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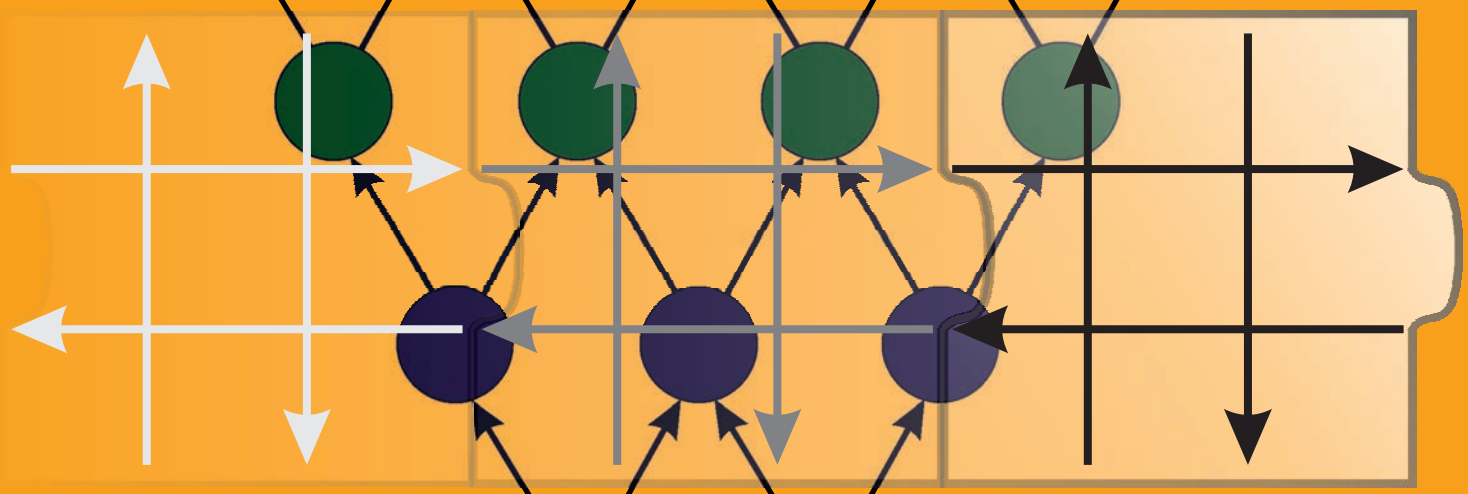

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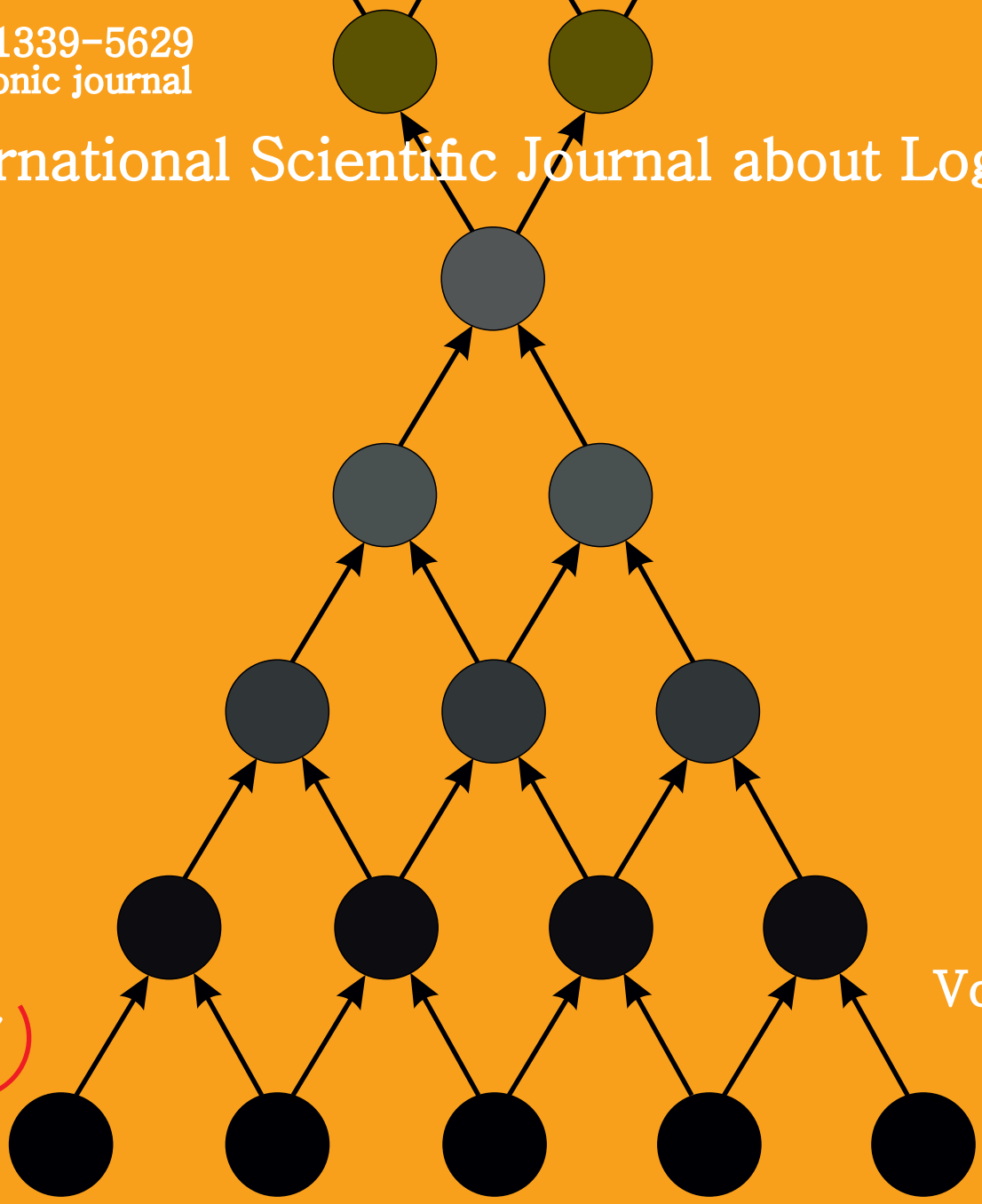

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# EXPLORING THE RELATIONSHIPS BETWEEN DEMAND ATTITUDES AND THE SUPPLY AMOUNT IN CONSUMER-DRIVEN SUPPLY CHAIN FOR FMCG

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***Keywords:*** demand, end-consumers, urban logistics, patterns, FMCG.
***Abstract:*** The development of the retail market in Ukraine and in the world requires the improvement of methods and models of effective interaction of supply and demand in the supply chain for the purchase of goods of daily demand. The article presents an integrated method for demand driven supply chain management at the distribution stage for FMCG (Fast moving consumer goods). The influence of end-consumers and demand on the functioning of the logistics system has been investigated. The approach is based on systems analysis, which shows the interdependence of the parameters of the logistics system and the consumption system. The approach takes into account the parameters of consumers and the logistics system and is an extension of knowledge on the use of consumer-oriented approach in the logistics system (demand-driven supply chain). The obtained results can be used in planning and organizing a modern demand driven supply chain.

## 1 Introduction

Over the last 5 years, the total number of grocery stores in Ukraine has decreased by 46.8%. At the same time, there is an increase in the number of modern retail outlets by 86% [1]. Thus, currently the most common in Ukraine are such large retail chains as «Auchan», «Silpo», «Trash!», «Fozzy», «Metro Cash and Carry», «Furshet», «Velika Kishenia», «ATB», «Eco-market», «Chudo-market» and others. This contributed to the significant development of competition within the market, the struggle for customers and the improvement of marketing methods [2].

In connection with the ongoing shifts in the structure of the population, it is important to take into account the level of economic activity, employment and unemployment, which affect the nature of purchases, the opening hours of retailers, their location, transport accessibility and other factors [3]. The study of these factors allows us to solve the issues of targeting the services offered, maximizing the use of limited resources of households, considering objective criteria that make it possible to make a choice between various alternatives [4]. It is obvious that a wide variety of households and significant differences in their way of life, traditions and living standards in individual regions require a differentiated approach to managing the distribution system.

As a result, changes in consumer behavior become the most influential factor in supply chains changes. New challenges for companies participating in the supply chain in modern conditions:

- customers do not want to wait - it is known that the level of tolerance of consumers in the supply chain to nonconformities is decreasing. If 10 years ago the buyer could transfer 1% of deviations in the received order, then 5 years ago this figure was already 0.5%, and today it is about 0.1% of inconsistencies. In modern supply chains, the level of tolerance for deviations, errors or defects is generally unacceptable.

- product lines have expanded significantly - the range of products is constantly increasing.
- long delivery times for raw materials and components
- more and more goods are ordered from China, the geographical factor causes an increase in delivery times by 2-3 months.
- shortening the life cycles of goods - goods quickly become obsolete, for example, the life cycle of a phone is 1 year, while components can be delivered for six months.
- inaccurate forecasts - forecast algorithms are based on historical information and the longer the planning horizon and detail, the less accurate the forecast.
- low inventory targets - the company must keep stocks low to minimize costs, but at the same time, stocks must match demand and not become "illiquid".

The variability of the situation in any market, seasonality, make the analysis of the distribution of goods among end-consumers necessary and compelled for the effective functioning of any supply chain [5]. In such conditions, improving the efficiency of logistics systems based on the preferences of end-consumers is a necessary component of the transition to the concept of Industry 4.0 [6]. Awareness of the significant role of the final consumer (person) in the distribution of goods requires constant and systematic analysis of its impact on the demand driven supply chain. Consideration of Consumer-driven logistics systems theory allows to revise modern concepts and expand them with new knowledge. The aim of the paper is to establish demand driven supply chain for FMCG and exploring relationships between demand attitudes and the supply amount in it. The article consists of the following sections:

- Introduction, which describes the relevance and feasibility of the study;
- Analysis of the literature, which describes modern methods of interaction of FMCG market participants, analyzes the relationship between logistics and marketing, and logistical approaches to demand and logistics systems, methods of demand distribution in the service area.
- Research methodology, which describes the main provisions of the proposed method. The proposed theory is considered in a case study. Patterns of Supply-Demand interaction in the supply chain for the purchase of FMCG are identified. The influence of the number of inhabitants, individual consumption, average time of movement to the store on EOQ are established.
- The last section presents the conclusions of the article.

## 2 Reference review

Over the past decade, there has been a clear shift in the manufacturer's attention towards end-consumers. Analysis of the theoretical and practical works [7] in the field of logistics and its applied implementation allows us to conclude that in recent years, approaches to the study of industry characteristics of the distribution of finished products have been updated. Simultaneously, the existing theoretical and methodological apparatus used in the management of cargo distribution does not allow to effectively address the identified challenges for FMCG, which necessitated the development of the current conceptual framework in this article.

FMCG is the most popular product in the public economy. Their volume, the number of items grows every year [8], the share of marketing and sales costs increases to expand their market share and make a profit. This article aims to study the interaction of supply and demand at FMCG, which will establish the impact of end-consumers behavior on logistics decisions in the supply chain, namely Economic Order Quantity (EOQ). This will enrich modern methods of managing the distribution of FMCG products on end-consumer behavior.

The successful development of the demand driven supply chain in the FMCG sector is facilitated by the automation of demand forecasting, planning sales, supplies, production, purchases, which has now become possible due to the use of a single tool – the SCM system [9]. SCM systems are supply chain management systems that should cover material flow management from forecasting sales to purchasing raw materials (for a manufacturer) or ordering a supplier (for a distributor). Modern demand centric SCM-system includes: Demand Forecasting, which takes into account the analysis of the influence of TMA and external factors [10]; Sales Planning [11]; Distribution Requirements Planning [12]; Advanced Planning & Scheduling [13]; Material Requirements Planning [14].

This path involves many processes (warehouse logistics, production, replenishment and sales planning, distribution by DC, planning trade marketing activities, etc.) that require careful planning, which allows to implement a set of SCM tools implemented in a demand driven supply chain.

In any supply chain, a plan for sales, production, procurement is developed. At the same time, there are few places where these plans can be rigidly linked to each other, and for the most part they are even developed «in different coordinate systems». For example, a production plan for a product can be planned in pieces or tons, a sales plan in euros or dollars, and a shipping plan in wagons or containers. Thus, it is very difficult to understand how many pieces of products needs to be produced in order for the company to fulfil the sales plan, or how many wagons and containers will need to be shipped to transport all manufactured. This is due to the fact that different divisions of the company solve different problems, and it is more convenient for each of them to look at the business from their own point of view. At the same time, close interaction between departments and the constant exchange of data between them is often not a priority in companies. In addition, FMCG require adjustments due to the specifics of their activities or market conditions. In different supply chains, depending on the type of business, specific problems can vary greatly, but the general tendency of data fragmentation in different links of the chain and a lack of

information exchange between them is very often observed. The most successful global companies have long gone from disparate planning to integrated planning, and for this, in particular, the concept of Logistics 4.0 and demand driven supply chain was developed [15]. Research of technologies of logistic management of urban freight flows allows to reveal sequence and approaches to management of technological stages of their advancement. The main directions of improving the efficiency of material flow distribution were identified, but, at the same time, it was found that scientific concept solve the problems of certain aspects of logistics, but do not fully considered the most important aspects of contemporary logistics - the end-consumer [16].

The analysis of the literature indicates that insufficient attention is paid to the issues of material flow management in logistics systems, especially at the stage of distribution among end – consumers [17]. So, in works [18, 19] the following types of logistic activities are considered: customer service [20]; demand forecasting; inventory management (warehousing, freight processing, packaging, etc.) [21]; selection of locations for facilities (warehouses, distribution centers, production facilities, etc.) [22]; reverse flows administration [23]; management of production processes [24]; fleet management [25] and more. In fact, Patterns of Supply-Demand interaction in the supply chain for the purchase of FMCG requires further consideration, especially in contemporary pandemic circumstances [26].

Recent studies stress significant attention on the influence of end-consumers on generating and distribution of FMCG, especially in cities. General approaches, macro- and micro- models of logistics management have been developed [27]. Most research focuses on demand modeling rather than on the supply-demand interaction methods. Customer-Driven Supply Chain is a new concept, which has evolved from the supply chain management research stream [28]. This approach leads to rethinking Supply Chain Management [29]. A new orientation in Supply Chain Management constantly leads to growing freight demand and transportation. In recent years, freight traffic has become an important factor in the development of countries. According to statistics, the efficiency of freight transportation is associated with an increase in gross domestic product (GDP) [30]. Thus, based on modelling and conducted an empirical analysis of freight traffic, the distance between supplier and place of production and prices for transport services during time-windows in India established influence urban regulation rules on the cost [31]. Prof. Kulshreshtha M. and Prof. Nag V. also used cointegration models «VAR» in modeling the demand for Indian rail freight [32]. More detail the demand for freight in Rome and other Italian cities using six econometric models [33]: traditional regression model (OLS), partial adjustment model (PA), reduced autoregression model with distributed delay (ReADLM), vector autoregression (VAR) model, time-varying parameter (TVP) model and structural time series model. Urbanization, increasing level of motorization, changing consumer behavior due to the spread of smart and green lifestyles, the adoption of new philosophies of production (such as Logistics 4.0) and many other factors have led to the emergence of new mechanisms of interaction in urban transport systems [34].

The references review allows to draw a conclusion that in recent years approaches concerning studying of branch features of distribution of FMCG are actualized. At the same time, the existing theoretical and methodological apparatus used in the management of the distribution of freight flows, does not allow to effectively address these challenges, which necessitated the exploring the relationships between demand attributes and the supply amount in consumer-driven supply chain set out in this paper.

# 3 Conceptual framework

## *3.1 Formalization of the Supply-Demand interaction model in consumer-driven supply chain*

Designing a consumer-driven supply chain is reduced to an end-to-end forecast of demand and sales markets, as well as the determination of the main planned characteristics of supplies that meet the needs of each zone of end consumers, Figure 1.

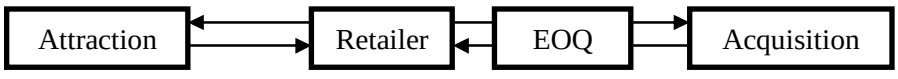


*Figure 1 Interaction of Attraction and Acquisition*

The frequency and size of purchases allow us to determine the assortment, volumes, packaging of goods, calculate the required stock, the rhythm of product supply, identify the main points of sale, the location of retail trade enterprises. Therefore, the «Acquisition» submodel, on the other hand, deals with determining the strategy for placing stocks and orders, the optimal delivery lot (EOQ) of different commodity items, the necessary logistics infrastructure for the optimal concentration of stocks in the distribution system.

It is advisable to formalize Patterns of Supply-Demand interaction in consumer-driven supply chain for the purchase of FMCG taking into account the elements of the system (subsystems) involved in the promotion of material flows in the form of:

$$C \in < \{x, y, z\}; S^{x,y,z} >, \quad (1)$$

where $C$ – consumer-driven supply chain; $x$ – «Acquisition» subsystem; $y$ – «Retailer» subsystem; $z$ – «Attraction» subsystem; $S^{x,y.z}$ – subsystem's links.

Connections $S^{x,y.z}$ depending on their nature can be informational, technical, organizational, technological, commercial and legal, etc.

Subsystem "Acquisition", in turn, has the following form:

$$x \in [\{x_1\} \cup \{x_2\} \cup \{x_3\}], \quad (2)$$

where $x_1$ – many logistics operators; $x_2$ – set of goods; $x_3$ – many technologies for the supply of goods.

Consists of subsets that detail the technology of operation of individual entities for the sale of goods in the form:

$$y \in [\{y_1\} \cup \{y_2\} \cup \{y_3\} \cup \{y_4\}], \quad (3)$$

where $y_1$ – many retailers in the market; $y_2$ – many technologies for the sale of goods; $y_3$ – many technologies for placing and processing orders; $y_4$ – range of goods.

Subsystem $z$ combines elements related to «Attraction»:

$$z \in [\{z_1\} \cup \{z_2\} \cup \{z_3\} \cup \{z_4\}], \quad (4)$$

where $z_1$ – many end users; $z_2$ – set of goods; $z_3$ – many technologies for purchasing goods; $z_4$ – many types of travel.

In turn, each of the elements of the subsystems can be detailed with elements of the next level. Thus, each subsystem can be considered as an independent system. The development and improvement of each structural element of the consumer-driven supply chain is aimed at improving the efficiency of the entire system. Conversely, a failure in any of the subsystems, or at the level of the elements and their connections, leads to the failure of the system as a whole. The global demand-driven supply chain should not provide for the integration of all its elements under a single governing body, but should provide for a reasonable coordination of their functions on the basis of mutually beneficial cooperation.

### *3.2 The management cycle in a demand-driven supply chain*

Demand-Driven Inventory Management — a methodology that is used for both planning and follow-up, by determining (1) where to store inventory and (2) and how much to keep (3), dynamically (4) generate purchase orders based on average daily use, taking into account the corresponding peaks in sales, and finally (5) coordinate and prevent execution in a visual way. The cyclical process of re-planning in the demand-driven supply chain can be divided into 4 phases: formation of outgoing data; identification and calculation of demand; planning of supplies; implementation, comparison and analysis of results. Each subsequent stage in the planning cycle uses the information from the previous stage, analyzes the reasons for the discrepancy between the plan and the fact, makes changes to the demand-driven supply chain management model, and repeats the process again, Figure 2.

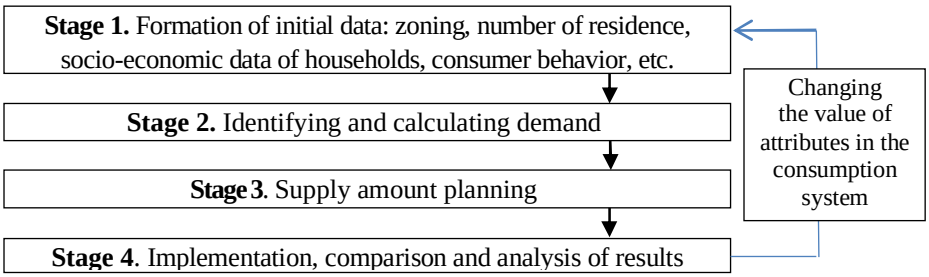


*Figure 2 The circle of management in a demand-driven supply chain*

#### 3.2.1 Formation of initial data

The area of service based on earlier developed approach [35]. The retailer service zones has designed under influence on individual end-consumer behavior parameters [36], geographic characteristics of the territory [37]. Considering the influence of these parameters will allow adjusting the limits of the retailer's service area. The presented zone is the basis for gathering socio-economic data of end-consumers in the zone [38]. Taking into consideration the set of attributes (end-consumer; journey; end-consumers zones; purchase) can be established for each zone, fig. 3. The set of such attribute values forms the attractiveness of the retailer in relation to end consumers and the volume of their individual demand from the participant of retail trade.

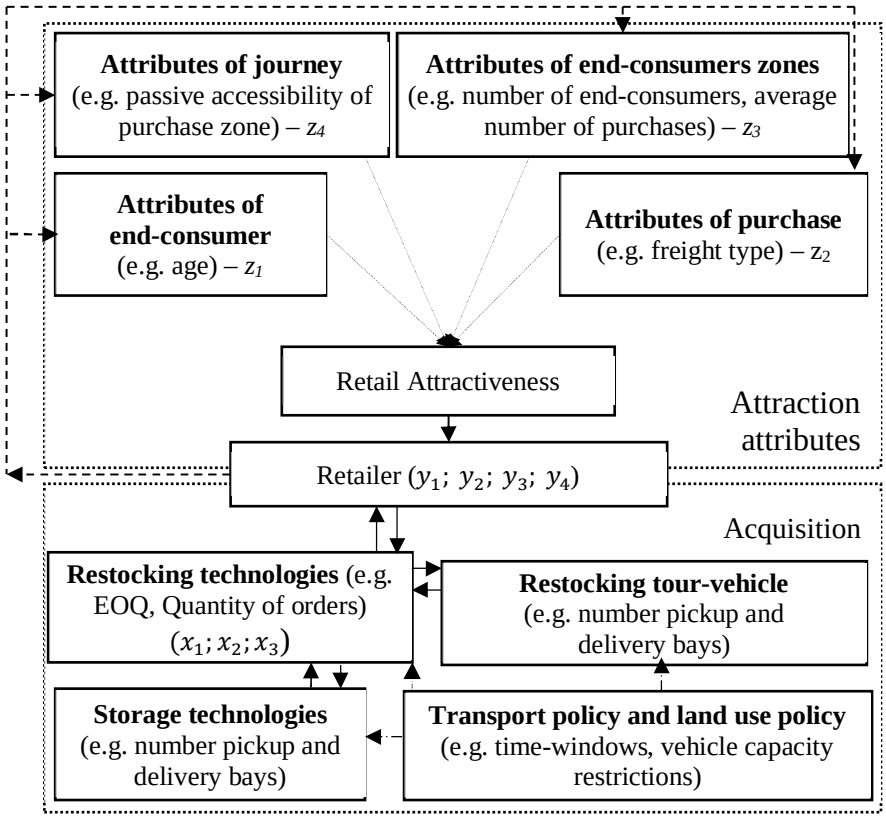


*Figure 3 Methodology for planning demand-driven supply chain in urban area*

– information flows (feedback between advertising, price, retailer service and attraction attributes of end-consumers);
– regulatory impact of the local transport and land use policy Restocking technologies;
– flows of goods; – shopping mobility

### 3.2.2 Identifying and calculating demand

Individual demand of end consumers generates their retailer sales. Retailers of different forms of ownership and organizational and legal forms have different parameters (size, service time, range, number of cash registers, etc.), which affects the flows of end users and their behavior. Generalizing all the parameters, it is possible to combine them into groups that form the volume of demand – on the one hand, and the technology of restocking – on the other: the set of retailers in the market ($y_1$); many technologies for the sale of goods ($y_2$); set of technologies for placing and processing orders ($y_3$); range of goods ($y_4$).

### 3.2.3 Supply planning

It is known that the demand for goods (demand) affects the EOQ value that must be supplied to the retailer. The formed Cycle of management in demand-driven supply chain, allows to define average volume of demand of the participant of a retail network taking into account parameters change of system of consumption.

The scope of delivery can be determined using the Wilson formula. When servicing a retail network, the volume of delivery will consist of the individual needs of each retailer.

### 3.2.4 Implementation, comparison and analysis of results

Based on the results of already completed shipments, it is possible to analyze the parameters of DDSC operation and clarify the characteristics of customers, their preferences and develop an optimal technology for their service. Conducting comparative analyses among those who have already made a purchase and those who have not. Then, based on the identified distinctive features, the profile of the client and the future offer to him are determined. When the system responds as quickly as possible to demand, estimates the lead time and "builds" them into the existing production plan, the synchronization of the rest of the supply chain is much faster, respectively, the response time increases significantly. The basic rule of business still works: the winner is the one who provides the customers with what they need with the best level of service faster.

To implement the proposed technology and study patterns, let us consider an abstract example.

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# 4 Case simulation

## *4.1 Zoning*

Consider an example (Figure 4). The figure shows a schematic location of four retail outlets (A, B, C, D) relative to the household.

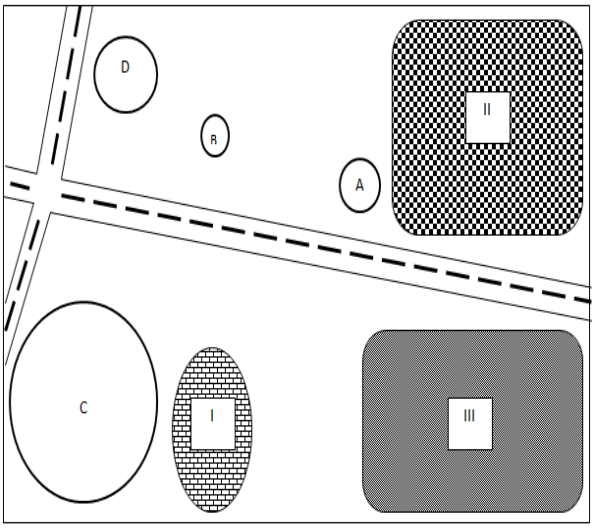



*Figure 4 Zone in which there are four retail outlets and three areas of residence of consumers, depending on their number of storeys:*

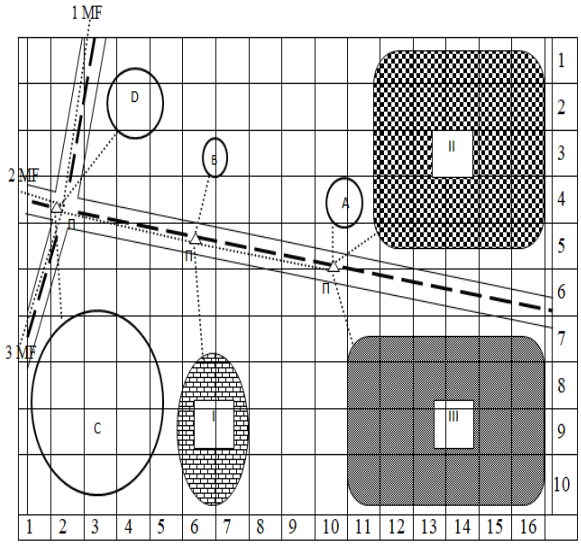



*Figure 5 Construction of the transport links:*

– Building area (10-12 floors); – Building area (1-2 floors); – Building area (5-7 floors); – retailers; $П_1$, $П_2$, $П_3$ – crossing; 1 MF, 2 MF, 3 MF – incoming material flow

Construction of the transport scheme is performed in the following sequence:

1. Fig. 4 presents the location of the participants of the shopping mobility process (retailers, places of residence of end-consumers).

2. We establish connections between related participants in the transport process. In real conditions they can be determined using Google maps [39], Figure 5.

The results of the calculations are presented in Table 1).

*Table 1 The matrix of the shortest distances for transportation of freights*

| | A | B | C | D | I | II | III | П1 | П2 | П3 | 1 MF | 2 MF | 3 MF |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | - | 0.58 | 1.24 | 1.21 | 0.72 | 0.22 | 0.27 | 0.94 | 0.48 | 0.07 | 100.94 | 150.94 | 200.94 |
| B | | - | 0.86 | 0.83 | 0.34 | 0.66 | 0.71 | 0.56 | 0.1 | 0.51 | 100.56 | 150.56 | 150.56 |
| C | | | - | 0.57 | 1 | 1.32 | 1.37 | 0.3 | 0.76 | 1.17 | 100.3 | 150.3 | 200.3 |
| D | | | | - | 0.97 | 1.29 | 1.34 | 0.27 | 0.73 | 1.14 | 100.27 | 150.27 | 200.27 |
| I | | | | | - | 0.8 | 0.85 | 0.7 | 0.24 | 0.65 | 100.7 | 150.7 | 200.7 |
| II | | | | | | - | 0.35 | 1.02 | 0.56 | 0.15 | 101.02 | 151.02 | 201.02 |
| III | | | | | | | - | 1.07 | 0.61 | 0.2 | 101.07 | 151.07 | 201.07 |
| П1 | | | | | | | | - | 0.46 | 0.87 | 100 | 150 | 200 |
| П2 | | | | | | | | | - | 0.41 | 100.46 | 150.46 | 200.46 |
| П3 | | | | | | | | | | - | 100.87 | 150.87 | 200.87 |
| M1 | | | | | | | | | | | - | 250 | 300 |
| M2 | | | | | | | | | | | | - | 350 |
| M3 | | | | | | | | | | | | | - |

## *4.2 Attraction and Acquisition system s interaction*

Characteristics of retailers in the zones of residence of consumers, shown in Figure 6 are presented in Table 2 and Table 3) D. Huff's model was used to estimate the probability of visiting the retailer. The results of calculations of the probability of visiting shops (A, B, C, D) by consumers living in zones I, II, III are given in Appendix A. Thus, the calculations show the probability of visiting each of their four retail businesses by consumers living in different zones. From the Table 4, it is seen that the probability of visiting the retailer by end-consumers of different groups differs. The most probable place of purchase for the first group of consumers was retailer A

(the first in size, and the closest to the consumers of this group, for the second group of consumers – retailer C (third in size, but located much closer to households than the largest shop C), for the third group – retailers C and A.

The least likely place of purchase among all consumers are retailers *B* and *D* – their share is – 13% of total sales in the zone. Different consumers have different propensities to consume different material flows. The propensity to consume the material flow depends on many factors (price, personal preference, etc.). We use a different level of consumer income, which depends on the zone of his residence, to determine the propensity to consume a certain material flow. In Table 5, the characteristics of the consumption of material flows for the month are given, depending on the level of their income.

*Table 2 Characteristics of retailers*

| Retailer (*j*) | Retailer area (*S*), m$^2$ | Travel time from the liviiling zone to retailesr, h | | |
|---|---|---|---|---|
| | | I | II | III |
| A | 785,3 | 0,42 | 0,025 | 0,25 |
| B | 282,7 | 0,37 | 0,44 | 0,56 |
| C | 7068 | 0,05 | 0,71 | 0,62 |
| D | 2405 | 0,5 | 0,62 | 0,85 |
| Total | 10,5417 | - | | |

*Table 3 Characteristics of consumer areas*

| Building area ($\omega$) | Number of floors | Area (Size) of the zone (*S*), ha | Population density depending on the number of storeys ($p_{эс}$)*, people/ha | Number of inhabitants in the area, pers. |
|---|---|---|---|---|
| I | 10-12 | 21,206 | 140 | 2969 |
| II | 5-7 | 27,563 | 125 | 3446 |
| III | 1-3 | 19,5 | 100 | 1950 |
| Total | | 68,269 | 365 | 8365 |

*Table 4 Determining the distribution of consumers across different retailers according to D. Huff's model*

| Number of consumers in the development area, pers. | Building area (ω), % | | | Building area (ω), persons | | | Total consumers, pers. |
|---|---|---|---|---|---|---|---|
| | I | II | III | I | II | III | |
| | 2969 | 3446 | 1950 | 2969 | 3446 | 1950 | |
| Retiler | Indicator of the relative attractiveness of the retailer $j(p_{ij})$ | | | Distribution of consumers by retailers, pers. | | | |
| A | 0,16% | 98,30% | 35,71% | 5 | 3387 | 696 | 4088 |
| B | 0,07% | 0,11% | 2,56% | 2 | 50 | 50 | 56 |
| C | 99,4% | 1,10% | 52,26% | 2952 | 38 | 1019 | 4009 |
| D | 0,34% | 0,49% | 9,46% | 10 | 17 | 185 | 211 |
| Total | 100% | 100% | 100% | 2969 | 3446 | 1950 | 8365 |

*Table 5 Characteristics of consumers and their preferences for consumption*

| Parameter | | Characteristics of consumers and their preferences for consumption | | |
|---|---|---|---|---|
| Consumer area (ω) | | I | II | III |
| Individual demand of a consumer who lives in a certain building area for a period of time, units | 1 MF | 300 | 200 | 50 |
| | 2 MF | 150 | 250 | 100 |
| | 3 MF | 50 | 150 | 250 |

In determining the flow of goods, the leading role is played by the size of purchases made by households. Social production and consumption in any state and region, taken over a relatively long period of time, is progressive and increases in scale. This requires a corresponding increase in the capacity of trade channels that ensure the movement and sale of goods in the main market of end consumers.

According to the considered zones of research and statistics on consumption it is possible to define necessary quantity of consumption for all trade zones:

$$q_m^n = N^n \cdot n_m , \quad (5)$$

where $N^n$ – the population of the n-th zone; $n_m$ – the required amount of product *m*, kg.

The consumption of products during the year is equal to the quantity of supply. Using the classic Wilson model (EOQ) we can find the optimal order quantity and number of deliveries, Table 6.

In determining the flow of goods, the leading role is played by the size of purchases made by households. The volume of sales of material flows in retailers is presented in (Table 7).

The material flows under consideration are interchangeable. The first material flow is the cheapest, the third is the most expensive, the cost of the second is between the values of the first and third material flows. Thus, the first material flow – with high, the second – with medium.

Models of analogy approach and regression analysis leave a lot of freedom to describe the benefits, namely, to interpret *P*. The scheme does not prohibit the use as an average estimate of the distribution of costs, which should give the output of the model turnover forecasts. Often, *P* means the distribution of visits or the distribution of stores according to the criterion of maximum importance for the consumer. In the latter case, the sample is artificially limited to those households that make the bulk of purchases in this category in only one outlet. The problem of measuring benefits comes down to the problem of asking basic questions. The effectiveness of ways to describe the benefits is determined by the type of enterprise for which the study is conducted.

The influence of the retailer's parameters on the optimal volume of delivery and the number of deliveries is presented in Figure 6.

*Table 6 Determination of the number of consumers for different retail facilities*

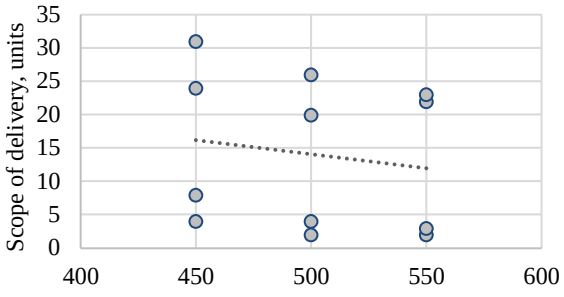
| Material flow | Transportation distance, km | Time of loading and unloading, h | Weight of unit, kg | Cost per order, USD/order | Annual holding cost per unitr, USD/unitr | EOQ, units | Quantity EOQ, ton | Necessary quantity of orders, units |
|---|---|---|---|---|---|---|---|---|
| 1 MF | 100 | 0,94 | 1 | 316,5 | 0,8 | 23764 | 23,764 | 31 |
| 2 MF | 150 | 0,94 | 1,15 | 421,5 | 1,2 | 25384 | 29,191 | 37 |
| 3 MF | 200 | 0,94 | 1,4 | 709 | 1,6 | 24593 | 34,430 | 28 |
| Total quantity for retailer A | | | | | | 73741 | 87,385 | 96 |
| 1 MF | 100 | 0,56 | 1 | 278,5 | 0,8 | 1655 | 1,655 | 3 |
| 2 MF | 150 | 0,56 | 1,15 | 383,5 | 1,2 | 2008 | 2,3092 | 4 |
| 3 MF | 200 | 0,56 | 1,4 | 671 | 1,6 | 3326 | 4,6564 | 4 |
| Total quantity for retailer B | | | | | | 6989 | 8,6206 | 11 |
| 1 MF | 100 | 0,3 | 1 | 252,5 | 0,8 | 24414 | 24,414 | 39 |
| 2 MF | 150 | 0,3 | 1,15 | 357,5 | 1,2 | 18172 | 20,897 | 31 |
| 3 MF | 200 | 0,3 | 1,4 | 645 | 1,6 | 18139 | 25,394 | 23 |
| Total quantity for retailer C | | | | | | 60725 | 70,706 | 93 |
| 1 MF | 100 | 0,27 | 1 | 249,5 | 0,8 | 3121 | 3,121 | 6 |
| 2 MF | 150 | 0,27 | 1,15 | 354,5 | 1,2 | 3780 | 4,347 | 7 |
| 3 MF | 200 | 0,27 | 1,4 | 642 | 1,6 | 6281 | 8,7934 | 8 |
| Total quantity for retailer D | | | | | | 13182 | - | 21 |

*Table 7 Determination of the volume of sales of material flows for different retailers*

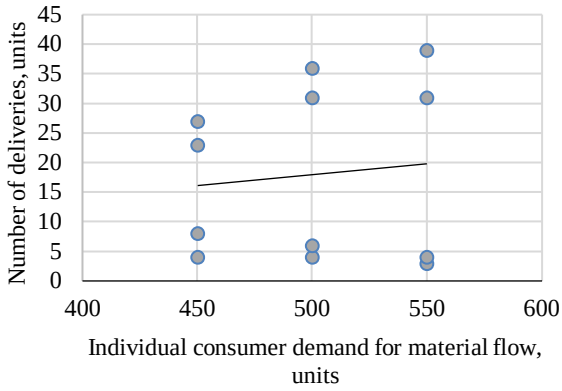
| Retailer | Total consumers, pers. | Material flow | Sales volume by zones, units | | | Total, units |
|---|---|---|---|---|---|---|
| | | | I | II | III | |
| A | 4088 | 1 MF | 1394 | 677478 | 34819 | 713692 |
| | | 2 MF | 697 | 846848 | 69638 | 917184 |
| | | 3 MF | 232 | 508109 | 174096 | 682437 |
| | | Total A | 2324 | 2032435 | 278554 | 2313313 |
| B | 56 | 1 MF | 647 | 787 | 2498 | 3932 |
| | | 2 MF | 323 | 984 | 4996 | 6304 |
| | | 3 MF | 108 | 591 | 12491 | 13189 |
| | | Total B | 1079 | 2363 | 19985 | 23425 |
| C | 4010 | 1 MF | 885645 | 7560 | 50957 | 944163 |
| | | 2 MF | 442823 | 9451 | 101915 | 554188 |
| | | 3 MF | 147608 | 5670 | 254787 | 408065 |
| | | Total C | 1476076 | 22682 | 407660 | 1906418 |
| D | 211 | 1 MF | 3014 | 3374 | 9226 | 15613 |
| | | 2 MF | 1507 | 4218 | 18451 | 24174 |
| | | 3 MF | 503 | 2532 | 46127 | 49159 |
| | | Total D | 5023 | 10122 | 73802 | 88947 |
| Total | 8365 | Total | 2969 | 3446 | 1950 | 4332103 |

**EXPLORING THE RELATIONSHIPS BETWEEN DEMAND ATTITUDES AND THE SUPPLY AMOUNT IN CONSUMER-DRIVEN SUPPLY CHAIN FOR FMCG**

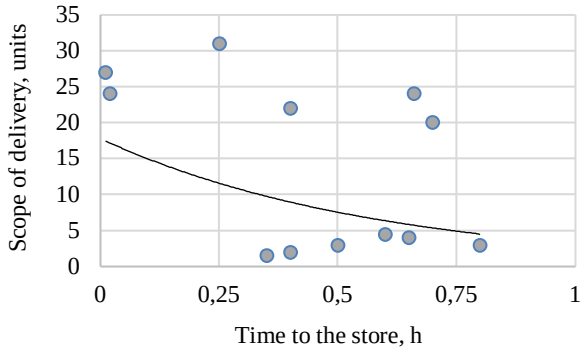
Andrii Galkin; Iryna Yemchenko; Svitlana Lysa; Mykhailo Tarasiuk; Yulija Chortok; Yuliia Khvesyk



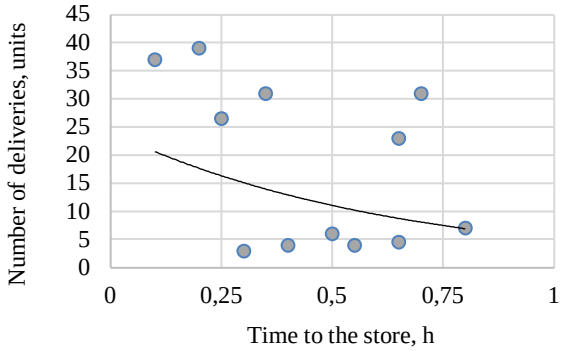

A) *Dependence of the volume of supply on individual consumer demand*



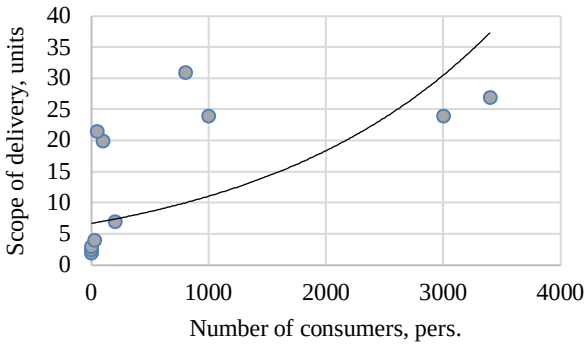

B) *Dependence of the number of deliveries on individual consumer demand*



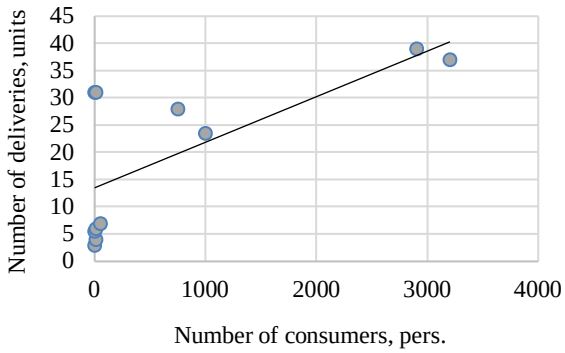

C) *Dependence of the volume of delivery on the travel time of consumers to the retailer*




D) *Dependence of the number of deliveries on the travel time of consumers to retailer*




*E) Dependence of the volume of supply on the number of consumers*




G) *Dependence of the number of deliveries on the number of consumers*

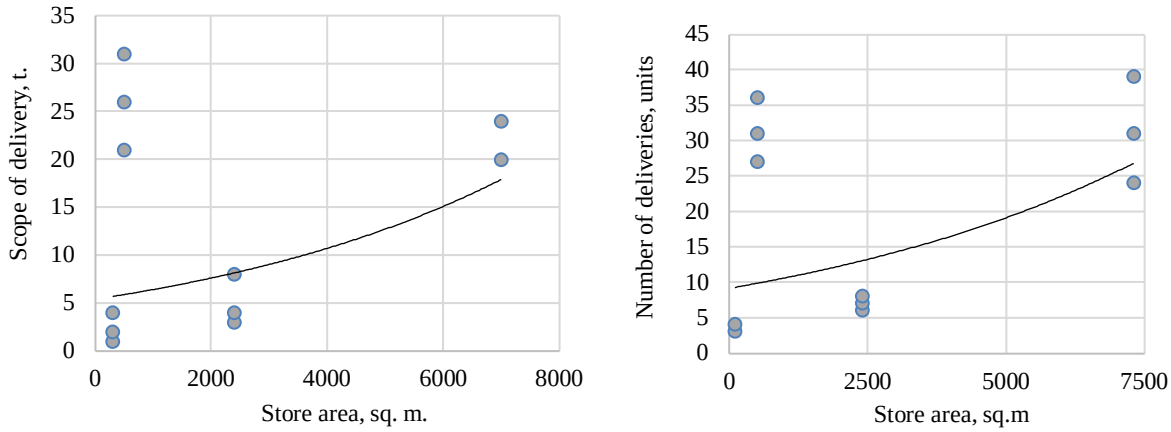
*Figure 6 Dependence of delivery volume and quantity of deliveries on parameters of zones of final consumers*

The dependence of the volume of supply and the number of deliveries to it on individual consumer demand (Figure 6, A and B) is described by a linear relationship. Although the closeness of the connection is quite low, but the analysis of Figure 6 shows that the increase in individual consumer demand reduces the value of EOQ and increases the number of deliveries to the store. The dependence of the volume of delivery and the number of deliveries to it from the time of travel of consumers to the store (Figure 6, C and D) are described by a parabolic function. The connection is average. Analysis of Figure 6 shows that stores that are closer to consumer areas need to be supplied with larger quantities of orders at a high frequency. Increasing the distance reduces the EOQ and the number of stores that are in the middle distance from their customers. As the distance increases further, the EOQ and the number of deliveries to the store increase. The presence of an extremum may indicate different types of stores and shopping zones that they serve: a store near the house, a supermarket, a hypermarket. Consumers try to make a lot of purchases in large hypermarkets in order to

save money, small everyday purchases – on the way home from work.

The dependence of the volume of supply on the number of consumers (Figure 6, E) is described by a power dependence, and the number of deliveries to the store on the number of consumers (Fig. 6, G) – by a linear function. Analysis of Figure 6 shows that an increase in consumers increases the value of EOQ and increases the number of deliveries to the store.

