2010 base year (OECD, 2019d). Data for the aggregate output (*Y_AGG*) was collected as the GDP index (OECD, 2019e). Wages for the aggregate economy (*W_AGG*) were gathered in monetary value from the dataset (OECD, 2019f), and converted to an index after deflating series. The base years of all the indexes in the study are 2010.

Summary statistics for 25 OECD economies are presented in Table 1, which includes all the variables used in the study. It shows the number of observations, mean, standard deviation, the minimum and maximum values for each variable. Statistics for the variables are presented without natural logarithms in Table 1. (See Appendix 1 for means of variables by each economy.)

Table 1. Summary Statistics, 1999-2016.

Variable	N	Mean	Std. Dev.	Min	Max
L_ICT	522	96.74	15.32	53.15	169.18
Y_ICT	516	89.31	22.46	20.52	149.26
W_ICT	513	91.43	23.42	30.80	196.95
X_ICT	600	15.30	12.91	1.59	71.84
L_IND	556	98.99	7.88	70.49	126.15
Y_IND	548	91.76	16.43	45.21	146.61
W_IND	533	91.39	16.13	44.59	159.23
X_IND	600	84.60	29.08	16.27	146.61
L_AGG	584	98.90	8.09	66.07	124.31
Y_AGG	597	93.96	16.49	48.24	167.97
W_AGG	599	92.71	13.62	42.78	140.78

Notes: L, Y, and W are employment, output, and wage index (2010=100). Suffixes ofICT, IND, and AGGare the ICT industry, the total industry, and the aggregate economy, respectively.X_IND is export index for the total industry. All indexes are calculated as 2010=100.X_ICT is thepercentage of ICT exports in total industry exports.

Table 2 shows the correlation matrix for employment, output, wages, and exports only in the ICT industry for simplicity. Table 2 shows that ICT employment is significantly, highly and positively correlated with the ICT output level, as parallel with the theory. However, it is significantly but positively correlated with wages. This outcome is not parallel with the labor demand theory, which proposes a negative relationship between demand for employment and wages. The correlation between ICT employment and ICT exports are significant, yet low.

Table 2. Correlation matrix,1999-2016.

	lnL_ICT	*lnY_ICT*	*lnW_ICT*	*lnX_ICT*
lnL_ICT	1			
lnY_ICT	0.73*	1		
lnW_ICT	0.69*	0.80*	1	
lnX_ICT	0.12*	0.13*	-0.02	1

Notes: lnL_ICT is employment in ICT, lnY_ICT is output in ICT, W_ICT is wages in ICT, and X_ICT is ICT exports. All the variables are in natural logarithms. Stars indicate significance level at $p<0.05$.

4. ESTIMATION RESULTS

The results are estimated using a two-way fixed effects (FE) model. Before the estimation, all the variables are demeaned from the time dimension, and then the parameters are estimated by within estimator. The tests for heteroscedasticity, serial correlation, and cross-sectional dependence show the existence of all, hence Driscoll-Kraay standard errors are estimated for robust results.

The study first aims to examine whether the impact of output growth on employment is different in the ICT industry, compared to that of the total industry and the aggregate economy. Such examination also serves for distinguishing the three to test the existence of jobless growth. Table 3 shows the estimation results. Model (1) indicates the ICT industry, which is the main consideration of this study; model (2) indicates the aggregate economy, and model (3) indicates the total industry.

Table 3.Estimation results: Two-way FE models for ICT Industry, Aggregate economy, and Total industry,1999-2016

	Model (1) Response var.: lnL_ICT	*Model (2) Response var.: lnL_AGG*	*Model (3) Response var.: lnL_IND*
lnY_ICT	0.211***		
	[0.0336]		
lnW_ICT	0.173**		
	[0.0582]		
lnY_AGG		0.537***	
		[0.0341]	
lnW_AGG		-0.273***	
		[0.0426]	
lnY_IND			0.122
			[0.0741]
lnW_IND			0.0491
			[0.0870]
constant	-0.000528	0.00187	0.00553
	[0.00196]	[0.00210]	[0.00394]
R-squared	0.4035	0.3868	0.1452
N	423	443	439

*Notes: Numbers without brackets are estimated parameters, and numbers in brackets are Driscoll-Kraay standard errors. Stars indicate the following significance levels: *p< 0.05, **p< 0.01, ***p< 0.001.*

Model (1) in Table 3 shows that the output level and wages contributed significantly to employment in the ICT industry.The impact of output on employment; in other words, output elasticity of labor demand, was positive, yet too low. One percentage increase in output in the ICT industry could only generate a 0.21% increase in ICT labor demand in OECD economies from 1999 to 2016. According to the theory, the impact of wages on employment is expected to be negative, whereas empirical findings showed the opposite.Model (2) presents that; output level significantly and positively, and wages significantly and negatively affected employment level, as the theory proposes.However, the output level couldgenerate low levels of employment in theaggregate economy, similar to that in the ICT industry. Estimationof the model (3) shows the findings for the total industry, which experienced insignificant impacts of both output and wages. This result signifies that the changes in labor demand could not be statistically explained by the output level and wages in the total industry.

Table 4. Estimation results of lagged variables: Two-way FE models for the ICT Industry, the Aggregate economy, and the Total industry, 1999-2016

Response var.: lnL_ICT	*Model (1) Level*	*Model (4) 1st Lag*	*Model (5) 2nd Lag*	*Model (6) 3rd Lag*
lnY_ICT	0.211***	0.262***	0.310***	0.343***
	[0.0336]	[0.0459]	[0.0619]	[0.0741]
lnW_ICT	0.173**	0.123	0.0525	-0.00459
	[0.0582]	[0.0683]	[0.0826]	[0.0828]
constant	-0.000528	-0.000923	-0.00143	-0.00274
	[0.00196]	[0.00164]	[0.00163]	[0.00186]
R-squared	0.4035	0.4127	0.3687	0.3470
N	423	425	424	420
Response var.: lnL_AGG	*Model (2) Level*	*Model (7) 1st Lag*	*Model (8) 2nd Lag*	*Model (9) 3rd Lag*
lnY_AGG	0.537***	0.569***	0.535***	0.414***
	[0.0341]	[0.0408]	[0.0412]	[0.0579]
lnW_AGG	-0.273***	-0.343***	-0.374***	-0.331***
	[0.0426]	[0.0434]	[0.0444]	[0.0386]
constant	0.00187	0.000632	-0.0000442	0.000494
	[0.00210]	[0.00224]	[0.00258]	[0.00305]
	0.3868	0.3940	0.3240	0.2107
N	443	443	443	442
Response var.: lnL_IND	*Model (3) Level*	*Model (10) 1st Lag*	*Model (11) 2nd Lag*	*Model (12) 3rd Lag*
lnY_IND	0.122	0.272***	0.394***	0.410***
	[0.0741]	[0.0695]	[0.0762]	[0.0621]
lnW_IND	0.0491	-0.116	-0.289**	-0.366***
	[0.0870]	[0.0692]	[0.0799]	[0.0668]
constant	0.00553	0.00525	0.00505	0.00510
	[0.00394]	[0.00409]	[0.00434]	[0.00458]
R-squared	0.1452	0.1372	0.1435	0.1661
N	439	440	439	436

Notes: Models (1), (2), and (3) are estimated by explanatory variables without lags. Models (4), (7), and (10) are estimated by using the first lags; models (5), (8), and (11) are estimated by using the second lags; and models (6), (9), and (12) are estimated by using the third lags of explanatory variables. Numbers without brackets are estimated parameters, and numbers in brackets are Driscoll-Kraay standard errors. Stars indicate the following significance levels: $^{*}p< 0.05$, $^{**}p< 0.01$, $^{***}p< 0.001$.

