Integrating vehicle tracking and routing systems in retail distribution management

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Abstract

Purpose: The purpose of this paper is to assess the benefits of integrating IT tracking and routing systems into last mile distribution operations. The paper also demonstrates the role of field experiments as a valid approach for improving the rigour of logistics research.

Design/methodology/approach: The study employs a field experiment approach. Data collected before and after the experimental treatment from 16 participating vehicles, which used as inputs and outputs to calculate vehicles' efficiencies using Data Envelopment Analysis (DEA).

Findings: Through employing manipulation and random assignment to investigate causality in naturally occurring contexts, our results show statistical evidence for the role of vehicle tracking and routing systems in enhancing fleet efficiency. Furthermore, results show that field experiment is an appropriate method for capital budgeting of deploying IT systems in the distribution function.

Practical implications: Distribution managers can use a field experiment setup to assess the potential impact of installing IT solutions prior to large-scale implementation or prior to purchasing.

Originality/value: The study fills a gap in the literature through the application of a field experiment approach to establish causality relationships in distribution and logistics research. This study should encourage new research on the role of field experimentation in evaluating the benefits gained from, and the capital budgeting of, the modern disruptive technologies in supply chains.

Keywords: Retail distribution; Retail logistics, Field experiment in logistics; Fleet efficiency; Vehicle routing; Tracking systems

Paper type: Research paper

1. Introduction

Assessing the true financial benefits of investing in information technology (IT) has been an area of keen interest to researchers over the past decade (Ko and Osei-Bryson, 2006; Wai *et al*., 2011). Dehning *et al*. (2007) emphasised that much of the IT benefits literature has been unable to measure the true benefit of IT investments because the metrics employed to measure the benefits not directly linked to the specific business objectives.

In today's competitive retail and complex marketplace, distributors are required to operate their fleet at peak efficiency, provide reliable customer service and still make a profit (Abushaikha *et al*., 2018; Haas, 2019; Buldeo Rai *et al*., 2019; Appelqvist *et al*., 2016). Literature on retail distribution handles efficient use of resources, operations, distances, and time (Buldeo Rai *et al*., 2019; Golinska and Hajdul, 2012; Wiese, *et al*., 2012). Some of the variables of interest are; vehicle capacity usage, number of kilometers travelled, fuel consumption, number of stops, loading costs, operations times, and environmental measurements. However, managing a retail distribution fleet of vehicles with rising fuel and maintenance costs, safety issues and timely customer service is a challenging mission to accomplish (Abushaikha *et al*., 2018). Therefore, the pressure to deliver faster and cheaper has made vehicle utilization an important aspect of fleet management systems. Thus, evolving and advanced fleet management systems used to improve logistics efficiency, effectiveness and flexibility (Salhieh *et al*., 2018). Furthermore, researchers suggested that information technology systems for coordination and routing at field level would have a positive impact on fleet performance and route optimization (Martinez *et al*., 2011; Buldeo Rai *et al*., 2019).

Extant literature has largely focused on integrating IT solutions in retail distribution, as demonstrated by a large and increasing number of publications on this topic in the last decade (Auramo *et al*., 2005; Evangelista and Sweeney, 2006). From the viewpoint of the IT solutions impact on company business, the literature highlights benefits at the strategic and at the tactical/operational levels (Pokharel, 2005; Kengpol and Tuominen, 2006). Accordingly, variety of research methods have been used to study the impact of IT solutions in retail distribution mainly based on field research (meaning non-experimental research) such as surveys (Piplani *et al*., 2004; Lai *et al*., 2006), and case studies or interviews (Marchet *et al*., 2012). In addition, analytical models and simulations are used to assess the potential impact of adopting IT solutions in transportation (Marchet *et al*., 2012). Furthermore, field research studies are more likely to be descriptive, developmental, correlational, and survey in design than they are to be experimental, and tends to observe, analyse, and describe what exists rather than manipulating a factor under study to establish causation (Aziz, 2017; Towers *et al*., 2020).