Analysis of different functions of the influence of store size on EOQ and their number in the period showed that the most suitable function in both cases is a power-law function. The coefficient of determination indicates a weak relationship between the independent and dependent variable. Analysis of Figure 7 shows that an increase in store size increases the volume of the shipment to it and the number of deliveries.




*E) Dependence of Scope of delivery on Store area* G) *Dependence of the number of deliveries on the Store area*

*Figure 7 Dependence of the scope of delivery and the number of deliveries on the parameters of retailers*

Changing the value of demand and attractiveness of retailers for the end-consumer in different periods or during distribution will affect the amount of material flow in the logistics system, which can change the delivery technology. Large volumes of demand can be served by simple routes, small consignments – by delivery routes for instance. The technological process, time and cost of maintenance in such cases will be different. The effectiveness of the use of different logistics technologies in the service of different stores and consumer groups with different parameters requires further study.

## 5 Conclusions

The resulting model takes into account the cost of purchasing goods, the parameters associated with the movement of end-consumers to members of the retail network, the characteristics of individual members of the retail network and their competitors. The change of these parameters affects the volume of sales of retail network participants.

Using the system opens up new opportunities that many companies did not know about before. In terms of inventory, demand driven supply chain takes a compromise position between MRP and Lean. This concept does not define stock accumulation as “waste” as it does Lean, but it also does not seek to set inventory levels in a static way, as MRP usually does. Rather, the methodology seeks to keep the right amount of inventory in the right place in the supply chain "to promote flow but minimize working capital" and "dynamically adjust the size of strategically located stock" based on a set of rules.

The advantage of the method is the ability to take into account the parameters of end users and the parameters of the external environment (distance to the retailer, its size, the average level of margin). However, the results of the method are sensitive to the range of data variation. Changing the parameters of the model used in the calculations (physiological characteristics of the residents of the zones, income, structure of food costs, etc.) will lead to a change in the structure of costs and redistribution of retailers’ attendance.

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**SUPPLY CHAIN MANAGEMENT PRACTICES AS A MEDIATOR VARIABLE FOR THE IMPACT OF THE PRODUCT DEVELOPMENT STAGES ON OPERATIONS MANAGEMENT DECISIONS**
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# SUPPLY CHAIN MANAGEMENT PRACTICES AS A MEDIATOR VARIABLE FOR THE IMPACT OF THE PRODUCT DEVELOPMENT STAGES ON OPERATIONS MANAGEMENT DECISIONS

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***Keywords:*** supply chain management, product development stage, operation management.
***Abstract:*** In this study, the researchers have attempted to determine the common Supply Chain Management (SCM) activities that were used as a mediator variable and influenced the effect of the product development stages on the implementation of operation management decisions in the companies belong to the Al-Manaseer Group in Jordan. For this purpose, they used a quantitative method, wherein they distributed questionnaires to the employees and management of the Al-Manaseer Company groups (such as the Director, Department Director, Head of the Section, Workers' Monitor). This helped them understand the relationship between the product development stage and the operational management decisions. They noted that the SCM activities were a significant variable that mediated the effect of the product development stage on the operational management decisions. Based on the findings of the study, the researchers recommended that The Group needs to show a higher interest in the site costs as the selection indicator and for determining the preliminary estimates while considering the information sharing.

## 1 Introduction

In the past few decades, massive globalisation has converted the whole world into a small village, which has increased competition amongst the different companies and markets, worldwide. The customer always strives to acquire products and services from the right place and values quality and price competition. If the companies wish to achieve this and cater to a large variety of customers, they need to fulfil their demands of speedy delivery, high quality, cost-effectiveness, creativity, and flexibility.

[1] Supply Chain Management (SCM) refers to a hard and fast of procedures utilized in enterprise that variety from suppliers, manufacturers, warehouses, distributors, and outlets to customers (very last customers). [2] demonstrating that optimizing logistics solutions, it has been proved that focusing on "best practices" enables for long-term supply chain development, greater market share, the formation of trust links, and the promotion of a strong brand identity.

The companies can derive all the above advantages by studying the Supply Chain Management (SCM) activities, which offer integrated and diverse services that suit the customers, decrease the costs and improve their profitability. The supply chain practices help in material flow, information flow, financial flow and also help in the sustainability of the organisation's relationships with its customers that is based on the Internet and information technology. These practices help in sharing the resources and information with other companies, which facilitates them to fulfil their objectives [3].

The organisations can also develop products using SCM practices. In one study, [4] highlighted the significance of developing novel products that are not available in the market, for ensuring that the companies enjoy longer business success. Many researchers have noted that the supply chain practices contribute to the company's growth, improve their profit performance, and play a vital role in business planning. The development of new products allows the companies they employ skilled people, increase their economic growth, achieve technological progress and improve the standard of living. Hence, the companies need to develop novel products and use better processes for their development.

The product development stages also affect the operational management decisions. [5] mentioned that operations are an important component of any organisation that helps them produce new products and services.

## 2 Methodology

H1: A significant relationship exists between the various product development stages (such as preliminary estimates, development and testing, economic analysis, final planning, and a broad production release) and the operation management decisions.

H2: The product development stages (such as preliminary estimate, development and testing, economic analysis, final planning, and a broad production release) significantly affect the operational management decisions, mediated by the SCM practices.

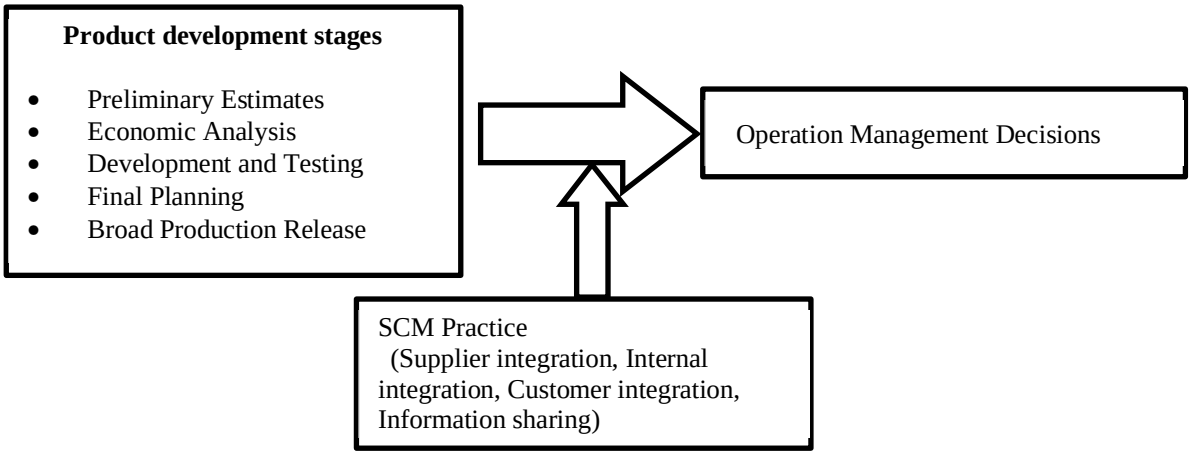


*Figure 1 Research model*

## 3 Literature review

Many researchers have noted that the supply chain practices were a significant step as they help the company decrease its costs and also ensure that the companies benefit from various external opportunities as these practices improve the relationships between the customer and companies, and also between the supplier and the company. SCM practices help in managing the information flow and control the number of resources and services offered by the company such that it increases its operations [6].

Furthermore, the SCM practices play a vital role in the modern economy and assist many companies to improve their finances, thereby improving the economic condition of the country. Many researchers attempted to integrate the different supply chain factors into the customer-driven management system [7]. The SCM practices allow the organisations to show their competitive advantage in business. These activities highlight the value of the organisations as all sections in the organisation can use and disseminate resources in a very effective manner [8].

The concept of SCM is very novel and modern. A few researchers stated that the SCM activities play an effective and vital role as they ensure that the companies can easily face their competitors. These activities allow all organisational members to control the complete product development process, right from their access to raw materials to the product marketing stage and finally to its delivery to the customer [9].

A supply chain consists of a group of 3 or more organisations that are directly connected through steps like Downstream and Upstream Suppliers, information flow, financial flow and exchange of products and services [10]. It can be also described as a group of close and interrelated activities, such as manufacturing, designing and delivery of products and services through distribution channels [11].

[12] stated that a supply chain creates a loop around a customer, as it starts and ends with the final customer. All the finished materials and products pass through the loop. The supply chain refers to a mobile network of all facilities that help organisations to fulfil their objectives. The SCM practices have the following characteristics:

- Cooperative relationships: The logistics of an organisation are dependent on the information technology processes since these processes improve the cooperative relationships. Cooperative relationships are vital as they improve the organisation's strengths that further improve and enhance their competitive advantage [13].
- Process Integration: This step is characterised by shared technology, trust, partnership, and better collaboration [14].
- Integration of information: This refers to the process of accurately accessing the information provided to the organisations and firms, at a reasonable cost and proper time. This step ensures that the cost of deriving information decreases over a period [15].

In their study,[16] presented 3 major objectives of the SCM activities. Objective 1 includes the overall framework and directions needed for fulfilling their needs and implementing the material management activities efficiently. Objective 2 includes a proper technique for managing the information input from outside the company. [17] described many SCM objectives, such as – 1) Decreasing costs and improving efficiency, 2) On-time delivery, 3) Improving the logistic services that are offered to the customers and company partners, 4) Decreasing the inventory levels, increasing the efficiency of the resource investments, and enhancing the value-added chain, and 5) Ensuring the flexibility of all the above steps.

[18] demonstrates that using SCM techniques increases corporate performance and is linked to competences such

as R&D, technology commercialization, production capability, and marketing capabilities. As a result, a combination of SCM methods and organizational competences can result in long-term overall sustainability. Small- and medium-sized businesses (SMEs) perform well.

[19] stated that the major objective of the SCM activities was to encourage the companies, institutes, people and employees in a specific sector to shift to a new system that improved the mutual trust amongst all these parties, by developing a novel communication and participatory system. Thus, it could improve the integration and consistency between the new procedures and work system.

[20] described many components that could be included in the SCM structure, such as control and planning, work structure, product flow structure, overall organisation's structure, information flow structure, management techniques, leadership and power structure, risk-reward structure, culture and attitude. The organisational structure of the supply chain included the following steps: Measure, Resource Management, Main data management, Production and processes, System management and Distribution [21].

## 4 Product development

The product development process includes different stages needed for developing a product from the idea or concept phase to market release and even beyond. Thus, this process consists of the product's complete journey, from identifying the market needs, conceptualising, or designing a product, constructing the product roadmap, developing a viable product, offering this minimal viable product to the users and iterating the product based on the user feedback (Product Plan 2018).

In their report, [22] stated that the Product Development process was a complete process that considered the product/ service from its conceptualisation to its market release. Rebranded or new products/services are developed for fulfilling the customer demands or exploiting an opportunity present in the market. Some of the steps included in the product development process include – drafting a concept related to the service or product, creating a product/service design, developing the product/service, and determining the marketing strategy.

This product development process is systematic and works in a stepwise manner to develop or modify new or existing products. This process ensures that the institutions and markets need to fulfil the customer demands, after considering the strengths and competitive advantage offered by the competing organisations [23].

[24] observed that a few institutions believe that people are reluctant to change and refuse to try new products or services. This could cause the failure of new products. Many factors contribute to the success of a new product, such as:

- Developing a better and novel product.
- The product needs to satisfy the customer or market demands.
- Product development requires a lot of work.
- The developer must define the properties of a product in the early development stage.
- Implementation quality.
- A proper institutional structure and good atmosphere.
- Making focused and better decisions during the product development process.
- Proper planning and collecting all resources before starting the product development.
- Senior management plays a vital role.
- Speedy development, without compromising on the product quality.

## 5 Operations management

Operation management is regarded as a significant component of any organisation that wants to succeed as it helps in managing resources needed for the development and transfer of new products or services. [25] stated that the main aim of operation management was to assist the business practitioners to improve their understanding regarding the operation management tools concepts and techniques related to their environment. The operations management process includes 3 primary tasks, i.e., Creation of new knowledge, transferring this knowledge, and Communicating ideas from the research stage to the development of novel teaching materials.

[26] stated that the operational management process has many benefits like Profitability Management, Manufacturing Edge Regulatory Compliance and Competitive Advantage.

## 6 Related literature

[27] investigated the supply chain disruptions faced by the 3rd-Party Logistics service providers (3PLs) and their subsequent effect on their clients in South Africa. For this purpose, they studied the disruptions that were faced by the organisations and the steps implemented for managing these issues. The researchers used a generic qualitative approach for collecting the data by conducting some semi-structured interviews of 22 respondents, comprising of 11 client organisations and 11 3PLs that were operational in South Africa. The researchers classified the disruptions noted in the study as intra-, inter-, and extra-organisational. They noted that the clients and 3PLs in South African faced a majority of inter- or intra-organisational disruptions. The primary focus of the 3PLs and clients shifted from the risk management process to disruption management. The researchers noted that the 3PLs and clients operating from South Africa preferred learning through disruptions rather than learning through the conventional risk management processes, for understanding ways for managing future disruptions.

In another study, [28] identified the different SCM practices that need to be adopted by the managers for

improving their company performance. In their study, they analysed 88 global firms spread over 13 different sectors for determining the effect of 31 activities using 5 enterprise operational performance indicators. They used a quantitative approach, specifically a multivariate analysis process. In Step 1, they described every variable statistically. The researchers noted that the SCM practices positively affected the enterprise performance indicators. Furthermore, even collaboration and distribution activities were used for determining the performance of SCM practices regarding forecast accuracy and on-time delivery.

[29] proposed a novel model that incorporated various factors that positively affected the new product development process and business performance of different firms. They also determined the important parameters that negatively affected the implementation of a new product development process and its business performance. For this purpose, they analysed 180 Nigerian manufacturing companies. The researchers determined the population sample in their study using the convenience sampling technique. They distributed 2 copies of their questionnaire to each of the manufacturing industries included in the population sample. Then, they analysed the data from 360 questionnaires that were collected using statistical techniques like correlation analysis, factor analysis and reliability analysis. The reliability and validity analysis indicated that all the variables were reliable and valid. They also noted that strategy, culture and ability of all personnel affected the NPD business plans and the business performance.

In another study, [30] determined the effect of SCM practices on supply chain efficiency and its performance. They collected the data from 104 manufacturing industries in Jordan. Then, they carried out a hierarchical regression for testing the hypothesised relationships. They noted that 3 SCM practices, i.e., internal integration, information sharing, and postponement (excluding customer and supplier integration) positively affected the supply chain efficiency. The competitive intensity also moderated the relationship between the supplier, internal and customer integrations, and the supply chain efficiency performance.

[31] investigated the effect of the relationship between the SCM strategy and SCM practices on supply chain performance. All data was collected using questionnaires that were distributed to 200 managers (based on their Job title). The respondents were categorised on their job functions into corporate executives, SCM, manufacturing production, purchasing, material, transportation, and operations, in the Malaysian manufacturing industry. They analysed the data using statistical tools like Mean, Standard Deviation (SD) and Correlation between the dependent and independent variables. They also used a few statistical tools like validity and reliability tests and multiple regression. They noted that the SCM practices were positively and statistically related to the firm performance.

[31] introduced the concepts related to the Supply chain and the SCM. They defined the supply chain and the SCM activities and presented a practical, theoretical and measurement analysis. For this purpose, they methodically analysed many randomly selected references articles from the literature. Their findings indicated that different researchers had differing perceptions regarding these topics. They also noted that the implementation of a theoretical view could significantly contribute while defining the scope of the supply chains. The literature review that was included in this study proposed many vital topics that were generally used in academic dissertations. All these concepts are helpful to the organisations and academicians involved in the SCM businesses.

[32] proposed a framework that included important success factors, tools, techniques and metrics for the implementation of a novel product development process. For fulfilling these objectives, the researchers conducted a literature review that investigated many studies related to the success of the new product development process. All studies were analysed for determining the common factors that were used by the firms that successfully launched new products in the market. The researchers also noted that the use of different research directions offered additional information to the firms that investigated Critical Success Factors (CSF), those measuring the success of a product development process and the academicians working on this topic. They further recommended that some metrics must be used for measuring the CSF responsible for the new product development process. They also proposed some tools and techniques for using these metrics.

[33] conceptualised and developed 5 dimensions of the SCM practices (i.e., customer relationship, strategic supplier partnership, information sharing level, quality of information that was shared, and postponement). They also tested the relationship between the SCM practices, competitive advantage and organisational performance. The researchers collected the data from 196 organisations and proposed all relationships using a Structural Equation Modelling framework. They noted that a higher SCM activity improved the competitive advantage and subsequently the firm performance. Also, competitive advantage showed a direct and positive effect on the firm performance.

## 7 Research methodology

In this study, the researchers have used a quantitative and inductive approach for theoretically analysing the data collected in the study. They also used an analytical and descriptive approach for understanding the SCM practices that mediated the relationship between the product development stages and operations management decisions.

The researchers used primary and secondary data sources, which could be derived using a self-completion questionnaire.

This study was based on 2 data types, i.e., primary and secondary data. The primary data includes the data derived using the questionnaires. However, the secondary data includes all the data that was derived from the field and

theoretical studies published in the literature, in addition to books and research articles related to the topic under discussion. This data was used for developing a theoretical framework and defining the dimensions that could be measured. Here, the SCM practices were regarded as a mediator variable that mediated the effect of the product development stages on the operations management decisions. The primary data was collected using the questionnaire and used for measuring the variables and dimensions and determining the study objectives.

The population sample included in the study comprised of different employees and management staff (such as Director, Head of Section, Department Director, Workers' Monitor), working in the in Al-Manseer Company groups, Jordan, totalling 938 employees. The researchers distributed 95 questionnaires to the respondents and collected 88 questionnaires. Out of the 88 questionnaires, 3 were rejected due to incomplete answers. Hence, 85 final questionnaires were found suitable for further testing. Table 1 presents the demographic characteristics of the respondents selected in the study.

*Table 1 Demographic characteristics of the respondents*

| **AGE (Years)** | **Frequency** | **Percent (%)** |
|---|---|---|
| Less Than 30 | 27 | 31.8 |
| 30-40 | 32 | 37.6 |
| 41-50 | 22 | 25.9 |
| More Than 50 | 4 | 4.7 |
| Total | 85 | 100.0 |
| **Gender** | **Frequency** | **Percent (%)** |
| Male | 45 | 52.9 |
| Female | 40 | 47.1 |
| Total | 85 | 100.0 |
| **Education** | **Frequency** | **Percent (%)** |
| Diploma | 7 | 8.2 |
| Bachelors | 61 | 71.8 |
| Higher Education | 17 | 20.0 |
| Total | 85 | 100.0 |
| **Experience (Years)** | **Frequency** | **Percent (%)** |
| Less Than 5 Years | 47 | 55.3 |
| 5-10 Years | 20 | 23.5 |
| 11-15 Years | 10 | 11.8 |
| More Than 15 Years | 8 | 9.4 |
| Total | 85 | 100.0 |

As shown in Table (1), 31.8% of the respondents were aged <30 years; while 37.6% of the respondents were aged between 30-40 years; 25.9% of the respondents were aged between 41-50 years; while 4.7% were >50 years. The results indicated that 52.9% of the respondents were male, while the rest were female. 71.8% of the respondents had a Bachelor's degree; whereas 20% of the participants had a higher education degree.

The results also showed that 55.3% of the respondents had <5 years of work experience, while 23.5% of the respondents had 5-10 years of work experience. It was also seen that 11.8% of the respondents had 11-15 years of work experience and 9.4% of the participants had >15 years of work experience.

## 8 Descriptive statistics

Table 2 presents the values of the Arithmetic Mean and SD calculated in the study for the Dependent and Independent variables included in the product development stages. Here, they identified the patient-based mean and SD. Table (2) presents the detailed results.

*Table 2 Values of Arithmetic Mean and SD for the Product development stages*

| **Statement** | **Mean** | **SD** | **Chi-Square** | **SIG** |
|---|---|---|---|---|
| Preliminary estimates | 3.582 | 0.88 | 19.98[a] | 0.000 |
| Economic Analysis | 3.871 | 0.89 | 31.18[a] | 0.000 |
| Devilment and Testing | 4.029 | 0.92 | 15.94[a] | 0.001 |
| Final Planning | 4.341 | 0.97 | 61.41[b] | 0.000 |
| **3.96** | **0.92** | | | |

Table 3 presented the attitude of the respondents to the questionnaire statements included in the Product development stages. The average mean was seen to be 3.96 while the average SD was 0.92. The average mean value indicated that there was a higher degree of estimating the variables included in the Product Development Stages. The researchers carried out a Chi-Square test for determining the statistical significance (0.05), thus, indicating a consensus amongst the respondents for the Operation Management Decisions.

Table 3 highlighted the attitude of the respondents to the questionnaire statements related to Operations Management Decisions, where the average mean was 3.88 and SD was 0.95. The value of the average mean showed a higher degree of estimation for the variables related to the Operations Management Decisions. The researchers conducted a Chi-Square test for determining the statistical significance of the values (0.05) and noted a consensus amongst the respondents.

The researchers also determined the Arithmetic Mean and SD for the values related to the SCM Practices. Table 4 presents these results.

**SUPPLY CHAIN MANAGEMENT PRACTICES AS A MEDIATOR VARIABLE FOR THE IMPACT OF THE PRODUCT DEVELOPMENT STAGES ON OPERATIONS MANAGEMENT DECISIONS**

Abdullah Abbas AL-khrabsheh; Sakher A. I. Al-Bazaiah; Abdelruhman Abbas AL-khrabsheh; Marwan Muhammad Al-Nsour

*Table 3 Mean and SD values for the Operations Management Decisions*

| Statement | No. | Mean | SD | Chi-Square |
|---|---|---|---|---|
| The company continuously develops its products | 3.8 | 0.881 | 20[a] | 0.000 |
| Employees are trained in accordance with technological requirements | 3.9 | 0.894 | 31.2[a] | 0.000 |
| Demand is constantly estimated | 3.8 | 0.921 | 16[a] | 0.001 |
| The company plans to produce what can be sold | 4 | 0.970 | 61.4[b] | 0.000 |
| Products are presented according to schedules | 3.9 | 1.036 | 51.3[b] | 0.000 |
| Company needs are scheduled out of stock | 3.8 | 0.995 | 51.3[b] | 0.000 |
| Lost time is minimised | 4 | 0.859 | 24.7[a] | 0.000 |
| There are plans for maintenance | 4 | 1.007 | 34[b] | 0.000 |
| The Company shall maintain preventive maintenance | 3.9 | 1.065 | 32.5[b] | 0.000 |
| The company seeks to have a location close to the markets | 3.9 | 0.921 | 22.6[a] | 0.000 |
| The Group is interested in site costs as a selection indicator | 3.6 | 0.901 | 27.800[a] | 0.000 |
| **Average** | **3.9** | **0.95** | | |

Table 4 presents the attitude of the respondents towards the questionnaire statements related to SCM practices, where the average mean was 3.76 and SD was 0.85. The value of the average mean showed a higher degree of estimation for the variables related to the SCM Practices. The researchers conducted a Chi-Square test for determining the statistical significance of the values (0.05) and noted a consensus amongst the respondents.

*Table 4 Arithmetic Mean and SD for the SCM Practices*

| Variables | Mean | SD | Chi-Square | SIG |
|---|---|---|---|---|
| The Company considers Supplier integration | 3.865 | 0.851 | 27.800[a] | 0.000 |
| The Company considers Internal integration | 4.306 | 0.868 | 25.353[a] | 0.000 |
| The Company considers Customer integration | 3.788 | 0.940 | 71.882[b] | 0.000 |
| The Company considers Information sharing | 3.065 | 0.731 | 76.118[b] | 0.000 |
| **Average** | **3.76** | **0.85** | | |

## 9 Research hypotheses

The researchers proposed the following hypotheses in this study: H1: A significant relationship exists between the various product development stages (such as preliminary estimate, development and testing, economic analysis, final planning, and a broad production release) and the operation management decisions. The researchers carried out a regression analysis for H1 and results are shown in Table 5.

*Table 5 Regression Analysis for H1*

| Model | Sum of Squares | df | Mean Square | R Square | F | SIG |
|---|---|---|---|---|---|---|
| Regression | 74.530 | 3 | 24.8 | 0.78 | 96.8 | 0.0 |
| Residual | 20.791 | 81 | 0.2 | | | |
| **Total** | **95.321** | **84** | | | | |

Table 5 presented the correlation coefficient value between the dependent and independent variables, i.e., 0.884. Furthermore, the coefficient of determination value ($R^2$) was 0.782, thereby indicating that the independent variables could explain 78.2% of the changes occurring in the dependent variables, while the remaining were attributed to other factors. The Examined value (F) was seen to be 96.788, with a significance of 0.00, which was <0.05. This highlighted a significant relationship between the product development stages and the operations management decisions.

Table 6 presents the standardised and unstandardised coefficients included in H1.

*Table 6 Coefficients*

| Model | Unstandardised Coefficients | | Standardised Coefficients | t | SIG |
|---|---|---|---|---|---|
| | B | Std. Error | Beta | | |
| Preliminary | 0.2 | 0.1 | 0.21 | 1.9 | 0.05 |
| Estimates | 0.2 | 0.0 | 0.15 | 2.0 | 0.04 |
| Economic Analysis | 0.5 | 0.1 | 0.59 | 6.2 | 0.00 |
| Development and Testing | 0.3 | 0.1 | 0.26 | 2.2 | 0.03 |
| Final Planning | 0.4 | 0.1 | 0.38 | 4.6 | 0.00 |
| Broad Production Release | 0.8 | 0.1 | 0.80 | 7.6 | 0.00 |
| a. Dependent Variable: Personal Mastery | | | | | |

*Table 7 Regression Analysis for H2*

| Model | Sum of Squares | df | Mean Square | R Square | F | SIG |
|---|---|---|---|---|---|---|
| Regression | 268.8 | 6 | 44.8 | 0.872 | 87.5 | 0.0 |
| Residual | 39.4 | 77 | 0.51 | | | |
| **Total** | **308.2** | **83** | | | | |

Table 7 presents the value of the correlation coefficient between the dependent and independent.

The F value was 87.552, while the significance was 0.00, which was <0.05, indicating the significant effect of the product development stages (such as preliminary estimate, development and testing, economic analysis, final planning, and a broad production release) on the operational management decisions, mediated by the SCM practices.

As shown in Table 6, a significant relationship existed between the product development stages and operations management decisions. The researchers noted that the T-test values were higher compared to the tabular value of 1.984, while the significance was <0.05.

The preliminary stages in the product development stage showed no significant relationship with the operations management decisions, since the T-value was lesser compared to the tabular value of 1.984, and even the significance level was higher than 0.05.

H2: The product development stages (such as preliminary estimate, development and testing, economic analysis, final planning, and a broad production release) significantly affect the operational management decisions, mediated by the SCM practices. The researchers tested the hypothesis by conducting a multi-Regression Weighted analysis for the SCM practices and results are presented in Tabvariables, i.e., 0.934, while the coefficient of determination value (R2) was 0.872. This indicated that the independent variables could explain 78.2% of the changes occurring in the dependent variables, while the remaining were attributed to another factor

## 10 Conclusions and recommendations

Based on the above results, the researchers concluded that the AL-Manaseer Company Group, Jordan displayed efficient Product Development Stages, made efficient Operations Management Decisions, and followed efficient SCM Practices. A significant relation was noted between the product development stages and the operational management decisions. The researchers further stated that the SCM practices are a very important variable that mediates the effect of the product development stages on the operations management decisions. In a similar study, [34] observed that the SCM practices positively affected the firm performance variables. [35] noted that 3 major SCM practices, i.e., internal integration, information sharing, and postponement (except the supplier integration and customer integration) positively and significantly affected the supply chain efficiency. [36] also showed that the SCM practices were statistically related to the supply chain performance. The above results indicated that the Al-Manaseer Group is primarily interested in the site costs as the selection indicator and considers the preliminary estimates and data sharing amongst the peers.

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# IMPLEMENTATION OF SMART-CITY TOOLS AS A RESPONSE TO CHALLENGES IN SOCIO-HUMANITARIAN FIELD IN UKRAINIAN METROPOLISES

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***Keywords:*** urbanization, information and communication technologies (ICTs), urban management, smart cities, socio-humanitarian sphere.
***Abstract:*** The article investigates theoretical foundations of public management in the socio-humanitarian sphere of metropolises based on the smart city concept. It defines the essence of the concept of "public management in the socio-humanitarian sphere" in a metropolis, which should be considered as a multi-branch and inter-sectoral complex formed with the involvement of local authorities, business partners, the public, and citizens, and aims to create, maintain, and develop a favorable safe environment as a unified system of life and livelihood of the city based on the balanced development of the main sectors of the economy and socio-humanitarian sphere. The abstract also defines criteria for the efficiency of public management in the socio-humanitarian sphere within a modern metropolis, which include integrity, sustainability, and security of the subjects in obtaining a positive effect of solving socio-humanitarian issues within a metropolis. The main mechanism of public administration in a metropolis is establishment of interaction in the triad "power - business - community" and coordination of their interests (business - "here and now", community - "the welfare of our children", the state - "the welfare of citizens"). It is confirmed that the digitalization of public administration contributes to strengthening control over the use of all types of resources for the optimal development of the socio-humanitarian sphere of Ukrainian cities.

## 1 Introduction

According to the forecast of WHO experts, already in the 2030-2050s more than 60% of the world's population will become urban residents [1,2] It is known that in 2020 in the world there were about 600 metropolises, which are already shaping the policy of the world economy. According to economists, by 2025, it is metropolitan cities that will produce about 2/3 of the world's gross domestic product [3]. Thus, changes in the historical significance of cities as a result of urbanization naturally determine transformation of their significance not only as centers of economic growth, but also as centers of spiritual and social activity. Today, many researchers who study the issues of metropolitan governance emphasize that the structure of metropolitan governance is similar to that of state governance. Therefore, in this management system such management subsystems as housing and communal services, transport networks, industry, urban planning and others, can be distinguished. At the same time, in the context of public administration activities carried out by municipal authorities in metropolises, the socio-humanitarian sphere deserves a special focus, since it

forms the labor resources and labor market to ensure the functioning of other spheres of life in large cities.

Important research trends in the study of life management in a large city are the issues of social welfare of the inhabitants and spiritual significance of large cities as the basis for the formation of a modern worldview and lifestyle. Many foreign and domestic researchers in their works emphasized that large cities spiritually dominate the state. It is from the positions of large cities that the state is managed [4].

Bogaenko considers a large city as a holistic system which is characterized by polystructurality and multifunctionality in terms of influencing the functioning of not only the city, but also the state as a whole [5].

Other experts focus on the processes of municipal governance of metropolises. These scholars understand the municipal management as activities of local government aimed to satisfy public interests and carried out in the forms prescribed by law through the municipal economy [6,7]. At the same time, the main activity of local governments is to direct enterprises and organizations located in the city for meeting public interests of the citizens [7]. Therefore, for the Ukrainian state, which has chosen the course of European integration reformation [8], in the research and applied aspect of public administration it is vital to consider the peculiarities of socio-humanitarian governance in a metropolis to achieve better governance and quality of life of Ukrainians in the conditions of European integration movement.

## 2 Methodology

The main goal of this work is to generalize and characterize the features of management in the socio-humanitarian sphere in a Ukrainian metropolis.

The structural approach is often used to study issues arising in metropolises and agglomerations, e.g. flood prevention in coastal areas [9]. The Analytical Hierarchy Process (AHP) approach [10] is used to assess and analyze the “network” cities management risks (The concept of ubiquitous cities (U-Cities), for example, Seoul.

To study the specifics of global megacities of the world (the most prominent global metropolises, such as London, New York, Hong Kong, Los Angeles, Sao Paulo, Rio de Janeiro, Paris, Berlin, Moscow, Beijing, Singapore, Shanghai, Sydney and Tokyo), the researchers used the ELECTRE III approach, a multi-criteria decision aid tool comprising twenty indicators [11,12].

To solve spatial problems, in particular, parking in metropolises, simulation of decision-making processes based on the Digital Twin platform "smart things" is used to develop an "ambient intelligence." It is a freight parking management system for last-mile delivery in a smart city, called Smart City Logistics Parking (SCLP) [13]. Modular Integrated Construction (MiC) has been one of the most innovative solutions to address the ever-growing housing demands in metropolises such as Hong Kong, which has been applied by Chinese researchers [14].

Contrast to the aforementioned research, in Ukraine the first developments in the implementation of the Smart City concept are associated with the formation of a distinct research area - municipal government, as well as with the formation and development of the legal framework. This direction accompanies management processes in urban areas, and also aligns them with the processes of decentralization, which has been going on in Ukraine since 2005, and is intermittent by nature. At this stage of decentralization in Ukraine, it is advisable to resort to the method of systems analysis in order to study the status and trends of the Smart City concept implementation in urban management. Using this method, it has been established that a high probability for realization of this concept is made possible due to the intensification of two processes - digitalization and decentralization [15,16]. While the process of digitalization is due to a certain level of investment and resources [17,18], including human, the latter is the result of efforts and agreements between major players in the Ukrainian government and parliament. Therefore, the political factor as a result, a response to external challenges, in particular, in decentralization promotion, is fundamental in modern Ukraine.

The method of statistical analysis is used in this study to compare the demographic characteristics and operation and city management features in European and Ukrainian metropolises. This method allowed to establish the differences between a metropolis and an agglomeration, through the coverage of other, specific characteristics that define the concept of "metropolis" in Ukrainian and overseas research.

The scientific-historical retrospective method is used to visualize the dynamics of the Smart City concept in the metropolises management in the context of intermittent decentralization and the civil society development, and the public sector and public services formation. This method allows to explain not only the backwardness of the processes, but, first of all, the evolution of perception of new political and social economic changes in the society as an objective necessary condition for further progress of the socio-humanitarian sphere in Ukrainian metropolises.

To illustrate the main research results of the study, the appeal to the graphic method allowed to demonstrate the differences between Ukrainian and European practices, and especially highlighted the difference in understanding of metropolises of global importance, such as London, New York, Hong Kong, Los Angeles, Sao Paolo, Rio de Janeiro, Paris, Berlin, Moscow, Beijing, Singapore, Shanghai, Sydney, and Tokyo, and awareness of management issues within the megapolises of the Ukrainian scale.

The study is based theoretically and methodologically on international agreements, laws of Ukraine, research works of domestic and foreign authors, and analytical and statistical thematic reviews.

## 3 Result and discussion

The concept of "metrolopolis" (Gottmann, 1989) is directly related to its root "polis", and is interpreted as the growth of large industrial cities accompanied by their merger with the surrounding areas [19,20]. Metropolises are only the nuclei of these extremely complex urban structures. Today this name is used for especially large urban concentrations of the world (in UN publications - with a population of over 10 million people) [2,19,21]. A characteristic feature of a metropolis is high population density and a significant number of out-of-towners. Other researchers [21] consider a city with a population of over 1 million people to be a metropolis. It is the demographic characteristics of metropolises that distinguish their economic and social identity and influence the formation of public administration mechanisms not only within large cities, but also within a state as a whole.

Many cities in Europe belong to the category of large cities (most often calculations are made from 500 thousand people) [22]. At the same time, taking into account the indicator of the number of over 1 million people, the European rankings also include the metropolises of Ukraine (Table 1).

*Table 1 Ranking of Ukrainian metropolises among the 100 largest cities in Europe, 2020*

| City | Total population (people) | Ranking |
|---|---|---|
| Kyiv | 2 590 000 | 7 |
| Kharkiv | 1 404 000 | 16 |
| Dnipro | 1 108 000 | 27 |
| Donesk | 1 050 000 | 31 |
| Odessa | 1 002 000 | 36 |
| Zaporizhzhia | 850 000 | 44 |
| Lviv | 790 000 | 48 |
| Kryvyi Rih | 705 000 | 57 |
| Mykolaiv | 510 000 | 95 |

So, as we can see, the first 36 positions of the European ranking that are occupied by millionaire cities include, in addition to the Ukrainian capital, such large Ukrainian cities as Kharkiv, Dnipro, Donetsk, and Odessa (positions 36$^{th}$ through 100$^{th}$ include cities with the population of over 500,000 people). In total, the ranking of 100 major cities in the Eurozone includes 9 Ukrainian cities.

In Ukraine, state urban planning norms [23] provide the division of urban settlements into 5 types:

- major (the largest) – over 1 million people;
- significant (very large) – from 500,000 to 1 million people;
- large – from 250,000 to 500,000 people;
- medium – from 50,000 to 250,000 people;
- small – up to 50,000 people.

Therefore, in contrast to European approaches in the ranking of large cities, according to the national ranking as of January 1, 2020, in Ukraine there were, in addition to the capital, 3 more cities with the population of over one million inhabitants (Table 2).

At the same time, as can be seen from the data in the figures, there is a steady downward trend in the population of millionaire cities in Ukraine, which distinguishes Ukrainian cities from global metropolises, which showed a positive population dynamics over the same period.

Scientists interpret the efficiency of metropolitan management through the processes of managing operation and development of a modern metropolis in terms of meeting the real needs and interests of citizens and the implementation of the public administration fairness principle [24-26]. It is emphasized that in international research traditions it is accepted to consider the bodies of municipal government as public organizations, and activities of such bodies are classified as power-administrative [25].

*Table 2 Dynamics in the number of metropolis inhabitants in Ukraine, 2001-2020*

| Metropolis name | Population number (people) | | | Dynamics |
|---|---|---|---|---|
| | 2001 | 2014 | 2020 | |
| Kyiv | 2 611 327 | 2 868 702 | 2 967 360 | Growth |
| Kharkiv | 1 470 902 | 1 451 132 | 1 443 207 | Decline |
| Odessa | 1 029 049 | 1 017 022 | 1 017 699 | Decline |
| Dnipro | 1 080 846 | 993 094 | 990 724 | Decline |

In the complex system of a large city, the socio-humanitarian sphere is singled out as an object of public administration, since the state of this sphere significantly affects preservation and development of the resource potential of a large city. The socio-humanitarian sphere infrastructure constantly evolves, and the driving forces of this development are the real needs of the community. Therefore, public management of the socio-humanitarian

sphere in a metropolis can be defined as a diversified and intersectoral complex. It involves local authorities, business partners, the community and citizens in order to create, maintain, and develop a favorable safe environment as a unified system of the city life and livelihood. It aims to develop the major sectors of the economy and socio-humanitarian sphere, in particular, improving the quality of social services in education, medicine, social welfare, innovative and creative development of culture, transport services, housing and communal services, tourism, leisure, etc.

Metropolises are characterized both as the means of material environment realization and the phenomenon of culture [6].

In the context of the public administration development in metropolises, their sustainable development is considered through the issues of effective interaction of government with the public. It is believed that this requires solving a number of problematic issues: organizational, personnel, etc. Also needed are the adaptation of international experience to Ukrainian realities, optimization of dialogue, solution of issues of public activity and community unity stimulation, and in-depth study of social partnership phenomenon, in particular, its conceptual and operational aspects [27].

According to urban development trends, currently metropolises are not only business and industrial centers, but also centers of social activity that create maximum opportunities in the social lives of their inhabitants.

We support the opinion of Makhinya that "metrolopolis" should be understood as a concentrated form of human settlements classified as large, the largest and very large cities, and associated with the merger of these cities boundaries with adjacent areas of conurbations [24]. "Conurbations" are understood as merging of small cities with metropolises due to the effects of approximation.

A significant advantage of the socio-humanitarian sphere of a metropolis is its saturation with objects of culture, education, health care facilities, sports facilities, etc. Therefore, in the implementation of public administration in this area, one must take into account a number of features that determine the choice of effective methods and tools to achieve the goal of public administration in the identified area. On the basis of systemic, structural-functional and institutional approaches it is possible to determine the following features of public management in the socio-humanitarian sphere in a modern metropolis:

- high social significance of trends in this sphere in the processes of life support of the territorial community (for example, the branches of health care, education, culture, etc.);
- dominance, among social service providers, of state and communal institutions (over 2/3 of the market) and slow entry to the social services market by private and public representatives. At the same time, the mechanisms of budget-funded financing of communal facilities protect them from the risks of bankruptcy or force majeure, such as the COVID19 pandemic, in contrast to private or public institutions;
- a high degree of intersectoral integration and cooperation in providing social and humanitarian services within a narrow territorial space (for example, sports complexes provide services in aesthetic cosmetology and nutrition, although these are branches of medicine);
- bringing social infrastructure facilities closer to the places of compact residence of citizens (residential neighborhoods), work or study, leisure, etc.

Public management of a metropolis is a set of economic, organizational and legal means of purposeful influence of public administration entities that ensure the coordination of the interests of public authorities, local governments and civil society structures operating in the metropolis.

An important mechanism of public administration in a metropolis is establishment of cooperation in the triad "power - business - community" and harmonization of their interests (business - "here and now", community - "the welfare of our children", the state - "the welfare of citizens").

It is possible to identify the following as the main criteria for the development of the socio-humanitarian sphere in a metropolis: integrity, sustainability, and security, which are determined by the ability of public administration bodies to find solutions to numerous and complex problems of the metropolis.

World practice has accumulated considerable expertise in implementing innovative tools for managing metropolitan cities, as their existence necessitates understanding of their intelligent population in economic, psychological, socio-cultural, environmental, and medical aspects, and implementation of the smart city ideology. Thus, no sphere of life in a metropolis exists separately; it functions as a single "smart network" that provides unity and rational approach to resource consumption, modern economy, high living standards, and ecological and safe life of the population. It is believed that after 2020 the global market for intelligent urban services may reach $ 400 billion a year [28].

Cities evolve, but so do requirements to them. The smart city concept has an interesting history: first came the idea of a digital city, and then the idea of a smart one. The evolution of the European network of smart cities has been too rapid, and today this network counts 136 cities (Figure 1).

The basis of a smart city is feedback, which means that people as central consumers of urban services must be involved in the process. The general concept is that not the inhabitant adapts to the city, but the city does to needs and behavioral models of people. It is essential that city residents have an opportunity to work with public

authorities to find the best solution for meeting their social needs and interests (through government websites and social networks).

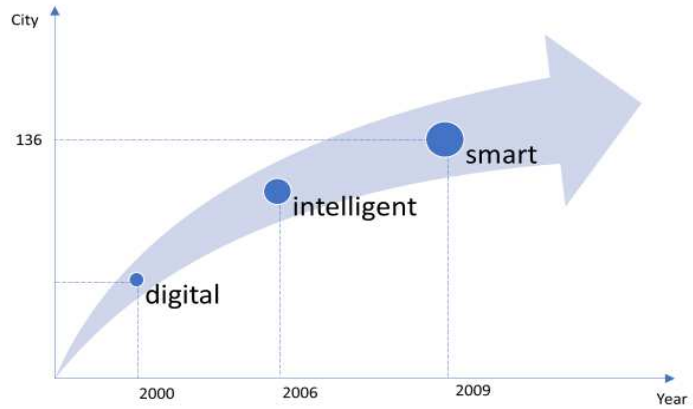


*Figure 1 Development of the European Smart Cities Network according to [2,29]*

The experience of implementing the program "Smart Seoul - 2015" is of particular interest. South Korea is concerned about its own image, and this program has been running for more than 10 years, so we see a whole range of activities. Here, a single operational center has been created to manage city services, a water and air quality monitoring system has been set up, and "smart metering" of energy consumption has been introduced. Also, smart cameras with video analytics have been installed, and mutual exchange of data between 30 thousand video surveillance systems has been established. A 192-kilometer network has also been built to provide Internet access in the Seoul subway. Naturally, there is an extremely wide range of electronic services in operation, including integrated websites of all government agencies, public access to information from city services, and a system of booking public services based on the "single window" principle. In total, there are over 150 services in such important socio-humanitarian areas as education, municipal infrastructure, tourism and leisure, medicine, municipal transport, etc [30].

As the world experience suggests, management based on Smart City principles consists of technologies that include the following aspects [17]:

- SMART-management: solutions that help increase the efficiency of providing public services, such as e-government and information communications technologies, e-learning, e-passport; transparency and open data, and political demand;
- SMART-residents: the main recipients of services in the socio-humanitarian sphere, the formation of which is provided on the basis of modern competencies, primarily such as educational, vocational, communication and speech (foreign language skills) ones, an opportunity for lifelong learning and taking an active part in urban life;
- SMART-education: global access to high-quality distance education based on interactive communication between participants in the educational process (educational platforms, distance courses, webinars, etc.); electronic final exams at schools; electronic registration for admission to higher education institutions; distance format of final exams and dissertation defenses in higher educational institutions; creation of a single state electronic database on education issues, etc.;
- SMART-medicine: remote level of service by a family doctor (telephone counseling), telemedicine counseling of in-patients on diagnosis and treatment, electronic clinic, electronic medical record and medical history, electronic prescription, electronic referral to hospital, E-register of doctors and patients by types of the most common and socially significant diseases (including infectious and dangerous ones), the use of the latest safe devices for diagnosing the body condition and appropriate treatment (non-contact thermometers, etc.);
- SMART-energy: solutions that ensure uninterrupted electricity supply to all households and commercial buildings;
- SMART-environment: technologies that will allow to restore energy, manage wastewater, and provide proper sanitation for citizens;
- SMART-transport: these solutions are related to the rationalization of transportation in order to optimize traffic flows (20% reduction of the total travel time to work / home) and increase urban connectivity;
- SMART communications and IT: powerful communication and sensor networks between cities will enable law enforcement agencies and other

institutions involved in public safety to collect and interpret data and respond effectively to any crime;
- SMART-buildings: solutions needed to build intelligent control systems that can help save up to 30% on water consumption, 40% on energy consumption, and reduce their maintenance costs by 10-30%.