Changes in output and wages can affect the labor market by a time lag (Akkemik, 2007). For this reason, the study also examines lagged effects. Table 4 consists of three parts: the ICT industry, the aggregate economy, and the total industry, from the top to the bottom, respectively. At each part, the first models estimate the models by using explanatory variables with no lag structure. In the second column, the models are estimated with the first lags of explanatory variables. The third column includes the second lag, and the last column includes the third lags of explanatory variables. The number of lags is limited with three, depending on the data availability in the time dimension.

The estimation results in Table 4 show that the impacts of output on labor demand were higher in the ICT, the aggregate economy and total economy by a time lag. A change in output led to gradually higher increases in labor demand by higher time lags and generated the highest increase after three periods in the ICT industry. Even though the output elasticity of labor demand coefficient reached 0.34% from 0.21% after three periods, the coefficient was still too low. In other words; despite its higher impact, an increase in output was still incapable of generating high employment by time lags. The impact of wages on employment became insignificant in the ICT industry throughout time.

The middle part of Table 4 presents estimation results for the aggregate economy. The findings show that a one percent increase in output generated only 0.57% increaseafter one period, and it started to decrease gradually by time lags, fell to 0.41% at the third lag. Change in wages resulted in higher effects on labor demand with time, and it generated the highest impact in the second lag. The bottom part of Table 4 indicates estimation results for the total industry. Even though, the effects of output and wages were insignificant without time lags; they turned to be significant after one period and two periods, respectively. Their impacts were higher in the third lag, and both of their signs were consistent with the theory. However, output increasesdid not create sufficient employment opportunities in the total industry, similar to that of the ICT industry and the aggregate economy. Output elasticity of labor demand coefficient rose from 0.27% in the first time lag to only 0.41% in the third time lag in total industry.

Table 5 shows the estimation results for only the ICT industry. Model (1) is the main model of this study, and it was also available in Tables 3 and 4. Model (13) includes an additional variable, ICT exports. The estimates indicate a statistically insignificant effect of ICT exports on ICT labor demand; and it was also estimated as insignificant by time lags, which are not included in Table 5 for simplicity. Models (14) and (15) examines the effect of industry’s output and wages levels on ICT labor demand; and models (16), (17), and (18) examines the effect of the aggregate economy's output and wage levels on ICT labor demand. The output of the total industry affected ICT employment significantly only after 3 periods. Since one lagged and two lagged variables of industry output were insignificant, they are not included in Table 5 for simplicity. The changes in the aggregate output significantly increased labor demand in the ICT industry; however, the relevant impact was insignificant at the third lag. Wages in the total industry and the aggregate economy did not have any significance in the ICT labor market. An important point worth mentioning in Table 5 is that R-squared values were extremely low in Models (14-18). These values signify that; output and wage levels in the aggregate economy and total industry could only statistically explain the smaller shares of the changes in the ICT labor demand.

Even though, employment elasticity coefficients of the aggregate output (0.395) in Model (17) and total industry output (0.495) in Model (15) were higher than the ICT output (0.21) in Model (1); r-squared of model (1) is higher, and the elasticity coefficient in model (1) had a higher significance level (three stars) compared to the others.

Table 5.Estimation Results: Two-way FE Model for the ICT Industry, 1999-2016

Res. var.: lnL_ICT	*Model (1) Level*	*Model (13) Level*	*Mode(14)Level*	*Model (15) 3rd Lag*	*Model (16) Level*	*Model (17) 2nd Lag*	*Model (18) 3rd Lag*
lnY_ICT	0.211***	0.204***					
	[0.034]	[0.0532]					
lnW_ICT	0.173**	0.172**					
	[0.058]	[0.058]					
lnX_ICT		0.0051					
		[0.017]					
lnY_IND			0.195	0.495*			
			[0.154]	[0.217]			
lnW_IND			0.0837	-0.224			
			[0.154]	[0.149]			
lnY_AGG					0.369*	0.395*	0.309
					[0.149]	[0.146]	[0.155]
lnW_AGG					0.0760	0.0506	0.122
					[0.151]	[0.117]	[0.091]
constant	-0.00053	-0.0008	-0.00096	-0.00274	0.00045	-0.0006	0.0002
	[0.0020]	[0.003]	[0.0019]	[0.0024]	[0.0001]	[0.0018]	[0.0027]
R-squared	0.4035	0.4038	0.0746	0.0802	0.1168	0.1129	0.1094
N	423	423	427	423	437	437	436

*Notes: The response variable is labor demand, n the ICT industry. Models (1), (13), (14), and (16) are estimated by explanatory variables with no lags. To keep the table as simple as possible, some of the lagged models are not presented. Numbers without brackets are estimated parameters, and numbers in brackets are Driscoll-Kraay standard errors. Stars indicate the following significance levels: *p< 0.05, **p< 0.01, ***p< 0.001.*

To examine the effects of the 2008 Global Economic Crisis, the study divides the entire period into two sub-periods. Hence, the models in Table 6 examine the existence of jobless growth in the ICT industry separately in the pre-crisis (1999-2007), and the post-crisis (2008-2016) periods. Output elasticity of labor demand was estimated as 0.21% without lagged effects before the crisis, and it increased gradually and reached to 0.45% at the third lag. The impact of wages on ICT employment was significantly effective by lags and it was estimated -0.26% at the third time lag. The findings for the post-crisis period showed significant, yet even lower output elasticity coefficients compared to that of the pre-crisis period, as expected. The relevant coefficient was 0.085% without lagged effects, and it reached to only 0.162% by the third time lag. The impact of wages on employment in the ICT industry was significant yet positive without lags, and it became insignificant with the third time lag after the crisis. These findings clearly show that the relationship between wages and employment in the ICT industry used to be consistent with the theory before the crisis. Estimation findings for the entire period also indicated a significant and positive parameter that was not parallel with the theory, as evidenced in Model (1) in Tables(3), (4), and (5). (See Appendix 2 for estimation results for the aggregate economy, and total industry for the pre-crisis (1999-2007) and the post-crisis (2008-2016) periods).