However, field research on adopting IT solutions have assumed a causal relationship between adopting and benefits without substantial statistical proof of such a relationship. Notwithstanding their advances, surveys, interviews, case analysis often involve post hoc data collection requiring respondents to remember and articulate past evaluations and decisions, which may result in recall bias and revisionism (Golden, 1992). Furthermore, field research methods, including field surveys and field qualitative investigation, about causal relationships will never satisfy advocates of the methods (random assignment, regression-discontinuity design , and case-study designs with repeated treatment applications, removals, and reapplications at known times and in controlled settings under researcher control) explicitly developed to test causal hypotheses (Cook, 2014). However, experimental research designs are well suited to overcome these weaknesses and are vital to empirical testing and falsification; experiments allow causal inference via controlled manipulation of treatment in the surroundings (Busenitz *et al*., 2003; Garaus and Wagner, 2019). Therefore, the experimental research method is well recognised in the literature for establishing causality (Highhouse, 2009; King *et al*., 2012). Experimental methods are different from other methods of research; every study that manipulates (instead of simply measuring) other potential causes of the responses of the participants, and is able to eliminate, control, or randomise them can be referred to as an experiment (Kraus *et al*., 2016). In other words, it is essential to identify a stable relationship between variables to assess cause and effect (King *et al*., 2012; Shadish *et al*., 2002). Experiments can be executed in the field, in the laboratory, or inside a system, e.g. in a firm (Croson *et al*., 2007). Furthermore, Highhouse (2009) stated it most cogently: "Randomised field experiments are the most potent research design for determining whether or not *x* causes *y".* Accordingly, testing causal hypotheses rigorously is crucial for scientific purposes and indispensable for putting the very best, evidence-based tools into the hands of practitioners (Rynes and Bartunek, 2017). Lacking evidence for causality leaves major unfinished business, and field experiments function as proofs-of-concept, that is, they designed to test core aspects of a theory (Baldassarri and Abascal, 2017). This study based on the tenets that causal inference is paramount to understanding organizations and that experimentation best establishes causality. Therefore, the aim of this study is to conduct field experimental studies (quasi experiments), and not to be confused with field research, to provide a statistical proof of such a claimed causal relationship between adopting IT solutions in vehicle fleet management, and benefits. This paper defines a field experiment approach as a data collection strategy that employs manipulation and random assignment to investigate causality in naturally occurring contexts (Harrison, 2013). This is an experiment where the researchers actively influence something to observe the consequences (Kerlinger, 1998). This experiment is conducted in the context of a retail distribution company of fast moving consumer goods (FMCG), operating in Jordan and is involved in a project for assessing the benefits of adopting a fleet management system. The case company, which employs around 200 employees, operates 40 vehicles to distribute its soft drink products to approximately 1500 customers on a daily basis. Therefore, the study first objective is to conduct a field experiment to assess vehicle efficiency improvement because of the installed fleet management systems using Data Envelopment Analysis (DEA) technique. The research questions answered in this study are as follows:

RQ1. To what extent installing a fleet management system (tracking system) improves vehicle's efficiency.

To answer the first question, the following hypothesis are investigated:

H1. Vehicles installing a fleet management system (tracking system) will improve their efficiency over time.

However, the installed fleet management system does not provide assignment and sequencing of customer orders, and this task is assigned to sales department and not under the fleet manager responsibilities. In other words, the tested system is only an IT tracking system and not a complete fleet system solution. Moreover, the company under study produces a variety of products with different volumes, and hence each customer order will have different revenue contribution. Furthermore, there is a heterogeneous fleet of vehicles to conduct delivery from main depot to all customers with a time window constraints, and back to main depot with time window constraints. Moreover, each type of vehicles available has different load capacities, fuel consumption rates, and operating costs. Consequently, the problem can be modelled as a Vehicle Routing Problem with profits (VRP with profits) (Archetti *et al*., 2014; Battarra *et al*., 2014), replacing revenue instead of profit. Accordingly, this study will adopt vehicle routing problem with time

windows (VRPTW), with the objective of maximizing the difference between the total collected revenue (retail price) and the cost of the total travelled distance (Dell'Amico *et al*., 1995). Herein, the product price (retail price) includes two main components; one is the final cost (or wholesale price) which includes the manufacturing cost, labour cost, overhead cost etc. and the other is the profit, which must be determined.

Therefore, the study second objective is to determine the revenue before and after proposing vehicle routing IT solution to find out if it results in improvement in the overall fleet vehicles' profit (revenue minus transportation costs). The study third objective is to determine vehicles' efficiency before and after proposing vehicle routing IT solution to find out if it results in improvement in the overall fleet vehicles' efficiency. The efficiency in this context refers to the efficient use of fuel consumption by reducing the distance travelled. Accordingly, our second and third research questions answered in this field experiment are as follows:

RQ2: To what extent can the proposed vehicle routing IT solution improve the overall fleet profit?