According to domestic experts, today Ukraine is taking confident steps in the development of domestic cities in their approximation to the standards of developed large cities in Europe and the world. The introduction of certain smart city components can be identified in such megapolises as Kyiv (the capital), Kharkiv, Odessa, Dnipro, and Lviv. According to the results of the Kyiv Smart City Forum 2020 [31], the city of Dnipro was recognized as the national leader in the management smart technologies implementation in the field of public safety. For instance, the municipal program "Safe City", funded by the local budget, has been operating in the city since 2016. As part of this program, 1,200 video cameras have been installed in the city and are supervised by two monitoring centers, one at the National Police and the Security Service of Ukraine (1), the other at the specialized Situation Center of Dnipro City Council (2). The video surveillance system helps to implement the information function of metropolis management through the tools of survey, robotic.

The city of Lviv was recognized at the Kyiv Smart City Forum 2020 as the best mobile, ecological and architectural city in Ukraine. In the development of smart-infrastructure, the city authorities use various communication formats, in particular, involving residents, business representatives, and various other stakeholders, including those from neighboring regions, to gain experience.

In 2020, the city authorities of Odessa introduced a system of non-cash fare payment in public transport through Transpod mobile application utilizing Bluetooth technology. Due to the application, it is possible to track public transport routes. For the convenience of citizens, the mobile application also allows users to find a route from point A to point B, also by public transportation.

The city of Kharkiv was recognized as the “Best Digital City” within the framework of the Kyiv Smart City Forum 2020 due to the introduction of the online platforms “Portal of Electronic Services” and “Portal of Kharkiv Citizens”, and the mobile application “My Kharkiv”. In addition, Kharkiv residents have the opportunity to pay for parking spaces online, and use the unified Helsi.me medical system in addition to other online services. In order to bridge the digital divide among the population, free digital literacy courses are provided for residents. Gradually, local authorities are building partnerships with the business environment to financially support the success of smart projects.

In 2015, the capital city of Kyiv approved a local program called The Safe Capital. The program covered the purchase of 7,000 video cameras, a video surveillance system, cloud storage, etc. Due to smart video cameras, it is possible to identify a human face and then determine personal data (the name and status). In addition, in 99% of cases the program is able to read cars license plates, regardless of weather conditions, to track the route of the vehicle within the city, and so on.

In general, as we see, many cities in Ukraine have introduced the experience of a smart and safe city based on expanding the capabilities of urban video surveillance networks in public places and places of large crowding such as airports, train stations, shopping and entertainment centers, etc. However, the implementation of "smart" city projects in Ukraine today lags far behind the world's current management practices in terms of the pace of innovation, quality and complexity. In Ukraine, no city or even metropolis is operating in the smart mode yet. The main barriers are the city's economic viability, budget support, and support from local businesses and the community in implementing smart solutions.

## 4 Conclusions

1. The issue of implementing public management of metropolis development requires taking into account the interaction of public and private sectors and paying special attention to the need to use people's initiative, introducing new relations between the urban community and government, and creating a fair economic system and productive urban environment.

2. Large cities (metropolises) are unique in their geographical location, historical development and architecture, cultural traditions, and development of financial, economic and socio-humanitarian spheres. This applies not only to European cities, but also to such metropolises of Ukraine as Kyiv, Dnipro, Kharkiv, and Odessa.

3. According to the conducted study, currently socio-cultural and research sphere, education and health care, physical education and sports, municipal transport and transport networks (bridges, roads, airports, streets, car lanes, bike paths), in short, everything that provides comfortable conditions, quality of services, safety of human life and community require accelerated development at the metropolitan level. After all, on the map of Europe, metropolises are increasingly playing the role of modern international, research, and financial attractors.

4. All this provides large cities with a special political status of national and international importance due to the greatest movement of goods, capital, and human resources. That is why further research on the issues of public management in the development of metropolises should be considered as an important factor in strengthening the economy for any country in the world. The experience of EU countries in this regard is extremely useful for Ukraine, which is currently actively pursuing the strategic goals of integration into the European Union.

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# THE NEXUS BETWEEN ORGANISATIONAL CAPABILITIES, ORGANISATIONAL READINESS AND REVERSE SUPPLY CHAIN ADOPTION

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***Keywords:*** environmental factors, organisational readiness, Reverse Supply Chain.
***Abstract:*** Successful Reverse Supply Chain Adoption (RSC) adoption requires a clear identification and understanding of Organizational Capabilities, assets, and resources internally and externally. Towards this end, this research assesses the nexus between organisational capabilities and RSC Adoption with a focus on the mediation role of organisational readiness. A survey method was used to achieve the research objectives. Different manager levels from the Jordanian industrial sector were selected by using a convenient sample technique. SMART PLS 3 was used to conduct Structural Equation Modelling (SEM). The outcomes represent a significant influence for internal organisational capabilities on the RSC adoption. As a mediation result, organisational readiness has a mediation role between internal organisational capabilities and the RSC adoption.

## 1 Introduction

Nowadays, business settings and environments are changing rapidly, which brings many challenges, forces, and pressures that are re-engineering and driving the scope and nature of organisations. Different types of organisations are struggling to keep up with these pressures and survive in a highly competitive environment. Modern society has been formed by a new environmental perspective and a high level of innovation. This is made possible by a great development in all fields of industry, service, technology, and concepts associated with globalisation and a significantly changing business setting. Among the results of these changes and developments, increased awareness about environmental issues, increased demand for green products and services, and increased interest in recycling operations [1]. Since the world is suffering progressively sturdy attention in environmental concerns and its influence on the worldwide society, the responsibility for businesses has to be focused on environmental issues during both directions of the supply chain: downstream and upstream.

Reverse Supply chain (RSC) refers to the movement of goods upstream, from the customer side (consumption point) to the organisation or supplier (origin point) to add extra value or suitably dispose of goods and as such has become popular among retailers and manufacturers given its potential to enhance customer experience and loyalty [2]. [3] pointed out that RSC is increasingly prominent since it has a significant benefit for all supply chain partners namely: reducing demand for new resources by providing more affordable materials; minimising transportation cost and production energy consumption, and reusing waste that would otherwise be lost in landfills.

[4] figure out that one of the most critical factors for achieving competitive advantage in today's business is to focus on environmental issues and implement all possible tools to minimise waste and pollution. This level of RSC, however, does not occur by chance and rarely happens organically. Instead, RSC activities are frequently seen as a journey that requires a strategic roadmap and needs more and more investment across the organisation, good relationships with supply chain partners, and organisational readiness to adopt. Besides, building sturdy partnerships with supply chain partners such as suppliers, distributors, customers, community and government has become a critical factor for executing and sustaining the business activities in general [5].

Furthermore, there are an increasing number of scholars that are explored supply chain issues regarding environmental concerns and RSC such as supply chain sustainability [6]; green supply chain [7]; lean production [8]; Outsourcing [9]; Inventory design [10]; RSC adoption and organisational capabilities combination with organisational readiness has however scarcely received any attention in the academic literature. Specifically, organisational capabilities refer to all organisational resources, equipment, facilities, infrastructure, contracts, and relationships with all partners (3PL, 4PL, Government, Supplier, laws, labor unions, pressure groups). These might consequence in a company's incapability to identify, estimate, and understand the potential influence of the RSC on the level of variations and how a company's response to such pressures might be successful or not [11,12].

Nevertheless, there are several organisational capabilities externally and internally that require implementation and adopting RSC in all sectors usually and in the industrial companies in particular. More so, this research will investigate the interrelationship among organisational capabilities, organisational readiness, and RSC Adoption. In terms of structure, this study starts by

providing contextual literature regards to supply chain and RSC, followed by methodology section; findings analysis, and conclusion.

## 2 Literature review

### *2.1 Supply Chain Management*

The common and initial definition of supply chain term is the flow of material through various companies which mainly start from the raw materials point and end to the customer point [13]. [14] pointed out that "logistics" and "SCM" terms are mentioned in the many scholars interchangeably despite logistics activities being a significant part of the supply chain. Supply chain can be defined as the process and network that is related directly to the production of goods and services and offer them to the customers based on their wants, need, and demands [15]. [16] stated that supply chain is mainly referred to the coordination between different activities: manufacturing, transportation, inventory, supplier relationship, and innovation combined with all supply chain partners. Mainly, the aim of supply chain management is to achieve effective use of different resources to minimise the processes costs and improve manufacturing quality while satisfying customers. [17] figure out that successful supply chain management is achieved by delivering the right products to the right customers at the right place, cost, and conditions.

As supply chain have derived to be more critical to society, customers, and more global, the more questions the community has had about the effect on the environment. Customers who care about environmental issues usually seek to minimise the negative impact of the industrial process on the environment. Accordingly, businesses, government, society, and pressure groups around the world are wondering about what is the best practices to minimise the negative effect and address this issue. This raised the need for a green process by conducting green initiatives. As companies have been encouraged to shape benefits in an efficiently tight market, they have progressively cantered around tactics to keep the expenses and cost regarding the production cycle under control. One method to accomplish those goals is to move from a typical manufacturing network to a green one. Green initiatives are aimed at saving and maintaining natural resources: power, water, animals, solar radiation which are the essential requirements of human survival.

Many scholars focus and call recently more research to save the global environment since the consumption level is increasing day by day and the dangers of hazardous materials and waste increased significantly [18-21]. Simply, green supply chain activities refer to working friendly with the environment and planning accordingly [22]. Recently, this topic has a focus from scholars in different contexts. This is a result of increasing awareness levels regarding environmental issues and increasing the pressure level on the companies to adopt such activities [23].

Furthermore, [24] concluded that the most significant supply chain activity that has a vital role in saving the environment and is mainly responsible for a significant decrease of the waste and pollution level is the reverse supply chain process. [23,25,26] stated that implementing this process will enhance the operational performance, decrease the total cost of production and increase the availability of resources. The following paragraph presents RSC in some more detail.

### *2.2 Reverse Supply Chain and organisational capabilities*

The most common detention of Reverse Supply chain (RSC) is defined by [27] as “the process of planning, implementing, and controlling the efficient, cost-effective flow of raw materials, in-process inventory, finished goods, and related information from the point of consumption to the point of origin to recapture value or proper disposal”. In contrast to the traditional logistics chain that begins at providing supplier raw materials to the producer and delivering it to the final usage stage by the end-customer, RSC involves the reverse movement that determines a closed-loop supply chain in combination with linear logistics [2]. The essential task in the RSC procedure is the product (waste) acquirement and that is a vital step for the establishment of a beneficial RSC. Recently, in the developed countries context, all businesses are working aggressively on the adoption of RSC in their activities due to the strict law and pressure associated with the proper disposal of waste, after the product life cycle is complete [28].

After reviewing numerous pieces of literature regarding RSC, it is determined that there is an immediate need to understand the RSC issues and fill the research gap by assessing the organisational capabilities from the industrial angle. Despite the potential benefits, it is not easy to implement and adopt the RSC as it requires a high level of preparedness in the various organisational components. [29] concluded that RSC required a high level of managerial awareness, clear rules and policies, financial resources, and strategic planning. [30] pointed out that the critical requirements that contribute to the successful adoption of RSC are the availability of financial support, infrastructure, high level of innovation, customer relationship management, and strong full coloration.

Regarding the organisational capabilities to adopt RSC, we can largely embrace the perspective offered by many scholars which categorise these barriers into internal capabilities such as infrastructure, organisation policy, strategic direction, employee qualifications, management commitment; and external capabilities such as government support, supplier integration, economical controls and customer orientation [31,32]. To overcome these challenges and to survive in RSC adoption, companies should draw a clear strong strategy throughput their experiences, efforts, and readiness to achieve successful RSC adoption.

In sum, we consider that when an organisation has a certain capability associated with different resources internally and externally it is further expected that it will pursue to enhance its readiness to adopt RSC. This assumption partially agreed with [33], who pointed out that companies should understand and maximise their capabilities to successfully adopt RSC. By investigating RSC adoption, the study refers to certain related factors that can shape the influential impact of organisational capabilities internally and externally. The logical basis of the proposed relationship between many factors associated with business readiness and RSC adoption can be justified based on the increasing awareness of environmental issues within all societies. Accordingly, the following hypothesise are generated:

- **H1**: Internal organisational capabilities have a significant statistical impact on the Organizational Readiness for the Reverse Supply Chain Adoption within the context of the Jordanian food industry.
- **H2**: External organisational capabilities have a significant statistical impact on the Organizational Readiness for the Reverse Supply Chain Adoption within the context of the Jordanian food industry.
- **H3**: Organisational readiness mediate the relationship between internal organisational capabilities and reverse supply chain adoption within the context of Jordanian industry.
- **H4**: Organisational readiness mediate the relationship between external organisational capabilities and reverse supply chain adoption within the context of the Jordanian industry.

Research Conceptual Model (Figure 1).

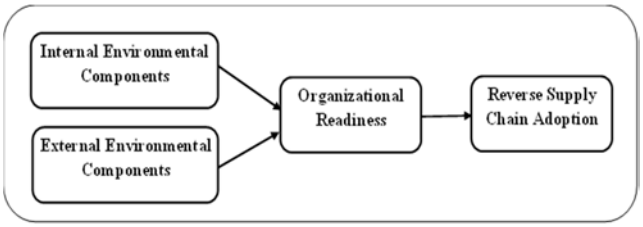


*Figure 1 Research Model*

## 3 Research methodology

The quantitative technique was mainly used in this research as the entitative technique allowed the researcher to emphasise numeric data and provide a well-grounded data source to improve understanding of the research topic. A convenient sampling approach was applied. The population of interest includes different managers at different managerial levels in the Jordanian industrial context. This is chosen according to the significant role of this sector in the adoption of RSC and the industrial sector mainly is the main stage of the RSC process. 350 questionnaires were collected from the target population. Table1 below summarises the demographic characteristics of the study sample.

*Table 1: Sample Characteristics*

| Personal Information | | Frequency | Percentage % |
|---|---|---|---|
| Gender | male | 206 | 58.9 |
| | female | 144 | 41.1 |
| Age | less than 30 | 171 | 48.9 |
| | 31-40 | 111 | 31.7 |
| | 41-50 | 60 | 17.1 |
| | more than 50 | 8 | 2.3 |
| Experience | less than 5 years | 165 | 47.1 |
| | 5-10 years | 141 | 40.3 |
| | More than 10 years | 44 | 12.6 |
| Total | | 350 | 100% |

The survey was drawn based on five Likert scales. Smart PLS 3 software was used to conduct Structural Equation Modelling (SEM) following the recommendations of [34,35]. Following the recommendations of [36], the model was assessed using 5000 bootstraps re-samples method and the following subsection presents the results.

## 4 Results

Validity and reliability analysis for research instrument. In line with [37,38], these analyses were measured by conducting Cronbach's Alpha; composite reliability (CR); Average Variance Extracted (AVE). Accordingly, all indices reveal the good reliability and validity of the constructs and exceed the cut-off values (CR>0.60; Alpha>0.60; AVE>0.50). Table (2) represents these findings.

*Table 2: Scale validity and reliability*

| Constructs | Alpha Cronbach's | Composite Reliability (CR) | AVE |
|---|---|---|---|
| External Organizational Capabilities | 0.845 | 0.878 | 0.521 |
| Internal Organizational Capabilities | 0.889 | 0.911 | 0.562 |
| Organizational Readiness | 0.883 | 0.915 | 0.684 |
| Reverse Supply Chain Adoption | 0.865 | 0.897 | 0.533 |

Besides, correlations by conducting Pearson bivariate test for all all-research variables, and the findings reveal that no multicollinearity concerns amid the research constructs and table 3 represents these findings.

The SEM (Figure 2) was assessed by checking path coefficients and the $R^2$ values. More so, both direct and indirect effects were evaluated to ensure that the mediation effect was checked following the [39] recommendations (Table 4).

*Table 3: Correlation matrix*

| Constructs | EOC | IOC | OR | RSCA |
|---|---|---|---|---|
| External Organizational Capabilities | 0.669 | | | |
| Internal Organizational Capabilities | 0.596 | 0.750 | | |
| Organizational Readiness | 0.314 | 0.554 | 0.827 | |
| Reverse Supply Chain Adoption | 0.472 | 0.574 | 0.549 | 0.730 |

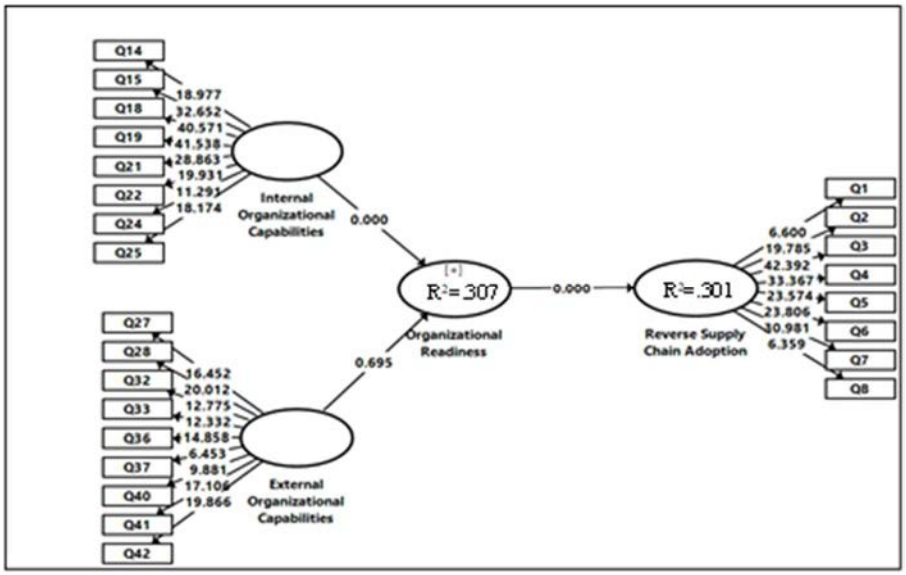


*Figure 1 Research Model*

*Table 4: Path analysis*

| IV | DV | β | S.E | t - value | P value |
|---|---|---|---|---|---|
| Internal Organizational Capabilities | Organizational Readiness | 0.568 | 0.053 | 10.630 | 0.000 |
| External Organizational Capabilities | Organizational Readiness | 0.025 | 0.063 | 0.390 | 0.697 |

*Table 5: Indirect Effect*

| Variables | β | S.E | t - value | Confidence Level LO - UP | P |
|---|---|---|---|---|---|
| Internal Organizational Capabilities >- Organizational Readiness >- Reverse Supply Chain Adoption | 0.312 | 0.044 | 7.167 | (0.226 - 0.398) | 0.000 |
| External Organizational Capabilities >- Organizational Readiness >- Reverse Supply Chain Adoption | 0.013 | 0.035 | 0.384 | (-0.056 - 0.082) | 0.701 |

As represented in figure 2, the values of R2 of the research variable organisational readiness and RSC adoption were 0.307; 0.301 respectively which advocate that the model provides a proper explanation, and its predictive power is meaningful. Furthermore, the H1 predicted that internal organisational capabilities are positively and directly associated with the organisational readiness for the RSC Adoption. This hypothesis is accepted as the path between these constructs is supported and significant at $p < 0.01$; and ($\beta = 0.312$; $t = 10.630$). The second hypothesis supposes that external organisational capabilities is positively and directly associated with the organisational readiness for the RSC Adoption. This hypothesis however is rejected as the path between these

constructs is non-significant ($p = 0.697$; $\beta = 0.025$; $t = 0.390$). The results of the specific indirect effects (mediation path) that shown in table 5 represented that Interestingly, organisational readiness mediates the relationship between internal Organisational capabilities and RSC adoption. Moreover, H5 predicted that organisational readiness mediates the relationship between external organisational capabilities and RSC adoption. This prediction is not supported as ($p = 0.701$).

## 5 Conclusion and discussion

This research set out to investigate a conceptual model on the mechanism through which the perceived organisational capabilities on the RSC adoption are associated with organisational readiness in the Jordanian industrial sector. To the best of our knowledge, it is the first research to investigate such a mechanism. The findings confirm the relevance of the research hypotheses and the literature that guided their formulation. Theoretically, this paper has sought to enhance the nuanced understanding of the RSC adoption and the significant organisational capabilities that require to successfully adopt RSC. The research results shed light on both the theory and practice of RSC adoption. RSC plays a significant and vital role and highlights the combination of organisational capabilities internally and externally allowing a strategic role. The RSC has been touted as a 'magic' for decreasing manufacturing cost, increasing availability of materials, increasing flexibility in an economy [28], especially during an uncertain situation. Successful adoption of RSC requires actual consideration of the organisational capabilities including strategic planning, infrastructure, high collaboration level, customer relationship management.

Regarding the role of organisational readiness, from the above arguments, we can state that the availability of these capabilities, especially the internal capabilities. All businesses that are considering the RSC adoption must promote supportive facilities to enhance their readiness level to adopt. Because of that, this research is considered the mediation role of organisational readiness as a prerequisite for successful adoption of RSC.

The RSC is an effective way to save the environment which reducing the pollution rate and transferring the waste and unused materials into valuable resources. Hence, it is crucial to promote the RSC due to the numerous benefits it offers. Upon reckoning the significance of RSC in promoting continuous awareness during the supply chain network, this study had looked into the key organisational capabilities that are required to adopt RSC associated with organisational readiness and the stance of managers and their intention towards RSC adoption. Supply chain managers should distinguish the significant role of the level of readiness in RSC and different organisational capabilities as a key requirement that can improve the organisational experience in RSC and in turn enhance efficiency and competitiveness. Due to the speedy and extreme awareness regarding environmental issues, the extended nature of RSC from local to regional to global alternatives is calling for more concern from supply chain managers. As a practical implication, the outcome of this research may support decision-makers and supply chain managers in the Jordanian industrial sector to develop, adopt a responsive RSC. All efforts ought also to be associated with the development of reliable organisational capabilities to ensure a successful RSC adoption. Future research might adopt a more holistic view by combining organisational strategy, supply chain relationship, and supply chain agility that could shape the future adoption of RSC.

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# PROGRAM FOR THE DELIVERY OF BASIC NECESSITIES OF A WAREHOUSE DURING THE COVID-19 PANDEMIC

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***Keywords:*** warehouse, vehicle routing with capacity, logistics costs, COVID-19 consequences.
***Abstract:*** The purpose of the research is to reduce the logistics costs of a warehouse supplier of products belonging to the primary consumer located in the central area of the State of Veracruz, Mexico. There is an increase in the number of stores to supply due to the quarantine. As a result, its high costs have been negatively affected. Therefore, the project focuses on minimizing the distances travelled in delivering its products, which will reduce costs. From applying vehicle routing with capacity (CVRP), a redesign of delivery routes is carried out weekly, proposing a new weekly delivery schedule of 22 routes and 162 destinations. Whit the CVRP application decreased 23.61% in the distance travelled even with an 8% increase in recipients. Thus, it reflects the fulfilment of the delivery objective to the current stores and those added by the warehouse. The research addresses two problems, first the costs incurred by the warehouse for the delivery of its products. The second is the increase in supply due to the initiative to prevent the spread of the COVID-19 virus, avoid the displacement of long distances to purchase products by the inhabitants and reduce those who attend the stores' Warehouse supplies.

## 1 Introduction

According to international organizations, all countries worldwide face various emergencies resulting from different risks in terms of scale, complexity, and global consequences. These can have profound political, economic, social, and public health repercussions, and their long-term consequences can sometimes persist for several years. These risks include *a)* infectious disease outbreaks; *b)* chemical and radiation contamination; *c)* armed conflicts; and *d)* consequences of climate change [1,2].

A pandemic is an epidemic disease that extends to many countries and affects almost all members of the region [3]. In Figure 1, the timing of some of the most deadly pandemics throughout history plasma, including the currently known as COVID-19.

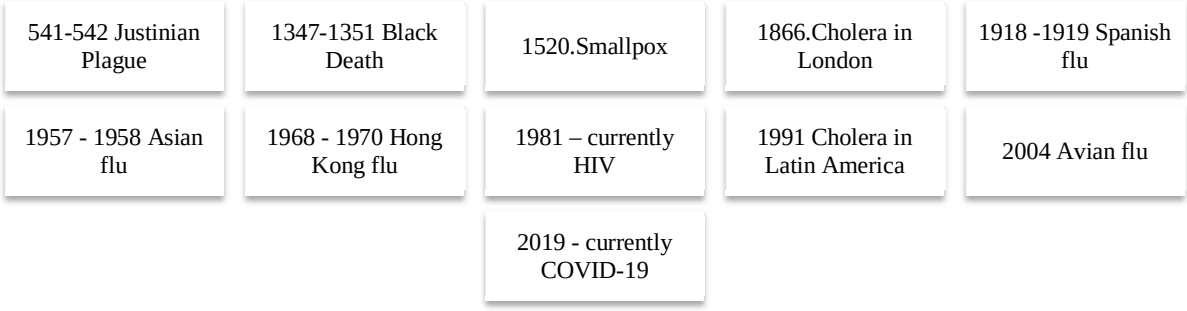



*Figure 1 Chronology of pandemics [4-7]*

### *1.1 SARS-COV-2 Virus*

At the end of 2019, the SARS-CoV-2 virus appeared and brought thousands of deaths and changes in society. The SARS-CoV-2 virus is the virus that causes a respiratory disease called coronavirus disease 2019 (COVID-19). It is a virus of the great family of coronaviruses, a type of virus that infects humans. SARS-CoV-2 infection in people was first identified in 2019. This virus is thought to spread from one person to another in droplets dispersed when the infected person coughs, sneezes, or talks. It is also possible to transmit it by touching a surface with the virus and then putting the hands to the mouth, nose, or eyes, although this is less frequent. There are ongoing research studies on treating COVID-19 and preventing SARS-CoV-2 infection. Also called severe acute respiratory syndrome coronavirus type 2 [8].

Many coronaviruses cause respiratory infections, which can range from a simple cold to serious illnesses as the Middle East respiratory syndrome (MERS) and severe acute respiratory syndrome (SARS). Recently, COVID-19 was discovered, an infectious disease caused by a coronavirus; both were unknown until December 2019, when the first outbreak exploded in Wuhan (China). Today, COVID-19 has become a pandemic that has affected many countries in the world [9].

### *1.2 Impact of the SARS-COV-2 Virus on the word*

The statistics classify the countries affected by COVID-19 (SARS-CoV-2) based on the number of confirmed cases as of February 23rd, 2021. China, where the outbreak is believed to have originated, has proved just over 89,800 cases of COVID-19. However, the ranking is led by the United States, with around 28.8 million confirmed positive cases. As for the Old Continent, the 47 European countries have registered infected citizens, highlighting Spain, Russia, the United Kingdom, Italy, and Germany. The first suspected cases were officially announced by the World Health Organization on December 31st, 2019, after the appearance of this new coronavirus about three weeks earlier in one of the markets of the Chinese region of Wuhan, from where it acquired its name [10].

Latin America and the Caribbean are geopolitical regions that include more than 40 countries and territories from Mexico to Cape Horn. It can be subdivided into four areas based on their geographical location: South America, Central America, the Caribbean, and Mexico [11]. Latin America has become the region hardest hit by the COVID-19 pandemic. The economic crisis generated by the outbreak comes with limited progress on social indicators. Unemployment rates have risen dramatically across the region [12]. As of February 22nd, 2021, 20,747,458 cases of COVID-19 have been registered in Latin America and the Caribbean. Brazil is most affected by the pandemic in the region, with around 10.2 million confirmed cases. Colombia is in second place, with more than 2.2 million infected. Mexico, for its part, has registered a total of 2,041,380 patients. Among the countries most affected by the new type of coronavirus in Latin America are also Argentina, Peru, Chile, and Ecuador [13].

The Mexican Republic is divided into 32 states and is home to 126,014,024 people [14]. On February 23rd, 2021, the Ministry of Health presented its daily technical report on the progress of the pandemic caused by the SARS-CoV-2 virus in Mexico, in which it detailed the number of new infections of Covid-19 and the number of deaths is (1) number of confirmed positive cases per day in Mexico: 8,634; (2) number of confirmed deaths per day in Mexico by Covid-19: 1,273; (3) total number of confirmed positive cases in Mexico: 2,052,266, and (4) total number of confirmed deaths in Mexico by Covid-19: 181,809 [15].

The Covid-19 pandemic is not only an unprecedented health emergency, but it is an economic and social emergency, the magnitude and consequences of which are having a dramatic impact on the most vulnerable families. According to recent ECLAC projections, the 5.3% fall in GDP and the 3.4% increase in unemployment in Latin America will generate an increase in poverty by 4.4 percentage points (reaching 34.7% of the regional population), and extreme poverty of 2.6 points (reaching 13.5% of the regional population) and inequality.

Measures must be taken to mitigate the economic impact that the Covid-19 crisis is causing on families and avoid an increase in economic precariousness and vulnerability. International experience shows that, in times of crisis, it is essential that countries have strengthened social protection systems that provide adequate and timely responses to families through economic support measures that reduce the adverse effects on employment and that guarantee access to essential benefits [16].

According to the above, social enterprises play a critical role in supplying necessities to vulnerable people. Said companies are a model of innovative companies, which encourages creating these to help solve a social problem and not maximize profits [17]. The objective of this model is none other than to face the most pressing needs of humanity, especially poverty. Every social enterprise creates employment good working conditions and, naturally, addresses a specific social pathology, such as the lack of schools, health care, and food.

The present research solves a vehicular routing problem with capacity (CVRP) in a Warehouse that supplies stores located in localities belonging to the Las Montañas region of the State of Veracruz. The warehouse presents problems of increase in logistics costs due to a rise in the number of points to supply (distance travelled) and the lack of vehicles for delivery on a new route due to a full delivery schedule. That is why, through the application of the CVRP model, a set of routes are proposed that allow supply to localities located within the region called Las Montañas of the State of Veracruz and at the same time reduce the distances travelled for the delivery of products. by the route and therefore a decrease in the logistics costs

of the warehouse, proposing a new aggregate delivery program.

The second section presents the research through which the authors solve the problem of delivery in different parts of the world. Section 3 sets out the contextual framework of the study, which is located in one of the regions of the State of Veracruz, Mexico, called the High Mountains. It presents its municipalities a level of marginalization from medium to very high, a situation that has brought with it the installation of social enterprises, which due to the penetration of the COVID-19 disease in the region, have had to establish strategies for more significant support to the population. In section 4, the methodology to follow is shown, for programming the Capacity Vehicle Routing Problem (CVRP) and the supply of data to it as a solution to the problem of increasing routes of a social warehouse; Section 5 presents the results obtained and their discussion, followed by the authors' conclusions and the bibliography that supports the research.

## 2 Literature review

Relevant investigations have been carried out on the subject of transportation, among which we can mention the researchers [18], Méndez et al., the present authors' results referring to research carried out on CVRP using commercial software. The first procedure considers alternative restrictions that grow polynomially with nodes and solve the new problem. For the second approach, using a metaheuristic such as the Memetic Algorithms, based on evolutionary computing techniques, focuses primarily on applying to a real problem of infectious waste collection in the city of Rio Cuarto, offering an optimal result based on the two options presented.

In the same area, the researchers [19], Suarez-Chilma, et al. address a vehicle routing problem in mountain cities. The main factor is the topography of the terrain in the mountains. The authors propose a multiobjective mathematical model, which determines a route with an adequate balance between the cost of transport and the environmental impact, concluding with the presentation of the model in a retail distribution channel of an Andean city in Colombia in mountain settings, giving as an answer that the shortest route is not necessarily the best.

Continuing with the investigations, the one carried out by [20], Rocha et al. shows a bibliographic review about the history, typologies, and methods of solving the Vehicle Routing Problem (VRP). Then, explaining the different variations that have arisen, referring to the other primary categories of VRP, the proposed solution methods, and their trends, emphasizing the main methods such as CVRP, concluding with their significant impact on solutions to problems of the big industries.

In Cavallin et al. [21], the research presents the problem of vehicle routing with capacity restrictions (CVRP) to a case of reverse logistics that deals with the collection of recyclable material in an urban environment. To find optimal solutions in reduced instances for this, they establish analytical examples, where the variation of the optimal solutions is shown as a function of the weights used for each objective. Likewise, the researchers [22], Prado-Torres et al. propose solutions close to the optimum concerning vehicle routing problems due to their high complexity according to the number of nodes or clients to minimize operating costs or maximize the number of clients served. With an emphasis on applying Clarke Wright's heuristic routing method, the implemented techniques reveal a lower cost routing to each client.

Researchers [23], Xiao et al. present a study on fuel consumption, which adds to the problem of generating routes for trained vehicles (CVRP) to expand traditional CVRP studies to minimize fuel consumption. They were applying a mathematical optimization model to characterize the FCR considering CVRP (FCVRP) formally. The experiments show a reduction in fuel consumption of 5% on average. Likewise, the researchers [24], González-Hernández et al. present a work based on the problem of vehicle routing trained and the location of a distribution center for a group of clients, the same problem that is solved with two software: Octave and Matlab to make a comparison of speed and reliability of the solution.

Vehicle Routing Problems are a class of problems that study the distribution of goods or services between a warehouse and end-users (customers). The goal of classic VRP is to allow multiple customers to create the lowest possible routes at the lowest cost, starting at the depot and ending [25].

## 3 Conceptual framework

### *3.1 Description of the study area*

The State of Veracruz is located in the Mexican Republic see Figure 2; it is located along the Gulf of Mexico. It is a coastal strip of 720 km of coastline, representing 6.5% of the national total. With an area of 72,815 km$^2$, it is the eleventh State of the Mexican Republic in extension and represents 3.7% of the total surface of Mexico [26].

*Figure 2 Location of the State of Veracruz [27-28]*

Monitoring the panorama of the coronavirus (COVID-19), the Ministry of Health (SS) reports in its emission 316

dated February 8th, 2021, that, in the State of Veracruz, 104,124 cases of contagion have been studied of Covid-19, of which 40,851 were negative. The number of confirmed cumulative cases is 52,355 (+113 new) in 209 municipalities. Forty-one thousand nine hundred ninety-two people recovered outpatient and/or in hospitals, although 3,010 still require medical surveillance. Regarding deaths, there is a record of 7,353 (+ 25 new) in 194 districts and 10,918 suspected of illness [29].

Marginalization is a multidimensional and structural phenomenon originated, ultimately, by the economic production model expressed in the unequal distribution of progress, in the productive structure, and the exclusion of various social groups, both from the process and from the benefits of the developing. Marginalization is associated with the lack of social opportunities and the absence of capacities to acquire or generate them, but also with deprivation and inaccessibility of goods and services essential for well-being. The marginalization index is a summary measure of nine socioeconomic indicators that make it possible to measure forms of social exclusion and that are lag or deficit variables. They indicate the relative level of deprivation in which necessary contingencies of the population are subsumed. Marginalization is divided from its concept to obtaining the index it represents into 1. Education: illiteracy and population without completed primary school; 2. Housing: inhabited private homes without drainage or sanitary service, inhabited private homes without electricity, inhabited private homes without piped water, inhabited private homes with some level of overcrowding, and inhabited private dwellings with dirt floors; 3. Population distribution: localities with less than 5,000 inhabitants, and 4. Monetary income: the employed population that receives up to two minimum wages. The entities are stratified into five groups to identify geographic nuclei with similar marginalization, attributing to each one a degree of marginalization among the five, which are: deficient, low, medium, high, and very high [30,31].

The state of Veracruz is made up of 10 regions: (1) Huasteca Alta; (2) Huasteca Baja; (3) Totonaca; (4) Nautla; (5) Capital; (6) Sotavento; (7) Las Montañas; (8) Papaloapan; (9) Los Tuxtlas, and (10) Olmeca [32,33]. In Table 1, the region and the degree of marginalization with respect to the number of municipalities that make up each is observed:

*Table 1 Degree of marginalization by region and number of municipalities in the State of Veracruz [34]*

| No. | Region | No. Of municipalities | Very high | High | Medium | % very high | % high | % medium |
|---|---|---|---|---|---|---|---|---|
| 1 | Huasteca Alta | 15 | 1 | 5 | 9 | 6.67% | 33% | 60% |
| 2 | Huasteca Low | 18 | 7 | 9 | 2 | 38.89% | 50% | 11% |
| 3 | Totonaca | 15 | 6 | 5 | 4 | 40.00% | 33% | 27% |
| 4 | Del Nautla | 11 | 0 | 6 | 5 | 0.00% | 55% | 45% |
| 5 | Capital | 33 | 4 | 11 | 18 | 12.12% | 33% | 55% |
| 6 | Leeward | 12 | 0 | 0 | 12 | 0.00% | 0% | 100% |
| 7 | Las Montañas | 57 | 17 | 17 | 23 | 29.82% | 30% | 40% |
| 8 | Papaloapan | 22 | 1 | 2 | 19 | 4.55% | 9% | 86% |
| 9 | Los Tuxtlas | 4 | 0 | 1 | 3 | 0.00% | 25% | 75% |
| 10 | Olmeca | 25 | 2 | 5 | 18 | 8.00% | 20% | 72% |

This research will focus on the region of Las Montañas see Figure 3, which is located in the central area of the State of Veracruz, with an area of 6.053 km$^2$ representing 8.4% of the state territory. Therefore, it occupies the fifth place by its territorial extension. With 1,4 million inhabitants, it covers 18,3% of the state population, which makes it the most populated in the State. The territory of this region comprises 57 municipalities located at the confluence of the Sierra Madre del Sur, the Neovolcanic Axis, and the coastal plain of the South Gulf. The Mountains make up the most significant number of municipalities among the State's ten regions. Due to their territorial size, Tezonapa, Paso del Macho, Comapa, Zongolica, Tlatetela, Carrillo Puerto, Omealca, and Huatusco stand out, representing 41% of the region. Similarly, the National Population Council (CONAPO) lists 17 of the 57 municipalities in the area as very highly marginalized and 17 as highly marginalized [35].


*Figure 3. Region of Las Montañas [36].*

Because of the above, within the region, there is the presence of so-called -social enterprises that allow a continuous supply of necessities to low-income people and whose localities to be supplied are challenging to access. In this document, a study is carried out of one of these companies, located in Las Montañas region, for confidentiality reasons will be called warehouse from now.

The warehouse is a company dedicated to the wholesale grocery trade. Among the activities carried out are the management of orders, reception, review, and authorization of entry of products, planning and control of inventories, and the planning, scheduling, and consolidating deliveries to 151 stores located in different regional communities.

Within the Montañas region, the COVID 19 pandemic has caused 3,402 suspected cases, 24,690 confirmed cases, and 2,734 deaths to date on March 9th, 2021 [29].

### *3.2 Problem statement*

Because of the presence of the Covid-19 in the region, the program delivery was modified to supply additional areas. It creates a new delivery program with which new delivery routes are generated.

The initial delivery program Warehouse's product supply contemplates making deliveries six days a week every day with approximately 26 points through 5 vehicle units (5 different routes). However, due to the SARS-CoV-2 virus in the region, 11 new delivery points are added, thus giving an aggregate delivery schedule that adds the scheduled and added stores. Which generates an increase in distances travelled, logistics costs, and quantity of products to supply.

Table 2 shows the initial delivery program; in the first column, the day of delivery is reflected, and in the second, the destinations to be supplied on that day. While in Table 3, the areas added to the program are shown, having in the initial program a total of 3,220.80 km travelled, which, added with the new supply points, generate a total of 3,732.80 km.

*Table 2. Schedule of initial daily deliveries of the warehouse*

| No. day | Locations to supply |
|---|---|
| 1 | Xopilapa–Acatitla–Apipitzactitla–Tehuipango-Tzompoalecca Dos–Acuayucan-Tepecuitlapa–Tlalchichilco–Axoxohuilco–Tepeica–Tepepa-Teapa Ocomtempa–Tepetlampa-Tzompoalecca 1–Tlacojtepec-Loma Bonita-Barrio Cuarto-Buena Vista–Mixtlantlakpak–Huapango–Opotzinga–Cuauyolotitla-Ojo de Agua–Zacatlaixco–Xonacayolca |
| 2 | Choapa–Totolacatla–Tezizapa-San Sebastián–Poxcautla–Independencia-Exohda Tlazololapan–Tlecuaxco–Coxitlitla–Tlanecpaquila–Xochitla-Palenque Cotlaixco–Coeztapotitla-El Campanario–Cotlaixco-Real del Monte-Emiliano Zapata–Teotzacualco- Ayojapa Dos–Xalxocotla–Ocotzocotla-San Francisco Atitla–Ocotepec–Cortezca-La Pila-Nexca Naranjal |
| 3 | Mixtla de Altamirano–Ayahululco-Coapa Pinopa–Xochtiitla-Barrio Segundo–Xochitla–Acontla–Tepetitlanapa–Apoxteca–Texhuacán–Acahualco–Tlalca-San Isidro (Apanga)–Cuautlajapa-Tonalixco Grande–Xala–Tecolotla–Atzingo-Tlaxcantla (Ocom)-Tlacuitlapa Chico–Palulca–Ahuacatla-Barrio Tercero-Ocotempa (B 1ª)–Coximalco -Zacatilica |
| 4 | Tlacuilolteca-Cortínez-Zomajapa-Xochiaca-Loma de Dolores-Amatepec-Nacaxtla-Comalapa-Linda Estrella-La Palma-Cuahixtlahuac- Palama Sola-Acuapa-Colonia Modelo-Macuilca-El Porvenir-Comalapa II-Tlacuiloltecac Grande-Zacatal Chico-Piedras Blancas-Cerro Chico-La Palma-Citlalapa-Huixtla-Azcuahutlamanca-Quetzaltototl |
| 5 | Los Reyes-Atlanca-Atlahuilco-Barrio San Pedro-Ahuatepec-Totolinga-Oxitotitla-Zihuateo-Llano Grande-Tlaquetzaltitla-Pitzcautla-Zincalco-Atlajco Cruz-Mitepecte-Tequila-Tequila Green–Tenexcalco–Ocotempa-Eyitepec-Cuacaballo-Abaloma Cautla–Cubanicuilco-Zacatlamanca |
| 6 | Tepepa I-Nepopualco-Moxala-Palapa-Xochiotepec–Ixpaluca-Huaxtcatl Uno-Xonamanca-Zacatal Grande-Atexoxocuapa-Ejuitepec-Loma Grande-Ixmaloyuca-Tlaixco-Tonacalco-Puente Porras-Laguna Chica-Chininiapan-Tecoxco-La Quinta-Laguna-Ixpaluca-Atempa-Ixcohuapa |
| | Total kilometres: 3,977.50 |

*Table 3. Zones added from the SARS-CoV2 virus*

| Localities added |
|---|
| El Porvenir-Totolacatla-Los Reyes-Xochiojca-Tepetlampa-Tehuipango-Mixtla de Altamirano-Ejuitepec-Moxala-Tonalixco Grande-Ixpaluca |

## 4 Methodology

Figure 4 presents the methodology used for the investigation, which begins with the compilation of the necessary information to feed the programmed system from the logistic model, followed by the feeding of said system, to later interpret the results.

**PROGRAM FOR THE DELIVERY OF BASIC NECESSITIES OF A WAREHOUSE DURING THE COVID-19 PANDEMIC**

Erika Barojas-Payán; Elsa-Nereyda de la Cruz-Zopiyactle; Diana Sánchez-Partida; Ignacio Sánchez-Bazán; Victorino Juárez-Rivera

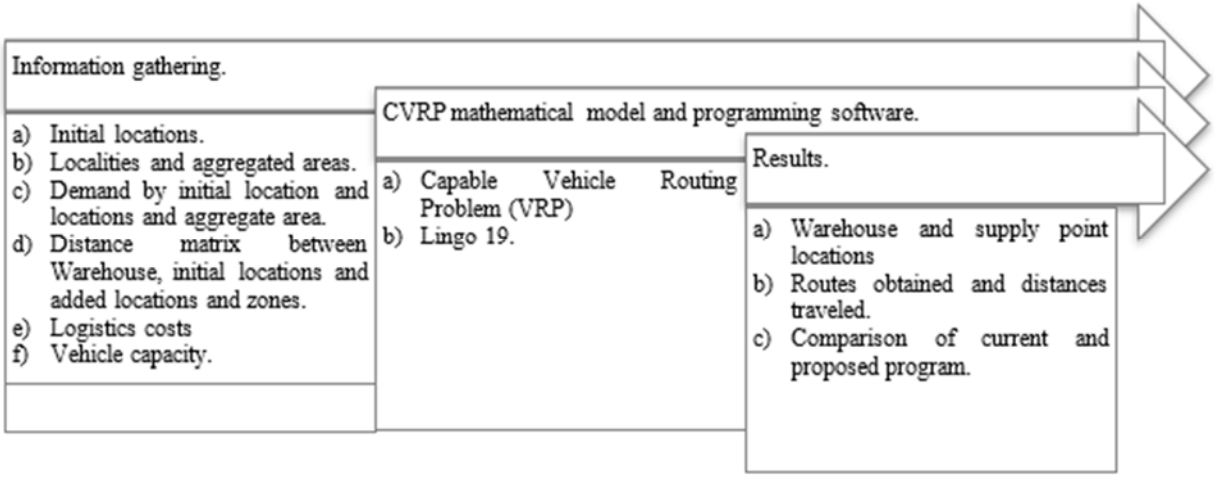



*Figure 4 Research methodology*

### *4.1 Information gathering*

The database is created that feeds the system from government pages, with information on:

- *Initial locations supplied within the initial Warehouse delivery program*, the number of headquarters locations for a store provided by the warehouse within its initial program add up to 151 sites.
- *Localities and areas in need of supply from the appearance of the SARS-CoV2 coronavirus*, from the presence in the region of the High Mountains of the disease called COVID-19, new 11 supply areas have added a total of 162 new towns and areas to be supplied.
- *Demands*, from the delivery histories of the community stores of the warehouse, the demands are obtained in weekly kilos for each community. Distance matrix between localities and areas to be supplied, a matrix of distances of the localities of initial stores and aggregates is created with the support of the Google Maps® software.
- *Matrix of distances between warehouse*, initial locations, and added locations and areas, a matrix of distances is created between warehouse and locations and areas to be supplied, which will feed the system to obtain delivery routes.
- *Vehicle capacity*, a fixed capacity of approximately 12000 kg, is maintained based on the model and characteristics.