Table 6. Estimation results: Two-way FE model for the ICT Industry, two sub-periods: pre-crisis (1999-2007), and post-crisis (2008-2016)

	Pre-Crisis (1999-2007)			Post-Crisis (2008-2016)		
Response Var.: lnL_ICT	*Model (19) Level*	*Model (20) 2nd Lag*	*Model (21) 3rd Lag*	*Model (22) Level*	*Model (23) 2nd Lag*	*Model (24) 3rd Lag*
lnY_ICT	0.210^{*}	0.385^{***}	0.445^{***}	0.0850^{**}	0.121^{***}	0.162^{**}
	[0.0968]	[0.0443]	[0.0523]	[0.0266]	[0.0265]	[0.0486]
lnW_ICT	0.0519	-0.139^{**}	-0.259^{***}	0.445^{***}	0.298^{***}	0.158
	[0.113]	[0.0417]	[0.0317]	[0.0341]	[0.0792]	[0.0796]
constant	0.00244	0.000953	-0.000865	-0.00343	-0.00317	-0.00400
	[0.00262]	[0.00217]	[0.00276]	[0.00316]	[0.00268]	[0.00288]
R-squared	0.1572	0.1812	0.2396	0.5057	0.2645	0.1776
N	214	210	207	209	214	213

Notes: Models (19), and (22) are estimated by explanatory variables with no lags; models (20) and (23) are estimated by using the second lags; and models (21), and (24) are estimated by using the third lags of explanatory variables. Numbers without brackets are estimated parameters, and numbers in brackets are Driscoll-Kraay standard errors. Stars indicate the following significance levels: $^{*}p< 0.05$, $^{**}p< 0.01$, $^{***}p< 0.001$.

5. CONCLUSION

This study aims to test the existence of jobless growth in the ICT industry in OECD economies. Selecting a period from 1999 to 2016, it first questions whether the relevant experience in the ICT industry is different compared to that of the aggregate economy, and the total industry. The study also examines the impact of lagged explanatory variables on ICT labor demand, since time is an important factor for the output-employment nexus.

The estimation findings show that output elasticity of labor demand was significant, positive, yet low in the ICT industry and the aggregate economy; and it was lower in the ICT industry than that of the aggregate economy. The impact of output on employment was insignificant in the total industry; however, it became significant with the first time lag. The impact of output on employment gradually increased as the number of lags increased in the ICT industry and the total industry. Empirical findings clearly showed that; even though employment creation of output is not at sufficient levels in all; it was the lowest in the ICT industry in OECD economies during the period examined. The impact of the wage level on ICT labor demand was significant, and negative, as the theory proposes; and it was higher by time lags in the aggregate economy and industry. However, it was estimated significant, yet positive without lags. The impact of lagged wages was insignificant. The findings also indicated an insignificant impact of ICT exports on ICT employment.

Finally, the entire period was divided into two periods: 1999-2007 and 2008-2016, to test the impact of the 2008 Global Economic Crisis on the ICT industry. Estimation results clearly showed that the output elasticity of labor demand coefficients was higher before the crisis in the ICT industry. For both periods, labor demand elasticity gradually increased at higher time lags. The division of the entire period into two sub-periods also clearly showed important evidence for the wage-employment nexus. Lagged wages in the ICT industry affected ICT labor demand significantly and negatively before the crisis, as the theory proposes. However, the estimation results indicate significant yet positive impacts after the crisis, as opposed to the theory. The estimation findings clearly showed that the impact of output and wages on employment worsened after the crisis in the ICT industry, as expected.

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REFERENCES

Abdioglu, Z., & Albayrak, N. (2017). İstihdam Yaratmayan Büyüme: Alt Sektörler Bazında Bir Araştırma. *KTÜ Sosyal Bilimler Enstitüsü Sosyal Bilimler Dergisi*, *7*(13), 215–228.

Akkemik, K. A. (2007). The Response of Employment to GDP Growth in Turkey: An Econometric Estimation. *Applied Econometrics and International Development*, *7*(1).

Altman, M. (2003). Jobless or job creating growth? Some preliminary thoughts. *TIPS/DPRU Annual Forum*, (September), 1–24. Retrieved from http://www.hsrc.ac.za/Document-481.phtml

Bhalotra, S. R. (1998). The Puzzle of Jobless Growth in Indian Manufacturing. *Oxford Bulletin of Economics and Statistics*, *60*(1), 5–32.

Blecker, R. A. (2016). The US economy since the crisis: slow recovery and secular stagnation. *European Journal of Economics and Economic Policies: Intervention*, *13*(2), 203–214. https://doi.org/10.4337/ejeep.2016.02.05

Graetz, G., & Michaels, G. (2017). Is modern technology responsible for jobless recoveries? In *IZA Discussion Paper Series* (No. IZA DP No. 10470). https://doi.org/10.1257/aer.p20171100

Hanusch, M. (2012). Jobless growth? Okun's Law in East Asia. In *Policy Research Working Paper* (No. 6156).

Hong, J. P., Byun, J. E., & Kim, P. R. (2016). Structural changes and growth factors of the ICT industry in Korea: 1995–2009. *Telecommunications Policy, 40*, 502–513. https://doi.org/10.1016/J.TELPOL.2015.08.001

Kannan, K. P., & Raveendran, G. (2009). Manufacturing Growth sans Employment : A Quarter Century Jobless Growth in India's Organised Manufacturing. *Economic and Political Weekly*, *44*(10), 80–91.

Martus, B. (2016). Jobless Growth: the Impact of Structural Changes. *Public Finance Quarterly*, *61*(2), 244–264.

Nasab, E. H., & Aghaei, M. (2009). The Effect of ICT on Economic Growth: Further Evidence. *International Bulletin of Business Administration*, (5), 46–56.

Niebel, T. (2018). ICT and economic growth – Comparing developing, emerging and developed countries. *World Development*, (104), 197–211. https://doi.org/10.1016/j.worlddev.2017.11.024

Onaran, O. (2008). Jobless growth in the central and east European countries: A country-specific panel data analysis of the manufacturing industry. *Eastern European Economics*, *46*(4), 90–115. https://doi.org/10.2753/EEE0012-8775460405

Organization for Economic Cooperation and Development (OECD). (2019a). STAN Economic Activities. Dataset. http://stats.oecd.org/wbos/fileview2.aspx?IDFile=dffae385-663c-46e8-98ae-1d404bca29ec (accessed 22.07.2019)

Organization for Economic Cooperation and Development (OECD). (2019b). STAN Industrial Analysis. Dataset. https://stats.oecd.org/Index.aspx?DataSetCode=STANi4 (accessed 22.07.2019)

Organization for Economic Cooperation and Development (OECD). (2019c). Bilateral Trade in Goods by Industry and End-use ISIC Rev.4. Dataset. https://stats.oecd.org/index.aspx?queryid=64755 (accessed 22.07.2019)

Organization for Economic Cooperation and Development (OECD). (2019d). ALFS Summary Tables. Dataset. https://stats.oecd.org/Index.aspx?DataSetCode=ALFS_SUMTAB (accessed 25.07.2019)

Organization for Economic Cooperation and Development (OECD). (2019e). Gross Domestic Product. Dataset. https://stats.oecd.org/Index.aspx?datasetcode=SNA_TABLE1_ARCHIVE (accessed 25.07.2019)

Organization for Economic Cooperation and Development (OECD). (2019f). Average Annual Wages. Dataset. https://stats.oecd.org/Index.aspx?DataSetCode=AV_AN_WAGE (accessed 25.07.2019)

Schreyer, P. (2000). *The Contribution of Information and Communication Technology to Output Growth: A Study of the G7 Countries Paul*. https://doi.org/10.1787/151634666253 PAPE

Telli, C., Voyvoda, E., & Yeldan, E. (2007). Modeling General Equilibrium for Socially Responsible Macroeconomics: Seeking for the Alternatives to Fight Jobless Growth in Turkey. *METU Studies in Development*, *33*(2), 255–293.