RQ3: To what extent can the proposed vehicle routing IT solution improve the overall fleet efficiency?

In order to answer the second and third questions of this study, the following two hypotheses are investigated:

H2: Proposed vehicle routing IT solution would improve the overall fleet profit.

H3: Proposed vehicle routing IT solution would improve the overall fleet efficiency

The remainder of this paper is organised as follows. Section 2 provides a literature review of fleet management system and vehicle routing problems. Section 3 provides research methodology. Analysis and results introduced in Section 4. Finally, conclusions presented in Section 5, and limitations and directions for future studies discussed in Section 6.

2. Literature review

This section presents a literature review on fleet management systems, field experiment, data envelopment analysis, and vehicle routing problems.

2.1 Fleet Management Systems

Fleet management is a function that enables distributors to improve vehicles and drivers' efficiency and productivity and mitigate the risks associated with their fleet investments.

Accordingly, the process of monitoring and increasing efficiency of transportation problems is termed fleet management. The scope and activities of fleet management covers: routing and scheduling, fuel management, vehicle acquisition, vehicle maintenance, driver briefing and debriefing (Pokharel, 2005; Ratcliffe *et al.*, 2011). These activities supervised by the fleet managers and primarily a policy formulated to serve as a guide for these activities. Furthermore, fleet managers have to ensure that these activities are cost effective (Ratcliffe *et al.*, 2011), ensure proper delegation of duties to large groups of personnel responsible for operating the fleet.

Nowadays, retail distribution entails the management of vehicles, routes, and workers using a variety of technologies, including numerous applications such as vehicle maintenance, vehicle tracking and diagnostics, improving driver performance, speed control and fuel management (Salhieh *et al.*, 2018). These technologies provided new opportunities to improve the management of retail distribution operations to improve fleet performance and customer satisfaction. Accordingly, fleet management system applications are mostly being used both as reporting tools by logistics managers who need to know vehicle travel times, service times, delivery points visited and other parameters (e.g. load temperature). In addition, retail distribution managers must possess the information as real-time input to dynamic vehicle management functions to efficiently manage a fleet of vehicles during the execution of retail distribution plans (Zeimpekis and Giaglis, 2006).

Literature on the adoption of fleet management systems have reported several benefits to retail distribution providers (Alessandro *et al*., 2011). These, benefits include improving internal retail distribution operations, reducing paperwork and waiting times (e.g. improved route planning reduces idle periods in combined transportation systems), optimizing the use of available resources (e.g. continuous communication with drivers leads to better use of transportation facilities), and minimizing input costs and sources of errors (Alessandro *et al*., 2011). Furthermore, the issue of identifying the benefits that retail distribution's companies performing freight transportation activities have achieved after IT adoption has been largely tackled by means of either empirical research (Auramo *et al*., 2005; Evangelista and Sweeney, 2006; Marchet *et al*., 2012) or modelling and simulation (Kia *et al*., 2000). However, according to Näslund *et al*. (2010), there are limited references on the adoption of the "Action Research" or "Field Experiments" approach in the field of supply chain management (Frankel *et al*., 2005;

Towers *et al*., 2020). In addition, very few studies provide tools able to quantify at least some of the addressed benefits (Kengpol and Tuominen, 2006). All previous research on the benefits of implementing fleet management systems in the retail distribution operations have claimed such a causal relationship without providing a statistical proof. This study chooses field experiment approach to study a truthfulness of the claimed relationship between independent and dependent variables in retail distribution operation. Finally, it should be noted that many authors call for greater links between the business and academic worlds, particularly with regard to the supply chain (Gutierrez *et al*., 2015; Coughlan *et al*., 2016; Towers *et al*., 2020). Accordingly, practitioners manage and researchers study the supply chain, each to their own, but each needing the other in order to produce and enrich the field's body of knowledge (Coughlan *et al*., 2016; Towers *et al*., 2020). This call has also been one of the motivating factors behind the field experiment approach adopted in this study (Näslund *et al*., 2010; Davis, 2014; Coughlan *et al*., 2016).