### *4.2 Mathematical model of Vehicle Routing with Capacity and programming software*

A mathematical model for a CVRP aims to design the lowest cost distribution route for a fleet of vehicles located in a distribution center that has to visit a set of customers (nodes). The vehicles belong to a fleet and are located in the distribution center and have a capacity. Each client is located in a geographic region (node) and has a demand. Two components generate distribution costs: a fixed cost associated with each truck required for the planning horizon and a variable cost per unit of distance travelled. Each route starts from the warehouse and ends there, and the vehicle's capacity should not be overloaded [37-41].

According to Kir et al. [41], the general model for a CVRP is:

$$Min\ Z = \sum_{i=1}^{N} \sum_{j=1, j\neq i}^{N} c_{ij} x_{ij} \quad (1)$$

Subject to:

$$\sum_{l=2, k\neq 1}^{N} x_{lk} + x_{1k} = 1 \quad \forall k \quad (2)$$

$$\sum_{l=2, k\neq 1}^{N} x_{kl} + x_{k1} = 1 \quad \forall k \quad (3)$$

$$\sum_{k=2}^{N} x_{1k} \leq V \quad (4)$$

$$\sum_{j=1, j\neq i}^{N} x_{ij} = \sum_{j=1, j\neq i}^{N} x_{ji} \quad \forall k \quad (5)$$

$$x_{kk} = 0 \quad \forall k \quad (6)$$

$$x_{lk} + x_{kl} = 1 \quad \forall k, l_{k\neq 1} \quad (7)$$

$$\sum_{j=1, j\neq i}^{N} F_{ij} = \sum_{j=1, j\neq i}^{N} F_{ji} + d_i \quad \forall k \quad (8)$$

$$d_i x_{ij} \leq + f_{ij} \quad \forall i, j_{i\neq j} \quad (9)$$

$$F_{ij} \leq (A - d_j) x_{ij} \quad \forall i, j_{i\neq j} \quad (10)$$

Where
*A*: Capacity of each vehicle.
*V*: Maximum number of vehicles.
$F_{ij}$: Product flow from node a.
*Z*: Total cost of transportation.
$d_i$: Demand at the node.
$c_{ij}$: Cost of travelling the distance from the node to node.
*N*: Number of nodes.

*Equation (1)* represents the objective function, which minimizes the total costs of all arcs route obtained solution. *Equations (2)* and *(3)* indicate precisely one output node i. *Equation (4)* provides not exceed the total number of vehicles. *Equation (5)* provides a balance between incoming and outgoing arcs at a given node. *Equation (6)* eliminates the flow of node i to node i. *Equation (7)* is a trivial restriction removal sub-tour. *Equations (8), (9),* and *(10)* provide a balance between the total input and output flow in the node.

*Programming software.*

The LINGO 19.0 software was used to carry out the CVRP programming, allowing building and solving models easily, quickly, and efficiently [42].

## 5 Result and discussion

With 22 routes obtained distributed over five days a week, a 26% decrease in the routes was achieved. Tables 4 and 5 show five delivery routes, the kilometres travelled, and the kilos of products supplied by said routes.

*Table 4 Route 1 and Route 2*

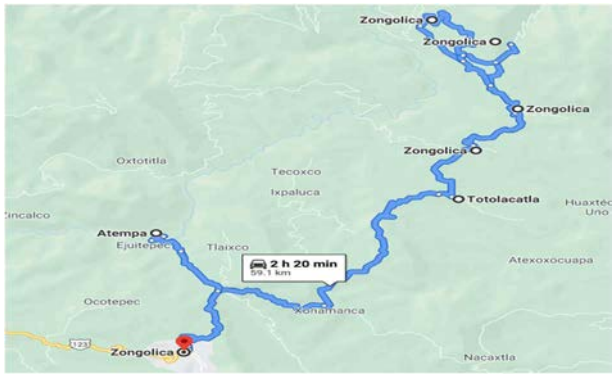
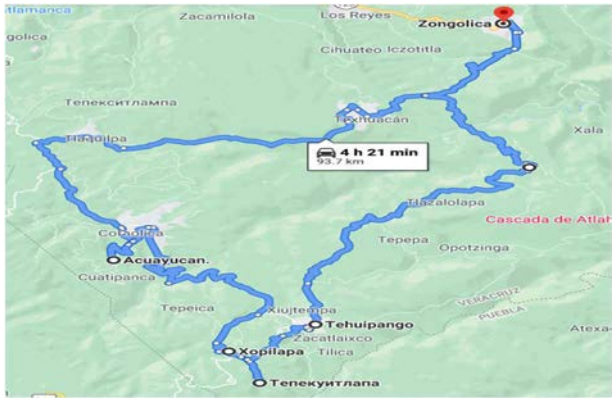
<table>
<tr><td rowspan="3">Route 1</td><td colspan="4">Destination</td><td>Km</td><td>Kg.</td></tr>
<tr><td>Totolacatla</td><td>Totolacatla</td><td>San Sebastian</td><td>Tlanecpaquila</td><td rowspan="2">59.1</td><td rowspan="2">10,700</td></tr>
<tr><td colspan="2">Coeztapotitla</td><td colspan="2">Cotlaixco</td><td>Atempa</td></tr>
<tr><td></td><td colspan="6"> 
</td></tr>
<tr><td rowspan="3">Route 2</td><td colspan="4">Destination</td><td>Km</td><td>Kg.</td></tr>
<tr><td>Acuayucan</td><td>Xopilapa</td><td>Tepecuitlapa</td><td>Tzompoalecca 1</td><td rowspan="2">93.7</td><td rowspan="2">11,300</td></tr>
<tr><td>Tlacojtepec</td><td>Coximalco</td><td>Axoxohuilco</td><td>Mixtla Altamirano</td></tr>
<tr><td></td><td colspan="6"> 
</td></tr>
</table>

*Table 5 Route 3, Route 4, and Route 5*

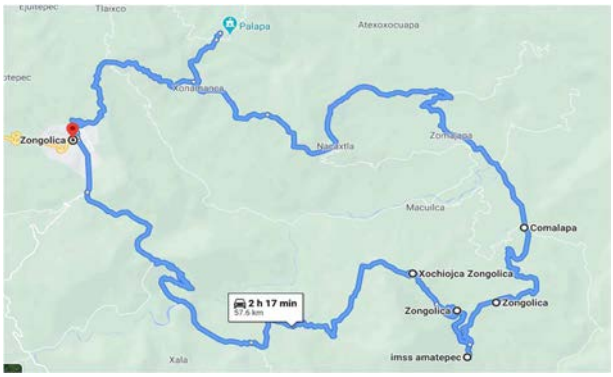
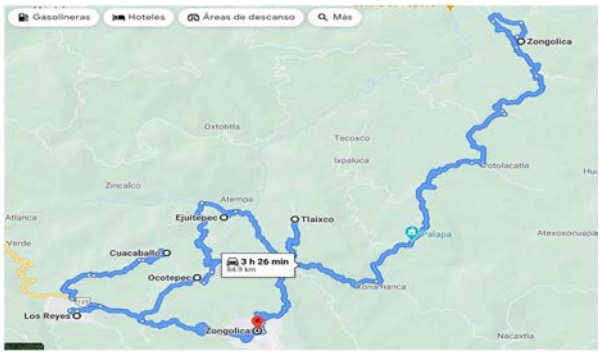
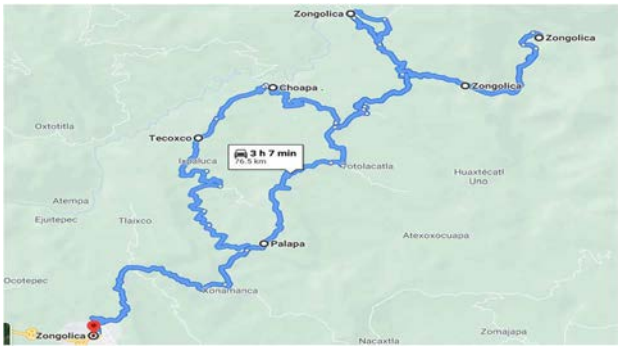
| | | | | | | |
|---|---|---|---|---|---|---|
| Route 3 | Destinations | | | | Km | Kg. |
| | Xochiojca | Amatepec | La Palma | El porvenir | 57.6 | 10,300 |
| | El Porvenir | | Comalapa | Zongolica | | |
| |  | | | | | |
| Route 4 | Los Reyes | Los Reyes | Cuacaballo | Ocotepec | 84.9 | 12,000 |
| | Ejuitepec | Ejuitepec | Emiliano Zapata | Tlaixco | | |
| |  | | | | | |
| Route 5 | Palapa | Zacatal Grande | Tecoxco | Choapa | 76.5 | 9,500 |
| | Independencia | La pila | | Real del Monte | | |
| |  | | | | | |

Table 6 compares the results obtained between the initial delivery program and the aggregate delivery program. It should be remembered that, within the first, there are a total of 151 supply points, distributed in 5 different routes each day during six days of the week, while the second has a total of 162 delivery points spread over a range of 4 and 5 different routes every day for five days of the week.

More specifically, column one presents the day of the week on which the products are delivered to the points

already set by the Warehouse; Columns two, three, and four refer to how the deliveries were carried out before running the model, that is, the initial program, while columns five, six and seven present the routes proposed through the application. CVRP and the increase in routes due to the pandemic, that is, the added program. These columns are described in detail below: (a) Column 2 and 5: show the number of routes to which the supply points for that day correspond; (b) Column 3 and 6: refer to the distance travelled to supply the points contained in the routes, and (c) Column 4 and 7: show the number of kilograms of product to be delivered, it should be mentioned that the capacity of delivery is measured in kilos. The last row or row of totals shows the sums of the columns of "total distance" and "total demand" to make a comparison and obtain a percentage of improvement. There is a decrease of 23.61% in the distance travelled, even with an 8% increase in the number of recipients and just over 19.84% in demand. Therefore, an improvement in the aggregate delivery program is established through a decrease in distance and a decrease in the company's logistics costs, and greater customer satisfaction.

*Table 6 Comparison of distance and delivered demand*

| Comparison | | Initial program | | Aggregate program | | |
|---|---|---|---|---|---|---|
| Day | Routes | Total distance (km) | Total demand (kg) | Routes to travel | Total distance (km) | Total demand (kg) |
| 1 | 1,2,3,4,5 | 647.40 | 36,300 | 1, 2,3,4,5 | 433.15 | 57.800 |
| 2 | 6,7,8,9,10 | 713.50 | 41,200 | 6,7,8,9,10 | 534.55 | 59,750 |
| 3 | 11,12,13,14,15 | 539.40 | 43,400 | 11,12,13, 14 | 472.20 | 59,800 |
| 4 | 16,17,18,19,20 | 387.00 | 44,200 | 15,16,17,18 | 493.60 | 60,300 |
| 5 | 21,22,23,24,25 | 553.10 | 42,350 | 19,20,21,22 | 526.90 | 57,900 |
| 6 | 25,27, 28,29,30 | 380.40 | 39,100 | | | |
| Totals | | 3,220.80 | 246,550 | | 2,460.40 | 295,550 |

## 6 Conclusions

The decrease in logistics costs is one of the challenges currently facing organizations, even more so, if they are providers of areas with a certain degree of marginalization, that is why the purpose of the research presented is to decrease the distances travelled by a Warehouse located in the central area of the State of Veracruz, Mexico. The initial delivery program supplies 151 destinations, but due to the virus in the region, 11 goals were increased; with the delivery schedule and the five vehicles that the company has, the supply was complicated.

The importance of this case study lies in the fact that, although the social activity is carried out all over the world, and there are many case studies carried out in private companies, in the social sphere, it is lacking. Hence, being of vital importance a reduction of costs, independently in the area of the organization in which it is present, which will allow more significant support to people who for any reason need it.

Based on the application of the CVRP, a redesign of delivery routes is carried out weekly. Proposing a new weekly delivery schedule added with 11 destinations and 22 routes spread throughout the week, which resulted in a decrease in the distance travelled, of 23.61% even with an 8% increase in the number of recipients and a little more than 19.84% in demand, thus establishing an improvement in the aggregate program, through a decrease in distance and therefore a reduction in the company's logistics costs and greater customer satisfaction.

As can be seen, the percentage of decrease in distance traveled is essential; this is because the distribution strategy is not carried out empirically. The CVRP programming facilitates the grouping of nearby points to supply products without leaving aside from the homogeneous vehicle capacity.

The future works are the application of a vehicular routing with time windows that ensure the vehicles accomplish during a mixed working day and with a heterogeneous fleet of vehicles due to the characteristics of the geographical area in which the products are delivered. On the other hand, establish inventory levels for each product according to their demand.

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RISK ASSESSMENT AND RISK MITIGATION IN A SUSTAINABLE TUNA SUPPLY CHAIN
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# RISK ASSESSMENT AND RISK MITIGATION IN A SUSTAINABLE TUNA SUPPLY CHAIN

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***Keywords:*** sustainable, tuna, risk, House of Risk, Aggregate Risk Priority.
***Abstract:*** This study aimed to conduct a risk assessment and minimize the risk of sustainable tuna supply chains in Ambon. The House of Risk (HOR) approach was utilized in this study to identify risk occurrences and risk agents in three aspects of sustainability. The study results identified 15 risk events and 26 risk agents consisting of four risk events and five risk agents on the environmental dimension, five risk events and eleven risk agents on the social dimension, six risk events, and ten risk agents on the economic dimension. The HOR phase I shows that the risk agent with the highest Aggregat Risk Priority (ARP) value is the lack of environmental management system standards (A4), and the risk agent with the lowest ARP value is inhumane treatment/harassment (A12). Based on the Pareto principle, 7 Risk Agents will be prioritized to be handled according to the highest ARP value, such as lack of environmental management system standards (4170), lack of quality control inspection (3790), lack of maintenance management (3346), lack of quality control from suppliers (3000), lack of enthusiasm for work (2984), decreased level of discipline (2832). The internal communication system of the company is poor (2538). Furthermore, 15 mitigating techniques are proposed. Twelve mitigation technique steps are chosen from 15 recommended solutions to prevent the causes of risk based on the effectiveness to difficulty (ETD) value from HOR phase II.

## 1 Introduction

Currently, the supply chain management system has developed not only by looking at the process of flow of goods, information, and money from upstream to downstream [1,2], but has now developed by looking at environmental, social, and economic aspects [3-5], even discusses the institutional aspects [6] in achieving company goals. This is what is better known as a sustainable supply chain [7].

The basic concept of sustainable supply chain management refers to the definition of sustainable development from the Brundtland Report [8], which includes three aspects of sustainability, namely economic, social and environmental aspects commonly known as the triple bottom line [9-11] which are interrelated with each other. The goal is that the managed supply chain can meet consumer desires (responsiveness) in terms of quality, quantity, delivery time, environmentally friendly, and sensitivity to social conditions [12-16].

Sustainability issues have become an important issue in recent times. One of the critical issues in sustainable supply chain management is managing uncertainty and risk [17]. In an uncertain business environment, the risk is always present. Risk is the chance of occurrence of something undesirable or the uncertainty of future events. Risk can not be avoided, but the risk can be minimized its impact on the overall supply chain performance with proper risk management [18-20].

Risk management in supply chain management is not much different from risk management in general, meaning that the basic concepts in risk management can be applied as usual, starting with understanding the risk management cycle [21]. Risk management is a planned and structured process that aims to help make the right decisions to identify, classify, measure risks, and then manage and control them [22].

Research on supply chain risk management (SCRM) is mainly done using several methods. [23-25] Identifying

supply chain risks using the Failure Mode Effect Analysis (FMEA) method based on occurrence, severity, and detection, which results in a Risk Priority Number (RPN), which is combined with several multi-criteria decision-making methods to see essential risk factors for mitigation [10]. [20,26] uses the Supply Chain Operation Reference (SCOR) technique to identify supply chain processes like Plan, Source, Make, Deliver, and Return risks. The House of Risk (HOR) technique is then used to assess the identified risks. [27] developed the HOR technique by combining the FMEA and the House of Quality (HOQ) models in the Quality Function Deployment (QFD). The advantages of this method are in the framework that can cover the whole process of risk management, and this method focuses on preventive actions determining the main risk agents and the priority of preventive actions.

Many studies have been conducted in supply chain risk management, but only a few focused on sustainable supply chain risk control for tuna fish products. Several studies developed a multi-stakeholder HOR technique for risk control of tuna commodities in North Sulawesi and East Java [28,29]. Others studied a risk mapping of the tuna supply chain in the Eastern Indian Ocean [30] and risk control of tuna commodities during the pandemic of Covid-19 in Ambon city [20]. Those research only identify risk factors on economic aspect and does not provide an analysis about sustainabilities aspects for tuna. The problem is what mitigation strategies must be carried out to prevent the risk of tuna's sustainable supply chain risks in Ambon City.

Issues about sustainability are exciting themes in terms of scientific studies and a business perspective [31]. Therefore, this study has a novelty in sustainable supply chain risk management (SSCRM) for tuna commodities. The purpose of this study is to map the most dominant risk priorities according to the Aggregate Risk Potential (ARP) value and to formulate a risk mitigation strategy for the company.

With the importance of sustainable supply chain risk management (SSCRM), companies can plan, implement, and control the supply chain management process in a sustainable manner so that it does not interfere with the supply chain and the sustainability of the fishing industry.

## 2 Methodology

Research methodology is a systematic step used to achieve the desired goal. This study discusses risk control in the sustainable supply chain of tuna fish products at companies in Ambon. This research refers to the stages in risk management, as shown in Figure 1.

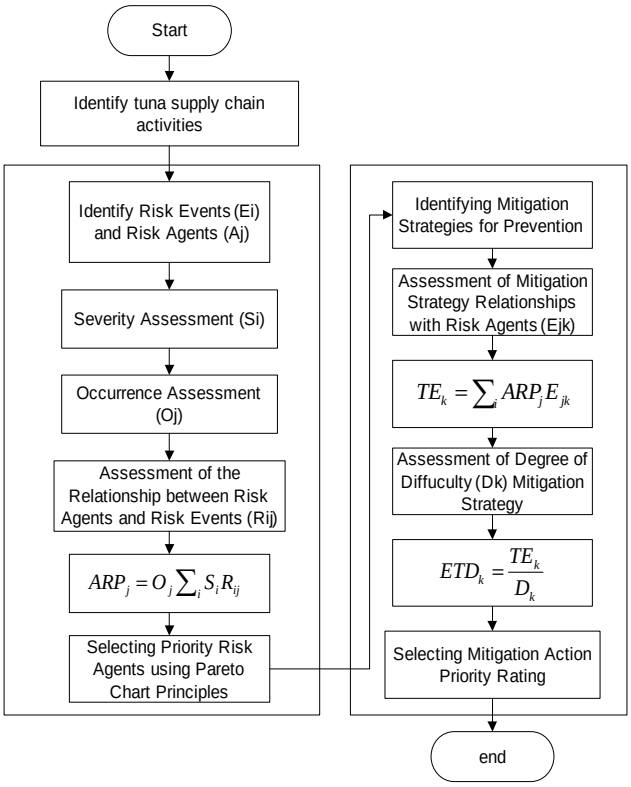


*Figure 1 The steps of risk assessment of the sustainable tuna supply chain*

1. Conduct initial mapping of the tuna supply chain in Ambon city based on interviews and literature studies from previous research.
2. Identify risk events ($E_i$) and risk agents ($A_j$) for the three dimensions of sustainability, namely the environmental, social, and economic dimensions through the collection of literature studies, brainstorming, and interviews with related experts such as the environmental service, academics, managers of fishing companies and fishers who which will then be used in the preparation of the assessment questionnaire as well as the relationship of causes and risk events that will be input to the House of Risk phase I model [27] in table 1.

*Table 1 Model HOR Phase I*

| Sustainable Dimension | Risk Event ($E_i$) | Risk Agent (Aj) | | | | Severity of Risk Event ($S_i$) |
|---|---|---|---|---|---|---|
| | | $A_1$ | $A_2$ | … | $A_{n+1}$ | |
| Environment | $E_1$ | $R_{11}$ | $R_{12}$ | | $R_{1(n+1)}$ | $S_1$ |
| Social | $E_2$ | $R_{21}$ | $R_{22}$ | | | $S_2$ |
| Economic | $E_3$ | $R_{31}$ | | | | $S_3$ |
| **Occurance of Agent j ($O_j$)** | | $O_1$ | $O_2$ | … | $O_{n+1}$ | |
| **Agregat Risk Potential ($ARP_j$)** | | $ARP_1$ | $ARP_2$ | … | $ARP_{n+1}$ | |
| **Priority Rank of Agent j** | | | | | | |

3. Conduct a severity assessment ($S_i$) with a value range of 1-10, where 10 represents the extreme impact shown in table 2.

*Table 2 Severity Rating*

| Score | Effect | Score | Effect |
|---|---|---|---|
| 1 | None | 6 | Significant |
| 2 | Very Minor | 7 | Major |
| 3 | Minor | 8 | Extreme |
| 4 | Low | 9 | Serious |
| 5 | Moderate | 10 | Hazardous |

4. Conduct an Occurrence ($O_j$) assessment of each risk cause with a scale of 1-10, shown in table 3.

*Table 3 Occurrence Rating*

| Score | Occurrence rate | Score | Occurrence rate |
|---|---|---|---|
| 1 | Almost never occurred | 6 | Rather Hight |
| 2 | Slight | 7 | Sufficient hight |
| 3 | Low | 8 | Hight |
| 4 | Relatively Low | 9 | Very Hight |
| 5 | Moderate | 10 | Almost certain to happen |

5. On a scale of 0 to 1, 3, 9, assess the relationship between the risk agent and the risk events ($R_{ij}$), with 0 indicating no relation and 1, 3, 9 indicating a weak, moderate, and strong relationship.
6. Calculate the $ARP_j$ value using equation 1. The $ARP_j$ value is obtained from the product of the occurrence value ($O_j$) and the aggregate severity ($S_i$) and risk event ($R_{ij}$) values.

$$ARP_j = O_j \Sigma_i S_i R_{ij} \quad (1)$$

7. Determine the ranking of priority risk causes based on the highest to the lowest ARP values.
8. Selecting the priority risk causes, using Pareto analysis of $ARP_j$ for treatment in HOR phase II in table 4 below.

*Table 4 Model HOR Phase II*

| Priority Risk ($A_j$) | Preventive Action ($PA_k$) | | | | $ARP_j$ |
|---|---|---|---|---|---|
| | $PA_1$ | $PA_2$ | …. | $PA_{(n+1)}$ | |
| $A_1$ | $E_{11}$ | | | | $ARP_1$ |
| $A_2$ | | | | | $ARP_2$ |
| $A_3$ | | | | | $ARP_3$ |
| $A_{(n+1)}$ | | | | | $ARP_{n+1}$ |
| Total Effectifness ($TE_k$) | $TE_1$ | $TE_2$ | … | $TE_{(n+1)}$ | |
| Degree of Difficulty (Dk) | $D_1$ | $D_2$ | … | $D_{(n+1)}$ | |
| Effectiveness to Difficulty (ETDk) | $ETD_1$ | $ETD_2$ | … | $ETD_{(n+1)}$ | |
| Rank of Priority | $R_1$ | $R_2$ | … | $R_{(n+1)}$ | |

9. Identify the relevant preventive actions ($PA_k$) to prevent or reduce the impact of risks..
10. On a scale of 0 to 1, 3, 9, assess the relationship between the priority risk ($A_j$) and preventive actions ($PA_k$), with 0 indicating no relation and 1, 3, 9 indicating a weak, moderate, and strong relationship.
11. Calculate the total value of effectiveness ($TE_k$) using the following formulation:

$$TE_k = \Sigma_i ARP_j E_{jk}, \forall k \quad (2)$$

12. Assess the level of difficulty ($D_k$) in carrying out each preventive action. Assessment can use the Likert scale approach, which is shown in the following table 5.

*Table 5 Degree Of Dificulty Scale*

| Scale | Description |
|---|---|
| 1 | Preventive actions are very easy to implement |
| 2 | Preventive actions are easy to implement |
| 3 | Preventive actions are quite easy to implement |
| 4 | Preventive actions are difficult to implement |
| 5 | Preventive actions are very difficult to implement |

13. Calculating the value of effectiveness to difficulty ($ETD_k$) using the following formulation:

$$ETD_k = {}^{TE_k}/_{D_k} \quad (3)$$

14. Determine the priority ranking of mitigation actions; the first rank is the mitigation action with the highest $ETD_k$ value.

# 3 Result and discussion

## *3.1 Initial Mapping of the Fish Supply Chain*

The initial mapping of the supply chain management of fish companies in Ambon City was adapted from [32] shown in Figure 2.

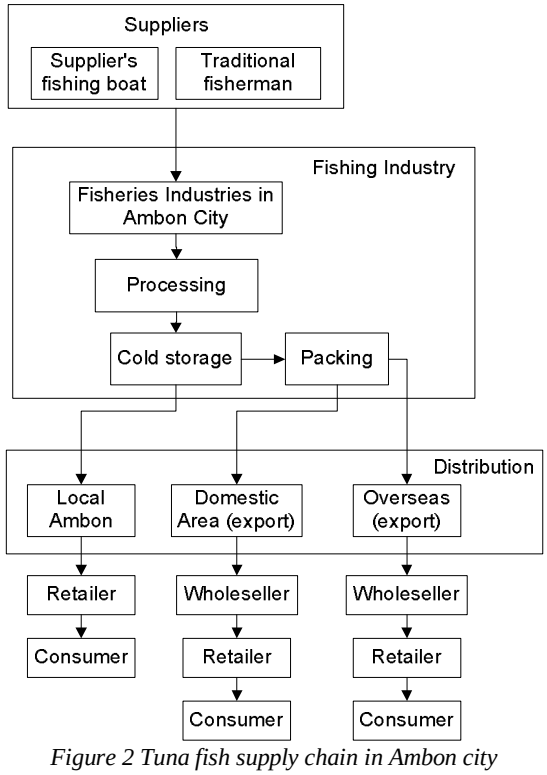


*Figure 2 Tuna fish supply chain in Ambon city*

The stages from upstream to downstream of a fishery industry supply chain system from each company are integrated. However, for the fish suppliers who are the most dominant in supplying fish to each company, namely the fishermen, the fishermen come from various regions and villages in Maluku province. Each raw material supplied to the 11 companies that are still actively operating will then be processed and stored in the cold storage of each company. Each company's product marketing distribution system is generally marketed to three locations, such as in the city of Ambon, regional areas, and exported abroad.

The distribution system of each company is carried out in a vertical marketing system, which starts from producers directly marketed to consumers, some from producers to retailers to consumers, and some from producers to wholesalers continued to retailers to consumers. In general, product marketing in the Ambon city area has happened because the company does not distribute products to consumers or retailers, but consumers and retailers who come directly to the company buy products using vehicles for both parties. Product marketing for regional areas is more dominant than any fishing company in Ambon city, namely in Jakarta, Surabaya, and Bali, because in these areas into various types of products. Transportation of product shipments to out of the region and overseas, using sea transportation and planes which shipping service companies own.

## *3.2 Risk Identification and Risk Assessment*

Risk identification is carried out through literature studies from previous studies and by interviewing or brainstorming with experts to obtain the accurate information as possible on risk events, the causes of risk, and where the risk occurs for the three dimensions of sustainability (environmental, social, and economic). The process of identification and risk assessment uses the Failure Mode of Effect Analysis (FMEA) approach to measure the level of risk impact (severity) of the risk events that have been identified and the level of probability of the occurrence of risk (occurrence) from risk agents [20].

The results of risk identification and risk assessment that experts have verified produce 15 risk events and 26 risk agents consisting of 4 risk events and five risk agents on the environmental dimension, five risk events and eleven risk agents on the social dimension, six risk events, and ten risk agents. Risk agent on the economic dimension. Risk events and risk agents may occur in the sustainable supply chain of tuna in Ambon City, as shown in table 6.

*Table 6 Identification of risk events, risk agents, value of severity and value of occurrence*

| Sustainable Dimension | Risk event and supported references | Code | Severity | Risk Agent and supported references | Code | Occurrence |
|---|---|---|---|---|---|---|
| Environment | Water pollution and marine biota degradation [33,34] | E1 | 8 | Domestic waste water [35] | A1 | 7 |
| | | | | Production waste water [35] | A2 | 9 |
| | Degradation of fish population [34] | E2 | 8 | Overfishing [36] | A3 | 7 |
| | Non-compliance with sustainability laws [37] | E3 | 8 | Lack of Standard Environmental Management System (EMS) [38] | A4 | 10 |
| | Uncomfortable working conditions [6,39] | E4 | 5 | Poor work environment (the ceiling, house floor, ventilation, waste disposal facilities) [40] | A5 | 2 |
| Social | Lack of occupational health and safety [41] | E5 | 7 | Inadequate personal protective equipment [41,42] | A6 | 3 |
| | | | | Lack of management support for OHS [43-45] | A7 | 2 |
| | Unfriendly relation between top management and workers [46-48] | E6 | 6 | The internal communication system of the company is poor [20] | A8 | 6 |
| | | | | Resistance and Lack of trust of workers with management [49] | A9 | 3 |
| | Lack of work culture [39,47] | E7 | 6 | Lack of enthusiasm for work [50] | A10 | 8 |
| | | | | Declining discipline level [51] | A11 | 8 |
| | Social Instability/unrest [37] | E8 | 7 | Inhumane treatment/harassment [52] | A12 | 1 |
| | | | | Fewer local workers [53] | A13 | 5 |
| | Labor strike//mass demonstrations [54] | E9 | 5 | Unfair wages ) [33] | A14 | 7 |
| | | | | Discrimination [37] | A15 | 4 |
| | | | | Excessive working time [37] | A16 | 2 |
| Economic | High maintenance cost [47,48] | E10 | 8 | Lack of maintenance management [55] | A17 | 7 |
| | Demand volume uncertainty [20,54] | E11 | 5 | Error in planning calculation [20] | A18 | 3 |
| | | | | Order changes from customer [20] | A19 | 2 |
| | Quality of finished product [20,54] | E12 | 8 | Lack of quality control from suppliers [20,29] | A20 | 10 |
| | | | | Lack of quality control inspection; [20,29] | A21 | 10 |
| | Production flow [20,54] | E13 | 5 | Delay in receiving raw materials (tuna fish) [20] | A22 | 6 |
| | | | | Lack of raw materials (tuna fish) ; [20,29] | A23 | 7 |
| | Timelines of delivery [20,54] | E14 | 5 | Late delivery for costumer; [20] | A24 | 2 |
| | | | | Error in recording shipping documents; [20] | A25 | 3 |
| | Product stock out [20,54] | E15 | 5 | Distortion of demand and supply [54] | A26 | 3 |

### *3.3 HOR Phase 1*

HOR phase I is a stage to identify the risks that need to be addressed first. This is calculated using the severity, occurrence, and correlation values of each risk. The first phase of HOR processing results produce the Aggregate Risk Priority (ARP) value calculated using equation (1) and is shown in table 7. This ARP value aims to determine the risk agent's priority be handled or mitigated first.

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**RISK ASSESSMENT AND RISK MITIGATION IN A SUSTAINABLE TUNA SUPPLY CHAIN**

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*Table 7 HOR Phase I Matrix*

| Risk Event ($E_i$) | Risk Agent | | | | | | | | | | | | | | | | | | | | | | | | | | Severity |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | A1 | A2 | A3 | A4 | A5 | A6 | A7 | A8 | A9 | A10 | A11 | A12 | A13 | A14 | A15 | A16 | A17 | A18 | A19 | A20 | A21 | A22 | A23 | A24 | A25 | A26 | ($S_i$) |
| E1 | 9 | 9 | 9 | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 8 |
| E2 | 9 | 9 | 9 | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 8 |
| E3 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 1 | 9 | 0 | 9 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 8 |
| E4 | 0 | 0 | 0 | 9 | 9 | 0 | 0 | 9 | 9 | 9 | 1 | 3 | 0 | 0 | 3 | 0 | 9 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 5 |
| E5 | 0 | 0 | 0 | 9 | 9 | 9 | 9 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 3 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 7 |
| E6 | 0 | 0 | 1 | 0 | 1 | 3 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 6 |
| E7 | 1 | 1 | 0 | 1 | 3 | 3 | 1 | 9 | 3 | 9 | 9 | 1 | 1 | 1 | 1 | 9 | 9 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 6 |
| E8 | 0 | 0 | 3 | 1 | 1 | 1 | 3 | 9 | 3 | 3 | 1 | 9 | 9 | 9 | 9 | 9 | 9 | 3 | 3 | 3 | 9 | 3 | 3 | 3 | 3 | 3 | 7 |
| E9 | 0 | 0 | 0 | 0 | 3 | 0 | 3 | 3 | 9 | 9 | 0 | 0 | 9 | 0 | 0 | 9 | 9 | 3 | 3 | 3 | 3 | 0 | 0 | 3 | 0 | 0 | 5 |
| E10 | 3 | 3 | 0 | 1 | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 9 | 3 | 9 | 3 | 0 | 0 | 1 | 1 | 1 | 1 | 8 |
| E11 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 3 | 1 | 3 | 3 | 0 | 0 | 0 | 0 | 0 | 3 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 5 |
| E12 | 3 | 3 | 1 | 9 | 9 | 0 | 3 | 9 | 9 | 9 | 9 | 0 | 0 | 0 | 0 | 3 | 3 | 1 | 3 | 3 | 9 | 9 | 9 | 9 | 9 | 9 | 8 |
| E13 | 0 | 0 | 1 | 0 | 3 | 0 | 0 | 9 | 9 | 9 | 9 | 0 | 1 | 3 | 0 | 0 | 3 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 5 |
| E14 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 9 | 3 | 3 | 3 | 0 | 0 | 0 | 0 | 0 | 3 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 5 |
| E15 | 0 | 0 | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 5 |
| *Occurrence* ($O_j$) | 7 | 9 | 7 | 10 | 2 | 3 | 2 | 6 | 3 | 8 | 8 | 1 | 5 | 7 | 4 | 2 | 7 | 3 | 2 | 10 | 10 | 6 | 7 | 2 | 3 | 3 | |
| $ARP_j$ | 1890 | 2430 | 2212 | 4170 | 800 | 534 | 510 | 2538 | 1197 | 2984 | 2832 | 138 | 865 | 966 | 552 | 480 | 3346 | 888 | 696 | 3000 | 3790 | 1854 | 2219 | 664 | 951 | 951 | |
| *Ranking* | 11 | 8 | 10 | 1 | 19 | 23 | 24 | 7 | 13 | 5 | 6 | 26 | 18 | 14 | 22 | 25 | 3 | 17 | 20 | 4 | 2 | 12 | 9 | 21 | 15 | 15 | |

From the HOR phase I matrix results, it is generally seen that the risk agent with the highest ARP value lacks an environmental management system standard (A4). On the environmental dimension. The risk agent's ARP value is high because it has a reasonably high impact on the sustainability of the tuna supply chain; besides that, the correlation with other risk events is also vital. The risk agent with the lowest ARP value is inhumane treatment/harassment (A12) on the social dimension because it has a small impact and correlation on other risk events.

Furthermore, preventive actions will be conducted to prioritized risk agents based on the Pareto principle. The Pareto diagram for the risk agent is shown in the figure 3.

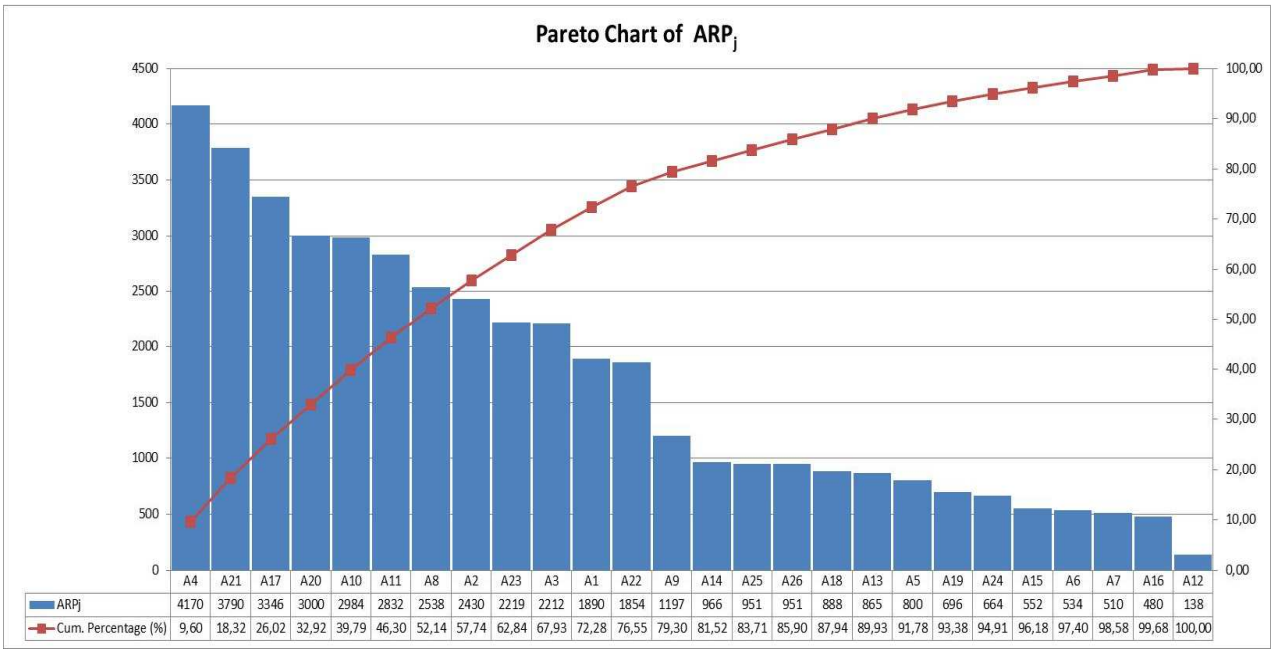


*Figure 3 Pareto chart for HOR phase I*

The Pareto principle used in risk evaluation is the 80:20 rule. In this study, 26.9% of risk agents were taken to design a treatment strategy that is expected to improve the other 73.1% risk agents. From the diagram above, the following are seven risk agents for which preventive measures will be taken:

- A4 (Lack of Standard Environmental Management System (EMS))
- A21 (Lack of quality control inspection)
- A17 (Lack of maintenance management)
- A20 (Lack of quality control from suppliers)
- A10 (Lack of enthusiasm for work)
- A11 (Declining discipline level)
- A8 (The internal communication system of the company is poor)

The social and economic dimensions are the highest priority for handling, followed by the environmental dimension. By choosing a priority risk agent, it is possible to concentrate more on the risk agent at the design stage of the treatment strategy. The focus of handling selected risk agents may indirectly reduce the impact of risks on the sustainable supply chain of the tuna fishing industry.

### *3.4 HOR Phase 2*

After the HOR phase I is complete, the next step is to design a mitigation strategy to prioritize handling actions on the seven leading risk causes by considering adequate resources and costs. Identifying preventive measures is carried out through literature studies, interviews, brainstorming with related experts (environmental service, academics, managers of fishing companies, and fishers). Table 8 shows mitigation strategies for the seven priority risk agents.

*Table 8 Preventive Action*

| No | Risk Agents | Preventive Action | Kode |
|---|---|---|---|
| 1 | A4 (Lack of Standard Environmental Management System (EMS)) | Committed to the environment in the implementation of ISO 14001 environmental management system | PA1 |
| 2 | A21 (Lack of quality control inspection) | Regular training for workers | PA2 |
| | | Routine audits on the production floor and receipt of raw materials (tuna fish) | PA3 |
| 3 | A17 (Lack of maintenance management) | Programmed maintenance scheduling such as preventive, corrective and predictive maintenance systems. | PA4 |
| | | Ensure that Maintenance SOPs are implemented effectively and efficiently | PA5 |
| 4 | A20 (Lack of quality control from suppliers) | Post-catch fish handling according to SNI standards, the temperature is less than 4 degrees and the histamine content is less than 50 ppm | PA6 |
| | | Improved Equipment and environmental Sanitation to reduce bacterial contamination | PA7 |
| 5 | A10 (Lack of enthusiasm for work) | Workload Reduction | PA8 |
| | | Incentive Increase | PA9 |
| | | Improved friendly work atmosphere | PA10 |
| 6 | A11 (Declining Discipline Level) | Improved 2-way Communication | PA11 |
| | | Implementation of reward and punishment policies according to company rules | PA12 |
| | | Placement of employees according to their expertise | PA13 |
| 7 | A8 (The internal communication system of the company is poor) | Frequent discussions between top management and employees | PA14 |
| | | Family Gathering program at the company regularly | PA15 |

After the design phase of the handling strategy, the next steps in HOR phase II are evaluating the level of correlation between the handling strategy and the current risk agent, calculating the Total Effectiveness ($TE_k$) and Degree of Difficulty ($D_k$) values, and calculating the Effectiveness to Difficulty ($ETD_k$) ratio calculated and shown in table 9 below.

Table 9 *HOR Phase II Matrix*

| Risk Agen | Preventive Action | | | | | | | | | | | | | | | ARP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PA1 | PA2 | PA3 | PA4 | PA5 | PA6 | PA7 | PA8 | PA9 | PA10 | PA11 | PA12 | PA13 | PA14 | PA15 | |
| A4 | 9 | 3 | | 3 | 1 | 1 | 3 | | | | | | | | | 4170 |
| A21 | 9 | 9 | 9 | | 1 | 9 | 9 | 3 | 1 | | | | 3 | | | 3790 |
| A17 | 1 | 1 | | 9 | 9 | | | | 1 | 1 | 1 | | 3 | | | 3346 |
| A20 | 9 | 9 | 9 | | | 9 | 9 | 3 | 3 | 1 | 1 | | 1 | | | 3000 |
| A10 | | | 1 | 1 | 1 | | | 9 | 9 | 9 | 9 | 9 | 3 | 3 | 3 | 2984 |
| A11 | | 1 | 3 | 1 | 1 | | | 9 | 9 | 9 | 3 | 3 | 9 | 3 | 3 | 2832 |
| A8 | | 3 | 1 | 1 | 1 | | | 9 | 9 | 9 | 9 | 3 | 3 | 9 | 9 | 2538 |
| TEk | 101986 | 87412 | 75128 | 50978 | 46428 | 65280 | 73620 | 95556 | 91322 | 81532 | 64540 | 42966 | 66462 | 40290 | 40290 | |
| Dk | 3 | 2 | 2 | 3 | 3 | 4 | 1 | 3 | 2 | 2 | 1 | 3 | 2 | 3 | 1 | |
| ETD | 33995 | 43706 | 37564 | 16993 | 15476 | 16320 | 73620 | 31852 | 45661 | 40766 | 64540 | 14322 | 33231 | 13430 | 40290 | |
| Rank | 8 | 4 | 7 | 11 | 13 | 12 | 1 | 10 | 3 | 5 | 2 | 14 | 9 | 15 | 6 | |

The most considerable ETD value indicates that the handling technique has the highest effectiveness to be carried out. To make it easier to find out the handling strategies that are carried out, a Pareto diagram is made as shown in the following figure 4.

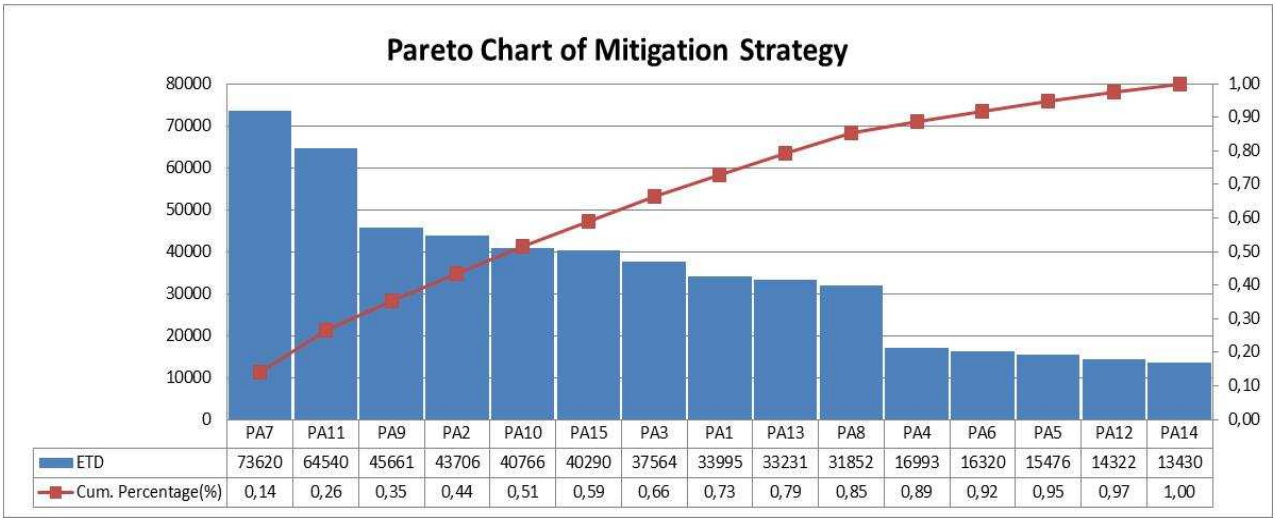


*Figure 4 Pareto chart of mitigation strategy*

With consideration and hope that the effective treatment strategy applied, only 80 percent of the total cumulative ETD value will be taken. As a result, 12 top strategies are suggested. The first possible prevention strategy is to improve equipment and environmental sanitation to reduce bacterial contamination (PA7), improve 2-way communication (PA11), incentive increase (PA9), regular training for workers (PA2), improved friendly work atmosphere (PA10), family gathering program at the company regularly (PA15), routine audits on the production floor and receipt of raw materials (PA3), committed to the environment in the implementation of ISO 14001 environmental management system (PA1), placement of employees according to their expertise (PA13), workload reduction (PA8), programmed maintenance scheduling such as preventive, corrective and predictive maintenance systems (PA4), post-catch fish handling according to SNI standards, the temperature is less than 4 degrees, and the histamine content is less than 50 ppm (PA6).