Thomas, J. J. (2013). Explaining the “jobless” growth in Indian manufacturing. *Journal of the Asia Pacific Economy*, *18*(4), 673–692. https://doi.org/10.1080/13547860.2013.827462

Upender, M. (2006). Output Elasticity Of Employment In The Indian Economy: An Empirical Note. *Applied Econometrics and International Development*, *6*(1), 197–206.

Wolnicki, M., Kwiatkowski, E., & Piasecki, R. (2006). Jobless growth: A new challenge for the transition economy of Poland. *International Journal of Social Economics*, *33*(3), 192–206. https://doi.org/10.1108/03068290610646225

Appendix 1. Means of variables by economies

Table. Means of Variables by Economies, 1999-2016.

	mean (L_ICT)	*mean (Y_ICT)*	*mean (W_ICT)*	*mean (X_ICT)*	*mean (L_IND)*	*mean (Y_IND)*	*mean (W_IND)*	*mean (X_IND)*	*mean (L_AGG)*	*mean (Y_AGG)*	*mean (W_AGG)*
Austria	103.76	106.79	109.97	9.46	96.16	90.13	94.60	85.24	97.54	94.83	95.74
Belgium	94.88	88.73	95.21	6.79	95.69	92.52	94.11	85.05	94.99	93.79	99.26
Canada	98.45	100.24	103.71	7.60	94.13	90.18	102.90	94.23	95.46	93.76	94.19
Czechia	88.00	76.92	79.80	21.89	99.40	89.37	90.05	75.16	100.16	90.81	89.31
Denmark	91.74	89.00	83.18	10.25	99.70	93.80	92.76	89.15	101.01	97.95	93.51
Estonia	96.74	82.14	83.44	23.85	110.44	98.18	95.27	77.81	108.79	96.99	84.98
Finland	99.66	95.50	90.10	23.94	96.03	90.55	88.21	93.91	97.39	92.96	92.69
France	98.65	91.58	90.65	12.23	97.42	92.72	91.95	90.79	97.94	95.55	94.55
Germany	97.89	94.35	96.09	12.33	98.24	95.78	101.31	84.86	99.60	97.91	100.75
Greece	84.24	85.37	113.55	4.93	92.93	92.94	81.60	82.65	92.68	89.27	90.93
Hungary	97.27	74.86	83.97	37.82	104.21	96.34	93.62	74.62	104.50	96.03	91.07
Ireland	97.77	107.58	82.75	37.60	96.41	92.40	88.54	92.10	96.69	97.39	86.26
Italy	95.92	94.14	92.07	5.81	96.78	95.72	92.97	91.66	97.53	97.75	96.20
Latvia	113.64	95.91	106.70	8.98	111.18	92.56	94.15	78.62	110.27	96.37	90.55
Lithuania	107.07	91.37	91.79	7.73	111.28	90.15	91.19	76.96	108.06	93.60	91.12
Netherlands	93.43	90.43	89.85	28.93	95.77	91.18	91.87	76.29	96.79	94.07	95.15
Norway	92.95	86.77	81.12	2.97	95.53	87.77	87.60	78.66	96.02	95.40	91.50
Poland	94.08	74.20	90.43	11.33	97.67	83.83	85.66	74.66	98.04	88.36	93.53
Portugal	91.01	95.40	87.72	10.52	99.56	92.34	91.07	92.21	98.43	94.07	95.44
Slovak Rep.	89.61	63.99	81.03	21.45	98.93	91.73	90.24	72.26	98.75	86.81	86.73
Slovenia	90.76	83.58	82.64	4.20	97.19	88.37	86.30	84.77	96.37	90.68	88.86
Spain	88.26	84.16	88.11	5.87	91.97	88.91	85.36	88.34	92.14	90.95	94.00
Sweden	101.84	90.10	90.61	20.17	98.54	89.03	90.57	86.27	98.45	93.47	93.91
UK	106.36	96.29	94.97	19.13	98.56	92.64	92.43	99.29	98.89	96.33	92.02
USA	109.47	102.19	106.49	26.72	101.76	95.86	99.93	89.37	101.03	93.88	95.33

Notes: *L, Y,* and *W* are employment index, output index, and wage index. Suffixes of *ICT, IND,* and *AGG* are ICT industry, total industry, and the aggregate economy, respectively. *X_IND* is exports index for the total industry. All indexes are calculated as 2010=100. *X_ICT* is the percentage of ICT exports in total industry exports.

Appendix 2. Estimation results by sub-periods

Table: Estimation Results of the Aggregate Economy and Total Industry, Pre-Crisis (1999-2007) and Post-Crisis (2008-2016) Periods

Response Var.:	Pre-Crisis (1999-2007)				Post-Crisis (2008-2016)			
lnL_AGG	*Level*	*1st Lag*	*2nd Lag*	*3rd Lag*	*Level*	*1st Lag*	*2nd Lag*	*3rd Lag*
lnY_AGG	0.550***	0.625***	0.623***	0.533***	0.525***	0.624***	0.616***	0.382***
	[0.0522]	[0.0581]	[0.0583]	[0.0589]	[0.0503]	[0.0816]	[0.0414]	[0.0789]
lnW_AGG	-0.346***	-0.409***	-0.391***	-0.316***	0.0763*	-0.100	-0.325***	-0.244***
	[0.0581]	[0.0536]	[0.0440]	[0.0309]	[0.0326]	[0.0503]	[0.0452]	[0.0646]
constant	0.00541	0.00390	0.00372	0.00545	-0.00156	-0.0031***	-0.0050***	-0.0055**
	[0.00299]	[0.00300]	[0.00281]	[0.00306]	[0.00148]	[0.00065]	[0.00070]	[0.0015]
R-squared	0.3394	0.4661	0.4924	0.4068	0.5728	0.5908	0.3819	0.1431
N	218	218	218	217	225	225	225	225