2.2 Field Experiment

Numerous publications explicate experimental methods thoroughly (Killias *et al*., 2009; Herrera *et al*., 2010; Shadish *et al*., 2002), including field experimentation in organizations (Highhouse, 2009, King *et al*., 2012) and retail contexts (Garaus and Wagner, 2019). The concept of the experiment is quite simple. By isolating and manipulating a single variable, and at the same time holding all other variables constant, the experimenter is able to measure the effect that the manipulated (independent) variable has upon the behaviour (dependent) variable of the subject of the experiment. The natural experiment (field experiment) brings an experimental interpretation to an event or process that has already taken place or that will take place in the future without any proactive effort by the researcher. Hence, it may be argued that the natural experiment is not an experiment since the researcher does not exercise control, directly or indirectly, over any of independent variables in the situation (Garaus and Wagner, 2019). The manipulation of the independent variable in the natural experiment is an event not controlled by the researcher, and seldom are control groups available. However, in the field experiment, the researcher controls the timing and extent of the change in the independent variable. In

addition, control groups established as further assurance that any change in the dependent variable that occurs after the independent variable manipulated is the result of that specific change and not the result of extraneous, uncontrolled factors (Sisk, 1973). Based on the experiment results, the change caused by the experiment may not intended to be permanent after the experiment or may be permanent if established such a causal benefit.

Few researchers have used field experimental as a research methodology to study issues in transportation field (Killias *et al*., 2009; Herrera *et al*., 2010). Most previous studies used different approaches to investigate IT adoption such as surveys, interviews, and analytical models and simulations (Lai *et al*., 2006; Marchet *et al*., 2009; Marchet *et al*., 2012). Therefore, this study contributes by filling this gap of research methodology in distribution management.

2.3 Data Envelopment Analysis (DEA)

In this study, we use data envelopment analysis (DEA) technique as a representative of the non-parametric methods. Nowadays, the DEA methodology is widely recognised as a universal tool for computing the efficiency of some production processes and for benchmarking (Salhieh *et al*., 2018; Beriha *et al*., 2011). DEA is a useful approach for measuring relative efficiency using multiple inputs and outputs among similar organizations or objects (Sufian, 2011; Phadnis and Kulshrestha, 2012). DEA assesses the extent of inefficiency for all other Decision Making Units (DMUs) that are not regarded as the best practice DMUs (Charnes *et al*., 1978). Since DEA provides a relative measure, it will only differentiate the least efficient DMU from the set of all DMUs. Thus, the best practice (most efficient) DMU is rated as an efficiency score of one, whereas all other less efficient DMUs are scored somewhere between zero and one.

Application of DEA to retail distribution fleet can be found in many research papers. Weber and Weber (2004) developed and estimated efficiency and productivity measures in the US trucking and warehousing industry using DEA. Furthermore, Hilmola (2011) evaluated public transportation efficiency in larger cities using DEA. In accordance with mentioned research, this paper utilises a data envelopment analysis (DEA) technique to assess vehicle’s efficiencies.

2.4 Vehicle Routing Problem

The retail distribution (last mile) problem in which vehicles based at a central facility (depot) are required to visit; during a given time period; geographically dispersed customers in order to fulfil known customer requirements are referred to as the Vehicle Routing Problem (VRP)

(Christofides *et al*., 1981). The main objective of the VRP is to minimise the distribution costs for individual carriers, and described as the problem of assigning optimal delivery or collection routes from a depot to a number of geographically distributed customers, subject to constraints. The most basic version of the VRP called vehicle scheduling, truck dispatching, or simply the delivery problem. Many variants of VRP have been introduced such as Heterogeneous Fleet Vehicle Routing Problem (HVRP), Fleet Size and Mix Vehicle Routing Problem with Time Windows (FSMVRPTW) (Liu and Shen, 1999b), the clustered vehicle-routing problem (CluVRP) and VRP with profits (Archetti *et al*., 2014; Battarra *et al*., 2014). This study adopts an IT solution VRP model, combined with capacitated vehicle routing problem and VRPTW model. The aim is to choose the optimal or near optimal routes, where one objective needs to be considered as follow: Maximise the total revenue minus total transportation costs in the retail distribution function. The constraints are:

(1) the vehicle capacities must not be violated;
(2) the demand of each customer must be satisfied, and must be serviced by exactly one vehicle;
(3) Each vehicle starts from the retail distribution centre and returns to it when finishing its route;
(4) Time duration restrictions on vehicles;
(5) Time window restriction to each customer and service time;
(6) Time window restriction on a central retail distribution facility.

This study will adopt a VRP Spreadsheet Solver (IT solution) for representing and solving the results of Vehicle Routing Problems developed by Erdoğan (2015).