## 4 Conclusions

Sustainable Supply chain risk assessment has been carried out using the House of Risk method, so it can be concluded that there are 26 risk agents identified and consist of 5 risk agents on the environmental dimension, 11 risk agents on the social dimension, and 10 risk agents on the economic dimension. The risk assessment in HOR Phase I is based on the Pareto principle with the 80:20 rule. There are seven risk agents to be prioritized for handling, namely Lack of Standard Environmental Management System (EMS) (A4) with an ARP value of 4170, lack of quality control inspection (A21 ) with an ARP value of 3790, Lack of maintenance management (A17) with an ARP value of 3346, lack of quality control from suppliers (A20) with an ARP value of 3000, lack of enthusiasm for work (A10) with an ARP value of 2984, declining discipline level ( A11) with an ARP value of 2832, the internal communication system of the company is poor (A8) with an ARP value of 2538.

HOR phase II is the stage to get a treatment strategy that can be done to reduce the possibility of risk agents. Based on 7 risk agents from HOR phase I, 15 possible handling strategies were proposed and after calculating the ETD value, 12 treatment strategies were obtained with the highest effectiveness value, namely improve equipment and environmental sanitation to reduce bacterial contamination (PA7) with an ETD value of 73620, improve 2- way communication (PA11) with an ETD value of 64540, incentive increase (PA9) with an ETD value of 45661, regular training for workers (PA2) with an ETD value of 43706, improved friendly work atmosphere (PA10) with an ETD value of 40766, family gathering program at the company regularly (PA15) with an ETD value of 40290, routine audits on the production floor and receipt of raw materials (PA3) with an ETD value of 37564, committed to the environment in the implementation of ISO 14001 environmental management system (PA1) with an ETD value of 33995, placement of employees according to their expertise (PA13) with an ETD value of 33231, workload reduction (PA8) with an ETD value of 31852, programmed maintenance scheduling such as preventive, corrective and predictive maintenance systems (PA4) with an ETD value of 16993, post-catch fish handling according to SNI standards, the temperature is less than 4 degrees, and the histamine content is less than 50 ppm (PA6) with an ETD value of 16320.

This research may be further developed by including Interpretive Structural Modeling (ISM) or dynamic modeling to determine the future cost of risk.

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# IMPROVING COMPETITIVENESS OF SMALL AND MEDIUM ENTERPRISES BASED ON LOCAL LEADING PRODUCTS IN TARAKAN CITY, INDONESIA

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***Keywords:*** local leading products, work sectors, Analytical Hierarchy Process, economic growth, improving competitiveness.
***Abstract:*** The competitiveness of SMEs is enhanced by compiling a map consisting of local superior employment sectors and local superior products. This study aims to identify and map the work sector and products of Small and Medium Enterprises that need to be developed to become the local carrying capacity of Tarakan City. Sources of data include primary data (questionnaires from respondents) and secondary data (GRDP data for the city of Tarakan). Data analysis methods include Location Quotient (LQ), Klassen Typology, and Analytical Hierarchy Process (AHP). The results showed that the fishery-based processing industry is an employment sector that has great potential to become a local leading sector in Tarakan City. The results also reveal that the competitiveness of SMEs can be increased by developing local superior products. This development must meet three criteria, respectively: development must be oriented towards the conservation of resources and the environment; its development must only involve products with local raw materials and local uniqueness, and its development is supported by local communities. Another finding is about three priority local superior products, namely Dried Fish/Peyek Pepija, Shredded Milkfish, and Amplang Milkfish Crackers. These results can be used as a basis for making policies regarding the development of a country's local superior products.

## 1 Introduction

The growth of the local and national economy is inseparable from the contribution of Small and Medium Enterprises (SMEs). Due to its capability to boost up people economics, therefore SMEs are considered as having a strategic role in national economics. The Government of Indonesia has recognized this role and then stipulated National Long-Term Development Plan for Period 2005-2025. One goal of this Plan is to improve the competitiveness of national resources. One way to improve this competitiveness is by empowering domestic economics based on the leading capacities of each locality. Consistent with this goal, the Government then focuses its effort on improving the competitiveness of SMEs by developing local leading products and legalizes this effort by the Regulation of Domestic Affairs Minister (Permendagri) Number 9, 2014 on Local Products Development.

Local economics improvement is initiated through the development of local economic potentials and local leading products. This development begins with identifying local economic potentials and local leading products and then mapping the potentials and products that involve local resources. Local leading products, therefore, also represent local economic potentials in delivering products that give value-added advantage to the locality. This advantageous situation comes up because local resources are widely utilized, which implies that this utilization will create jobs, raise the income of people and government, improve productivity and facilitate investment flow [1].

Research was conducted in Tarakan City, which is precisely an island city located on the eastern part of North Kalimantan Province. Tarakan City has strategic position for the Province because the City becomes the entry gate and also the transit center for inter-island trades in northern part of Kalimantan Island and also for international trade involving Indonesia, Malaysia and Philipine. According to the Data in 2017, Tarakan City has several work sectors with potentials to be developed into local leading sectors. Of these work sectors, two have the greatest effect on local economics, namely Fishery and Agriculture. In Fishery Sector, productivity level of captured fishery is 10,726.41 tons. Brackish commodities (fish, shrimp and crab) has productivity level of 56,270 tons whereas productivity level of fresh water fish reaches 52,724 tons. Meanwhile, Agriculture Sector has productivity level of 7.120,5 ton [2]. In 2017, there were 4,451 SMEs in Tarakan City [3]. The

problem is that SMEs in Tarakan City have their own leading products but are weak on marketing [4]. This problem emerges because there is no yet effort to map the products that can be categorized as local leading products. Therefore, it is necessary to both identify and map the potentials of local leading sectors. Comparative theory said that a certain state can get competitive advantages if it can produce goods or services at lower cost than the other states. The state with competitive advantages must emphasize its economic activities on industries that have international comparative advantages. The state needs to do international trading with other states to fulfill the demand in the domestic for the products that are not available or not produced in the state. This situation corresponds to international trade theory [5].

The objective of this research is to identify work sectors that have potentials to become local leading sectors and to map the products of Small & Medium Enterprises that need be developed to become local leading products in Tarakan City. Result of research showed that fishery-based processing industry is a work sector that has great potentials to become local leading sector in Tarakan City. Result of research also revealed that the competitiveness of SMEs can be increased by developing local leading products. This development must fulfill three criteria, respectively: the development must be oriented toward the conservation of resources and environment; the development must involve only products with local raw materials and local uniqueness; and the development is supported by local people. Other finding is about three priorities for local leading products, which respectively are Dried Fish/Peyek Pepija, Shredded Milkfish and Milkfish Amplang Crackers.

Researcher expects that results of this research can give contribution to empirical studies, methodology and policy making. The implication of this research might be useful for the making of development model for any products that have potentials to be developed in the future. Other expectation is that results of this research may guide the Government of Tarakan City in making policies concerning leading products development. The priority of this research is to become an alternative reference for new sources of economic growth for the acceleration, expansion and development of the economy both regionally, nationally and internationally.

## 2 Local Leading Products (LLP)

Two obstacles have impeded SMEs, respectively limited resources and low innovative capacity. When the SMEs learn how to be competitive, then the SMEs must compare the asset, process and performance to other SMEs that sell leading products in the industry [6]. Comparative theory has explained that a certain state can get competitive advantages if it can produce goods or services at lower cost than the other states [5]. According to comparative theory, leading products can emerge from commodities that exist abundantly in a certain locality but not yet economically utilized. These commodities can then be managed to become local leading products.

Local Leading Products (LLP) refer to products, either goods or services, delivered by cooperatives or small and medium works, that have potentials to be developed by using all resources in the locality, including natural and human resources and also local culture, in order to raise the income of local people and local government, which is then becoming the economic power of the locality because the products have competitiveness, marketability and driving foces toward global market [7]. Daryanto and Hafizrianda [8] said that some criteria must be met before declaring certain products as local leading products. These criteria are that: (1) the products become the main driving force for local economic development; (2) the products have strong forward linkage and backward linkage to either leading products at the same competition or to those in different competition; (3) the products can compete either at national or international markets; (4) the products still involve other locality either for market or for raw material supply; (5) the products have technology in advancing status; (6) the products can absorb workers who have high qualification; (7) the products must be durable in longer term; (8) the products are not easily vulnerable to internal and external fluctuations; (9) the development of the products is facilitated by many supports; and (10) the development of the products is oriented toward conservation of resources and environment.

Pardede, et al. [9] proposed 4 indicators as predictors of local leading products. These indicators are: (1) economic contribution, (2) social aspect, (3) cultural aspect, and (4) organization. Of these indicators, cultural aspect has the greatest effect because local leading products are generally commodities that have been used daily by local people and have become their pride. Products that can compete in longer term in global economic are products with great competitive advantages, which are brought by local characteristics, local knowledge, local relationship, and local motivation, which all of these are hardly imitated by competitors [10]. Location has been neglected as a determinant factor since long ago. But, there is strong proof showing that successful innovation and competition are mostly concentrated in certain geography. Therefore, besides fulfilling ten criteria suggested by Daryanto and Hafizrianda (2010), local leading products must fulfill two criteria, respectively the uniqueness based on cultural aspect and the geographical position of the locality. Geographically, Tarakan City is in the position as “transit city” for other localities. This position implicates to the diversity of Indonesian ethnics that do business and domicile at Tarakan City, including Javanese, Padang, Bugis, Madura, Chinese and others. Such ethnical heterogenity has created unique culture related to entrepreneurship. This uniqueness has become a leading capacity in products made by local people. Moreover, geographical position of Tarakan City as “transit city”

gives competitive advantage to the products because the products easily enter inter-regional trade.

## 3 Methodology

In Stage 1, local leading sectors were identified using secondary data collected from Central Bureau of Statistics (BPS) for Tarakan City. The data concerned with Gross Regional Domestic Products (GRDP) of Tarakan City from 2016 to 2020. Data analysis technique in this stage involved Location Quotient (LQ) and Klassen Typology.

### *3.1 Location Quotient (LQ)*

Location Quotient (LQ) is conducted to ensure whether a locality acts as *net importer* or *net exporter* after comparing its local production with its local consumption.

The value of LQ (1) is counted through the following formula:

$$LQ = \frac{{}^{Si}/_{S}}{{}^{Ni}/_{N}} \quad (1)$$

Where: LQ = the value of Location Quotient, Si = GRDP of sector i of Tarakan City, S = total GRDP of the sector of Tarakan City, Ni = GRDP of sector i in North Kalimantan Province, and N = total sector GRDP of North Kalimantan Province.

Tarigan [11] suggested three conditions to estimate LQ value. First condition is that if LQ value is >1, then the role of Sector i in local domain will be more dominant or stronger than its role in national domain. Based on this condition, Sector i is said to be exporter (*Relative Specialization in Sector*). This sector exports the products because there is surplus. This Sector is also considered as leading sector because it has high prospect for development and also has high contribution to local economics improvement. Second condition is that if LQ value is < 1, then the role of Sector i in local domain is less dominant or weaker than its role in national domain. This Sector must import products from outside (*Production Deficit in Sector*) because the Sector fails to fulfill its own needs. Third or final condition is that if LQ = 1, the role of Sector i at local and national domains is similar. Productivity level of this Sector at both domains is in balance. However, the Sector can only fulfill the demand of local people and never think about exporting (*Average Production in Sector*).

### *3.2 Klassen Typology*

Klassen Typology is carried out with two comparisons. First is the comparison between the growth of each work sector in Regency/Town with the growth of GRDP of Tarakan City. Second comparison is comparing the contribution of each work sector in Regency/Town to GRDP of Tarakan City. Klassen Typology classifies work sectors into four categories, respectively (a) Prime (Leading) Sector, (b) Potential Sector, (c) Developing Sector, and (d) Laggard Sector.

Work sectors are categorized based on mean growth level of each work sector and mean contribution level of each work sector to GRDP. By this categorization, a matrix of Klassen Typology is constructed as shown in the following table:

*Table 1 Category Matrix of Klassen Typology*

| Mean Contribution Rate of Each Work Sector to GRDP / Mean Growth Rate of Each Work Sector | Y of Work Sector > Y of GRDP | Y of Work Sector < Y of GRDP |
|---|---|---|
| r of Work Sector > r of GRDP | Prime Sector | Developing Sector |
| r of Work Sector < r of GRDP | Potential Sector | Laggard Sector |

Source: Widodo [12]

Where: Y of Work Sector = Mean Contribution Level of Each Work Sector, Y of GRDP= Mean Value of GRDP, r of Work Sector = Mean Growth Rate of Each Work Sector, and r of GRDP = Mean Growth Rate of GRDP

### *3.3. Analytical Hierarchy Process*

In Stage 2, local leading products were decided by making reference to local leading sectors identified in Stage 1. After local leading sectors were ascertained, then some alternatives of local leading products were suggested. The alternatives were compiled after conducting observation and interview with informants regarding local leading products in Tarakan City. Informants were sorted out with two criteria. First is that informants must have knowledge, capability and experience in local leading products. Second is that informants must have authority in policy making. These informants are three officers from three departments in Tarakan City. Informant selection technique is one informant for one department. The departments involved in the analysis are Department of Cooperatives, Trade and Small & Medium Enterprises; Department of Industry; and Department of Fishery.

The alternatives of local leading products were then sorted by 12 (twelve) criteria based on three literatures, respectively Daryanto and Hafizrianda [8], Pardede, et al. [9] and Porter [10]. The criteria require: (1) the products to be the driving force for local economic development; (2) the products to have strong forward linkage and backward linkage to either leading products at the same competition or to those in different competition; (3) the products to have capability to compete either at national or international markets; (4) the products to still involve other locality either for market or for raw material supply; (5) the products to have technology in advancing status; (6) the products to absorb workers who have high qualification; (7) the products to be durable in longer term; (8) the products to not easily vulnerable to internal and external fluctuations; (9) the development of the products to be

facilitated by many supports; (10) the development of the products to be oriented toward conservation of resources and environment; (11) the products to be used daily by local people and to become their pride; and (12) the products to use local raw materials and to represent local uniqueness.

After sorting out the alternatives by 12 criteria, the selected products were then analyzed with *Analytical Hierarchy Process* (AHP) facilitated by computer application of Expert Choice Version 11. The process of this analysis uses primary data obtained from questionnaires given to informants as the respondents. The questionnaires require respondents to make comparison on two items (pairwise comparison), either across criteria or across alternatives. Answers given by respondents were scored at a scale from 1 to 9. Value, definition and quantitative opinion from comparison scale are presented in Table 2.

*Table 2 Scale of Comparison Matrix*

| Importance Intensity | Definition | Explanation |
|---|---|---|
| 1 | One element is similarly important to other element. | Contribution level of both elements to the characteristics of local leading products is similar. |
| 3 | One element is a bit more important than other element. | Experience slightly favors one element. |
| 5 | One element is clearly more important than other element. | Experience strongly favors one element. |
| 7 | One element is extremely clearly more important than other element. | Experience has been strongly preferred and dominated by one element. |
| 9 | One element is absolutely more important than other element. | Experience shows that one element is extremely clearly more important. |
| 2,4,6,8 | There is no decision due to hesitancy on two elements, especially when the values of two elements are in proximity to one another. | This range of values is provided as middle-way solution. |

*Source: Saaty [13]*

## 4 Result and discussion

### *4.1 Result of LQ and Klassen Typology Analysis*

Results of analysis with LQ and Klassen Typology have produced the identification of work sectors, precisely four work sectors, that have been classified as leading sectors (by LQ value > 1) and prime sectors (through Y of Work Sector > Y of GRDP, r of Work Sector > r of GRDP) with contribution level to GRDP above 10%. These results are displayed in Table 3.

*Table 3 Results of LQ and Klassen Typology Analysis*

| No. | Work Sector | LQ | Klassen Typology | Contribution to GRDP (Percent) |
|---|---|---|---|---|
| 1 | Wholesale and Retail Tradings; Reparation of Cars & Motorcycles | 1.87 | Prime Sector | 20.01 |
| 2 | Construction | 1.24 | Prime Sector | 15.47 |
| 3 | Transportation and Warehousing | 2.00 | Potential Sector | 12.51 |
| 4 | Processing Industry | 1.33 | Prime Sector | 12.46 |

*Source: Data of BPS are processed (2021)*

Based on the results of Stage 1 Analysis, four work sectors have been regarded as leading sectors. Those work sectors are Wholesale and Retail Tradings, Construction, Transportation and Warehousing, and Processing Industry. Of these four sectors, Processing Industry is categorized as leading sector with high prospect to be developed for improving local economics. Processing Industry has become the backbone of local economics in Tarakan City because this industry has given Tarakan City with *competitive advantage* over the other localities on the same province, which in this case is North Kalimantan Province. This *competitive advantage* has put Tarakan City in a better position to export its outputs (*Relative Specialization in Sector*) to other localities in North Kalimantan Province, such as to Bulungan Regency, Nunukan Regency, Malinau Regency and Tana Tidung Regency.

One sub-sector under Work Sector of Processing Industry has been exporting its products to outside Tarakan City. This sub-sector is fishery-based processing industry. The activity of exporting products makes this sub-sector highly potential for development because fishery commodities are available abundantly in Tarakan City. Based on data the results of fishery production in Tarakan City compared to other areas in North Kalimantan Province, ranked the highest [14]. This position gives Tarakan City with capability to supply fishery

commodities to other localities. The development of local leading products in Tarakan City has been focused on Processing Industry that emphasizes on the processing of fish raw materials. This development is in line with the government program stipulated in "Spatial Order Plan for North Kalimantan Province, Number 1 for Period 2017-2037". According to this Plan, Tarakan City will be given a status as National Activity Center. This status has several orientations and one of them is to make Tarakan City to become the center of processing industry that is based on fishery commodities with environmentally friendly procedures.

## *4.2 Result of Analytical Hierarchy Process*

### 4.2.1 Hierarchy of Research

Referring to the results of Stage 1 Analysis, local leading products in Tarakan City are products delivered by fishery-based processing industry. Results of observation and interview with the experts of local leading products have produced the suggestion of eight (8) alternatives of local leading products for SMEs in Tarakan City. These alternative products include: (1) Shredded Milkfish, (2) Milkfish Amplang Crackers, (3) Presto Milkfish, (4) Terap Layer Sponge Cake, (5) Crispy Soka Crab, (6) Meat/Sampit of Crab & Surimi, (7) Dried Fish/Peyek Pepija, and (8) Chips/Crackers (processed from Fish/Shrimp/Crab/Sea Grass). All these products derive from the processing of fishery commodities except for Terap Layer Sponge Cake, which uses raw material from agriculture. This sponge cake product is considered unique because the making involves raw material of fruit called "terap" which only grows in North Kalimantan. Twelve criteria and eight alternatives of local leading products for SMEs in Tarakan City are then arranged through AHP into a hierarchy of research, which is depicted in Figure 1.

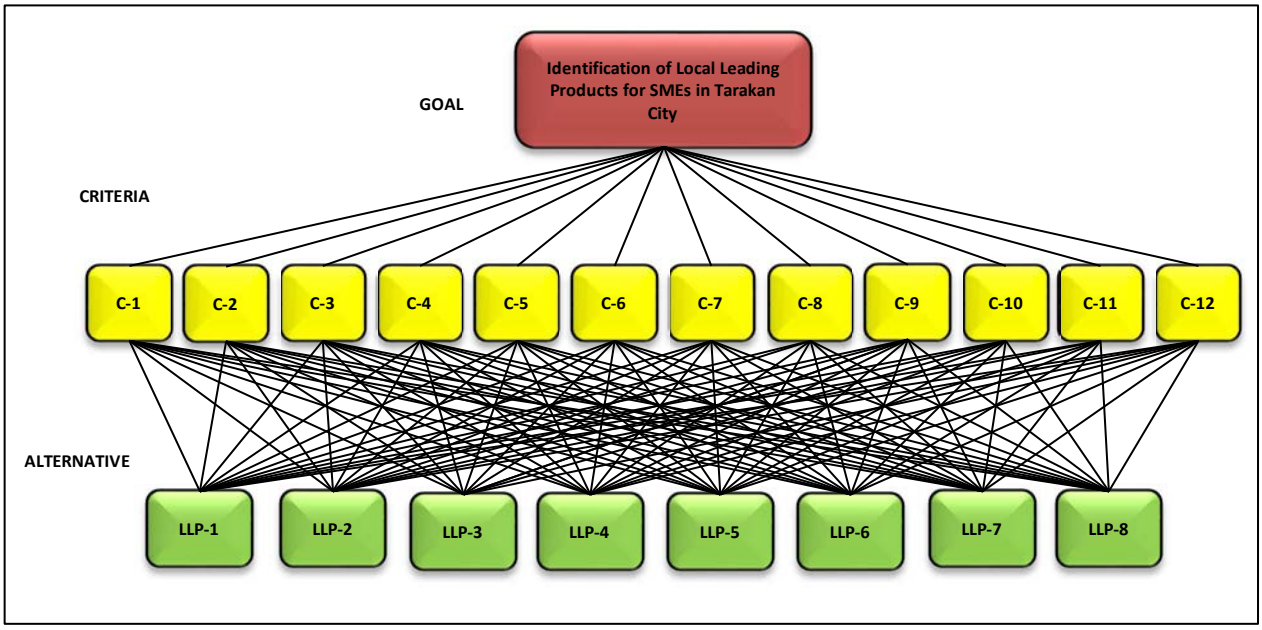


*Figure 1 Hierarchy of Research*

Where: C-1 = Become the driving force for local economic development; C-2 = Have strong forward linkage and backward linkage to either leading products at the same competition or to those in different competition;
C-3 = Have capability to compete either at national or international markets; C-4 = Still involve other locality either for market or for raw material supply; C-5 = Have technology in advancing status; C-6 = Absorb workers who have high qualification; C-7 = Durable in longer term; C-8 = Not easily vulnerable to internal and external fluctuations; C-9 = Facilitated by many supports for its development; C-10 = Oriented toward conservation of resources and environment; C-11 = Used daily by local people and become their pride; C-12 = Use local raw materials and represent local uniqueness.

LLP-1 = Shredded Milkfish; LLP-2 = Milkfish Amplang Crackers; LLP-3 = Presto Milkfish; LLP-4 = Terap Layer Sponge Cake; LLP-5 = Crispy Soka Crab; LLP-6 = Meat/Sampit of Crab & Surimi; LLP-7 = Dried Fish/Peyek Pepija; LLP-8 = Chips/Crackers (processed from Fish/Shrimp/Crab/Sea Grass).

### 4.2.2 Pairwise Comparison Across Criteria

Each criterion to determine LLP for SMEs in Tarakan City will be compared through pairwise comparison. There are 12 criteria for LLP and all these criteria are arranged based on its importance intensity. This arrangement is shown in Figure 2.

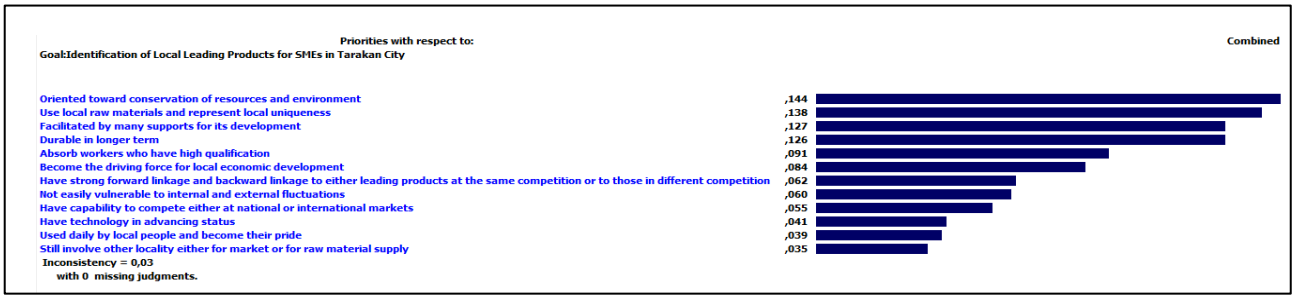


*Figure 2 Pairwise Comparison for Importance Intensity Across Criteria*

As depicted in Figure 2, three criteria to determine LLP for SMEs in Tarakan City have become top priorities based on its importance intensity. These criteria are: the development of the products is oriented toward conservation of resources and environment (0.144); the products must use local raw materials and represent local uniqueness (0.138); and the development of the products is facilitated by many supports (0.127). Criterion with the lowest importance intensity is that the products still involve other locality either for market or for raw material supply (0.035).

The development of LLP for SMEs in Tarakan City must emphasize on three most important criteria in order to achieve high level of competitiveness. The first of these criteria is that the development of the products is oriented toward conservation of resources and environment. This criterion is consistent to the latest trend among Indonesians who begin to develop strong favor on green products (environmentally friendly). In 2020, green products were becoming popular in Indonesia and most of them were sold out. The producers of these products then reaped huge profit because their cash turnover increased to 25% [15]. Environmentally friendly products have become a requirement and also a challenging task if SMEs decides to enter international market. Despite this challenge, any business managed with orientation toward environmentally friendly posture can give positive impact on its export performance in international market [16,17]. Therefore, there is a belief that one criterion for developing LLP to improve the competitiveness of SMEs is by building orientation toward conservation of resources and environment.

Second criterion is that the products must use local raw materials and represent local uniqueness. Comparative theory asserted that a state is said to be competitive only if the state can produce goods and services at lower cost than other state [5]. Raw materials in this criterion is those that can be obtained at lower price, are available locally in great abundance, and have uniqueness. This position is in line with Resources-Based View (RBV) theory, which said that specific (specialized) resources can give the companies with sustainable competitive advantages [18]. Specific resources are usually possessing economic value, heterogenous, and hardly imitated by others. Such resources are then considered as unique [19]. The uniqueness of specific resources can be the strategy to develop value-added to the products and to distinguish itself from other products [20].

Third criterion is that the development of the products is facilitated by many supports. The development of LLP for SMEs must get supports from the government that always has interest on improving local economics growth. Successful development of LLP always involves the supports and cooperation from LLP entrepreneurs, government and other stakeholders [21].

### 4.2.3 Pairwise Comparison Across Alternatives

The alternatives of LLP will be compared through pairwise comparison based on 12 criteria for LLP. Results of pairwise comparison for LLP alternatives in criterion "Become the driving force for local economic development" are presented in Figure 3.

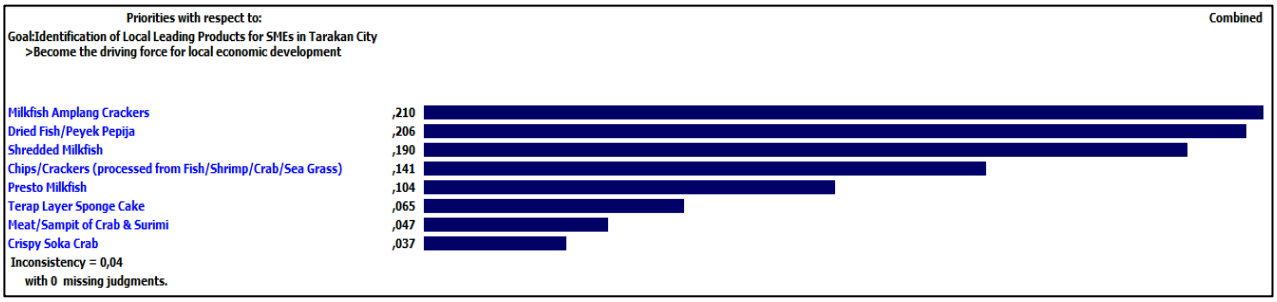


*Figure 3 Pairwise Comparsion of Importance Intensity Across LLP Alternatives in Criterion "Become The Driving Force For Local Economic Development"*

With respect to the description in Figure 3, the most important LLP alternatives are Milkfish Amplang Crackers (0.210), followed by Dried Fish/Peyek Pepija (0.206), Shredded Milkfish (0.190), Chips/Crackers (processed from fish/shrimp/crab/sea grass) (0.141), Presto Milkfish (0.104), Terap Layer Sponge Cake (0.065), Meat/Sampit of Crab & Surimi (0.047), and Crispy Soka Crab (0.037).

Results of pairwise comparison for LLP alternatives in criterion "Have strong forward linkage and backward linkage to either leading products at the same competition or to those in different competition" are displayed in Figure 4.

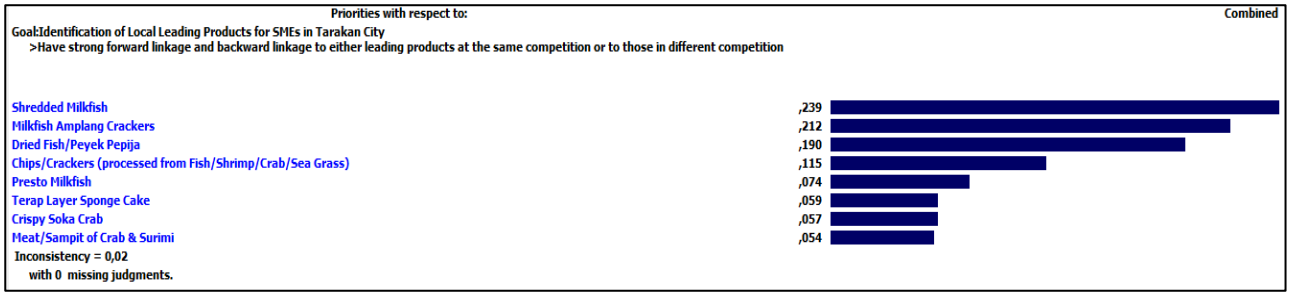


*Figure 4 Pairwise Comparsion of Importance Intensity Across LLP Alternatives in Criterion "Have Strong Forward Linkage And Backward Linkage To Either Leading Products At The Same Competition Or To Those In Different Competition"*

Based on the description in Figure 4, the most important LLP alternatives are Shredded Milkfish (0.239), followed by Milkfish Amplang Crackers (0.212), Dried Fish/Peyek Pepija (0.190), Chips/Crackers (processed from fish/shrimp/crab/sea grass) (0.115), Presto Milkfish (0.074), Terap Layer Sponge Cake (0.059), Crispy Soka Crab (0.057), and Meat/Sampit of Crab & Surimi (0.054).

Results of pairwise comparison for LLP alternatives in criterion "Have capability to compete either at national or international markets" are shown in Figure 5.

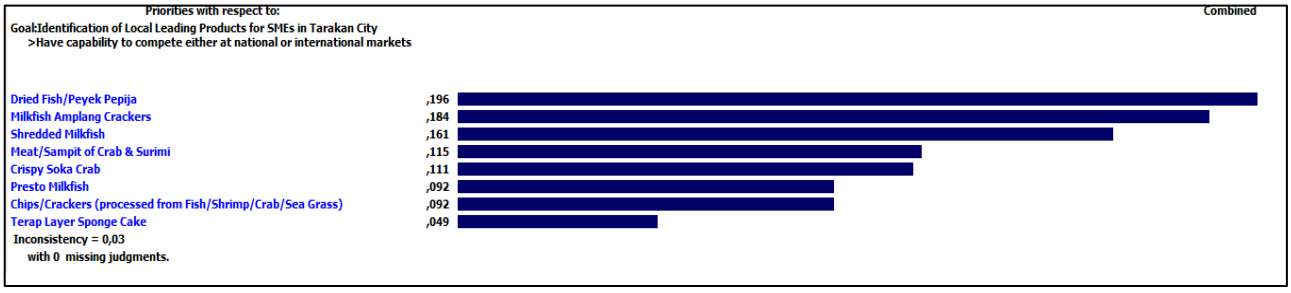


*Figure 5 Pairwise Comparsion of Importance Intensity Across LLP Alternatives in Criterion "Have Capability To Compete Either At National Or International Markets"*

The description in Figure 5 shows that the most important LLP alternatives are Dried Fish/Peyek Pepija (0.196), followed by Milkfish Amplang Crackers (0.184), Shredded Milkfish (0.161), Meat/Sampit of Crab & Surimi (0.115), Crispy Soka Crab (0.111), Presto Milkfish (0.092), Chips/Crackers (processed from fish/shrimp/crab/sea grass) (0.092), and Terap Layer Sponge Cake (0.049).

Figure 6 exhibited the results of pairwise comparison for LLP alternatives in criterion "Still involve other locality either for market or for raw material supply".

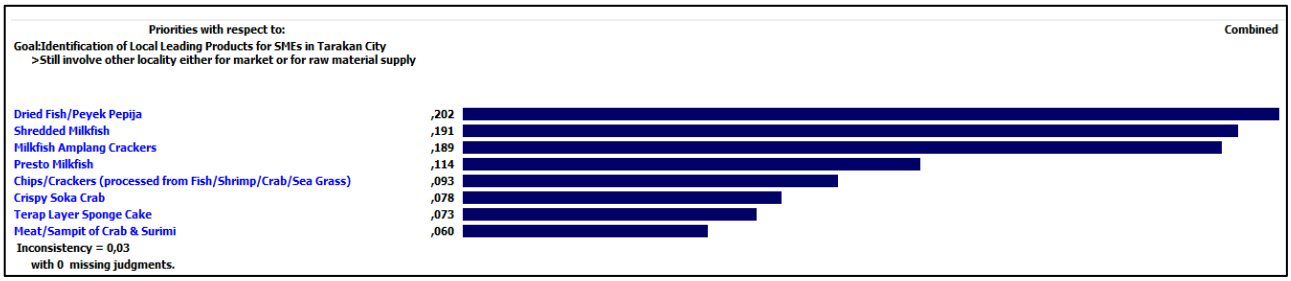


*Figure 6 Pairwise Comparsion of Importance Intensity Across LLP Alternatives in Criterion "Still Involve Other Locality Either For Market Or For Raw Material Supply"*

According to the description of Figure 6, the most important LLP alternatives are Dried Fish/Peyek Pepija (0.202), followed by Shredded Milkfish (0.191), Milkfish Amplang Crackers (0.189), Presto Milkfish (0.114), Chips/Crackers (processed from fish/shrimp/crab/sea grass) (0.093), Crispy Soka Crab (0.078), Terap Layer Sponge Cake (0.073), and Meat/Sampit of Crab & Surimi (0.060).

Results of pairwise comparison for LLP alternatives in criterion "Have technology in advancing status" is depicted in Figure 7.

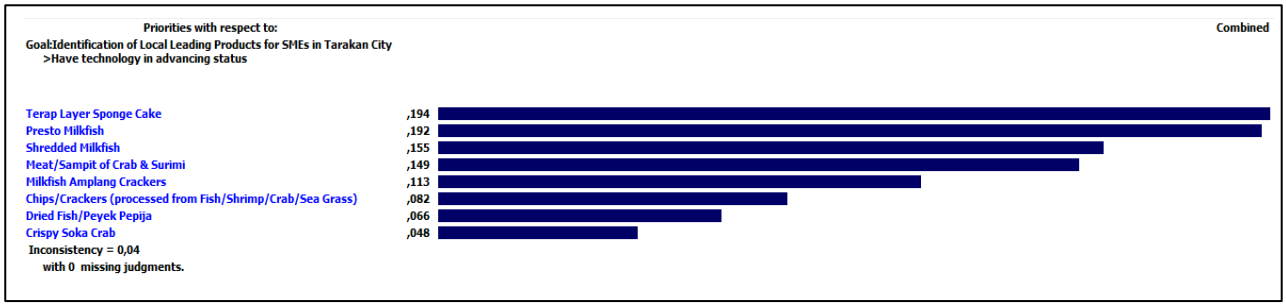


*Figure 7 Pairwise Comparsion of Importance Intensity Across LLP Alternatives in Criterion "Have Technology In Advancing Status"*

Referring to the description of Figure 7, the most important LLP alternatives are Terap Layer Sponge Cake (0.194), followed by Presto Milkfish (0.192), Shredded Milkfish (0.155), Meat/Sampit of Crab & Surimi (0.149), Milkfish Amplang Crackers (0.113), Chips/Crackers (processed from fish/shrimp/crab/sea grass) (0.082), Dried Fish/Peyek Pepija (0.066), and Crispy Soka Crab (0.048).

Figure 8 presents the results of pairwise comparison for LLP alternatives in criterion "Absorb workers who have high qualification".

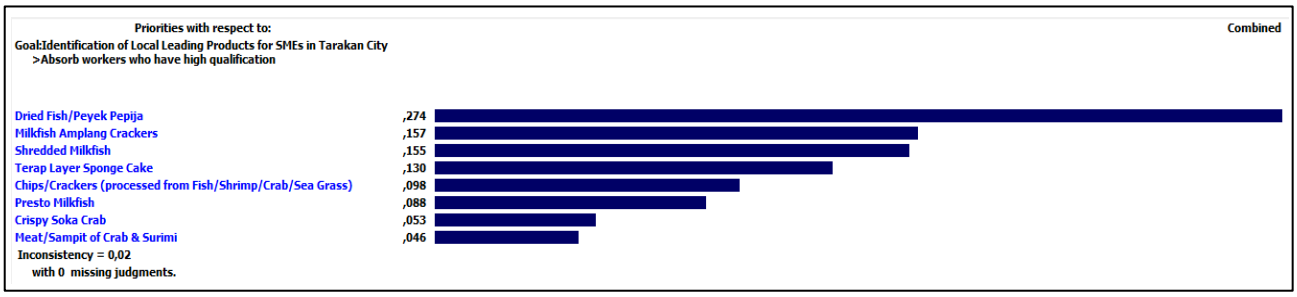


*Figure 8 Pairwise Comparsion of Importance Intensity Across LLP Alternatives in Criterion "Absorb Workers Who Have High Qualification"*

In respect of description in Figure 8, the most important LLP alternatives are Meat/Sampit of Crab & Surimi 00 (0.274), followed by Milkfish Amplang Crackers (0.157), Shredded Milkfish (0.155), Terap Layer Sponge Cake (0.130), Chips/Crackers (processed from fish/shrimp/crab/sea grass) (0.098), Presto Milkfish (0.088), Crispy Soka Crab (0.053), and Meat/Sampit of Crab & Surimi (0.046).

Figure 9 displays the results of pairwise comparison for LLP alternatives in criterion "Durable for longer term".

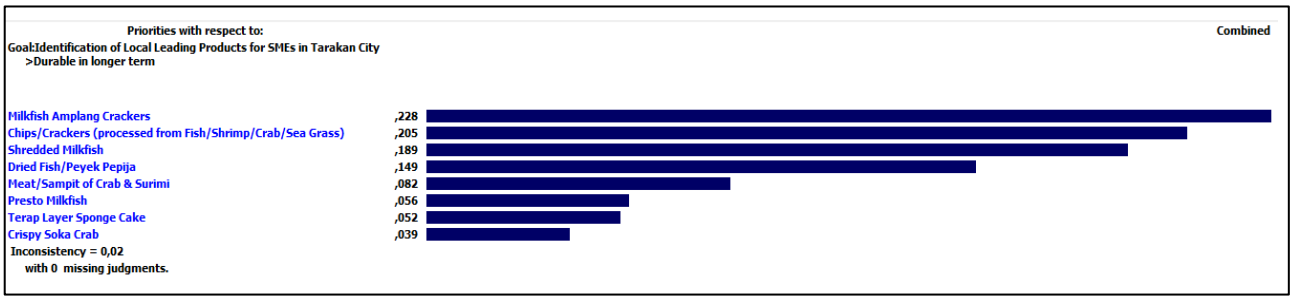


*Figure 9 Pairwise Comparsion of Importance Intensity Across LLP Alternatives in Criterion "Durable For Longer Term"*

Based on the description in Figure 9, the most important LLP alternatives are Milkfish Amplang Crackers (0.228), followed by Chips/Crackers (processed from fish/shrimp/crab/sea grass) (0.205), Shredded Milkfish (0.189), Dried Fish/Peyek Pepija (0.149), Meat/Sampit of Crab & Surimi (0.082), Presto Milkfish (0.056), Terap Layer Sponge Cake (0.052), and Crispy Soka Crab (0.039).

Results of pairwise comparison for LLP alternatives in criterion "Not easily vulnerable to internal and external fluctuations" are shown in Figure 10.

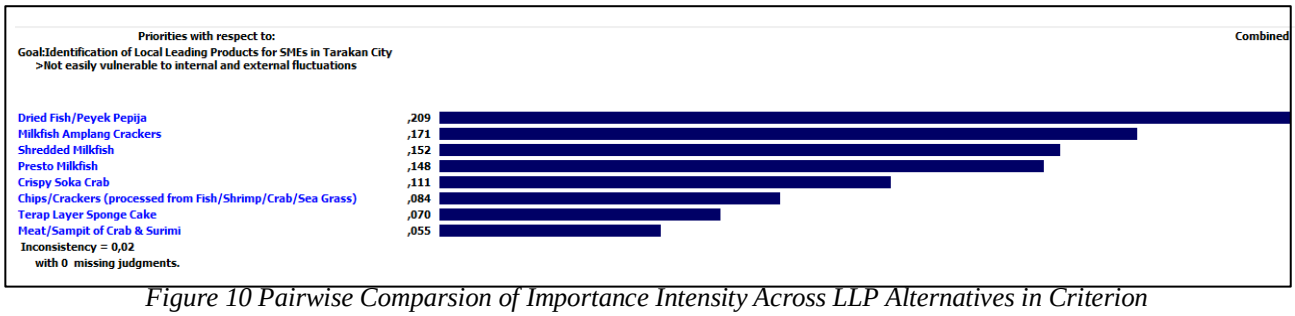


*Figure 10 Pairwise Comparsion of Importance Intensity Across LLP Alternatives in Criterion "Not Easily Vulnerable To Internal And External Fluctuations"*

The description in Figure 10 shows that the most important LLP alternatives are Dried Fish/Peyek Pepija (0.209), followed by Milkfish Amplang Crackers (0.171), Shredded Milkfish (0.152), Presto Milkfish (0.148), Crispy Soka Crab (0.111), Chips/Crackers (processed from fish/shrimp/crab/sea grass) (0.084), Terap Layer Sponge Cake (0.070), and Meat/Sampit of Crab & Surimi (0.055).

Figure 11 exhibited the results of pairwise comparison for LLP alternatives in criterion "Facilitated by many supports for its development".

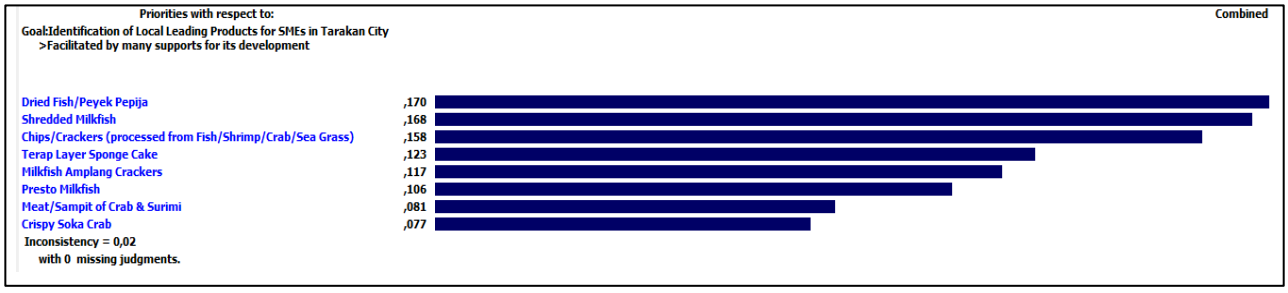


*Figure 11 Pairwise Comparsion of Importance Intensity Across LLP Alternatives in Criterion "Facilitated By Many Supports For Its Development"*

According to the description of Figure 11, the most important LLP alternatives are Dried Fish/Peyek Pepija (0.170), followed by Shredded Milkfish (0.168), Chips/Crackers (processed from fish/shrimp/crab/sea grass) (0.158), Terap Layer Sponge Cake (0.123), Milkfish Amplang Crackers (0.117), Presto Milkfish (0.106), Meat/Sampit of Crab & Surimi (0.081), and Crispy Soka Crab (0.077).

Results of pairwise comparison for LLP alternatives in criterion "Oriented toward conservation of resources and environment" is depicted in Figure 12.

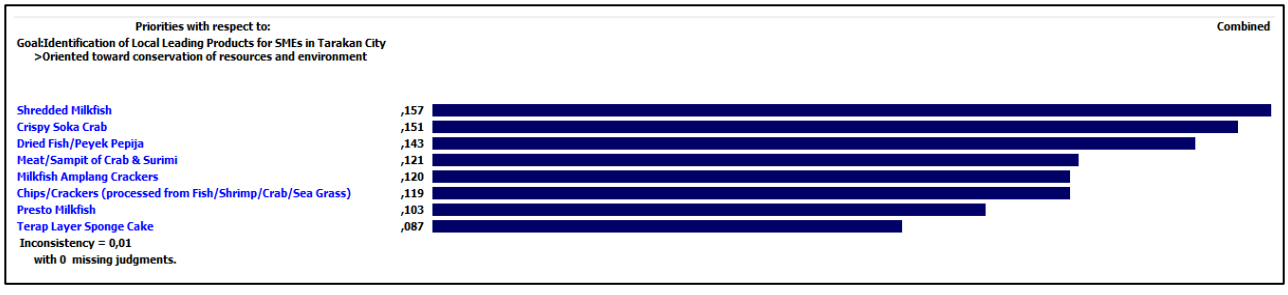


*Figure 12 Pairwise Comparsion of Importance Intensity Across LLP Alternatives in Criterion "Oriented Toward Conservation Of Resources And Environment"*

Referring to the description of Figure 12, the most important LLP alternatives are Shredded Milkfish (0.157), followed by Crispy Soka Crab (0.151), Dried Fish/Peyek Pepija (0.143), Meat/Sampit of Crab & Surimi (0.121), Milkfish Amplang Crackers (0.120), Chips/Crackers (processed from fish/shrimp/crab/sea grass) (0.119), Presto Milkfish (0.103), and Terap Layer Sponge Cake (0.087).