Response Var.:	Pre-Crisis (1999-2007)				Post-Crisis (2008-2016)			
lnL_IND	*Level*	*1st Lag*	*2nd Lag*	*3rd Lag*	*Level*	*1st Lag*	*2nd Lag*	*3rd Lag*
lnY_IND	-0.0186	0.155***	0.310***	0.361***	0.120**	0.326***	0.457***	0.408***
	[0.0439]	[0.0285]	[0.0169]	[0.0484]	[0.0379]	[0.0497]	[0.0818]	[0.0899]
lnW_IND	0.113**	0.0140	-0.0867**	-0.125**	0.307***	0.0956*	-0.142	-0.231*
	[0.0373]	[0.0409]	[0.0292]	[0.0347]	[0.0528]	[0.0433]	[0.0725]	[0.0966]
constant	0.0156***	0.0147***	0.0138***	0.0134***	-0.00269	-0.00373*	-0.0048***	-0.00497**
	[0.00202]	[0.00212]	[0.00228]	[0.00252]	[0.00217]	[0.00134]	[0.000834]	[0.00166]
R-squared	0.0989	0.1637	0.2507	0.2926	0.7543	0.6971	0.3967	0.1761
N	217	216	215	213	222	224	224	223

Notes: Upper part of the table shows estimation results of the aggregate economy, and the below part shows the total industry. Numbers without brackets are estimated parameters, and numbers in brackets are Driscoll-Kraay standard errors. Stars indicate the following significance levels: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

TECHNOLOGIES AND METHODS FOR DEVELOPMENT OFA CORPORATE DIGITAL MARKETING STRATEGY

Kremena Stefanova, Veselina Naneva, Ivan Jelev

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ABSTRACT

The main purpose of marketing is to present a business in a fast, accessible and quality way to potential customers. In the development of the information society, it is necessary to consider what are the possibilities of promoting a business not only through the means of direct communication, but also through digital technologies. In order to be successful, the business should not only measure its profit but also to focus on its presence in the virtual space. The paper aims to suggest a successive corporate strategy for digital marketing. It combines various software tools and marketing techniques, which can be implemented in different business environments. The application of special software platforms for creating of brand campaign can elevate the marketing performance of a business to a customer-friendly layer. Additionally, to the building of pattern based email campaign, it is paid attention to Google products for advertising. Also, the suggested strategy concerns with the development of precise profiles in the most popular social media.

Keywords: Corporate strategy, digital marketing, software tools.

1. INTRODUCTION

Digital marketing and its impact on business growth are an important area of research. Although there are different application models and many up-to-date tools for digitalization of services, the development of technologies and current trends in consumer behavior are a prerequisite for conducting new up-to-date studies and selecting appropriate software tools for building successful corporate digital marketing strategies. We will look at some specific scientific developments on the subject.

Charles Gibson concludes in his paper [1] that the internet is not related to just an additional sales or advertising method but it has also become a tool which has essentially revamped the way that an organization does business. In the same article, the author shares the idea of the president of ED ventured according to whom the digitalization is projected to have exponential growth in the future.

As demonstrated Madhu Bala and Deepak Verma in their study [2], it is necessary to have an effective email marketing software, so that everyone could maintain email lists that are segregated based on several factors, including customers' likes and dislikes, and spending habits. It is also pointed out the importance of sending personalized emails in order to develop customer trust. With all detailed described marketing techniques, in this articles is made a synthesized marketing strategy including all necessary models.

Verhoef and Bijmolt mention in their paper [3] that the strong digital developments are changing markets, and firms may adopt a digital business model to deal with these developments. They focus on such digital business models and their relevance. They also propose a conceptual framework, and discuss how digital business models affect firms, firm performance, and markets. The authors show how they each fit within a conceptual framework and pay attention to important areas for future research.

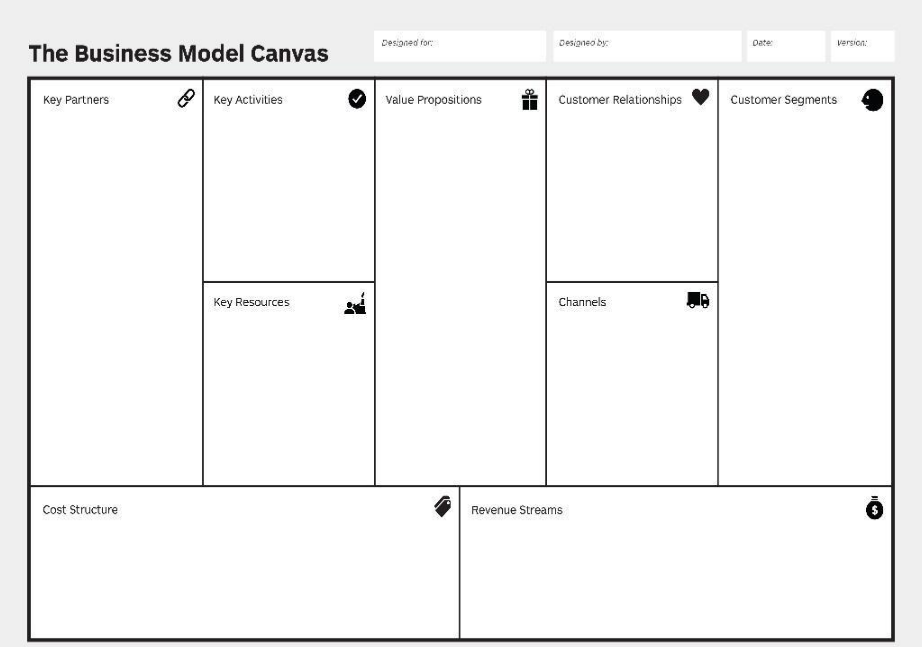
According to Juan José et al. [4], the future of generating actions in the mobile ecosystem will be influenced by voice searches from mobile devices and the influence of Artificial Intelligence. There are mentioned plenty of methods related to mobile artificial intelligence, which are in help of developing a successful digital marketing strategy. In order to implement the new approach in the study there are considered also web technologies for evaluating user trends.

2. OVERVIEW OF THE BUSINESS MODEL AND STRATEGIC LAYOUT

Marketing as an ideology was first introduced in the early 20th century, presenting some of the techniques and features of established American universities. In 1960, McCarthy offered a marketing model based on four main pillars – commodity, price, placement and promotion. More than 50 years later, his ideas have played a major role in the growth of marketing to his appearances in the digital world. It is because of the modernization of daily activities, the promotion of every aspect of a person’s work contributes to his or her success. A common spread and nowadays it remains “mouth to mouth”. Simultaneously with the known techniques, computerization methods have already been successfully applied. In order to raise the status of a business or a service, it is crucial to find the right target audience.

It is no coincidence that the target audience is mentioned in the first place. There is a defined business model structure that illustrates the exact specifics of a business. This structure is divided into nine distinct sectors, which, although individually important in their own right, determine the overall characteristics of the particular business.