3. Research Methodology

This research is explanatory in nature, because it is concerned with determining cause-and-effect relationships among investigated variables (Highhouse, 2009). Hence, this study tries to ascribe causality (Cohen *et al*., 2007), and to make sure that "A" caused "B", not anything else that may cause the truck's efficiency such as driving behavior, driver age, procedures and planning, this study adopted the positivism philosophy paradigm, which referred to as the scientific method (Oates, 2006). In addition, this research is considered quantitative in nature since the data produced are numerical data.

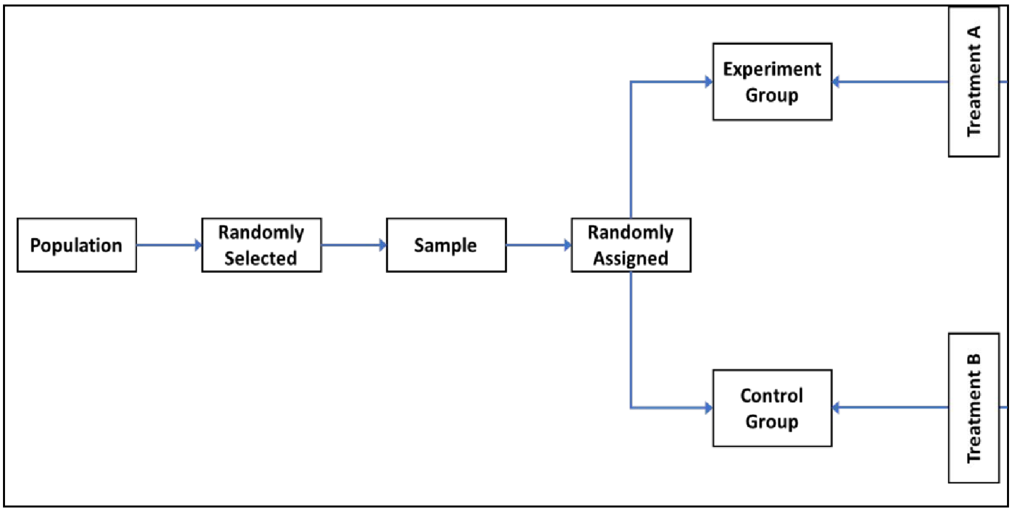
Furthermore and in order to investigate the proposed study hypotheses, the study adopted field experimental research (Oates, 2006). Accordingly, the design of the experiments adopted to investigate the study hypotheses are as follow:

- Before-and-after with control design for installing a tracking system (Imai *et al*., 2013).
- Before-and-after without control design for proposed VRP solution (Houlind *et al*., 2012)

In addition, the current study is considered as longitudinal research since the participants, processes or systems are studied over time, with data being collected at multiple intervals and it takes place over a specific period (Trochim and Donnelly, 2006).

At the end, the target population for investigating the effect of installing a tracking system on vehicles' efficiency, the study have considered all the fleet of vehicles that are active in the retail distribution operation (40 vehicles). However, procedure to select a sample is discussed in the following sub-sections.

Figure 1: The procedure of randomization study (Houlind *et al.*, 2012).