Figure 13 presents the results of pairwise comparison for LLP alternatives in criterion "Used daily by local people and become their pride".

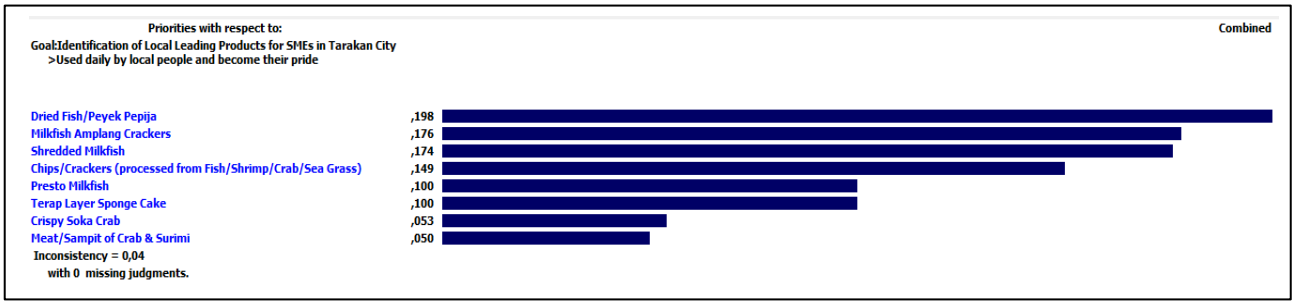


*Figure 13 Pairwise Comparsion of Importance Intensity Across LLP Alternatives in Criterion "Used Daily By Local People And Become Their Pride"*

With respect to the description in Figure 13, the most important LLP alternatives are Dried Fish/Peyek Pepija (0.198), followed by Milkfish Amplang Crackers (0.176), Shredded Milkfish (0.174), Chips/Crackers (processed from fish/shrimp/crab/sea grass) (0.149), Presto Milkfish (0.100), Terap Layer Sponge Cake (0.100), Crispy Soka Crab (0.053), and Meat/Sampit of Crab & Surimi (0.050).

Results of pairwise comparison for LLP alternatives in criterion "Use local raw materials and represent local uniqueness" are displayed in Figure 14.

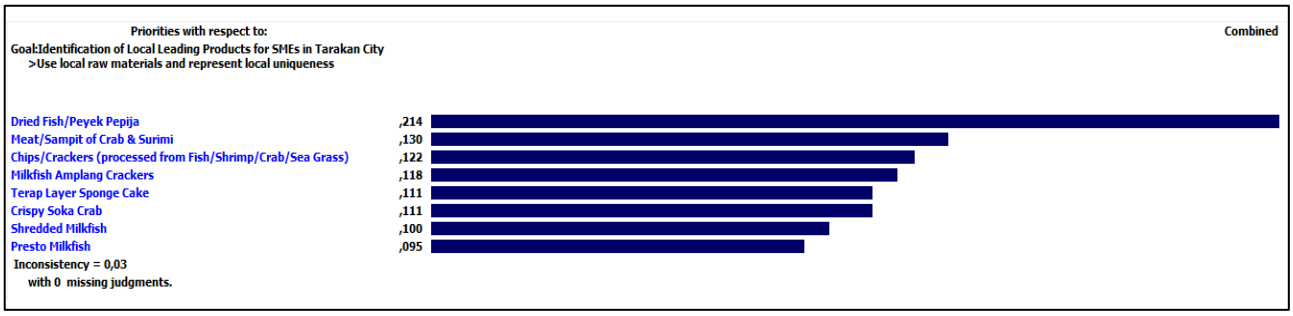


*Figure 14 Pairwise Comparsion of Importance Intensity Across LLP Alternatives in Criterion "Use Local Raw Materials And Represent Local Uniqueness"*

Based on the description in Figure 4, the most important LLP alternatives are Dried Fish/Peyek Pepija (0.214), followed by Meat/Sampit of Crab & Surimi (0.130), Chips/Crackers (processed from fish/shrimp/crab/sea grass) (0.122), Milkfish Amplang Crackers (0.118), Terap Layer Sponge Cake (0.111), Crispy Soka Crab (0.111), Shredded Milkfish (0.100), and Presto Milkfish (0.095).

### *4.2.4 Priorities of Local Leading Products Alternatives for SMEs in Tarakan City*

Local Leading Products (LLP) alternatives have been compared and the results of the comparison guide the determination of priority for these alternatives. Opinions regarding the best alternatives are given by expert informants. Results of prioritization of LLP alternatives are exhibited in Figure 15.

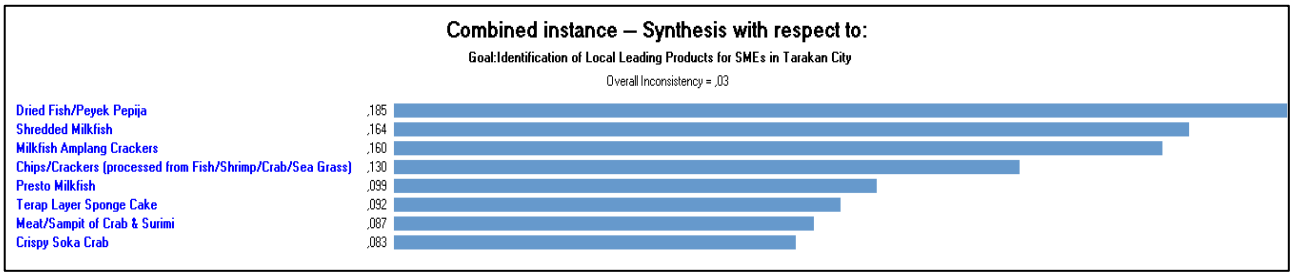


*Figure 15 Prioritization of LLP Alternatives*

The description of Figure 15 shows that there are three alternatives of Local Leading Products (LLP) receiving top priority. These alternatives are: (1) Dried Fish/Peyek Pepija; (2) Shredded Milkfish; and (3) Milkfish Amplang Crackers. First priority is focused on "Dried Fish/Peyek Pepija". Result of analysis on this LLP alternative indicates that this alternative has fulfilled LLP criteria, such as: still involve other locality either for market or for raw material supply; absorb workers who have high qualification; not easily vulnerable to internal and external fluctuations; facilitated by many supports for its development; used daily by local people and become their pride; and use local raw materials and represent local uniqueness. Dried Fish/Peyek Pepija is processed from Nomei Fish, or also known as *Ikan Pepija* (local name). In Latin, this fish is called *Harpadon Nehereu* whereas international name for this fish is bombay duck. Nomei Fish (*Harpadon Neheru)* is commercial fish widely marketed as one of food commodities consumed by people in Tarakan City. Economic value of this fish is very high with production level reaching 10 tons per month for fresh nomei fish or 3 tons per month for dried nomei fish [22].

Second priority is given to "Shredded Milkfish". According to the result of analysis on this LLP alternative, this product alternative has met some criteria, such as: have strong forward linkage and backward linkage to either leading products at the same competition or to those in different competition; have capability to compete either at national or international markets; and oriented toward conservation of resources and environment. Shredded Milkfish is a product processed from meat fiber of milkfish. Latin term for milkfish is *chanos chanos.* Milkfish production dominantly derives from embankment pool cultivation. Productivity level of milkfish embankment in Tarakan City is relatively high. Economic value of milkfish embankment is quite promising with mean value of 1.2 tons/ha/year in 2017 [23].

Furthermore, third priority is emphasized on "Milkfish Amplang Crackers". Result of analysis on this LLP alternative shows that this product alternative has fulfilled two criteria, namely become the driving force for local economic development and durable in longer term. Milkfish Amplang Crackers is snacks processed from milkfish (*chanos-chanos*) mixed with powder. *Amplang* has been known as traditional snacks that are widely consumed by people in northern and eastern parts of Kalimantan Island.

## 5 Conclusions

The objective of this research is to identify work sectors and local leading products that need to be developed to improve the competitiveness of Small & Medium Enterprises in Tarakan City. Result of research showed that four work sectors have been identified as having potentials to be developed into local leading sectors. These sectors are: Wholesale and Retail Tradings, Construction, Transportation and Warehousing, and Processing Industry. Research recommends fishery-based processing industry to be developed into local leading sector. This recommendation is consistent to the government program stipulated in "Spatial Order Plan for North Kalimantan Province, Number 1 for Period 2017-2037". This Plan intends to develop Tarakan City to become the center of processing industry that is based on fishery commodities with environmentally friendly procedures. This research also found three criteria that have the highest importance intensity to be applied on identification of local leading products that help Small & Medium Enterprises to improve its competitiveness. These criteria are: the development of the products is oriented toward conservation of resources and environment; the products must use local raw materials and represent local uniqueness; and the development of the products is facilitated by many supports. Besides these criteria, research also discovered three alternatives of Local Leading Products that shall be given priority for development. These product alternatives are Dried Fish/Peyek Pepija, Shredded Milkfish and Milkfish Amplang Crackers.

Local leading products are very much in line with comparative theory, so the results of this study can be a reference in increasing the economic growth of a country based on local advantages. In addition, this research can be a recommendation for future research, especially designing a strategy model for the development and sustainability of selected local leading products. Development and sustainability strategies can be directed at increasing product quantity and quality, strengthening derivative product innovations, increasing sales promotions, developing science and technology, and building partnership programs. Thus, local leading products can compete in a wider market both nationally and internationally.

**Acknowledgement**
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# VEHICLE ASSIGNMENT WITH PENALTY COSTS: A CASE OF MEXICAN FREIGHT TRANSPORT

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***Keywords*:** assignment model, freight transport, trucks productivity, operations research, vehicle assignment.
***Abstract:*** The reduction of logistics costs is very important for Mexican companies, especially for those from freight transport industry. They must manage their operations efficiently and effectively to increase the revenue, which is reduced if trucks are not being productive. The objective of this research is to provide a model for a Mexican freight transport company, which lets the company reduce transportation costs, based on assignment models to make daily assignment programme of trucks. One particularity of the model being built is the fact that it will not only include general costs as in a Generalised Assignment Procedure (GAP), but also penalty costs caused by truck drivers. The main problem consisted in minimize the total cost of assigning 100 vehicles owned by the company to 10 routes (in which it was required to be transported molasse, and sand), considering that trucks cannot be assigned to some routes due to their characteristics, as well as they must assign different operators to the routes (which are classified as A, B, and C, depending on the characteristics like license type, performance, among others); thus, it was able to assign 100 operators with different characteristics to 100 different units required in 10 routes to satisfy market demands, achieving a reduction about 44.11% of current costs related to assignment, maintenance, idle time, penalty, and logistics costs.

## 1 Introduction

Freight transport is an important activity around the world, but particularly in Mexico, according to [1], road freight transport is accounting for 56% of the domestic and international freight transport. This activity plays an important role for the economy of the country. Many companies must deal with delays of their products by many issues, such as mentioned by [2], in which they are including natural disasters, road closing, road accidents, and others such as truck drivers time, vehicle age. It is important for the assignment to trucks and drivers to the routes consider different factors related to penalty costs, which results in the reduction of the company margin since prices are not able to be changed once the contract is signed. Thus, through this document we will propose a model to assign trucks weekly to help the company to assign and move the transport from one route to another to accomplish customer plans. One of the main problems for the company under study is the fact that 50% of the time is loss by operators, 40% due to maintenance and 10% due to external factors, which causes reduction of route productivity, which is about 60% average. With proposed model, it will be measured the impact of time in costs. By considering the penalty cost for maintenance or truck driver, it is expected to improve the delivery time and to fulfil the Estimated Time of Arrival (ETA) of each route, or at least, reduce the difference between ETA and real arrival time.

## 2 Freight transport

Logistics activities are core among companies, and, as established by [3], it is part of the value chain. Moreover, logistics function provides a link between supply and demand, product transformation and market of goods, as a result we deal with business complexity [4]. To increase supply chain productivity for freight transport companies, it is important to work with the distribution network on daily basis, it means, take in count the assignment of the driver to the truck, regarding the client and regarding the type of employee.

Assignment problem is a method to match “tasks” (jobs) with an “agent” (man, machine capacity, ant it is applied to vehicle assignment problems to minimize total assignment costs [5], one characteristics of these problems is the fact that the demand is not stochastic, like in this case, since they have to work with a monthly programme [6],

which is known in advance, but they have to programme the units in a way that the productivity was increased. Moreover, even though there are some algorithms as used by [7], everything depends on the problem, it means, what applies to one problem does not mean will apply to others or will impact in the same way.

Due to the high demand of logistics activities, in Mexico, Third Party Logistics (3PL) or outsourcing companies are important in states and Estado de Mexico, being large companies or small those who more uses this kind of service [8], which is critical for every company, since they put their products on the hands of other companies looking for benefits like [8]:

- Logistics operations flexibility.
- Concentration on business core activities.
- Improved expertise to market since secondary activities are carried by a third party.
- Cost savings from having their own trucks.
- Re-engineering of logistics processes.
- Access to new methods and technologies to develop core activities and involvement of all personnel.
- Risk reduction in transportation management.

## 3 Freight transport productivity factors

According to [9], there are some factors to take in count regarding truck utilization, which were related to vehicle capacity utilization, average speed, average lost time, average distance of transport, as well as the assigned route, which is important to make the right assignment. Identified as main factors affecting cost of truck operations [9,10]:

- Lorry size and its utilization (productivity).
- Use of Back-hauls (according to the demand).
- Empty running.
- Freight forwarding availability as well as other services.
- Traffic conditions.
- Road conditions.
- Social problems.
- Direct costs such as lubrication oil, labour costs, tires, vehicle maintenance, spare parts, and fuel.
- Quality management.

Other categories used for the optimization of the transport use are [11]:

- Profitability: Related with performance ratios, truck use, profits, use of outsourcing.
- Service quality: Objective's achievement, measurement of inconveniences, service levels, non-conformance.
- Equity: Service equity, client prioritization and segmentation, workload balance, collaborative planning.
- Consistency: Oriented to people, time consistency, delivery consistency, issues management.
- Simplicity: Separation, truck segmentation or service segmentation.
- Reliability: Expected cost or loss, probability of failure, risks management, truck driver management.
- External factors: Emissions, safety risks, social factors.

On the other hand, even though [9] and [12], mention these factors, they do not use or propose any model in which those factors are able to be used to improve truck productivity. Moreover, talking about Mexico, some problems related to transport products we have:

- Lack of road maintenance, having poor conditions of roads, producing productivity reduction.
- Lack of preventive maintenance to units, and more corrective maintenance.
- Lack of truck training.
- Truck drivers have inadequate maintenance and poor driving habits.
- Managerial and operational practices are not accurate, causing the delay and liberation of daily assignment programme for units.
- Measurement system was not accurate to measure the quantity of fuel used in each travel.

Despite the factors considered in the different models, we always talk about cost minimization or profit maximization, in terms of profits. However, time is an essential factor in products delivery by third party logistics, since we have some constraints like:

- Opening hours of load and unload depot.
- Closing hours of load and unload depot.
- Road closure because of social problems in any region or climate.

Those other factors cannot be controlled by the 3PL.

## 4 Vehicle Routing Problems

In order to solve vehicle assignment problems in which capacity constraints must be addressed (ensuring the minimum quantity required by the market is satisfied), whilst costs are minimised and truck drivers have to be assigned, it can be used the classical model of Vehicle Routing Problem (VRP), which can be found in the literature as many models adapted to different problems, as mentioned in papers [13] and [14]; however, none of them uses penalty costs as it was mentioned previously (even though time or distance can be considered as a cost). Regarding the literature review, in the Table 1 it is shown main factors considered by each model.

*Table 1 Vehicle routing problems models*

| Paper \ VRP Model | Classical VRP | Capacitated VRP | Asymmetric Capacitated VRP | Open Vehicle Routing | Simultaneous Pickup and Delivery | Mixed Pickup and Delivery | Multi-Depot | Multi-Depot with Mixed Pick Up | Heuristic | Time Windows | Stochastic | Time Dependent/ Periodic | Cross-Docking | Fixed Origin and Destination | Dynamic | Occasional Drivers | Fuel Consumption Minimizing | Emission |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Subramanian et al. [15] | X | X | X | X | X | X | X | X | X | | | | | | | | | |
| Korablev et al. [16] | | | | | | | | | | X | | | | | | | | |
| Haughton [17] | | | | | | | | | | | X | | | | | | | |
| Cordeao et al. [18] | | | | | X | | | | | X | X | X | | | | | | |
| Huang and Liu [19] | | | | | X | | | | | | | X | | | | | | |
| Vidal et al. [11] | X | X | | | | | X | | | X | | | | X | | | | |
| Yeun et al. [20] | X | X | | | X | X | | | | X | | | | | | | | |
| Christofides [21] | X | X | | | | X | X | X | | X | X | X | | | | | | |
| Saint-Guillain [22] | X | X | X | | | | | X | | | X | X | | | X | | | |
| Archetti et al. [23] | X | | | | | | | | | | | | | | | X | | |
| Nazari et al. [24] | X | | | | | | | | | | | | | | | | | |
| Ghannadpour and Hooshfar [25] | | | | | | | | | | X | | | | | | | X | |
| Caric and Gold [26] | X | X | | | | | | | | X | | | | | | | | |
| Lu, Zhang, and Yang [7] | X | X | | | | | | | | | | | | | | | | |
| Londoño et al. [27] | X | X | | | | | | | | | | | | | | | | |
| Haughton [28] | | X | | | | | | | | | X | | | | | | | |
| Gendreay [29] | X | X | | | | | | | | X | | | | | | | | |
| Dahle et al. [30] | X | X | | | | | | | | | | | | | X | X | | |
| Nagy et al. [31] | | | | | | X | | | | | | | | | | | | X |
| Frazzoli and Pavone [32] | X | X | | | | | | | | | | | | | | | | |
| Guo et al. [33] | X | X | X | | | | | | | X | X | | | | | | | |
| Hanum et al. [34] | X | X | | | | | X | X | | X | | | | | | | | |
| IbrahIm et al. [35] | | X | | | | | | | | | | | | | | | | |
| Irnich et al. [36] | | X | X | X | X | X | X | X | X | X | | X | X | X | | | | |
| Maleki et al. [37] | | | | X | | | | | | | | | | | | | | |
| Kara and Bektas [38] | X | | | | | | | | | | | | | | | | | |
| Toro et al. [39] | X | X | X | | | | X | X | X | X | | X | | | | | | X |
| Braekers et al. [40] | X | X | X | X | X | X | X | X | X | X | X | X | X | | | | | |
| Khodabandeh et al. [41] | | | | | | | | | | X | | X | | | | | | |
| Bent and Hentenryck [42] | | | | | | | | | | | X | | | | | | | |
| Coene, [43] | | | | | | | | | | | | X | | | | | | |
| Pavone et al. [44] | | | | | | | | | | X | X | | | | | | | |
| Hoogeboom et al, [45] | X | X | | | | | | | | X | | | | | | | | |
| Backer et al. [46] | X | X | | | | | | | | | | | | | | | | |
| Ochoa-Ortiz et al. [47] | X | X | | | | | | | | | | | | | | | | |
| Chepuri and Homem-De-Mello [48] | | | | | | | | | | | X | | | | | | | |
| Belachgar, [49] | X | X | | | | | | | | | | | | | | | | |
| Kallehauge et al [50] | | | | | | | | | | X | | | | | | | | |
| Liñan-García [51] | | | | | | | | | | | X | | | | | | | |
| Ralphs [52] | X | X | | | | | | | | | | | | | | | | |

As it can be seen in Table 1, many models work in general way with constraints of time, capacity, pickup and delivery and routing. In fact, regarding models, according to [29] the more used VRP models according to 144 articles are (Figure 1): Capacitated Vehicle Routing Problem (CVRP), VRP with Time Windows (VRPTW), Heterogeneous VRP, Multi-Depot VRP, Backhauls VRP, Split Delivery DRP and Dynamic DRP. Which is what it was found in the literature review, but there are two models that were not considered previously like VRP with fuel consumption proposed by [25] and VRP with emissions proposed by [31] and [39]. Those late models are important, since they are not just focusing on time or a general constraint, but a constraint per unit or in a global way with environmental focus. It is important to highlight this since the models continue to use general costs, total times from one departure point to a destination point, time constraints, but they are not considering important factors that costs that can be caused by delays in the load centres, delays in destinations centres, delays due to operator undiscipline or due to truck failure due to it has to be send to maintenance, as well as the sending of the unit in advance to comply with preventive maintenance programs (in this company trucks have to be deviated from the current route just because the preventive maintenance was programmed with one day in advance, instead of being programmed at least with one week in advance to move units impacting the less possible the transport programme).

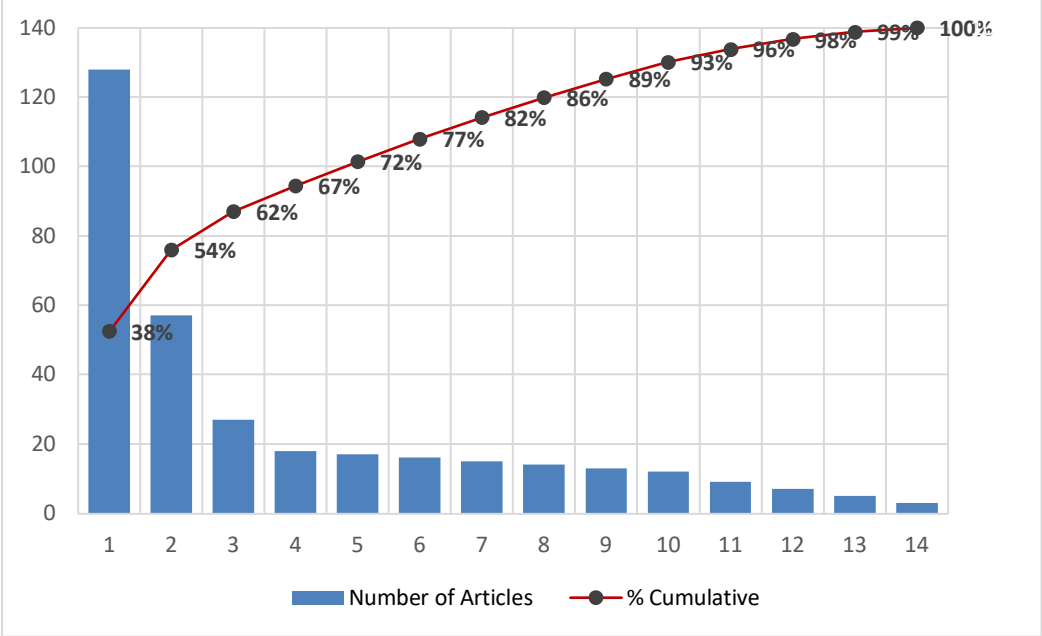


*Figure 1 Most used VRP models in literature, own elaboration with data from [53]*

As it can be seen, from literature, there are many variants of VRP models, but all of them works in general way with distances, costs, or revenues, in global way, without taking in count any penalties caused for transportation delay, being responsible mainly the truck driver. Moreover, this costs are not considered in some cases, since they only are focusing on distance optimization, when not necessarily the distance is proportional to the cost, since they are other factors as the fuel, which is spent depending on the route, it means, if the street has a slope, the effort required to move the unit will be greater and they will require more fuel than if the truck was operated in a plain road.

## 5 Methodology

The objective of this research was to help the company to create the daily programme of units assigned to the routes, using assignment on the vehicle routing problem considering costs of maintenance, for trucks assignment considering not a global unitary cost, but units costs of maintenance idle time, costs of truck driver idle time, as well as internal logistics costs, which will impact operations as reduce company profits. It helps to the organization to provide a better trucks assignment, reducing in the short-term these costs and in the long-term maintenance costs as well as the loss of customers due to lack of programmes fulfilment. Finally, it is compared the current assignment costs (for one day) to the costs related with the assignment using the mathematical model.

### *5.1 The Classic Vehicle Routing Problem*

This problem parts from a Classic Vehicle Routing Problem (VRP). However, since trucks must stay in the same route going from an origin to a destination, the problem is simplified to an assignment problem in which it must be assigned trucks and operators to any route [30]. The general model for this problem is an assignment model, which is given by the direct costs (cd) – related to

unit wear, tires, toll payment, driver wage, fuel, insurance – and penalty costs – truck driver idle time ($c_t$), maintenance idle time ($c_m$), internal logistics costs (cl), caused by delays for the traffic department, and fine costs (cs), the following equations.

***Objective function:***

$$Min\ z = \sum\sum\sum c_d x_{ijk} + \sum(c_t + c_s)t_i + \sum c_m t_m + \sum c_l t_l \quad (1)$$

***Subject to:***

$$\sum x_{ijk} q_k \leq Q_k \quad \text{Route programme} \quad (2)$$

$$\sum x_{ijk} \leq O \quad \text{Operators available} \quad (3)$$

$$\sum x_{ijk} \leq U \quad \text{Trucks available} \quad (4)$$

$$x_{ijk} \geq 0 \quad \forall i \geq 0, \forall j \geq 0, \forall k \geq 0 \quad (5)$$

***Where:***

$x_{ijk}$ = Binary variable representing the assignment of unit $i$ to the driver $j$, to the route (6)

$q_k$ = Quantity of product transported by the assigned unit (truck capacity) (7)

$Q_k$ = Quantity of product demanded in route k (8)

$O$ = Total number of operators available (9)

$U$ = Total number of trucks available (10)

Since each operator has specific characteristics, costs depend on assigned operator and units available. The objective is to minimize the assignment cost for the company, taking in count penalties. Once the routes are stablished, it must be analysed if any of them are close enough to interchange operators or units and any programme can be completed faster or can be completed reducing costs, depending on the conditions.

### *5.2 The application of VRP model to a Mexican freight transport company*

As the objective of this research is to define a model to assign vehicles to a route, it will be applied quantitative cross-sectional research because the sample is taken from one part in time [54]. For this study, data were collected from logs used in the company to record times of each unit, which are divided into: Departure time, Arrival Time to Load, Documentation, Departure Time from Load Centre, Arrival Time to Destination, Unload Time in Destination, Documentation Time, Available Time. All those times are arranged in a matrix to measure times from the origin to the destination and compare it with the Estimated Time of Arrival (ETA), which allows to see how much difference of time there are between planned and real times. Also, using the data from truck logs, it was obtained the driver performance.

To create the model, it was used a set of data of one day, it means, it is going to be created the programme for the units assuming 100 trucks are available, and they will be assigned to any route, and it was selected the most representative products which account for 80% of incomes. These data were selected since it is a planning period in which the company, and once units are assigned, it can be used the adapted VRP model to work with the units attending close routes without increasing costs meaningfully. Moreover, it is important to mention that origin and destination centres normally does not work on weekend, allowing units to be swapped between routes, unless the programme has been finished. The sample is representative, because we are going to use all the units that in this case are 100 and they are classified according to number of trailers they can pull, type of trailer, product to be transported, the capacity of the truck and the route that can be assigned due to vehicle aging (Table 2).

*Table 2 Trucks classification*

| Number of Trucks | Trailers | Type | Product | Volume | Route | Classification |
|---|---|---|---|---|---|---|
| 40 | 2 | Tanker | Molasses | 60 | Any | A |
| 25 | 1 | Tanker | Molasses | 30 | Plain | B |
| 15 | 2 | Tanker | Molasses | 60 | Plain | C |
| 20 | 2 | Dump body | Sand | 60 | Any | A |

Trucks Type A are the newest, requiring zero maintenance, Type B requires preventive maintenance (which is scheduled based on the kilometres travelled by the truck, established as 15000 kilometres) and type C requires corrective maintenance, whose hours where calculated based on the company standard work rates from the maintenance system (Table 3). Maintenance costs are given in Table 3.

Table 4 shows number of available Truck Drivers for each type, classification used by the company considering driver performance, type of license (which is considered when transporting dangerous material such as alcohol, which can be only transported by drivers A).

*Table 3 Driver's classification*

| Truck Type | Maintenance($/Hour) | Required hours |
|---|---|---|
| A | 0 | 0 |
| B | 250 | 5 |
| C | 750 | 24 |

*Table 4 Driver's classification*

| Driver Type | Number of Drivers |
|---|---|
| A | 50 |
| B | 40 |
| C | 10 |

To run the mathematical model, it was selected the 10 main client routes, which accounts for about 60% of the sales. And the programme for each one is shown in Table 5. "Routes A" are plain, and it can be used any kind of truck, Routes B are able to be assigned Trucks type A and B, and Routes C only can be assigned Trucks Type A.

*Table 5 Routes and programmes*

| **Route** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Tons** | 500 | 500 | 400 | 600 | 550 | 650 | 120 | 240 | 300 | 120 |
| **Type** | A | B | C | A | A | B | B | A | B | C |
| **Product** | Molasses | Molasses | Molasses | Molasses | Molasses | Molasses | Sand | Sand | Sand | Sand |

To assign every unit to a driver and a route, there is a cost, as it was mentioned previously, which are shown in Table 6. Also, to differentiate the units of molasses from sand, it was used the letter M and S.

*Table 6 Assignment cost for every route regarding truck and driver type*

| **Truck** | **Driver** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **MA** | **A** | 50 | 100 | 50 | 50 | 50 | 100 | 1000 | 1000 | 1000 | 1000 |
| **MA** | **B** | 75 | 50 | 50 | 75 | 75 | 50 | 1000 | 1000 | 1000 | 1000 |
| **MA** | **C** | 200 | 150 | 50 | 200 | 200 | 150 | 1000 | 1000 | 1000 | 1000 |
| **MB** | **A** | 50 | 75 | 150 | 50 | 50 | 75 | 1000 | 1000 | 1000 | 1000 |
| **MB** | **B** | 75 | 50 | 150 | 75 | 75 | 50 | 1000 | 1000 | 1000 | 1000 |
| **MB** | **C** | 200 | 150 | 150 | 200 | 200 | 150 | 1000 | 1000 | 1000 | 1000 |
| **MC** | **A** | 75 | 50 | 150 | 75 | 75 | 50 | 1000 | 1000 | 1000 | 1000 |
| **MC** | **B** | 50 | 25 | 150 | 50 | 50 | 25 | 1000 | 1000 | 1000 | 1000 |
| **MC** | **C** | 150 | 75 | 150 | 150 | 150 | 75 | 1000 | 1000 | 1000 | 1000 |
| **SC** | **A** | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 75 | 50 | 50 | 50 |
| **SC** | **B** | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 50 | 75 | 50 | 75 |
| **SC** | **C** | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 100 | 100 | 100 | 100 |

## 6 Results and findings

According to the results obtained from running the problem by using Excel solver and GAMS, it was obtained the solution shown in Table 7, in which it is shown how many trucks of each type and driver type is assigned to each route. Assigning 5 trucks classified as Type A (tanks transporting volumes of 60 tons) that transport molasse to the route 1 using drivers type A, 5 units of this type to the route 3 and so on.

*Table 7 Route assignment by truck and driver type*

| | | **Route** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Truck Type** | **Driver** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** |
| MA | A | 5 | 0 | 5 | 6 | 7 | 1 | 0 | 0 | 0 | 0 |
| MA | B | 0 | 5 | 1 | 0 | 0 | 9 | 0 | 0 | 0 | 0 |
| MA | C | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MB | A | 0 | 1 | 0 | 8 | 3 | 0 | 0 | 0 | 0 | 0 |
| MB | B | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MB | C | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MC | A | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MC | B | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MC | C | 4 | 3 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 |
| SA | A | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 3 | 5 | 1 |
| SA | B | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 |
| SA | C | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | **TONS** | 540 | 510 | 420 | 600 | 570 | 660 | 120 | 240 | 300 | 120 |

As it is shown in Table 7, in some cases, the demand was satisfied and in other cases the demand was exceeded (Table 8 shows decoded results built by considering tables 2 – 6), for this kind of problems there is not an issue if the demand surpasses the transported quantity, since everything depends on the unit capacity, and it is not allowed to run any route with less product than the truck capacity.

*Table 8 Units and type of drivers assigned by route*

| | | | | | | Route | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **TT** | **PR** | **TR** | **Tons** | **Route** | **DR** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** |
| MA | Mol. | 2 | 60 | Any | A | 5 | 0 | 5 | 6 | 7 | 1 | 0 | 0 | 0 | 0 |
| MA | Mol. | 2 | 60 | Any | B | 0 | 5 | 1 | 0 | 0 | 9 | 0 | 0 | 0 | 0 |
| MA | Mol. | 2 | 60 | Any | C | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MB | Mol. | 1 | 30 | Plain | A | 0 | 1 | 0 | 8 | 3 | 0 | 0 | 0 | 0 | 0 |
| MB | Mol. | 1 | 30 | Plain | B | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MB | Mol. | 1 | 30 | Plain | C | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MC | Mol. | 2 | 60 | Plain | A | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MC | Mol. | 2 | 60 | Plain | B | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MC | Mol. | 2 | 60 | Plain | C | 4 | 3 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 |
| SA | Sand | 2 | 60 | Any | A | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 3 | 5 | 1 |
| SA | Sand | 2 | 60 | Any | B | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 |
| SA | Sand | 2 | 60 | Any | C | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | | | | **TONS** | 540 | 510 | 420 | 600 | 570 | 660 | 120 | 240 | 300 | 120 |

**Keys:** TT: Truck Type TR: Trailers PR: Products DR: Drivers Mol.: Molasses

According to the values in Table 8, it is important to assign the right type of driver and truck to the route to reduce costs, if it is not done, costs start increasing due to penalties caused by maintenance, truck drivers, or other factors. The minimum cost found by running the model is shown in Table 9, which it can be observed that maintenance represents an important cost in the logistics process, as well as idle time cost, due to it is important to train drivers to reduce or eliminate those costs affecting the company incomes and profit.

*Table 9 Assignment total cost*

| Costs | Current | Using the Assignment Model | % Reduction |
|---|---|---|---|
| Assignment | $278 | $228 | 18.27% |
| Maintenance | $367,331 | $195,000 | 46.91% |
| Idle Time | $123,981 | $75,250 | 39.31% |
| Penalty | $13,957 | $11,400 | 18.32% |
| Logistics | $3,232 | $2,500 | 22.64% |
| **TOTAL** | **$508,779** | **$284,378** | **44.11%** |

In this case, since the data from company is sensitive, there were used values representing costs of penalties; however, those costs are proportional to the current costs in the company; thus, it is important to make an alignment into the operations of the logistics and traffic department to reduce costs and increase revenues. Savings are calculated just for one assignment, showing the impact in those costs, but if it is considered that each month units are assigned at least 20 times (depending on the route), it would be shown the real impact that can be achieved by considering a mathematical model instead of just using trial and error techniques as currently it is done.

## 7 Conclusion and recommendations

For freight transport companies, it is important to develop a strategy to minimise logistics costs, since their main business is related to this activity, and it is the case of this Mexican freight transport company, for which it is important to consider costs incurred in operations to help the company to find out ways to reduce them. Hence, it was applied and adapted a vehicle assignment problem based on the classic vehicle routing problem to create the daily programme in which it was assigned the one hundred units, however, to apply the model in posterior days, assigned units should be removed from it, or add some constraints to avoid consider them. Moreover, with obtained results, it was confirmed the impact of low trucks productivity due to delays due to maintenance, idle time caused by the truck drivers or by delays on road from a source point to a destination point, which will cause additional costs or less incomes since the units will make less travels, causing those trucks cannot be assigned to other routes or programmes. The application of the VRP adapted to consider penalty costs shows a reduction about 44.11% of the total costs, which is important, since many of hidden costs of the company are due to lack of productivity due to short time in scheduling preventive maintenance programmes, idle time caused by the truck driver, delays caused in origin and destination centres, and also delays on road (caused, for instance, by weather conditions), which impacts to the company and it is reflected directly in the costs and incomes.

On the other hand, this research can be extended by taking in count different factors identified as those that cause more impact to the company, since in this case just were included the penalty costs, but there are other considerations that can impact the operations and work with the segregation of them, like the logistics costs (caused by the delay in the release of daily programme, lack of deposits of travel expenses to the truck drivers, delay in releasing load orders or purchase orders in fuel stations, among others). Also, further research can be developed by using the VRP model to move trucks between routes, considering a specific rout as starting point and incorporating it to others until it is assigned to the final circuit, if it is required because of operations.

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# MANAGEMENT TOOLS AND SYSTEMS – USAGE IN LOGISTICS COMPANIES IN THE CZECH REPUBLIC

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***Keywords:*** management, tools, systems, trends, strategy, logistics companies.
***Abstract:*** The paper presents the analysis and comparison of management tools and systems usage in companies in Czech Republic as the part of the research that has been done in 2013 and then in 2021 via structured questionnaires. The aim of the paper is to define which management tools and systems are being used by Czech logistics centers, distribution and transport companies and warehouses, what are differences based on the company size (micro, small and medium, large size companies) and what are similarities and new trends across the research sample. The output of the research presents the total and relative frequency of management tools and systems usage comparing 2013 and 2021 outputs and describe current trend of usage, especially with continuous improvement tools (Kaizen, Lean, 6Sigma) that popularity and positive impact on companies' metrics and results is unarguable. TOP 10 management tools and systems are almost same in 2013 and 2021. Usage of management tools and systems in 2021 is higher than 2013 and the increase is significant. We can see the progress of KPI which total frequency (TF) was 25 and relative frequency (RF) was 5.80% in 2013 and 2021 results presents TF: 292 and RF 76.40%.

## 1 Introduction

The management of every company plays a key role to define the strategy and philosophy with steps how to achieve planned goals and how to ensure competitiveness. The primary points or management functions of strategy set up are planning, organizing, leading and controlling [1].

The main purpose of the planning is to realize opportunities and to choose the most effective way to achieve goals on time, with planned costs and available resources. There are three areas of managerial planning – strategic (long-term), tactical (mid-term) to support strategic plan and operative (day-to-day) to cover daily progress and prioritization of activities [2]. Prioritization is closely connected with organizing – the process of resources assignment to tasks, activities and projects that are key to achieve company goals. The leading includes key managerial abilities for effective planning and organizing in the company process. The controlling is the process of continuous progress check and comparing with plans to define if any corrective action is required or not. There are many researches that analyze these points separately and describe their importance but from the overall perspective it is necessary to have complex coverage of planning, organizing, leading and controlling to fulfill the strategic goal as one point cannot work with another [3-5].

The secondary management functions are decision-making, communication and implementation. These secondary functions are omitting very often but they are very important to make a suitable work-environment and to support primary management functions. Decision-making includes wide range of techniques and attitudes to make the right decision in the right time. In the most ideal way, the decision is made based on the objective inputs or data, but managers are facing decision-making problem without any data available – experience, knowledge and also luck are important. Based on the decision-making, planning, organizing, leading and controlling are easier or more difficult. The communication builds bridges between decision making and all primary management functions [6]. The implementation relates to processes, products and their changes in the time – change management [7].

Dynamic progress and development push companies to constantly improve all processes to maintain a position in the market. Management tools are one of the basic elements for managing the company´s performance [8]. More and more, it is important to collect the right data for the necessary analyzes so that the right decisions can be made. An appropriate set of tools plays a crucial role in the whole cycle of the company and it is very important for the natural and sustainable development of the organization [9]. The basis of every company is a vison and a plan. A common cause of failure is the application of inappropriate tools or their incorrect use [10]. For this reason, companies also need to focus on training in management tools, whether they are employees working on internal process or working on business development or supply chain management [11,12].

Management tools and systems allow the companies to manage internal processes easily and more effective. There are lot researches on management tools and systems using worldwide but only couple of these researches focus on Czech Republic. The following chapters presents the outputs of research to understand and describe usage of management tools and systems in logistics companies in Czech Republic and discusse obtained results in the context of similar, previously conducted research studies. This research builds on a study from 2013 [9,11,13] and compares the results achieved in 2021.

## 2 Management tools and systems – theoretical background

Academics define an immense number of management methods, tools, techniques or indicators that were developed to help the companies achieve their goals. Summary of management methods, tools, systems according to the areas of management are listed in Appendix 1. For a purpose of this study, we were aware that finite, processable number of tools must be chosen. Finally, there were 17 selected and considered management tools, methods, systems, techniques or indicators to put into questionnaire. The theoretical background of these methods is as follows:

- **BCG Matrix** (Growth-share matrix) is a portfolio planning tool developed by the consulting company Boston Consulting Group (BCG). The BCG matrix is based on the product life cycle and is used for the evaluation of the organization's product portfolio from two points of view: market growth and relative market share. This tool helps managers determine which product the company should investigate and which one they should avoid or withdraw from the market [14].
- **Business Plan, Strategic Planning (strategic document)** is a comprehensive process for determining what a business should become and how it can best achieve that goal. It appraises the full potential of a business and explicitly links the business's objectives to the actions and resources required to achieve them. Strategic Planning offers a systematic process to ask and answer the most critical questions confronting a management team - especially large, irrevocable resource commitment decisions [15].
- **BSC** (Balanced Scorecard) has become the most widely applied performance management system today. It is a system of management and measurement of the performance of the organization, which is based on defining a balanced system of interrelated indicators of business performance. It measures performance across a number of different perspectives (financial, internal business process, innovation and learning and customer perspective) [16].
- **EFQM** Excellence Model (also used in short version EFQM Model) was developed by the European Foundation for Quality Management as a framework for the implementation of quality management methods in the organization. The process perspective is comprised of several categories of indicators from financial and customers to people and leadership [17].
- **EVA** (Economic Value Added) is a frequently used indicator of organizational performance. A positive EVA signifies the value for the shareholders. A negative EVA indicates the loss of value. The basic idea of the indicator is that a company can reach the profit only if its revenue covers the company's cost and the cost of capital. EVA is designed to give shareholders better information about the efficiency of managers' decisions that should create the greater company's wealth [18].
- **ISO 9000 family** is a part of the family of international standards issued by the ISO (International Organization for Standardization) focusing on quality management. Standards of this system are not a management method, it is a standard or norm, which serves as a reference model for setting the basic management processes in an organization that continuously helps improve the quality of provided products or services and customer satisfaction (quality management system). It can be used as a tool for business process and continuous performance improvement [19].
- **ISO 14000 family** is used for environmental management systems. This standard requires the organization to identify all the environmental impacts and related aspects of its business. In addition, it defines the objectives of environment and introduces measures to improve performance through process improvement in areas of high priority [19].
- **Kaizen** is a method of gradual improvement based on cultural traditions of Japan. The improvement focuses on the gradual optimizing of the processes and work practices, quality improvement and scrap reducing, material and time savings leading to cost reduction, work safety and reducing workplace accidents [20].
- **KPI (Key Performance Indicators)** defines key metrics of performance that relate to processes, services, business

unit and whole organization. KPI measures strategic goals achievement in the time [21].

- **Lean Management** is a very broad management tool [22]. The term philosophy that the organization (enterprise) must accept is most often used in connection with Lean. Lean is based on several basic principles. Primarily it is the effort of the organization to continuously improve in all areas and to avoid unnecessary wastage. The second principle is the best possible satisfaction of customers' needs, no matter how. Lean is often used with different attributes; depending on the field this philosophy is applied [20].
- **MBO** (Management by Objectives) was designed by Peter F. Drucker as a method based on setting and mutual agreement of the objectives and the evaluation of the success of their achievement. The task implementers are allowed to decide which method is most appropriate to achieve the objective. The implementer delegates responsibility to meet the objective. The method is applicable in virtually all management fields [23].
- **PEST(LE)** analysis is an analytical technique used for the strategic analysis of organizational surroundings. PESTLE (sometimes also PESTEL, SLEPTE etc.) is an acronym and each letter represent a different type of external factors (Political, Economic, Social, Technological, Legal, and Ecological) [24].
- **Porter's five forces** is the work of Michael E. Porter. It is a way of analyzing the industry and its risks. The model works with five elements (Five Forces). The principle of this method is forecasting the development of the competitive situation in analyzed industry, based on estimating the potential behavior of subjects and objects involved in a given market and forecasting the risk of imminent business [25].
- **Six Sigma** is a complex method of management. It is known more as a philosophy that a company must follow. It is one of the TQM approaches initiated by Motorola (further adopted and propagated by GE), where the focus is put on continuous improvement (innovation) of the organization by understanding customers' needs, using the process analysis and standardization methods in the measurement. It is a comprehensive, flexible management system that is based on understanding customers' needs and expectations, on disciplined use of information and data to management and decision making. It measures the process capability and stability by determining the rate of DPMO (defects per million opportunities) [20].
- **SMART** is an analytical technique for designing objectives in management and planning. SMART is an acronym from the initial letter of the English names of the objective attributes (Specific, Measurable, Achievable/Acceptable, Realistic/Relevant, and Time Specific/Track-able) [23].
- **SWOT** analysis is a universal analytical technique focusing on the evaluation of internal and external factors affecting the success of an organization or any other evaluated system. Most often, SWOT analysis is used in the strategic management of an organization in the evaluation of a strategic intention. The author of SWOT analysis is Albert Humphrey, who designed it in the sixties of the 20th century [24].
- **TQM** (Total Quality Management) is a very complex management approach that puts emphasis on quality management in all dimensions of the organizational life. It goes beyond quality management. This method ensures cooperation of everyone in a company. It is also a method of strategic management and a management philosophy for all the organizational activities. Associated business processes within this tool force the production to meet and exceed the needs and expectations of a company's customers [19].