Figure 1. Business model canvas



Source: The Mission Model Canvas: An Adapted Business Model Canvas For Mission-Driven Organizations

The business model starts with the introduction of segment users. By definition, this represents the group of users to whom we will offer value. The target unit combines the mass market and the market niche. It is necessary to list all the characteristics of the potential users of the service offered by the respective business. The consumer section will be discussed in detail in other distributed models that may find a place in the main business canvas. After customer segments, the value proposition should be defined.

A value proposition can be presented as the idea of the real "value" that people belonging to the target audience are about to receive [5]. Value as a term in marketing is the difference between a prospective customer's assessment of the benefits and costs of one product compared to others. In the ideology of strategic performance, value is a reflection of consumer needs. Human needs can be divided into cultural (national, religious and financial) levels as well as individual needs that determine everyday demands, family relationships and self-expression. The value proposition includes four types of characteristics – functional value, monetary value, psychological and social value. For each type, there is a specific definition that represents the customer vision for each service offered:

Functional value – build value on the principle of an offer that meets the needs of the client;

Monetary value – a relationship between price and quality for a product or service related to the client's wishes;

Social value – a certain type of service is provided as it reaches its customers with the ability to compare them with competing businesses that offer it;

Psychological value – represents the extent to which a product or service allows consumers to express themselves and feel better.

The value proposition can be measured in both quantitative and qualitative measures. From the point of view of quality, and taking into account the points listed above, the profit itself should be assessed as an emotional and psychological unit. On the quantitative side, clear information is given with exact numbers, percentages and amounts.

After defining the value proposition, it is time to consider customer relations. It is of the utmost importance that we have a clear idea of what quality relationships we have with our customers. They can be divided into short-term with benefits, short-term with no benefits, beneficial long-term and long-term without benefits. In every business, besides meeting the needs of the clients, it is necessary to build relationships with potential returns. Such would be with clients directly related to the activity of our business, as well as those who have rich communication and would bring us more client resources. In a growing service-related business, the customer is transformed to a liaison partner into market share statistics. There are two obvious reasons for this. First, the difficulty of managing relationship-oriented customer relationships increases as the number of clients. Second, the growing influence of non-relational marketing approaches based on popular consumer goods. It is important to define the cost of each relationship with a particular client. Do we have a responsibility to communicate with him periodically and does it cost us more.

Consideration should be given to where the business will be promoted. In the canvas of the business model, these needs are being described in the section – Channels. The entire strategic layout of the advertising route should be organized in this sector. The question that should be asked is – how and where it will reach the target audience. Like the waterfall model, known in software development, the channel section must be separated into several stages that are independent of each other and follow a certain arrangement. By definition, this model is used when there will be no critical changes in each part of the process. From a marketing point of view, it should be argued that the construction of advertising follows the consumer interest, but in terms of strategy accuracy it is appropriate to justify the given steps and to give their exact specifics:

Awareness – at this stage, the service, company representatives and contacts of the company are presented through a selected channel. No other costs than advertising funds are foreseen at this stage.

Evaluation – after analyzing consumer interest data, it should be prepared a report with relative data on customer engagement, their positive feedback, as well as their negative comments;

Purchasing – at this stage are taken significant costs for the business, i.e. material and human resources are purchased in order to achieve the set goal;

Delivery – the required service or product should be provided after the investment, which can be reached directly to the consumer or through an intermediary firm/software;

After-sales period – this is the period of expectation of a lasting return. The valuation of this period is characterized not only by an increase in revenue, but also by a constantly active group of consumers who require to use the services of a given business.

After defining the channels through which we will advertise, we need to present the sources of revenue. Depending on the individuality of each business, revenue would be of a different nature, but in any case would be measurable. In this aspect of the canvas, the types of users from the target audience should be distinguished and their reaction monetized.

Key activities and resources must be reflected after channels. The activity of each business classifies all aspects of its client's needs. By defining a number of services, a business can derive the value of each of its resources responsible for providing those services. In this way, the integrity of the "value proposition" is organized and the marketing strategy is facilitated. In terms of resources, they are divided into material, intellectual (patent, copyright, and brand data), human and financial. Human resources need to be addressed taking into account the fact that in order to properly calculate income and expenses, the human resources section also includes those employees who are not directly involved in the activity of the company, but support it in a specific way.

Once the key elements have been considered, it is necessary to reflect the partners involved. These are employees, services and products that contribute to the proper and successful operation of the business. These partners need to come up with three basic solutions to be in this section. These are optimization and cost savings, reducing risk and uncertainty and acquiring new resources. Finally, we need to define the cost structure. This is not a coincidence given the fact that every aspect considered so far has to do with the financial dimension of the business.

The canvas of the business model is a strategic tool for managing entrepreneurship. This model aims to facilitate the description, design and management of a particular business by focusing on its strengths, weaknesses, activities and assets. Thus, optimizing his marketing strategy or creating a new one is based on clear and defined bases.

3. PLANNING THE STRATEGY

The business we will be looking at is related to the printing and production of plastic cards, print publications, indoor and outdoor advertising in small and medium-sized prints for Bulgarian and foreign companies, retail chains and sites, hotels, clubs and establishments, medical centers and other public and private organizations. Essential to 2019 is to pay attention to email marketing. In view of the adopted GDPR data protection regulations [6], access to the corresponding email is becoming an increasingly desirable recognition option. Under the regulation, receiving an email is subject to the voluntary consent of its holder, and making an active email list is a long process. Taking into account the theory of digital marketing, an active email list is characterized by a list of active users who review and implement the CALL TO ACTION of the respective campaign at each iteration. Email marketing features are distinguished, which give a sample report for a particular email campaign, such as:

Delivery rate – how many emails have reached our users. Our database can be hot or cold. The cold database is characterized by a lack of active emails, nonexistent or poorly accessible ones.

Open rate – depends on the Subject Line. The larger our base, the lower it will be. Extensions or platforms need to be used to track how many times an email has been opened.

Click rate – depends on Content. The larger our base, the lower it will be. It is important to build an optimized email.

Click through rate (%) – it determines the success – the ratio of open and clicked Email.

Conversion rate (%) – how many people “bought” what we offered.

In order to reach the ad agency’s clients, it is necessary to build a suitable email campaign with exact criteria. It is of paramount importance to determine the vision of the content as well as the length of the Subject Line. According to campaign trends, it is a good idea to rely on a personalized product that engages every email on the active list. We may use software for sending out bulk advertising emails such as Mailchimp. This is a multifunctional platform for building brand representation by describing potential customers and accessing their features and subsequently sending personalized emails to suit a specific vision and style. In addition to being an email marketing tool, Mailchimp offers building of a Social media content, Landing pages, Digital ads, Postcards and Automations.

When mentioning social networks, one of the main steps to reach a specific target audience is the social network Facebook. This platform is well known as a means of direct communication – chat, commentary, etc., but has specific features regarding advertising activity. In order to define the actions to be taken, it is imperative to clarify the principle of action of Facebook. Facebook’s algorithm is divided into three main steps. They define visible and suggested content in order to shape the marketing strategy. A direct reference is made to our personal algorithm and to the one that acts as a universal vehicle for promotion. Both algorithms are characterized by:

Inventory – these are the posts of our friends or the pages we have followed;

Alerts – actions that Facebook concludes about the content of a post (like, comments, share);

Assumptions – the Facebook algorithm predicts how much a post will be liked and shared.

On this basis, it determines its relevance score. Relevance score is the unit of measure by which posts that are to be seen on the wall are ranked. The higher it is, the higher the News feed will go up and the user will access it before the rest of the posts. Ranking is calculated based on our attitude to the individual sites. If we return to a page or are interested in its posts, we will see content from the page again while using Facebook. So the relevance score never stays the same. With each interaction we give a signal to the Facebook algorithm and it recalculates the score.

To get the most out of Facebook's advertising concept, we should use the extension they offer – Facebook manager [7]. The created ad page, which is related to the business we describe, will automatically appear in the manager and we will be able to organize its promotion. Facebook offers to activate the algorithm with the personal content of the page or the publication, which will be promoted after a certain payment. The amount we anticipate is for a specific period of time and it is divided into days and number of iterations by users. We need to create an appropriate advertising post and track the impact on users and their user path so that we can build an overall Facebook marketing strategy.

In addition to the already mandatory website and presence on social networks, an analysis of the digital status should be attached in order to track the user path and the consumers' engagement with our business. This can be possible through Google Analytics. In order to bind a website or page with Google Analytics services, it is necessary to place a JavaScript code that indexes the reference to the site.

A relatively large percentage is the use of another Google service – Google Ads [8]. This service provides the creation of advertising, recognition and identity on Google, so that by writing a specific keyword in the search engine, the specificity of the business to stand out from the other results displayed. Again, there is a definite fee with three separate directions for advertising:

Stimulate website visits – increase online sales or sign-up listings for online ads that direct people to the business website;

Receive more phone calls – increase the number of calls from customers with ads containing the phone number and click-to-call button;

Increase business office visits – attract more customers with business ads that help people find their business on the map.

4. THE APPLICATION OF THE STRATEGY

In order to activate Facebook presence, it is necessary to use the Facebook – Facebook manager extension. To do this, we need to add the business page to the platform. After designing the page and access to the specific campaign, it is planned to install a special Pixel plugin. It loads with the site and records the user login and path. In addition, it creates special "audiences" to our site. We can then advertise to these audiences. Pixel comes with a special predefined code, and a typical plugin type is used to match the personality of the business and the site's type. If we have Pixel Events, we can find out exactly where our sales came from. Pixel Events only exist for sites. If our site is informative only – we can use a single Pixel on it. However, if we have a product site and sell it – we need to put in there to track where the sales flow comes from. The events hook up to our only Pixel as he does both actions – gathering special audiences and making complex events.

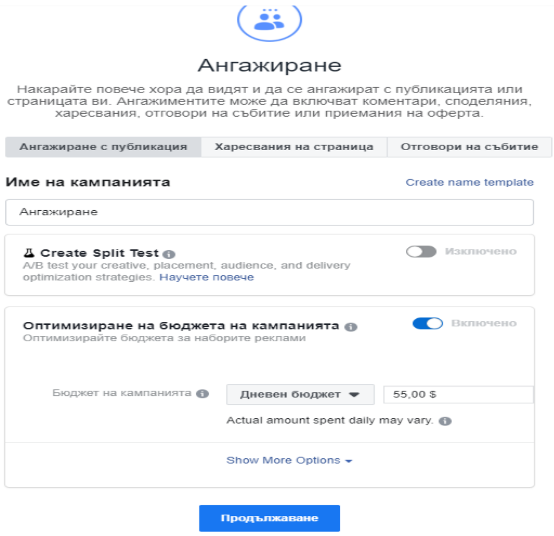


Figure 2. Facebook ads (Source: Personal Facebook account of the authors)

The service through which we create relevant mass advertising is Google Ads. While creating our ad, we have the right to choose a few titles and a few descriptions. We have to be careful with them. The reason is that they will appear in different combinations on different sources. It is good practice to use as few titles and descriptions as possible. Usually, images for an ad can be downloaded from the URL that we set as a link to the product/service from the ad. We also have the option to upload our own pictures. The idea is that the images must match regardless of the ad's size. This ad can be either reworked for google search or displayed on social networks or YouTube.

One of the most powerful tools for analyzing user activity and business status is Google Analytics. You need to add a site reference with the account to the service, which it will provide to get the best results. The system enables the use of Google Analytics, which contains various data for visitors to sites where the code to be used for cookies is placed. Google Display Network, such as European Directives of cookies, also includes data from views on Google ads that have also been commercially presented. Google Analytics also monitors the effectiveness of several sponsored posts on social networks and reads the perception of funds from the investments made. Google equipped products are handy for tracking the performance of paid ads on Facebook.

5. RESULTS

By creating a personalized email campaign, the marketing strategy intents to get as many users as possible. To this aim, 100 specific email recipients are provided to analyze the consumer response. The campaign is a landing page and contains all information about the type of business, key activities and individual offers. Through the functionality of the platform, each recipient has access to the campaign, can open it and subsequently communicate with the site by selecting the call to action button. After submitting the campaign, there is made a daily, biweekly and monthly results report. The figure shows that there are 70% open emails. A certain percentage of them have selected the button for more information. It is good to note that there are no bounced emails. They are divided into hard and soft bounced according to the type of error – no email or no message received. The given 45% click rate proves the enviable success of the email campaign, which is a combination of well-selected and accessible sent information and a properly selected list of recipients.

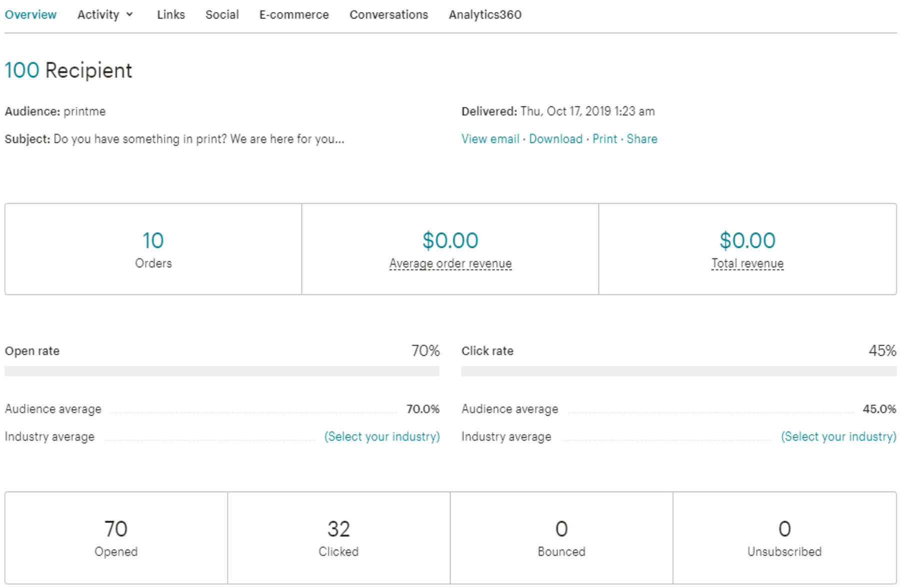


Figure 3. Mailchimp (Source: Personal Mailchimp account of the authors)