## 3 Current state of knowledge

The current researches describe the importance of management tools and systems but mostly from the very strait perspective – by single tool or system. Strategic document has been described and analyzed by lot of researches. Naseri et al. [25] identified the strategic plan as the critical document for operation and budget planning. They also described close interaction between strategic document and SWOT as the key input for the strategic planning. Dewi and Sunpranto [26] presented similar outputs of the research as they identified strategic document importance from the companies standards and policies perspective as an important part of the strategy.

SWOT analysis is well-known and popular tool. Based on Řehoř et al. [27], the quality of strategic plan and document is always as good as SWOT analysis inputs are. Begon and Todorova [28] evaluated that it doesn´t make sense to prepare strategy without SWOT because the SWOT provides a knowledge level that is critical to understand an organisation from the different point of view to apply the most effective strategy and to focus on the right things together with SMART approach.

ISO standards – 9000 and 14000 are also very important systems for industrial companies. Especially ISO 9000 is being the part of industrial companies for a long time. Bello-Pintado et al. [29] presented research outputs with ISO 9000 positive impact on job satisfaction and affective commitment as the system supports the quality extremely. ISO 14000 is controversial topic based on Wang and Zhao [30]. Based on their research, ISO 14000 is perceived as the necessary standard without any added value from the employees perspective. The different outputs were presented from the economic perspective presented by Romero et al. [31] who evaluated positive impacts on economic results especially in large sizes companies who reduced emission and got the certification.

Total Quality Management (TQM) is the purpose of many researches. Romero et al. [31] identified that TQM is critical tool that required well-experienced experts with capabilities to cover quality planning, quality control ,

quality assurance and quality improvement together with the digitalization and lean manufacturing systems implementation. The TQM is closely connected with Lean Management [32]. Outputs of Poppendieck and Poppendieck research [33] presented three critical points – reduction of wasting, effectivity and employee motivation as the key of the TQM and Lean approach. Tetteh et al. [33] also define Lean management as the key technique to redesign the internal process with positive business impact but with continuous development of employees as the key factor and resource to define the opportunities and to work on improvements as the lean manufacturing is continuous improvement process. Six Sigma (6Sigma) is also being more and more popular. The current researches describe DMAIC approach popularity, f.e. Patil et al. [34] because DMAIC (define, measure, analyze, improve, control) covers all critical parts of improvement process so this methodology has its popularity especially in the large size companies with Black Belt experts onsite.

Management tools are one of the basic elements for managing the company´s performance. More and more, it is important to collect the right data for the necessary analyzes so that the right decisions can be made. An appropriate set of tools plays a crucial role in the whole cycle of the company and it is very important for the natural and sustainable development of the organization [35].

The trend and probably a key area of using management tools is digitization. It allows you to combine all the needs in one place with the application of the necessary tools and visualizations to satisfy all the areas of the company [36].

## 4 The methodology of the paper and data collection

Goal of the paper has been set to analyze and describe the current situation of 17 management tools and systems usage in logistics companies in Czech Republic in 2021 compared to research data from 2013 to analyze the progress. The data from 2013 was part of authors research about management tools, systems, techniques usage [9,11,13]. All respondents had an option *Other Tool* that was not mentioned above.

The questionnaire has been prepared a sent into the Czech companies from the different logistics business areas (logistics centers, distribution and transport companies, warehouses). Then data has been analyzed and evaluated with using of statistical methods (percentage, summary, total and relative frequency), comparison with usage of bar charts visualization.

For the purpose of this paper research, the company size categories are defined in Table 1.

Three research questions were formulated:

1. What is the frequency of defined management tools and systems in companies in Czech Republic in 2021 compared to 2013?
2. What are the biggest differences of management tools and systems usage in 2013 and 2021?
3. What are differences of management tools and systems application between micro size, small and medium size and large size companies?

*Table 1 Company size categories based on quantity of employees*

| Company size categories | Number of employees | Group |
|---|---|---|
| Micro size | 1 – 10 | A |
| Small size | 11 – 50 | B |
| Medium size I | 51 – 100 | B |
| Medium size II | 101 – 250 | B |
| Large size | 250 + | C |

The primary data were collected in 2013 in Czech Republic. Totally 500 questionnaires were sent and after filtration and reduction, 431 replies were evaluated so totally 86.20% of feedback was analyzed in 2013.

The purpose of 2021 questionnaires were to analyze the current state of management tools and systems usage in industrial company in Czech Republic. The data presented in this research are made of totally 382 replies that were received from total amount of 415 questionnaires, so 2021 success of return is 92.00%.

From the total amount of 431 inputs, the structure of the 2013 sample was following:

- **Company size categories:** 98 micro size (22.70%), 216 small and medium size (50.10%), 117 large size (27.10%).
- **Logistics business areas:** 82 logistics centers (19.00%), 195 distribution and transport companies (45.20%), 154 warehouses (35.70%).
- All companies provide the current status of the management tools and systems usage.

The sample of 2021 was following:

- **Company size categories:** 42 micro size (11.00%), 203 small and medium size (53.10%), 137 large size (35.90%).
- **Logistics business areas:** 30 logistic centers (7.80%), 206 distribution and transport companies (53.90%), 146 warehouses (38.20%).
- All companies provide the current status of the management tools and systems usage.

Even if samples from 2013 and 2021 are not completely the same, the portion of small and medium size and large size companies is very similar. The same similarity is visible from the business areas perspective.

## 5 Results of the research

The questionnaire has been prepared a sent into the Czech companies from the different logistics business areas (logistics centers, distribution and transport companies and warehouses). Then data has been analyzed and evaluated with using of statistical methods

(percentage, summary, total and relative frequency), comparison with usage of bar charts visualization. Chapter present most important findings of research. Following outputs presents trends of management tools and systems usage in companies in Czech Republic from logistics centers, distribution and transport companies and warehouses. Table 2 presents the frequency (total and relative) of 17 chosen management tools and systems usage within research sample in 2013 and 2021.

*Table 2 Total and relative frequency of management tools and systems usage in 2013 and 2021*

| Method, Tool, System | Total Frequency 2013 | Relative Frequency 2013 | Total Frequency 2021 | Relative Frequency 2021 |
|---|---|---|---|---|
| Strategic document | 234 | 54.29% | 357 | 93.42% |
| SWOT | 189 | 43.85% | 288 | 75.34% |
| ISO 9000 | 154 | 35.73% | 250 | 65.41% |
| ISO 14000 | 70 | 16.24% | 152 | 39.77% |
| SMART | 57 | 13.23% | 99 | 25.93% |
| TQM | 57 | 13.23% | 125 | 32.71% |
| EVA | 30 | 6.96% | 24 | 6.27% |
| KPI | 25 | 5.80% | 292 | 76.40% |
| BCG | 23 | 5.34% | 28 | 7.30% |
| BSC | 23 | 5.34% | 36 | 9.40% |
| Kaizen | 14 | 3.25% | 160 | 41.82% |
| Lean | 14 | 3.25% | 150 | 39.21% |
| MBO | 12 | 2.78% | 15 | 3.87% |
| 6Sigma | 10 | 2.32% | 81 | 21.14% |
| EFQM | 10 | 2.32% | 17 | 4.41% |
| 5F Porter | 7 | 1.62% | 9 | 2.33% |
| PESTLE | 6 | 1.39% | 7 | 1.81% |
| Others | 10 | 2.32% | 43 | 11.20% |

Table 2 presents the answer to the first research question. The most important tool in 2013 was strategic document that was used by 234 companies (54.80%). Surprising result was shown by SWOT 189 (44.30%) that popularity and benefit has been increasing in last couple of years generally. ISO systems (9000 and 14000) came after – ISO 9000 154 companies (36.10%) and IS0 14000 70 companies (16.40%). The rest of management tools and systems were below 15.00% of usage that was interesting finding. Especially for Kaizen, Lean and 6Sigma, the results of very low usage were not expected.

The biggest difference of 2021 outputs are visible in increase of management tools and systems usage in general. The strategic document is being used by 357 (93.42%) of respondents. SWOT, ISO 9000. ISO 14000 and TQM still have their important role in Czech companies. The biggest progress has been performed by continuous improvement tools – Kaizen, Lean and 6Sigma. These tools are often presented as a key for companies operation and progress at the market. A growth of continuous improvement tools is significant – Kaizen (2013: 14 companies; 3.25% vs. 2021: 160 companies; 41.82%), Lean (2013: 14 companies; 3.25% vs. 2021: 150 companies; 39.21%), 6Sigma (2013: 10 companies; 2.32% vs. 2021: 81 companies; 21.14%).

Following figures presents the details of micro, small and medium, large size companies.

Figure 1 shows the relative frequency of management tools and systems that are being used in micro size companies (up to 10 employees). Figure 2 shows the usage of tools and systems in 2021 and outputs are compared.

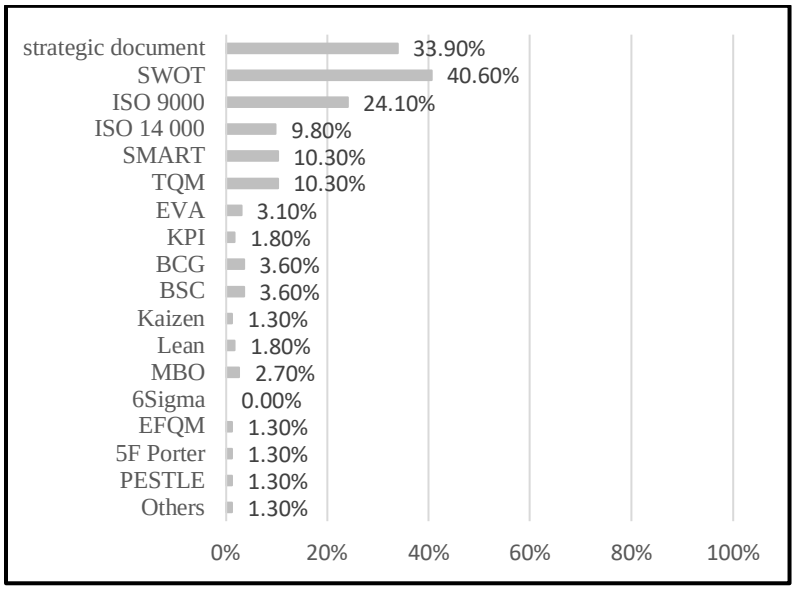


*Figure 1 Usage of management tools and systems in micro size companies in 2013*

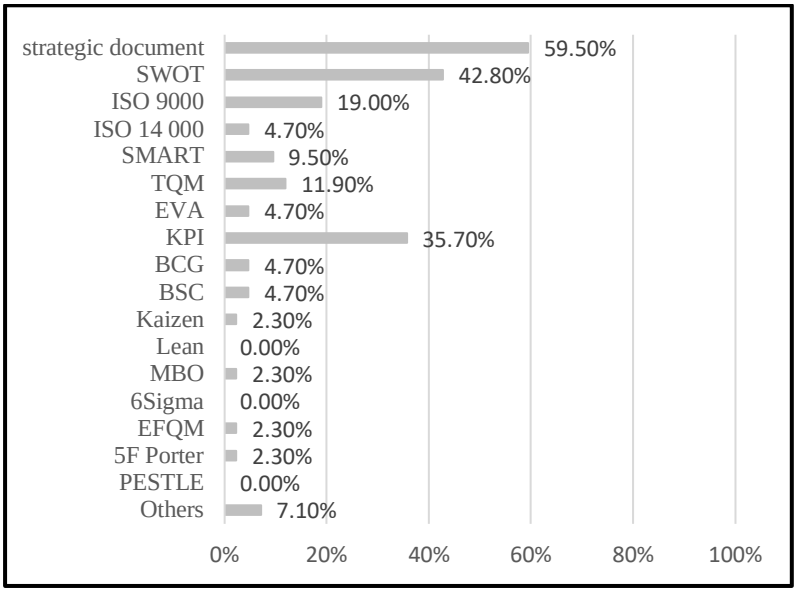


*Figure 2 Usage of management tools and systems in micro size companies in 2021*

The detail of micro size companies from 2013 presents, that also for this area strategic document (33.90%), SWOT (40.60%), ISO 9000 (24.10%) are the three most important tools and systems that are used. Boundary of 10% was also exceeded by SMART (10.30%), TQM (10.30%). ISO 14000 (9.80%) is nearly. SMART role is to define the goal of the micro size companies as all employees needs to understand clearly what the mission is and what is required to achieve the goal. TQM presents the key system to rise the competitiveness of the micro companies that are facing the larger companies. The rest of the management tools and systems are being used rarely and 6Sigma is not used in our sample of micro size companies.

The data from 2021 are very similar to 2013 outputs. There is a significant growth of strategic document usage (2013: 33.90% vs. 2021: 59.50%). The biggest increase is performed by KPI (2013: 1.80% vs. 2021: 35.70%). We can see also small drop of ISO 9000 (2013: 24.10% vs. 2021: 19.00%). The rest of tools are on same level of usage in 2021 as in 2013. The trend of continuous improvement tools (Kaizen, Lean and 6Sigma) is almost the same in 2021 as it was in 2013 – Kaizen (2.30%), Lean and 6Sigma (both 0.00%).

Figures 3 and 4 present the outputs of small and medium size companies (11-250 employees) usage of management tools and systems in research sample from 2013 and 2021 and their comparison.

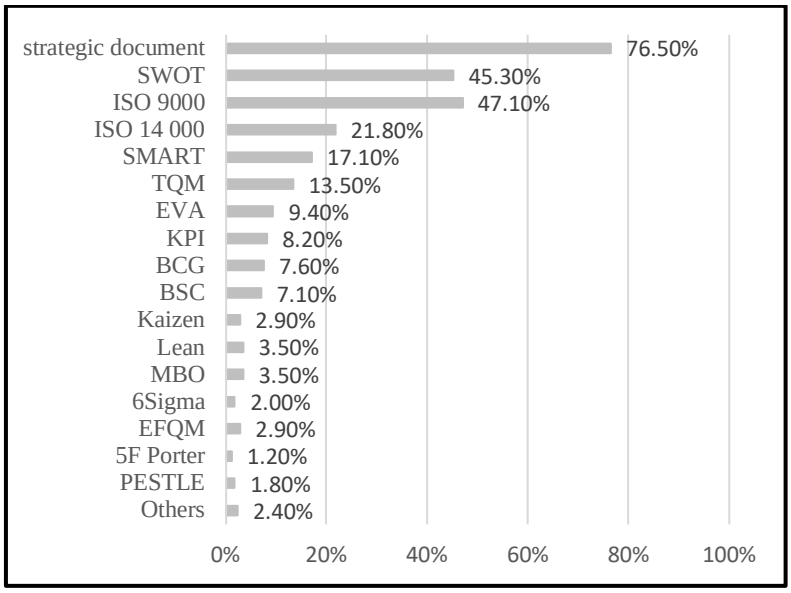


*Figure 3 Usage of management tools and systems in small and medium size companies in 2013*

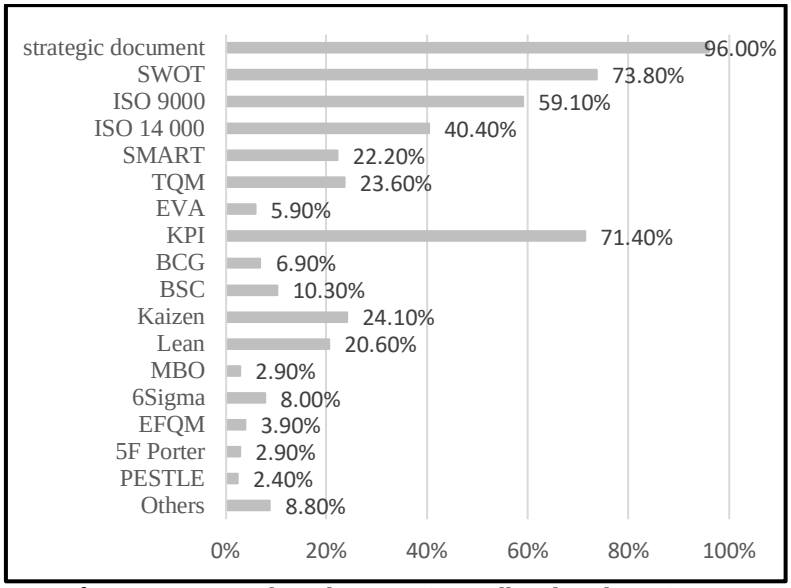


*Figure 4 Usage of management tools and systems in small and medium size companies in 2021*

The outputs from 2013 of small and medium size companies show the increasing trend of strategic document importance as 76.50% are using it. ISO 9000 (47.10%) exceeded SWOT (45.30%). Comparing to micro size companies – also IS0 14000 (9.80% vs. 21.80%) is more important for small and medium size companies. We can see increasing trend of EVA (9.40%), KPI (8.20%), BCG (7.60%), BSC (7.10%) comparing to micro size companies. However, the occurrence of Kaizen (2.90%), Lean (3.50%) and 6Sigma (1.80%) is still not extensive as we would predict higher volume based on the current trend in the world.

The 2021 results present significant increase of all management tools and systems usage comparing to 2013. Strategic document (96.00%) is still the most important tool. SWOT (73.80%), ISO 9000 (59.10%), ISO 14000 (40.40%) are still very important for small and medium size companies and their growth is confirming that. However, the biggest progress is again performed by KPI (71.40%) that causes jump of KPI to the third position of usage in 2021. We can also see a positive growth of continuous improvement tools (Kaizen, Lean, 6Sigma) as in 2013 all of them were below 4.00% of relative frequency and in 2021 results are: Kaizen (24.10%), Lean (20.60%) and 6Sigma (8.00%) that confirms the popularity of these tools especially in industrial companies.

Figures 5 and 6 present the data of large size companies with more than 250 employees from 2013 and 2021.

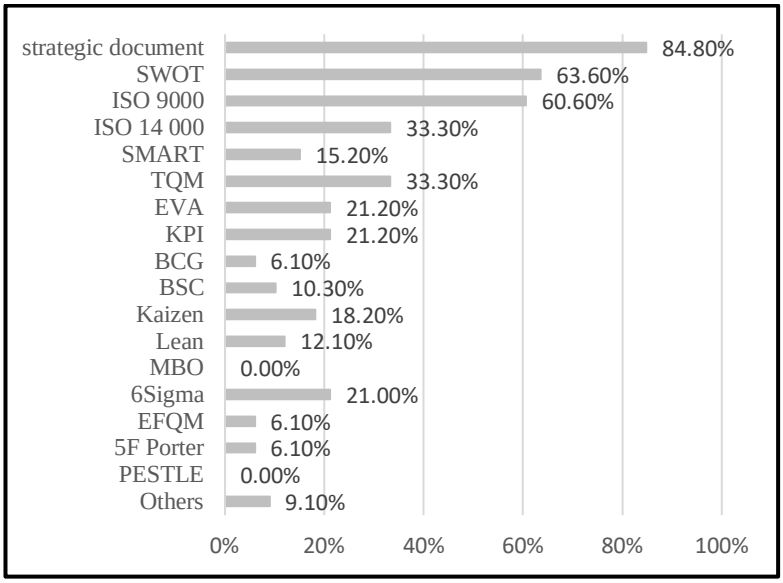


*Figure 5 Usage of management tools and systems in large size companies in 2013*

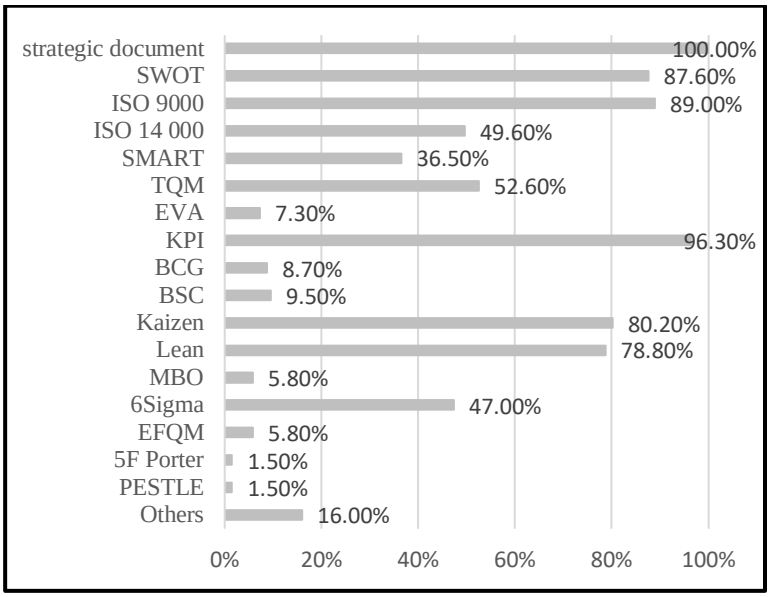


*Figure 6 Usage of management tools and systems in large size companies in 2021*

The results of large size companies research from 2013 show that strategic document (84.80%), SWOT (63.60%), ISO 9000 (60.60%) are key tools and systems. The impact of SMART is almost on the same level as in small and medium size companies (15.20%). The increasing trend of TQM (33.30%), EVA (21.20%), KPI (21.20%) continues. The significant growth is in Kaizen (18.20%), Lean (12.10%), 6Sigma (21.20%). Based on that, we can say that bigger companies focus on the continuous improvement tools that Kaizen, Lean and 6Sigma are. Large size companies have also 9.10% of Other tools and systems.

The 2021 outputs follow on increasing trend of small and medium size results. The strategic document (100.00%), ISO 9000 (89.00 %), SWOT (87.60%), are still key tools and systems for large companies. As we saw in micro, small and medium size companies, new key management tool in 2021 is KPI that presents 96.30% in 2021 and it means the second position and confirm the increase of importance of KPI that is currently one of the most important tools. The continuous improvement tools jump from 2013 to 2021 is extreme Kaizen (2013: 18.20% vs. 2021: 80.20%), Lean (2013: 12.10% vs. 2021: 78.80%) and 6Sigma (2013: 21.00% vs. 2021: 47.00%).

## 6 Discussion of research results

The summary of TOP management tools and systems for micro, small and medium, large size companies from 2013 and 2021 is presented in Table 3.

*Table 3 Summary of TOP 10 management tools and systems usage comparing 2013 and 2021*

| TOP 10 | 2013 | Total Frequency 2013 | Relative Frequency 2013 | 2021 | Total Frequency 2021 | Relative Frequency 2021 |
|---|---|---|---|---|---|---|
| **1** | **Strategic document** | 234 | 54.29% | **Strategic document** | 357 | 93.42% |
| **2** | **SWOT** | 189 | 43.85% | **KPI** | 292 | 76.40% |
| **3** | **ISO 9000** | 154 | 35.73% | **SWOT** | 288 | 75.34% |
| **4** | **ISO 14000** | 70 | 16.24% | **ISO 9000** | 250 | 65.41% |
| **5** | **SMART; TQM** | 57 | 13.23% | Kaizen | 160 | 41.82% |
| **6** | **SMART; TQM** | 57 | 13.23% | **ISO 14000** | 152 | 39.77% |
| **7** | EVA | 30 | 6.96% | Lean | 150 | 39.21% |
| **8** | **KPI** | 25 | 5.80% | **TQM** | 125 | 32.71% |
| **9** | BCG; BSC | 23 | 5.34% | **SMART** | 99 | 25.93% |
| **10** | BCG; BSC | 23 | 5.34% | 6Sigma | 81 | 21.14% |

Table 3 presents the overall results for usage of management tools and systems in micro, small and medium size and large size companies. We can see that in TOP 10 are almost the same management tools and systems in 2013 and 2021 – strategic document, SWOT, ISO 9000, ISO 14000, SMART, TQM an KPI. However, the total and relative frequency is different together with the position of every single system or tool. Generally, 2021 usage of management tools and systems is higher than 2013 and the increase is significant. We can see the progress of KPI which total frequency (TF) was 25 and relative frequency (RF) was 5.80% in 2013 and 2021 results presents TF: 292 and RF 76.40%. New members of TOP 10 are continuous improvement tools (Kaizen, Lean and 6Sigma) which popularity and importance is growing and our research confirms the trend.

We can say that the goal of the paper to analyze and describe the current situation of management tools and systems usage in companies in Czech Republic was fulfilled. The three research questions were answered as follows:

1. *What is the frequency of defined management tools and systems in companies in Czech Republic in 2021 compared to 2013?* Both (total frequency and relative frequency) for all tools are presented in Table 2 and TOP 10 summary is shown in Table 3.
2. *What are the biggest differences of management tools and systems usage in 2013 and 2021?* The biggest differences between 2013 and 2021 are frequency of management tools and systems usage, importance of KPI and usage of continuous improvement tools. All tools have higher total and relative frequency in 2021. The growth of KPI was presented above but to summarize that, 2013 outputs are TF 25 and RF 5.80% and 2021 outputs are TF 292 and RF 76.40% that is significant increase. Continuous improvement tools deserve own research but as a part of this paper, we can see that the importance and popularity has grown significantly as KPI - Kaizen (2013: TF 14; RF 3.25% vs. 2021: TF 160 companies; RF 41.82%), Lean (2013: TF 14; RF 3.25% vs. 2021: TF 150; RF 39.21%), 6Sigma (2013: TF 10; RF 2.32% vs. 2021: TF 81; RF 21.14%).
3. *What are differences of management tools and systems application between micro size, small and medium size, and large size companies?* The data that are shown in chapter 3 presents very similar trend of management tools and system usage with little differences. For all groups – micro, small and medium and large size, strategic document, KPI, ISO 9000 and SWOT are the most important ones. The biggest difference is with continuous improvement tools usage in large companies comparing to micro and small and medium size. The micro size companies almost don´t use them. Small and medium size companies have the usage of Kaizen, Lean and 6Sigma but the real progress and usage is visible in the large size companies that have completely different attitude to Kaizen, Lean and 6Sigma usage.

The main research findings of authors that worked on same area of research are listed in Table 4. We can state that our results are in accordance with the conclusions of previous research studies.

*Table 4 Main findings of similar research studies*

| # | Author | Research output |
|---|---|---|
| 1 | Johnson [37] | Key tool for competitiveness is strategic document. |
| 2 | Analoui [38] | Strategic document and other management methods increase preparation of enterprises to dynamic markets changes. |
| 3 | Andersen [39] | Strategic document is important tool for company performance. |
| 4 | Song [40] | Performance increase is supported by strategic document and overall planning process and management tools, method usage. |
| 5 | Rudd [41] | Strategic document is key element that needs to be updated to increase the possitive impact. |
| 6 | Drucker [42] | Strategic document and other management method and techniques is a must for long-term success. |
| 7 | Stonehouse [43] | Strategic management is mainly focused by large size companies comparing to medium and small size companies that focus on process management and planning. |
| 8 | Frost, 2003 [44] | The size of company correlates with usage of management methods and techniques as in large size company is higher usage of these managemenet tools. |
| 9 | Laforet 2008 [45] | Large size companies – more resources to utilise an advantage of management tools to support KPI´s |
| 10 | Tapinos, 2005 [46] | Strategic document defined as key for success in long term perspective. |
| 11 | Hartz, 1998 [47] | Long term goals, managerial tools and regular updates are three important elements of successful company. |
| 12 | Hussey, 1997 [48] | Small size companies use arround 2-3 management tools at the average. |
| 13 | Temtime, 2003 [49] | Strategic planning is important for resources planning and development. |

Research outputs from Table 4 underline important fact that usage of management tools, methods, techiques are crucial especially for strategic management of companies and that strategic document is key element of company success and development. Strategic planning is an effective approach to increase companies competitiveness at the market. The important fact of these research studies was that for large size companies is more common to use management tools and methods than for medium or small size companies.

## 7 Conclusion

The research questions were answered and fulfilled. The sample and data of the research are reliable and huge. The output of research performed in 2021 presents the usage of management tools and system in logistics centers, distribution and transport companies and warehouses and from the different size of companies – micro, small, medium and large compared to 2013 research results. Future researches could be aimed also on other countries as our research was performed only in Czech Republic companies so it would be good to compare the attitudes across different countries. It would be also good to deeply analyze concrete companies based on size or business area.

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**Review process**
Single-blind peer review process.

## Appendix 1 Management methods, tools, techniques, systems according to areas of management

| Area of management | Name of tool, technique, method, system |
|---|---|
| Strategic Management | 7 Classes of Strategic Risks (Slywotzky), **Strategic document**, **Porter 5F** (Five Forces) Analysis, **BCG** (Boston matrix), **BSC** (Balanced Scorecard), the Blue Ocean Strategy, Gap Analysis, EFE Matrix, IFE Matrix, Hierarchy of Strategies, Management by Objectives, MOST, **PESTLE** Analysis, the Strategy → Structure Principle, Forecasting, Scenarios Technique, SPACE Analysis, **SWOT** Analysis, **SMART** - Goal Design, VRIO Analysis, Winterling Crisis Matrix, Critical Success Factors, **KPI** (Key Performance Indicators). |
| Management Organization | **BSC** (Balanced Scorecard), ERP (Enterprise Resource Planning), MBC (Management by Competencies), **MBO** (Management by Objectives), Organizational Development, Process |

| | |
|---|---|
| | Management, Project Management, Change Management, SOEM (Service Oriented Enterprise Management), SOM (Service Oriented Management), **Porter 5F** (Five Forces) Analysis, **BCG**, Critical Success Factors, Pareto principle, Strategy → Structure Principle, **PESTLE** Analysis, Reengineering, **SMART** - goal design, **SWOT** analysis, VRIO analysis, KGI (Key Goal Indicators), **KPI** (Key Performance Indicators), Excellence Model EFQM. |
| Quality Management | APQP (Advanced Product Quality Planning), PDCA (Deming Cycle), **DMAIC** Improvement Cycle, Excellence Model **EFQM**, **Kaizen**, Quality Rings, **Lean**, Poka-yoke, Six Sigma, **TQM** (Total Quality Management), the 5S, DOE (Design of Experiments) Ishikawa diagram, Kano model, Pareto Principle, FMEA (Failure Mode and Effect Analysis), FTA (Fault Tree Analysis), QFD (Quality Function Deployment), House of quality, G8D (Eight Disciplines), MSA (Measurement System Analysis), PPAP (Production Part Approval Process), Quality Management Systems **ISO 9001**, |
| Innovation Management | Blue Ocean Strategy, **CAF** (Common Assessment Framework), **DMAIC** Improvement Cycle, **PDCA** (Deming cycle), Excellence Model **EFQM**, Kaizen, Quality Rings, Open Innovation, Six Sigma, **TQM** (Total Quality Management), User Centered Design, Brainstorming, Mindmaps, Pareto principle, SMART- goals design. |
| Change Management | Three step change (Lewin), Four step change, Eight step change, organizational development, change management by CSF (Critical Success Factors), **Porter 5F** (Five Forces) Analysis, Kolb Cycle of learning, Delphi method, Pareto principle, **SMART** - goals design, **SWOT** analysis, Scenarios Technique, **PESTLE** analysis. |
| Production Management | ABC-D, BOA (Belastungorientiere Auftragsfreigabe), CIM (Computer Integrated Management), CRP (Capacity Resource Planning), DBR (Drum Buffer Rope), JIT (Just-in-time), MRP (Material Requirements Planning), MRP II (Manufacturing Resource Planning), ERP (Enterprise Resource Planning), KANBAN, FIFO (First In First Out), FEFO (First Expired, First Out), HIFO (Highest In First Out)**,** LIFO (Lowest In First Out), Lean Production, BCG Matrix, Pareto principle, VRIO analysis, **ISO 9001**, **ISO 14000**. |
| Marketing and Sales | 5K Method, TLM (Total Loyalty Marketing), Branding, Blue Ocean Strategy, Holistic marketing concept, Marketing strategy, Marketing mix 3V, 4C, 4P, Positioning, CRM (Customer Relationship Management), Brand Management, PR (Public Relations), Market segmentation, Targeting, Product concept, Web marketing mix 4S, WOMM (Word of Mouth Marketing), **Porter 5F** (Five Forces) analysis, An off matrix, **BCG** (Boston matrix), Kano model, Customer portfolio matrix, **PESTLE** analysis, **SWOT** analysis, VRIO analysis. |
| Process Management | BCM (Business Continuity Management), **BPM** (Business Process Management), ITIL (ICT processes management), **Six Sigma**, PDCA (Deming cycle), **DMAIC** improvement cycle, reengineering, Time frames, statistical methods, **ISO 9001**, **TQM** (Total Quality Management). |
| Economy and Finance Management | Pareto principle, Financial leverage, **PESTLE** analysis, **SWOT** analysis, VRIO analysis, Break Even Point Analysis, Financial statements analysis, Determination of financial indicators (liquidity, rentability, investments, indebtedness, activities, market value, productivity), TCO (Total Cost of Ownership), EBIT (Earnings before Interest and Taxes), Gross margin, Cash Flow, NOPAT (Net Operating Profit after Taxes), **EVA** (Economic Value Added), MVA (Market Value Added), WAAC (Weighted Average Cost of Capital), 29NPV (Net Present Value), IRR (Internal Rate of Return), Altman analysis (Altman Z-score). |
| Service Management | **BCG** matrix, Pareto principle, CorSet Framework, ITIL, ITSM (IT Service Management), SSME (Service Science, Management and Engineering), SOEM (Service Oriented Enterprise Management), SOM (Service Oriented Management), Services management system ICT ISO 20000. |
| Computer science and IT Management | SOA (Service Oriented Architecture), Code and Fix, EUP (Enterprise Unified Process), MSF (Microsoft Solutions Framework), MMDIS (Multidimensional Management and Development of Information Systems), DSDM (Dynamic System Development Method), ASD (Adaptive Software Development), BPEL (Business Process Execution Language), BPMN (Business Process Modelling Notation), ISO 8000, **ISO 9001**, ISO 15504, ISO 20000. |
| Facility Management | Process analysis, Benchmarking, Insourcing, Business Process Improvement, Outsourcing, Spatial optimization, SLA (Service Level Agreement), SLM (Service Level Management), **SWOT** analysis, Maintenance, FMS (Facility Management Systems), CAFM (Computer Aided Facility Management). |

| | |
|---|---|
| Logistics and Transport | APS (Advanced Planning & Scheduling), Benchmarking, ERP (Enterprise Resource Planning), JIT (Just-in-time), KANBAN, MRP (Material Requirements Planning), MRP II (Manufacturing Resource Planning), Outsourcing, SCM (Supply Chain Management), CPM (Critical Path Method), TOC (Theory of Constraints), Network Analysis, model SCOR (Supply Chain Operations Reference-model). |
| Project Management | Gantt chart, Project schedule, Network analysis methods, RACI and RASCI responsibility matrix, Project plan, Project-Based Management, WBS (Work Breakdown Structure), Impact Analysis, PMBOK (Project Management Body of Knowledge), PRINCE2 (Projects in Controlled Environment), Project management standards ISO 10006, ISO 21500. |
| Crisis Management | Crisis plan, Winterling Crisis Matrix, Pareto principle, Forecasting, **SMART** - objective design, Scenarios technique. |
| Knowledge Management | Social network analysis, Sociogram, Sociometrics, Management epistemology, Learning. |
| Risk Management | BASEL I-III, CorIA (Core Impact Assessment), Checklist analysis, CCA (Cause-Consequence Analysis), CRI (Continuous Risk Improvement), Delphi method, CCTA Risk Analysis and Management Method), CPQRA (Chemical Process Quantitative Risk Analysis), EWRM (Enterprise-Wide Risk Management), ETA (Event Tree Analysis), FMEA (Failure Modes and Effects Analysis), FMECA (Failure Mode, Effects and Critical Analysis), FTA (Fault Tree Analysis), HAZOP (Hazard and Operability Study), HAZID (Hazard Identification Study), HRA (Human Reliability Analysis), PHA (Preliminary Hazard Analysis), PPAP (Production Part Approval Process), Forecasting, RIPRAN (Risk Project Analysis), RR (Relative Ranking), SA (Safety Audit) SR (Safety Review), VaR (Value at Risk), W-I (What-if Analysis), Winterling Crisis Matrix, Risk Management ISO 31000, OHSAS 18001. |
| Human Resources Management | 360° feedback, Jobs analysis, Social network analysis, BEI (Behavioral Event Interview), Jack Welch Matrix, Job description, Staff audit, Role prosets, Sociogram, Sociometry, Job specification, Satisfaction Survey Methods. |

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# THE IMPACT OF THE DEVELOPMENT OF PERSONNEL COSTS ON THE PROFITABILITY INDICATORS OF ROAD FREIGHT TRANSPORT COMPANIES IN THE CZECH REPUBLIC

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***Keywords:*** personnel costs, profit, labour productivity.
***Abstract:*** The paper's main objective is to investigate the effects of personnel cost growth between 2014 and 2019 on the profitability of selected large road freight transport companies based on the collection of publicly available data of these transport companies. The first sub-objective of the paper is to conduct the necessary data collection from the financial statements of road freight transport companies with more than 250 workers. The second sub-objective of the paper is to define financial ratios and to assess the impact of personnel cost growth on the profitability of these enterprises. The third sub-objective is to determine the development of selected financial ratios over the period 2014 to 2019 and to evaluate the impact of personnel cost growth on the development of these ratios for selected transport companies. As a result of the fulfilment of these goals, we identified that an increase in personnel cost led in chosen transport companies in the years 2015 – 2016 to a significant decrease in labour productivity in the form of sales per employee and decreased profit. In the years 2017 – 2018, the year-on-year increase in personnel cost slowed down with impact to improved labour productivity and improved profit. In 2019 although another increase in personnel cost occurred, the situation changed, and labour productivity and profit increased. Analysis of these data showed that an increase of labour productivity in the form of sales per employee and profit increase in 2018 and 2019 was done thanks to the increasing price of transportation that covered higher personnel costs.

## 1 Introduction

Reducing costs and increasing efficiency are very important objectives for all service providers, which is made possible by a thorough survey of demand in this area. The intensity of transport activities linked to production and services is constantly increasing due to the economy's inefficiency of growth and supply chains' greater interconnectedness. The importance of carrying out research studies in this area stems from the fact that at least 30% of the costs of the entire supply chain come from transport [1].

Road transport accounts for the largest share of freight performance in the EU of the three inland modes. For example, from 2014 to 2019, road transport always accounted for more than three-quarters of total land freight transport (based on tonne-kilometres performed) [2].

Cost management is becoming crucial for all transport companies, and the rational organisation of freight transport in time from A to B must be at minimum cost [3].

From the perspective of freight transport companies, the cost structure is also important. Many analyses have shown that the majority of costs in these companies are fuel costs, personnel costs and tolls [4].

Also, Sergio Camison-Haba and Jose A. Clemente-Almendros state that personnel costs (concerning transport time), energy consumption and depreciation of assets are among the significant components that have a major impact on transport costs [5].

Between 2014 and 2019, the average gross monthly wage per employee in the Czech Republic grew significantly across all economic activities [6]. This increase also applied to road freight transport companies, with a significant increase in gross wages for truck and trailer truck drivers and other overhead transport workers, see Table 3 [7].

The fact that the issue of the minimum wage in road transport and its impact on the costs of transport companies is very topical is evidenced, among other things, by the presented outputs of the analysis of taxes and fees, which

included, among other things, the amount of the minimum wage in road freight transport in selected EU countries (12 countries, including the Czech Republic). Based on a comprehensive comparison, it can be concluded that the level of tax burden and charges on hauliers in EU countries are significantly different. Hauliers are forced to include increased taxes and charges in the prices for the services provided, which may lead to a deterioration of competitiveness on the European road freight transport market for carriers from countries with the highest tax burden and charges (among other things, the value of the minimum wage in road freight transport was analysed) [8].

An increase in average monthly gross wages without a corresponding reduction in the number of employees causes a significant increase in personnel costs for road freight transport companies. Suppose this increase in personnel costs cannot be reflected in an increase in the selling prices of transport services or an increase in the volume of such services or both. In that case, this development leads to a reduction in the profitability of the company. This has the effect of reducing Operating Profit (OP) and Earnings Before Taxes (EBT) and subsequently Earnings After Taxes (EAT), leading to a deterioration in Cash Flow. The main objective of financial management is to generate cash to meet the business's operational and strategic needs (objectives). Analyses show that cash flow forecasts encourage managers to focus on activities that significantly improve the long-term cash position of the business [9].

Lee (2012) provides evidence in his analyses that cash flow forecasts support managerial behaviour that has a meaningful impact on reported earnings and reported cash flows [10].

Ensuring growth in the selling prices of transport outputs, or growth in these outputs to the extent that it eliminates growth in personnel costs means ensuring growth in labour productivity. Researchers define labour productivity as the total output divided by operating inputs. Huselid calculates labour productivity as the logarithm of the ratio of sales to the total number of employees. It turns out that this method of calculation is convenient because it is the only index that allows to compare the performance of enterprises and to evaluate the monetary value of the return on investment fund [11].

Labour productivity in the form of Sales per Employee has already been increased in freight transport companies to a level that is difficult to increase further, as operational downtime has already been eliminated to the maximum extent possible. Further increases are, therefore, only possible due to increases in transport prices unless they lead to a reduction in transport performance. However, in order to determine the impact of the growth in personnel costs on the profitability of transport companies, it is necessary to calculate labour productivity as a proportion of sales and personnel costs, i.e. to calculate labour productivity not per worker but per CZK of personnel costs. When personnel costs increase due to the growth in average wages, which is no longer (cannot be) eliminated by the growth in labour productivity per worker, labour productivity is expressed as a share of sales per CZK of personnel costs logically decreases. Therefore, labour productivity expressed in this way is the right indicator for assessing the impact of average wage growth on the profitability of any enterprise.

The increase of personnel cost after 2014 in the Czech Republic impacted all areas of businesses, and each business has different possibilities to mitigate the impact of this increase on the profit. From cost reduction and productivity increase to increasing selling prices for higher personnel cost impact. As a result of the fulfilment goals defined in the abstract, we found the answer to the question of how big transport companies were mitigating personnel cost increase.

## 2 Methodology

### *2.1 Data sources*

In order to ensure the objectives of this article, data obtained from the Merk [12] company database Justice [13] portal were used. From the Merk database, economic data of companies belonging to the field of activity 4941 - Road freight transport within the CZ-NACE classification of economic activities were taken. Only enterprises with 250 or more employees were selected, of which there were 33 in total. For the analysis, data of 25 enterprises were used, which fulfilled the condition of their availability for all years within the assessment period from 2014 to 2019. The economic data taken included information on costs and revenues from the Profit and Loss Statement and on assets and sources of their coverage from the Balance Sheet. Missing data for 2019, which were not yet included in the Merk company database, were taken from the Justice portal.

Data on the development of average monthly gross wages for economic activities, including transport and warehousing within the Czech Republic, were obtained from the Czech Statistical Office portal [6], and average monthly gross wages of truck and trailer truck drivers were obtained from the ISPV portal (Average earnings information system), which is managed by the Ministry of Labour and Social Affairs [7]. ISPV is a system of regular monitoring of the earnings level and working hours of employees in the Czech Republic and contains data from a regular statistical survey, which is included in the program of statistical surveys published by the Czech Statistical Office (CSO) in the Collection of Laws for the relevant calendar year.

### *2.2 Methodology for calculating labour productivity from the value of sales*

In order to demonstrate the impact of personnel cost growth on labour productivity, the labour productivity indicator was chosen, which is based on the ratio of the value of sales to personnel costs:

$$LP = \frac{S}{PC} \quad (1)$$

where:
LP - Labour Productivity (CZK/CZK)
S - Sales (CZK)
PC - Personal Costs (CZK)

### 2.3 Methodology for calculating operating profitability ratios

The following indicators were chosen to assess the impact of the growth of personnel costs on the development of operating profitability of selected transport companies:

$$ROA_{OP} = \frac{OP}{A} \quad (2)$$

where:
$ROA_{OP}$ - Return on Assets within Operating Profit (%)
OP - Operating Profit (CZK)
A - Assets (CZK)

$$ROE_{OP} = \frac{OP}{E} \quad (3)$$

where:
$ROE_{OP}$ - Return on Equity within Operating Profit (%)
E - Equity (CZK)

$$ROP_{OP} = \frac{OP}{P} \quad (4)$$

where:
$ROP_{OP}$ - Return on Personnel Costs within Operating Profit (%)
P - Personal Costs (CZK)

### 2.4 Selected companies

For the purpose of this article, data for the period 2014–2019 of the 25 largest companies (over 250 employees) providing road freight transport were used:

- C.S.CARGO a.s.
- Raben Logistics Czech s.r.o.
- NIKA Logistics a.s.
- O.K. Trans Praha spol. s r.o.
- Šmídl s.r.o.
- ANEXIA s.r.o.
- COMETT PLUS, spol. s r.o.
- FTL-First Transport Lines, a.s.
- KOUBA Trans, s.r.o.
- Logistics Solution, a.s.
- MD Logistika a.s.
- M-Logistic CZ, s.r.o.
- MOOS logistic s.r.o.
- Nagel Czech Republic s.r.o.
- CDS s.r.o. Náchod
- Georgi trasporte s.r.o.
- HÖDLMAYR Logistics Czech Republic a.s.
- Transcentrum automotive logistics a.s.
- VCHD Cargo a.s.
- NICOTRANS a.s.
- Bítešská Transport Company s.r.o.
- BODOS Czechia a.s.
- Elflein Trasport s.r.o.
- AGF Food Logistics a.s.
- ICOM transport a.s.

Based on the data obtained in this way, summary data for the selected transport companies were created using a contingency table in MS Excel, and they are included in Table 1.