There is displayed screen of the demographic distribution of user activity on Facebook manager. It is important to mention that the buyer persona is a man of working age whose job is a fashion designer for example. He has the financial means, he is communicative and he has technical skills. The client wants to be involved in the process of creating printed material, which is the main business activity of the publication. Based on the demographic data, it can be clearly seen that the fundamental of the persona set and the goal are achieved by being possible in the platform to make a detailed filtration. It is of particular importance to reflect the consumer's place of residence, because, for example, in small settlements, even if the demographic user meets the criteria, he or she would hardly need to have the necessary computer skills to participate in the process or to have enough financial resources.

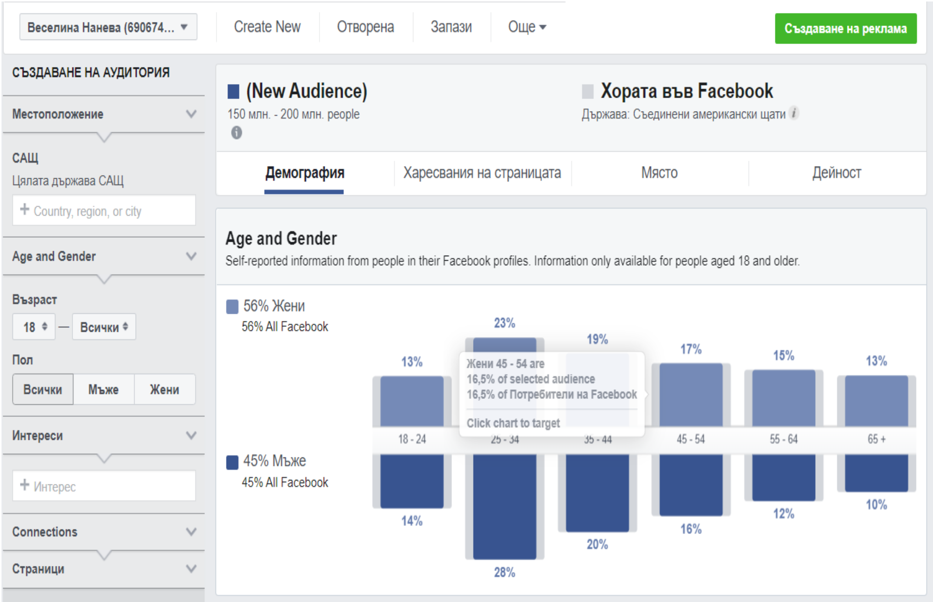


Figure 4. Facebook Manager (Source: Personal Facebook account of the authors)

The established marketing strategy in every aspect should evaluate the consumer presence. The Monthly User Activity Timeline screen is displayed. It can be seen that, following the application of marketing growth techniques, a deviation in the curve is observed. The platform itself has the ability to offer both an activity curve and a distribution of users across countries. Exact values are displayed for a particular ad, page, or link, as well as the exact duration of a particular user session.

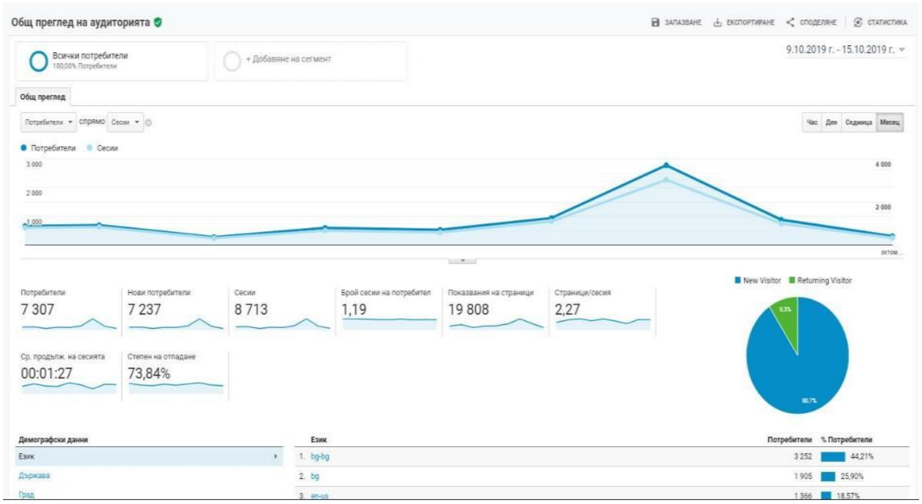


Figure 5. Google Analytics (Source: Personal Google account of the authors)

6. CONCLUSION

Once all the theoretical rationale for the need for a marketing strategy has been established, the opportunities should be offered for its implementation. There is a large number of software tools and platforms that can be classified as tools to help the brand's elevation. Therefore, screening the most appropriate and current techniques is of the utmost importance. In this paper, we chose a sector of human activity as an example and the campaign was applied to its buyer persona. As a result, the levels of business recognition and its accessibility for users and website activity increased. This inevitably leads to an improvement in profits from organic customers.

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REFERENCES

Gibson, Ch., The Most Effective Digital Marketing Strategies & Approaches: A Review of Literature, *International Journal of Scientific and Research Publications*, Volume 8, Issue 2, 2018

Bala, M., and D. Verma, A Critical Review of Digital Marketing, *International Journal of Management, IT & Engineering* Vol. 8 Issue 10, 2018

Verhoef, P, and T. Bijmolt, Marketing perspectives on digital business models: A framework and overview of the special issue, *International Journal of Research in Marketing* 36 (2019), pp. 341–349.

José, J.,L. García, N. Matos, Digital Marketing Actions That Achieve a Better Attraction and Loyalty of Users: An Analytical Study, *Future Internet* 2019, 11, 130; doi:10.3390/fi11060130.

Hassan, A., The Value Proposition Concept in Marketing: How Customers Perceive the Value Delivered by Firms – A Study of Customer Perspectives on Supermarkets in Southampton in the United Kingdom, *International Journal of Marketing Studies*, 2012, pp. 68-87.

Fedorova, A., M. Ferrara, P. Fierro, The General Data Protection Regulation (GDPR): From static to dynamic compliance, *Law and Economics Yearly Review*, 2017, pp. 283-302.

Montalvo, R. Social Media Management, *International Journal of Management & Information Systems – Second Quarter*, 2016, pp. 45-50.

https://www.forbes.com/sites/ajagrawal/2017/10/31/3-marketing-channels-you-need-to-master-in-2018/#19cd43e6cd4b (Accessed 10.10.2019).

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