*Table 1 Total values of financial indicators from 2014 to 2019 (CZK million). Source: author's calculation*

| Indicator | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|
| Assets | 8 364 | 9 537 | 10 044 | 9 871 | 9 831 | 10 457 |
| Equity | 2 893 | 3 506 | 3 695 | 3 385 | 3 717 | 4 182 |
| Personnel costs | 2 822 | 3 196 | 3 607 | 3 838 | 4 040 | 4 341 |
| Impact of personnel costs on profit | -2 822 | -3 196 | -3 607 | -3 838 | -4 040 | -4 341 |
| Operating Profit | 535 | 779 | 572 | 224 | 210 | 645 |
| Operating profit before personnel costs | 3 357 | 3 975 | 4 179 | 4 062 | 4 250 | 4 986 |
| Sales | 15 991 | 17 230 | 18 339 | 18 882 | 19 520 | 20 782 |

### 2.5 Comparison of labour productivity and personnel costs

For selected road freight transport companies, a comparison was made of the development of labour productivity, personnel costs and average monthly gross wages of all employees in economic activities, including transport and warehousing, as well as of truck and trailer truck drivers between 2014 and 2019 in terms of their impact on profits.

Based on the sales and personnel costs values presented in Table 1, labour productivity was calculated in Table 2 below, expressing the ratio of sales revenue from transport performance to personnel costs.

*Table 2 Calculation of labour productivity as a ratio of the value of sales and personnel costs. Source: author's calculation*

| Indicator | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|
| Sales (mil.CZK) | 15 991 | 17 230 | 18 339 | 18 882 | 19 520 | 20 782 |
| Personnel costs (CZK million) | 2 822 | 3 196 | 3 607 | 3 838 | 4 040 | 4 341 |
| Labour productivity Sales/Personnel costs (CZK/CZK) | 5.667 | 5.391 | 5.084 | 4.920 | 4.831 | 4.787 |

Based on labour productivity and personnel costs presented in Table 2, average monthly gross wages of all employees in economic activities, including transport and warehousing obtained from the Czech Statistical Office portal [8] and average wages of truck and trailer truck drivers obtained from the ISPV (Average Earnings Information System) portal [9], Table 3 was created demonstrating the development of these indicators between 2014 and 2019.

*Table 3 Development of labour productivity, personnel costs and average gross monthly wages of drivers. Source: author's calculation*

| Indicator | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|
| Labour productivity Sales/Personnel costs (CZK/CZK) | 5.667 | 5.390 | 5.085 | 4.920 | 4.831 | 4.788 |
| Personnel costs (CZK million) | 2 822 | 3 196 | 3 607 | 3 838 | 4 040 | 4 341 |
| Average gross monthly wage of drivers (CZK/month) | 18 808 | 19 739 | 21 206 | 22 747 | 25 618 | 26 856 |
| Average gross monthly wage in transportation (CZK/mouth) | 23 879 | 24 657 | 25 822 | 27 438 | 29 462 | 31 626 |

Based on the values presented in Table 3, the year-on-year differences of these values were calculated in Table 4 and Table 5 in terms of their impact on profits.

*Table 4 Year-on-year differences in labour productivity, personnel costs and average gross monthly wages in terms of their impact on profits. Source: author's calculation*

| Indicator | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|
| Labour productivity (Sales/Personnel costs) | 0.0% | -4.9% | -5.7% | -3.2% | -1.8% | -0.9% |
| Personal Costs | 0.0% | -13.3% | -12.9% | -6.4% | -5.3% | -7.5% |
| Average gross monthly wage of drivers | 0.0% | -5.0% | -7.4% | -7.3% | -12.6% | -4.8% |
| Average gross monthly wage in transportation | 0.0% | -3.3% | -4.7% | -6.3% | -7.4% | -7.3% |

*Table 5 Cumulative annual differences in labour productivity, personnel costs and average gross monthly wages in terms of their impact on profits. Source: author's calculation*

| Indicator | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|
| Labour productivity (Sales/Personnel costs) | 0.0% | -4.9% | -10.3% | -13.2% | -14.7% | -15.5% |
| Personnel costs | 0.0% | -13.3% | -27.8% | -36.0% | -43.2% | -53.8% |
| Average gross monthly wage of drivers | 0.0% | -5.0% | -12.8% | -20.9% | -36.2% | -42.8% |
| Average gross monthly wage in transportation | 0.0% | -3.3% | -8.1% | -14.9% | -23.4% | -32.4% |

The data in Table 4 were used to create the graph in Figure 1 and the data in Table 5 were used to create the graph in Figure 2.

**THE IMPACT OF THE DEVELOPMENT OF PERSONNEL COSTS ON THE PROFITABILITY INDICATORS OF ROAD FREIGHT TRANSPORT COMPANIES IN THE CZECH REPUBLIC**

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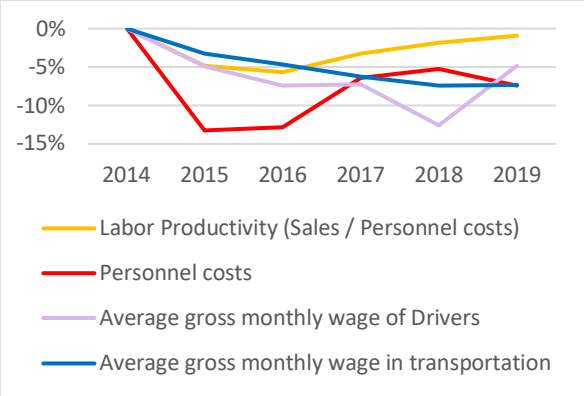


*Figure 1 Year-on-year increases in labour productivity, personnel costs and average gross monthly wages in terms of their impact on profits*

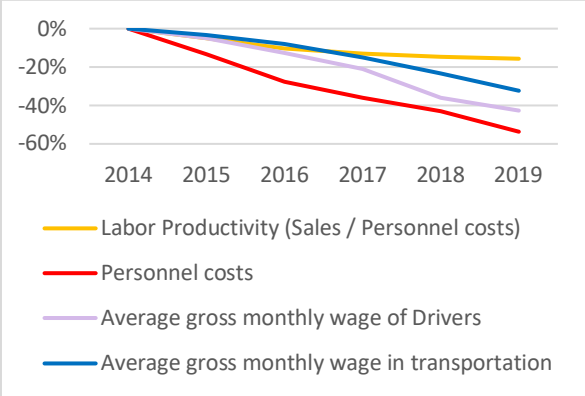


*Figure 2 Cumulative annual increases in labour productivity, personnel costs and average gross monthly wages in terms of their impact on profits*

From the tables 2-5 and from pictures 1 and 2 for years 2015-2018 we can identify correlation between increasing negative impact of higher personnel cost and decreasing labor productivity. In 2015 there was significant increase of negative impact of higher personnel cost to profit that lead to decrease of labor productivity. In 2016 increase of personnel cost slightly slow down and labor productivity increase also slow down slightly. In 2017 and 2018 year-on-year decrease of both these indicators reduced by 50%. In 2019 year-on-year decrease of labor productivity again slow down even negative impact of personnel cost increase.

### *2.6 Comparison of the development of personnel costs and operating profit*

Based on the values presented in Table 1, Table 6 below was created with the data necessary to determine the development of operating profit after excluding personnel costs, the development of the impact of personnel costs on profit and the development of operating profit.

*Table 6 Development of operating Profit and personnel costs from 2014 to 2019 (CZK million)*
*Source: author's calculation*

| Indicator | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|
| Operating profit before personnel costs | 3 357 | 3 975 | 4 179 | 4 062 | 4 250 | 4 986 |
| Impact of personnel costs on profit | -2 822 | -3 196 | -3 607 | -3 838 | -4 040 | -4 341 |
| Operating profit | 535 | 779 | 572 | 224 | 210 | 645 |

Based on the values presented in Table 6, the year-on-year increments of operating profit excluding personnel costs, the impact of personnel costs on profit and operating profit (see Table 7) and the cumulative year-on-year increments of these indicators (see Table 8) were calculated.

*Table 7 Year-on-year differences in operating profit and personnel costs from 2014 to 2019 (CZK million)*
*Source: author's calculation*

| Indicator | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|
| Operating profit before personnel costs | 0 | 618 | 204 | -117 | 188 | 736 |
| Impact of personnel costs on profit | 0 | -374 | -411 | -231 | -202 | -301 |
| Operating profit | 0 | 244 | -207 | -348 | -14 | 435 |

*Table 8 Cumulative differences in operating profit and personnel costs from 2014 to 2019 (CZK million)*
*Source: author's calculation*

| Indicator | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|
| Operating profit before personnel costs | 0 | 618 | 822 | 705 | 893 | 1 629 |
| Impact of personnel costs on profit | 0 | -374 | -785 | -1 016 | -1 218 | -1 519 |
| Operating profit | 0 | 244 | 37 | -311 | -325 | 110 |

The data in Table 7 were used to create the graph in Figure 3, and the data in Table 8 were used to create the graph in Figure 4.

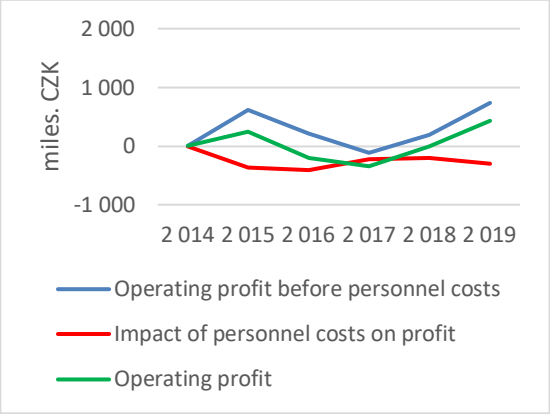


*Figure 3 Year-on-year increases in operating profit personnel costs*

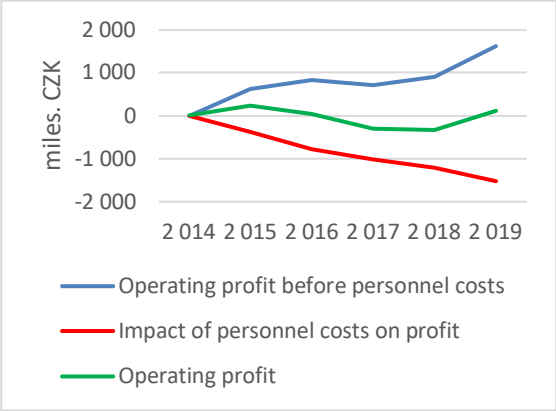


*Figure 4 Year-on-year cumulative increases in operating profit and and personnel costs*

From the tables 6-8 and from pictures 3 and 4 is visible that in 2015 increase of personnel cost did not negatively impact operating profit yet. But in 2016 operation profit drop significantly. In 2017 is operation profit further reduced and increase of personnel cost slow down slightly. From 2018 operating profit is improving even personnel cost continued to increase. From picture 3 correlation between operating profit before personnel costs and final operation profit is obvious. Cumulative amounts in picture 4 shows that negative impact of increasing personnel cost is growing continually. Operating profit starting in 2018 is back on 2014 level and continue growth despite increasing personnel cost in 2019.

### *2.7 Operating profitability ratios*

Based on the values shown in Table 1, the operating profitability ratios within Return on Assets, Equity and Personal Costs within Operating Profit were calculated (see Table 9, Table 10 and Table 11).

*Table 9 Calculation of $ROA_{OP}$ - Return on Assets within Operating Profit from 2014 to 2019*
*Source: author's calculation*

| Indicator | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|
| A - Assets (mill. CZK) | 8 364 | 9 537 | 10 044 | 9 871 | 9 831 | 10 457 |
| OP - Operating Profit (mill. CZK) | 535 | 779 | 572 | 224 | 210 | 645 |
| $ROA_{OP}$ = OP/A·100 (%) | 6.40% | 8.17% | 5.69% | 2.27% | 2.14% | 6.17% |

*Table10 $ROE_{OP}$ - Return on Equity within Operating Profit from 2014 to 2019*
*Source: author's calculation*

| Indicator | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|
| E - Equity (mill. CZK) | 2 893 | 3 506 | 3 695 | 3 385 | 3 717 | 4 182 |
| OP - Operating Profit (mill. CZK) | 535 | 779 | 572 | 224 | 210 | 645 |
| $ROE_{OP}$ = OP/E·100 (%) | 18.49% | 22.22% | 15.48% | 6.62% | 5.65% | 15.42% |

*Table 11 Calculation of $ROP_{OP}$ - Return on Personal Costs within Operating Profit from 2014 to 2019*
*Source: author's calculation*

| Indicator | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|
| P - Personal Costs (mill. CZK) | 2 822 | 3 196 | 3 607 | 3 838 | 4 040 | 4 341 |
| OP - Operating Profit (mill. CZK) | 535 | 779 | 572 | 224 | 210 | 645 |
| $ROP_{OP}$ = OP/PE·100 (%) | 18.96% | 24.37% | 15.86% | 5.84% | 5.20% | 14.86% |

Based on the values presented in Tables 9, 10 and 11, a summary table of Return on Assets, Return on Equity and Return on Personal Costs within Operating Profit was created (see Table 12).

*Table 12 Operating profitability indicators from 2014 to 2019 Source: author's calculation*

| Indicator | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|
| $ROA_{OP}$ - Return on Assets within operat. profit | 6.40% | 8.17% | 5.69% | 2.27% | 2.14% | 6.17% |
| $ROE_{OP}$ - Return on Equity within operat. profit | 18.49% | 22.22% | 15.48% | 6.62% | 5.65% | 15.42% |
| $ROP_{OP}$ Return on Personal Costs within OP | 18.96% | 24.37% | 15.86% | 5.84% | 5.20% | 14.86% |

Based on the values presented in Table 12, the annual percentage increases of the selected operating profitability ratios were calculated (see Table 13 and 14).

*Table 13 Year-on-year differences in operating profitability ratios between 2014 and 2019*
*Source: author's calculations*

| Indicator | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|
| Return on Assets ($ROA_{OP}$) | 0.00% | 1.77% | -2.47% | -3.43% | -0.13% | 4.03% |
| Return on Equity ($ROE_{OP}$) | 0.00% | 3.73% | -6.74% | -8.86% | -0.97% | 9.77% |
| Return on Personal Costs ($ROP_{OP}$) | 0.00% | 5.42% | -8.52% | -10.02% | -0.64% | 9.66% |

*Table 14 Annual cumulative differences in operating profitability ratios between 2014 and 2019*
*Source: author's calculation*

| Indicator | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|
| Return on Assets ($ROA_{OP}$) | 0.00% | 1.77% | -0.70% | -4.13% | -4.26% | -0.23% |
| Return on Equity ($ROE_{OP}$) | 0.00% | 3.73% | -3.01% | -11.88% | -12.84% | -3.07% |
| Return on Personal Costs ($ROP_{OP}$) | 0.00% | 5.42% | -3.10% | -13.12% | -13.76% | -4.10% |

The data in Table 13 were used to create the graph in Figure 5, and the data in Table 14 were used to create the graph in Figure 6.

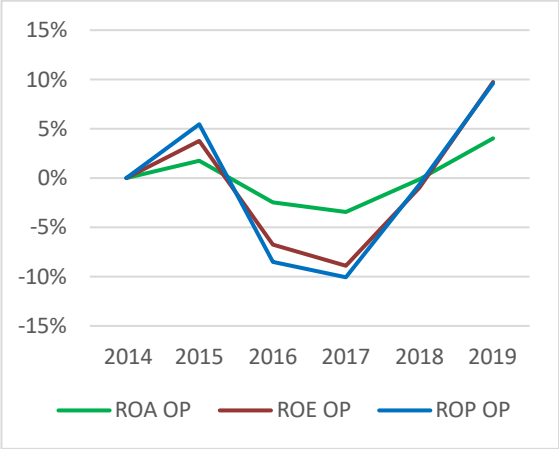


*Figure 5 Year-on-year increases in operating profitability ratios*

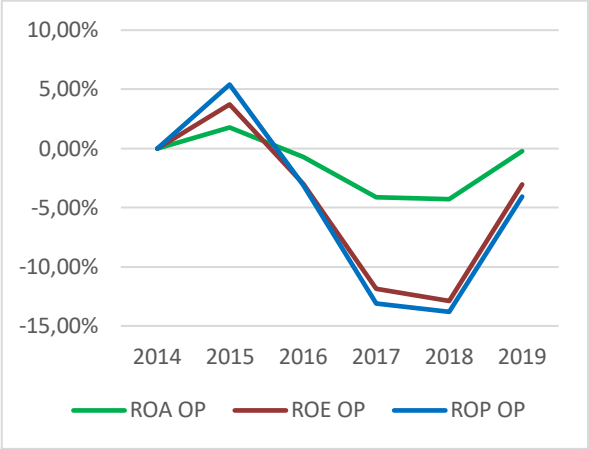


*Figure 6 Year-on-year cumulative increases in operating profitability ratios*

From the tables 9-14 and pictures 5-6 for year 2015-2018 is obvious correlation between evolution of chosen rentability indicators which are directly impacted by evolution of operating profit. Almost the same evolution of ROE and ROP indicators is because of similar level of personnel cost and equity.

## 3 Result and discussion

From Tables 2 to 5 and the graphs within Figures 1 and 2, it is clear that in 2015 and 2016, the decrease in labour productivity expressed as a ratio of sales to personnel costs, was due to the negative impact of the increase in personnel costs. Their growth was higher than the growth in the average gross monthly wages of all employees in transport and warehousing activities as well as truck and trailer truck drivers. Since 2017, this labour productivity has been declining more slowly year-on-year, despite the continued increase in personnel costs and average gross wages of employees. However, even in 2019, labour productivity expressed as sales per CZK of personnel costs did not reach the level of 2014. Reducing the decline in labour productivity since 2017 is logically due to the increase in sales, which could have been due to either an increase in freight volumes, an increase in the price of transport or both. Within Figure 1, it can be seen that while the negative impact of personnel cost growth on operating profit slowed in 2018, the growth in average driver wages continued and only slowed in 2019. According to economic principles, personnel cost growth should not have a negative impact on operating profit, which can only be achieved by higher transport volumes or higher utilisation of own capacity if the transport price is not increased. However, further increasing the use of own capacity (increasing its yield) already faces technical and legal constraints, and the

possibilities of significantly increasing efficiency (savings) are almost exhausted. The only way forward, in this case, is to reflect the increase in personnel costs in transport prices gradually, which raises considerable problems, resulting in a time lag in the increase in transport prices against the increase in personnel costs, as can be seen in the graphs in Figures 1 and 2 in 2018.

Tables 6 to 8 and the graphs within Figures 3 and 4 show that the year-on-year increase in personnel costs in 2015 has not yet led to a reduction in operating profit. It only occurs from 2016 onwards, with a de facto halt to the reduction in operating profit in 2018 and a return to growth in 2019. This development is consistent with the observed evolution of labour productivity. This means that the increase in personnel costs started to be reflected more strongly in the prices of transport performance in 2018. Among other things, this led to an increase in operating Profit of CZK 645 million (at the EUR / CZK 25.50 exchange rate it does so EUR 25.3 million) in 2019. This is despite a further increase in personnel costs of CZK 301 million (EUR 11.8 million) in comparison to 2018.

From Tables 9 to 14 and the graphs within Figures 5 and 6, it is clear that there are relationships between the $ROA_{OP}$, $ROE_{OP}$ and $ROP_{OP}$ operating profitability ratios. This is due to the interesting fact that the value of equity in the base year 2014 (CZK 2 893 million, EUR 113.5 million) is almost the same as the value of personnel costs (CZK 2 822 million, EUR 110.7 million). This can be considered as a random relationship within 2014. However, the very similar changes in the values of these indicators in the following years make their correlation quite obvious.

As there were no significant changes in Equity between 2015 and 2019 due to owner contributions or profit-sharing (dividends), Equity values were affected by the impact of the economic result in those years. There is a clear correlation between the changes in Return on Equity ($ROE_{OP}$) and Return on Personnel Costs ($ROP_{OP}$), which is due both to the common numerator for these ratios, which is Operating profit, and the fact that the increase in personnel costs was significantly reflected in a decrease in Operating Profit in 2016 and 2017. Given the fact that there was an increase in sales volume in each year during the period under review, the increase in labour and the associated increase in personnel costs has its own logic. However, the percentage increase in personnel costs over the period was higher than the percentage increase in sales, which translated into a reduction in operating profit in those years. This faster growth in personnel costs against the increase in sales was mainly due to the increase in average wages of both truck and trailer truck drivers and other transport workers, as shown in the previous findings.

From the development of Return on Assets ($ROA_{OP}$), it is clear that the value of assets did not decrease as significantly as the value of equity, thanks to the increase in the share of foreign capital in the given period.

## 4 Conclusions

The main objective of the paper was to analyse and evaluate the effects of personnel cost growth on the profitability of selected road freight transport companies. As already mentioned, between 2014 and 2019, a very significant factor in the growth of personnel costs in road freight transport companies in the Czech Republic was mainly the growth of average wages of truck and trailer truck drivers. The paper presents the outputs of the analyses and quantifies the impact of the growth of personnel costs on the development of selected indicators, and also evaluates them in terms of their possible causality.

The Czech Republic is one of the countries with the fastest-growing wage costs. The average monthly gross wage in 2020 has also increased compared to 2019, with the average monthly wage for the Czech Republic rising by 4.4 % to CZK 35,611 (at the EUR / CZK 25.50 exchange rate it does so EUR 1,397), and for transport and storage activities by 1.6 % to CZK 31,931 (EUR 1,252). [14] Wage growth against the 2020 average stopped in the first quarter of 2021 when the average monthly gross wage for the Czech Republic was CZK 35,285 (EUR 1,384) and for transport and storage activities, it was CZK 31,556 (EUR 1,237). However, compared to the first quarter of 2020, wages for the Czech Republic grew by 3.2 %, and for transport and storage activities by 0.9 % [15]. David Marek, an economist at the company Deloitte, says that "As the pandemic fades and the economy accelerates again, there will be room for faster wage growth. For this year as a whole, average monthly gross wages can be expected to grow by 3 to 4 %" [16].

It follows from the above that enterprises providing road freight transport in the Czech Republic will have to continue to count on the growth of personnel costs due to the increase in average monthly gross wages. Over the last ten years, the average monthly wage in the Czech Republic has risen by 51 %, the highest of any neighbouring country, and this trend is not slowing down. Given the findings made in this paper, it is safe to assume that further wage increases in transport will be reflected primarily in price increases for transport services.

However, there is a risk that the capital-intensive transport companies may take advantage of this situation to "significantly slow down" the growth in the prices of their services in order to liquidate the capital-weak competitors. Once this "task" has been accomplished, it can be assumed that the subsequent rise in these prices will catch up with this delay.

Capital-weaker companies have no choice but to:

- Maximise the use of all its current labour and transport capacity, thereby ensuring fixed cost utilisation at a higher rate than is and will be the case for capital-intensive companies. In principle, there is now a no more effective tool for reducing costs than better use of own capacity.

- Ensure maximum utilisation of its capacities to offer comprehensive services with the highest possible value for customers.
- Create favourable working conditions, including various benefits that will reduce the pressure on employees to increase wages.
- Make every effort to find other possible cost savings that do not result in reduced sales.

The methods used in this article have some limitations. For example, using ROE indicator works well when comparing companies in similar business areas. However, using ROE for comparison for different business areas has limited objectivity.

Analysis from this article can continue with the focus on other types of cost and their impacts on operating profit. The study was done for 2014-2019 without the impact of the Covid pandemic. Therefore, the study for 2020-2021 is a reasonable next step with the opportunity to evaluate the impact of the Covid pandemic on increasing personnel cost and its impact on operating profit.

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# FACTORS AFFECTING STOPPING BEHAVIOUR AT SUBURBAN INTERSECTIONS

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***Keywords:*** driver compliance, stop sign, suburban, intersections.
***Abstract:*** This study focused on how drivers dealt with intersections controlled by a stop sign at suburban in Al-Husn city at Irbid governorate, Jordan. The videotape was used at eight unsignalized intersections for one complete peak hour on weekdays. Any at-grade intersection that is not controlled by a traffic signal is defined as an "unsignalized intersection." The results showed that 48% out of 1,208 drivers took the decision to stop completely compared to 52% who chose to keep driving. Female drivers (75%) were observed to stop at intersections more frequently than male drivers. In terms of vehicle type, drivers of buses stopped more frequently than drivers of small passenger cars, which are road car, other than a motorcycle, that is designed to transport passengers. Driver age and compliance to a stop sign were found to be directly proportional to each other, but as the number of passengers in the vehicle increased, the rate of non-compliance also increased. Compliance was highest among leading vehicles, followed by following vehicles, and lowest among single vehicles. A binary logistic model showed that age, vehicle occupancy, and arrival pattern significantly affected stopping the behaviour. Gender and vehicle type were not significantly related to stopping the behaviour.

## 1 Introduction

One of the important objectives of installing stop signs is to regulate traffic streams at different approaches to an intersection. It is well-known that stop signs are very popular as traffic control devices (TCD) worldwide, including Jordan. According to the Jordanian Traffic Institute, the number of stop signs installed has increased rapidly in recent years. The value of stop signs cannot be overstated and is supported by law; as mentioned in the Manual on Uniform Traffic Control Devices (MUTCD), "regulatory signs shall be used to inform road users of selected traffic laws or regulations and indicate the applicability of the legal requirements."

However, if there is no respect to this sign and drivers violate the laws by crossing the intersection without stopping, many drawbacks could occur, such as accident frequency. For instance, data on road traffic accidents in Al-Husn city showed an increasing number of accidents at intersections controlled by stop signs due to the failure of drivers to stop at stop bars. Although many studies have been performed to examine stopping the behaviour, it remains unclear which factors influence drivers to stop or not stop before a stop sign.

This research aims to identify the factors that affect the compliance of drivers at selected intersections controlled by a stop sign in a suburban area at Irbid city in Jordan.

## 2 Literature review

Many studies were performed to check the main factors that led the drivers to decide whether to stop or not. Shaaban et al. [1] focused on driver behaviour at minor streets controlled by a stop sign. Several variables were studied, such as driver gender and age, peak and off-peak hours, the time of the week (weekday or weekend), and whether the intersection was located on residential or commercial land. Authors found that both male and young drivers were less likely to perform a complete stop. In terms of the influence of driver age toward violation of traffic laws, Devalla [2] showed that drivers aged less than 18 years (young drivers) were more likely to violate traffic laws such as exceeding the speed limit, driving in an aggressive way, and non-compliance with road and traffic signs. Arhin [3] et al. studied thirty unsignalized intersections to analyse driver compliance rate to the stop sign and found that compliance to the stop sign was high when the distance between the intersection and the nearest signalised intersection was short. Xiamei et al. [4] presented a new approach to classifying drivers' behaviour at intersections by using a special vehicle with a computer-vision technique to record full types of data. The authors found five different types of driver behaviour with different classes of risks for stopping behaviour when approaching the intersection. DeVeauuse et al. [5] studied vehicle compliance at a stop sign on a pedestrian crosswalk. They analysed different factors, such as how many pedestrians were using the crosswalk, pedestrian clearance, vehicle type, hour of the day, any day of the week. These factors were used at three different pedestrian crosswalks. The authors found that the total compliance percentage for stop signs was 22.8 for every 100 vehicles. The authors also noticed that compliance increased by 53% for every 100 vehicles if there was a pedestrian using a crosswalk.

## 3 Methodology

Eight suburban intersections located at al-Husn city were chosen to conduct the study. All the intersections were located far from any police enforcement. The camera's location was hidden to reduce the influence of driver behaviour. A total of 1,208 drivers were observed through videotape. Driver characteristics and vehicle

characteristics were observed by videotape during peak hours on weekdays.

Because there was no driver contact, age and sex were estimated based on the external appearance of the driver as they appeared on videotape. For vehicle characteristics, vehicle occupancy (i.e., the number of passengers inside the vehicle aside from the driver) and vehicle type (i.e., passenger car, bus, or others) were recorded, and vehicle type was recorded whether it was passenger car (PC), bus, or other types. Arrival patterns were recorded based on whether a vehicle was leading, following or solitary (i.e., alone in the road). Data were analysed using the Statistical Package for the Social Sciences (SPSS).

## 4 Result and Discussion

### *4.1 Gender*

Altogether, less than half were observed to perform a complete stop before a stop sign (Table 1). Female drivers (75%) were observed to stop more frequently at a stop sign compared to male drivers (Table 2, Figure 1).

On the other hand, the vast majority of male and female drivers perform a complete stop. This may be explained by the fact that female drivers start driving at a later age than male drivers, and we know that driving needs skills and experience that a person acquires with time. As a result, females in our society felt all the time that they needed to be more careful, especially when they recognised the aggressive driving style of males.

*Table 1 Descriptive Statistics of the Dependent Variable*

| The Dependent Variable | Cases | Percentages |
|---|---|---|
| Stopping types | | |
| 0-No stop/rolling stop | 632 | 52% |
| 1-Complete stop | 576 | 48% |

*Table 2 Percentages and Counts of Drivers vs Gender*

| | Stopping | | Rolling | | Not Stopping | |
|---|---|---|---|---|---|---|
| Gender | Count | Percentages | Count | Percentages | Count | Percentages |
| Male | 480 | *44%* | 352 | *33%* | 248 | *23%* |
| Female | 96 | *75%* | 24 | *19%* | 8 | *6%* |

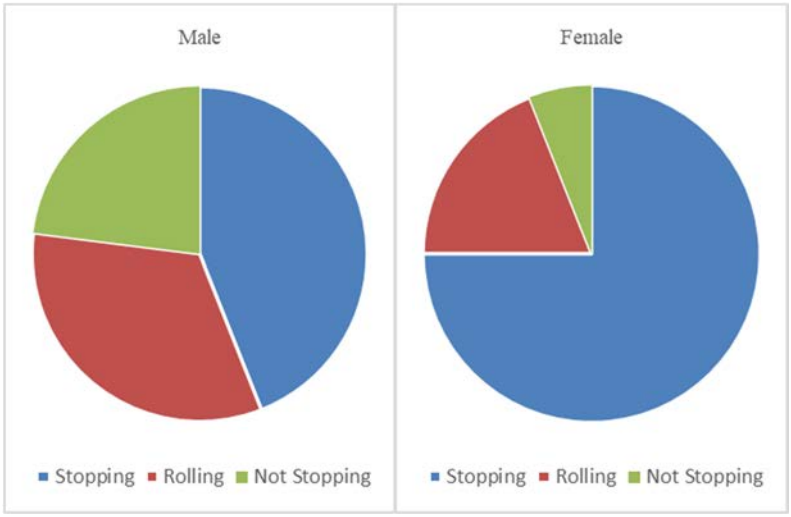


*Figure 1 Driver Gender vs Stopping Behaviour*

### *4.2 Age group*

The age group was estimated based on the external appearance of the driver. Table 3 and Figure 2 show the stopping characteristics of drivers (i.e., complete stop, rolling stop, or non-stop) based on the estimated age group. Older drivers (75%) were observed to perform a complete stop more frequently than middle-aged and young drivers. Middle-aged drivers were observed to continue driving despite a stop sign more frequently than other age groups. The middle-aged group may be overlapped between both young and old, so if we ignore this class, it becomes obvious that as the age group increases, the awareness of the surrounding traffic culture improves. Old drivers are the best group regarding respect for the law.

*Table 3 Percentages and Counts of Drivers vs Age Group*

| Age Group | Stopping | | Rolling | | Not Stopping | |
|---|---|---|---|---|---|---|
| | Count | Percentages | Count | Percentages | Count | Percentages |
| Young | 344 | 52% | 184 | 28% | 128 | 20% |
| Middle | 108 | 27% | 168 | 44% | 112 | 29% |
| Old | 128 | 76% | 24 | 14% | 16 | 10% |

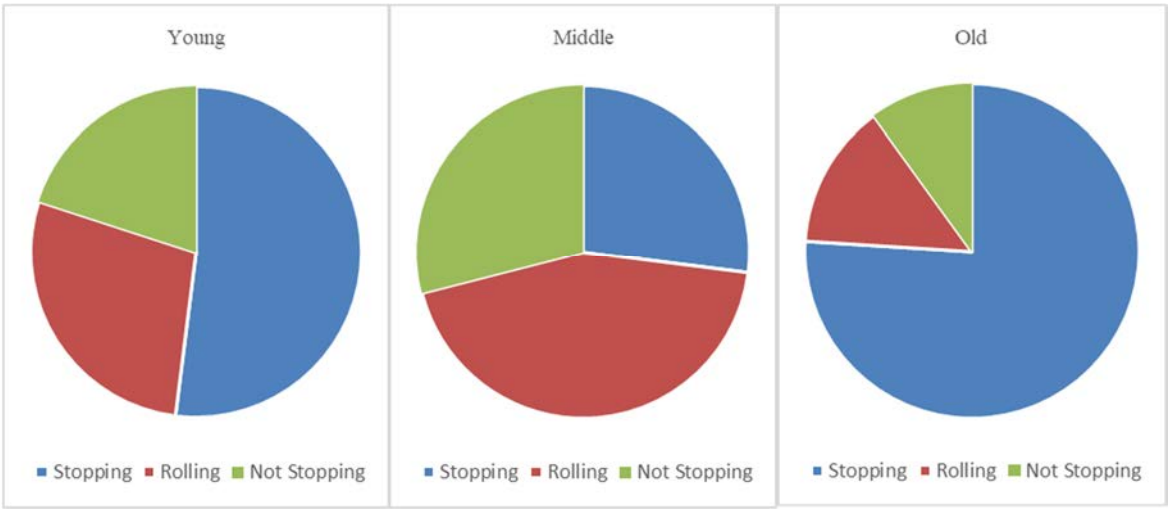


*Figure 2 Age Group vs Stopping Behaviour*

### *4.3 Occupancy*

Table 4 and Figure 3 show the stopping characteristics of drivers based on vehicle occupancy. Again, single-occupied vehicles were observed to stop more frequently than vehicles with more than one occupant.

*Table 4 Percentages and Counts of Drivers vs Occupancy*

| Occupancy | Stopping | | Rolling | | Not Stopping | |
|---|---|---|---|---|---|---|
| | Count | Percentages | Count | Percentages | Count | Percentages |
| 1 | 480 | 54% | 240 | 27% | 168 | 19% |
| 2 | 56 | 28% | 80 | 40% | 64 | 32% |
| >2 | 40 | 33% | 56 | 47% | 24 | 20% |

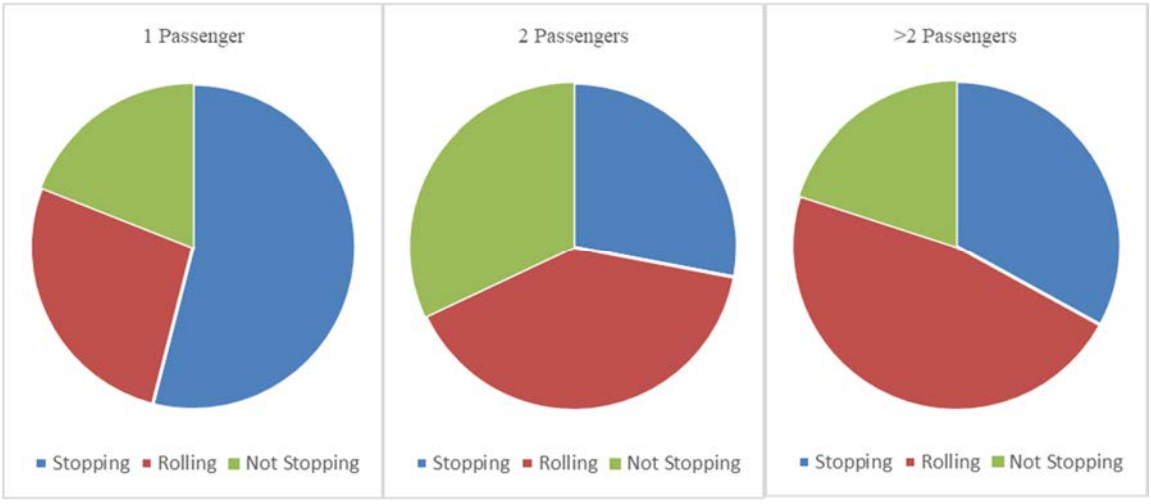


*Figure 3 Occupancy vs Stopping Behaviour*

### *4.4 Vehicle type*

Table 5 and Figure 4 show the stopping characteristics of drivers based on vehicle type. Passenger cars stop more frequently at unsignalized intersections than buses and other vehicle types.

The observed data shows that PC is less likely to stop completely than buses or other vehicles. It may be because trained drivers drive buses. In Jordan, most bus drivers were classified as professional and well-trained drivers, and they were most likely to respect the law.

*Table 5 Percentages and Counts of Drivers vs Vehicle Type*

| Vehicle Type | Stopping | | Rolling | | Not Stopping | |
|---|---|---|---|---|---|---|
| | Count | Percentages | Count | Percentages | Count | Percentages |
| PC | 432 | 49% | 288 | 32% | 168 | 19% |
| Bus | 104 | 57% | 32 | 17% | 48 | 26% |
| Others | 40 | 29% | 56 | 42% | 40 | 29% |

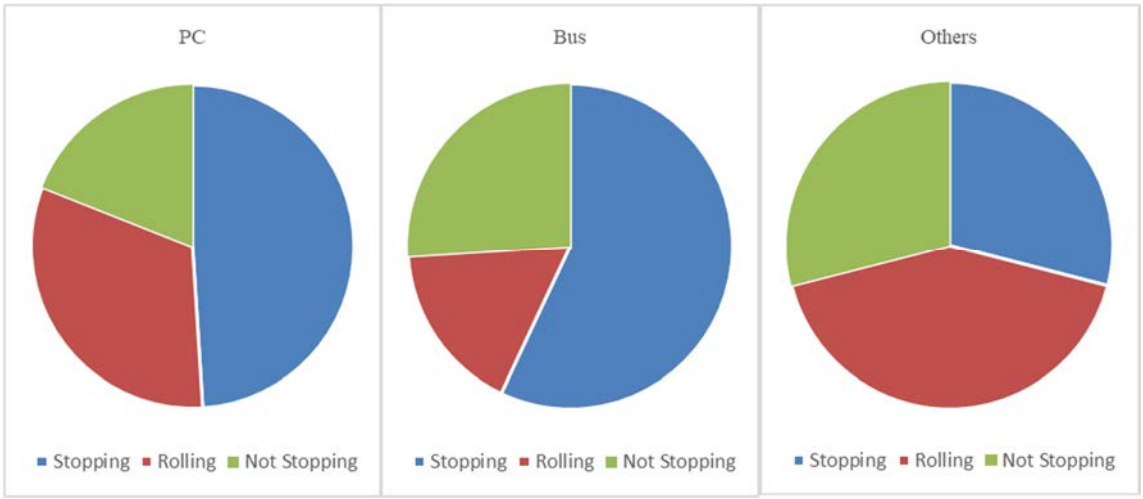


*Figure 4 Vehicle Type vs Stopping Behaviour*

### *4.5 Arrival pattern*

Table 6 and Figure 5 show the stopping characteristics of drivers based on arrival patterns. Leading vehicles were found to completely stop more frequently at stop signs, followed by following vehicles, and lastly, single or solitary vehicles.

This could be explained by the fact that when single vehicles enter the intersection, they have extra time to see the entire intersection clearly if the vehicles going in different directions exist or not.

*Table 6 Percentages and Counts of Drivers vs Arrival Sequence*

| Arrival Pattern | Stopping | | Rolling | | Not Stopping | |
|---|---|---|---|---|---|---|
| | Count | Percentages | Count | Percentages | Count | Percentages |
| Single Vehicle | 136 | 35% | 136 | 35% | 112 | 30% |
| Leading Vehicle | 168 | 64% | 88 | 33% | 8 | 3% |
| Following Vehicle | 272 | 49% | 152 | 27% | 136 | 24% |

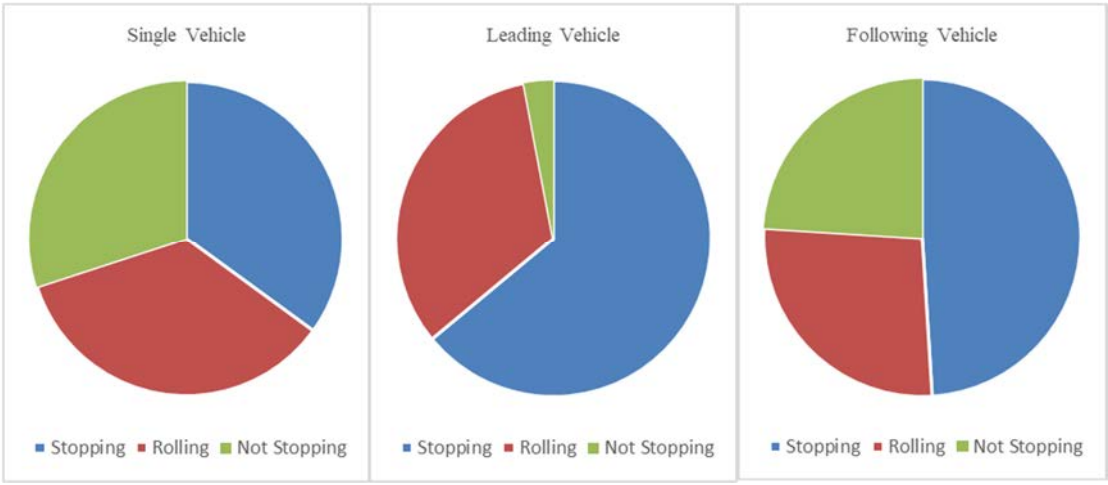


*Figure 5 Arrival Pattern vs Stopping Behaviour*

### *4.6 Statistical analysis*

Binary logistic regression was performed to identify factors that influence drivers' stopping behaviour who completely stopped at a stop sign compared to those who did not. It is familiar in the transportation field to use the binary model because it shows the decision to choose one among a group of different independent alternatives. As the driver reached the intersection, they were to choose to make a complete stop (let it (i)) or not make a stop (let it (j)). The form of the binary logistic model is [6] (1):

$$Prob[Yi = 1\ making\ a\ complete\ stop] = \frac{Exp(\alpha+\sum\beta ixi)}{1+Exp(\alpha+\sum\beta ixi)]} \quad (1)$$

Where βi is the coefficient associated with the independent variables; xi is the value of the independent variables; α is the constant estimated by the model.

SPSS was used to perform a chi-square test to determine the correlation between independent and dependent variables. The summarised results for the chi-square test are shown in table 7, with a value of the level of confidence to be 95%.

*Table 7 Results of Chi-square test*

| Independent Variables | β | Exp (β) | Stranded Error | p-value |
|---|---|---|---|---|
| Constant (α) | -2.583 | - | 1.816 | 0.001 |
| Gender | -0.081 | 0.922 | 0.087 | 0.351 |
| Age | 0.133 | 0.875 | 0.059 | 0.025 |
| Vehicle Occupancy | 0.085 | 1.089 | 0.044 | 0.05 |
| Vehicle Type | 1.639 | 5.15 | 0.999 | 0.101 |
| Arrival Pattern | -1.109 | 0.33 | 0.632 | 0.039 |

According to statistical analysis, gender does not affect the stopping behaviour because of the estimated model with a p-value of 0.351 (which is more than 0.05). At the same time, age has an important rule for deciding on the driver with a p-value of 0.025. Regarding vehicle occupancy, the estimated p-value is 0.05, which significantly affects the driver's behaviour. Finally, vehicle type doesn't significantly affect driver behaviour with a p-value of 0.101.

So, according to the above results, and taking into account the variables that significantly affected the stopping behaviour and ignoring the weak variables, the binary model could be as shown in equation (2).

$$Yi = \frac{Exp(-0.159+0.026x1+0.189x2-2.785x3)}{1+Exp(-0.159+0.026x1+0.189x2-2.785x3)} \quad (2)$$

$R^2 = 0.806$

Where:

$Y_i$: Probability to make a complete stop.

$x_1$: Driver Age.

$x_2$: Vehicle Occupancy.

$x_3$: Arrival Pattern.

A log transformation logit (π) was used to model the dependent variable, which is the stopping behaviour. The resulting coefficient's explanation is according to the transformation of the coefficient to exponential form, which is defined as odds ratio as shown in equation (3) and Table 8.

$$Odds = \frac{\text{P(event)}}{\text{P(no event)}} \quad (3)$$

$$P(no\ event) = 1 - P(event)$$

*Table 8 Model Results*

| Dependent Variable | Independent Variable | Classes of the variable | Coefficient | P-value | Odds ratio |
|---|---|---|---|---|---|
| Making a complete stop | Driver Age | Young | Reference | - | - |
| | | Middle | -0.398 | < 0.0001 | 0.672 |
| | | Old | -0.357 | < 0.0001 | 0.821 |
| | Vehicle Occupancy | 1 | Reference | - | - |
| | | 2 | 0.256 | 0.082 | 0.365 |
| | | >2 | 0.270 | 0.038 | 0.462 |
| | Arrival Pattern | Single | Reference | - | - |
| | | Leading | -0.322 | 0.004 | 0.632 |
| | | Following | 0.221 | 0.001 | 0.265 |

## 5 Conclusion

This study focused on the main factors affecting stopping behaviour at unsignalized intersections in Jordan. The data were collected at eight different intersections located in a suburban area. Results showed that 52% of 1,208 drivers observed by videotape completely stopped before a stop sign, while 48% did not. Older drivers had the lowest violation rate compared to other age groups. Drivers appeared to have less of a tendency to cross the stop bar as they got older. Single and following vehicles had similar rates of violation, while a vehicle with one passenger showed the most respect to law compared to other types of occupancy.

A stop bar should be installed clearly at unsignalized intersections so drivers can detect it easily and make the right decision to stop. On the other hand, traffic violations should be monitored using new technologies in transportation, such as sensors or cameras.

**Acknowledgement**

To the soul of my dear professor, Dr. Bashar Al-Omari. May your soul rest in peace.

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