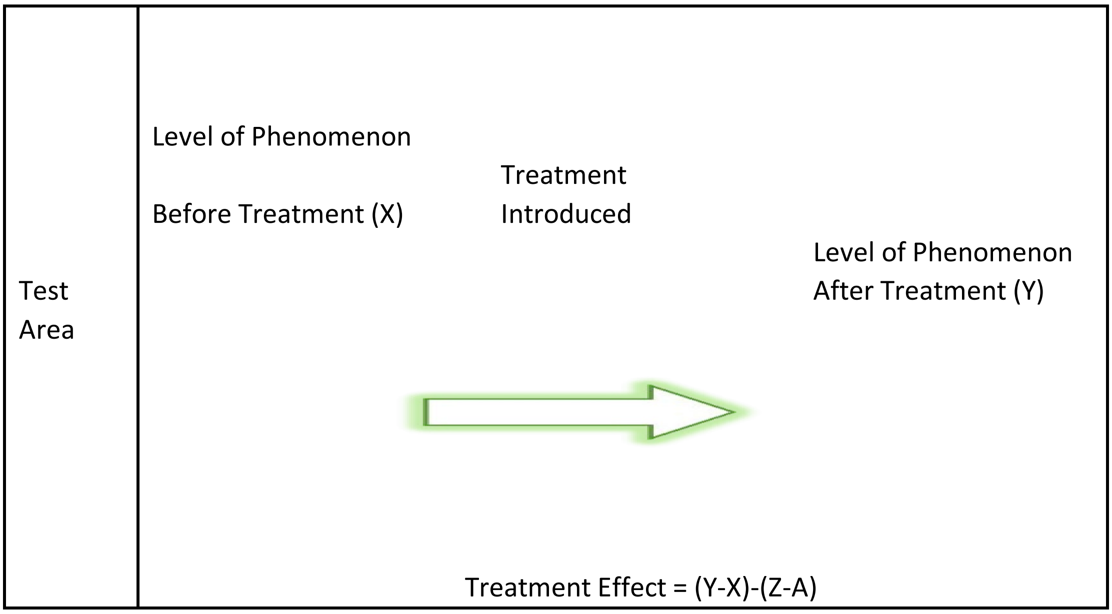


Following Figure 1 procedures for randomization purpose, 16 vehicles randomly selected to constitute the study sample. Afterwards, randomly assigned eight vehicles to experimental group (G1) and eight vehicles randomly assigned to control group (G2) and the treatment effect calculated as shown in Figure 2. However, in investigating the effect of using a VRP IT solution on vehicles' efficiency, the targeted population was the eight vehicles that have installed tracking system as shown in Figure 3.

Figure 2: The treatment effect (Imai *et al.*, 2013)

	Time Period I	Treatment Introduced	Time Period II
Test Area	Level of Phenomenon		Level of Phenomenon
	Before Treatment (X)		After Treatment (Y)
Control Area	Level of Phenomenon		Level of Phenomenon
	Without Treatment (A)		Without treatment (Z)
Treatment Effect = (Y-X)-(Z-A)			

Figure 3: the effect of the treatment on the phenomenon (Imai *et al.*, 2013)



Before-and-after with control design for installing a tracking system

A longitudinal field experiment designed to assess and measure vehicles' efficiency over a four-month period in a company (kept anonymous) which run its own in-house distribution. One type of longitudinal design that incorporates a randomised experiment is the pre-test post-test control group design (Bonate, 2002; Shadish, *et al*., 2002). Therefore, in order to address the first objective and determine the causal effect of installing a "Tracking system" on vehicles' efficiency, a pre-test post-test control group design utilised. This design consists of randomly assigning units to a control group and a treatment group, measuring theoretically relevant variables before delivery of a treatment, and then measuring these same variables again at a later point in time after treatment (Bonate, 2002; Shadish *et al*., 2002) as shown in Table 1. Furthermore, this design allows researchers to measure variables twice for each unit, and units randomly assigned to different treatment groups, researchers can answer questions about within-group changes between pre-test and post-test and betweengroup differences in change between pre-test and post-test (Bonate, 2002; Shadish, *et al*., 2002).

Table 1: Two groups, Random Selection, Pre-treatment, and Post-treatment

Group	Pre-treatment period	Treatment	Post-treatment period
Experimental group (G1)	G1	X	G1
Control Group (G2)	G2		G2

The dependent variable in this experiment is the monthly vehicle's efficiency for 16 vehicles participated in this experiment with different capacities and costs. The participated vehicles randomly chosen to participate and then segmented randomly to two equal groups. Group one (G1) is randomly selected to receive the experimental treatment (Tracking system), and the other group served as the control group (G2). In this company, on a daily basis, the dispatching department assigns loads and routing to vehicles. Accordingly, the final arrangements of these categorizations kept blind to the dispatching department and treated as a contaminating factor, and must normalise its effect on the experiment.

A two-month daily history of vehicle's information collected for both groups before the introduction of the treatment (tracking system) as shown in Table 2, which established a baseline of comparison.

Table 2: Input-Output data for vehicles' efficiency evaluation

	Inputs								*Output*				
	Truck Operational Cost				*Mileage*				*Effective vehicle's capacity*				
	Pre-treatment		Post- treatment		Pre- treatment		Post- treatment		Pre- treatment		Post- treatment		
	Month-1	Month-2	Month-3	Month-4	Month-1	Month-2	Month-3	Month-4	Month-1	Month-2	Month-3	Month-4	
V4	371	410	304	412	1,661	1,837	851	1,154	320	303	477	259	
V9	258	258	235	258	1,156	1,156	722	722	175	149	357	314	
V14	160	177	216	191	717	793	605	534	207	243	319	234	
V21	173	264	170	206	774	1,183	476	576	258	272	311	236	**Group #1**
V24	293	307	277	368	1,312	1,375	775	1,029	203	251	280	267	
V26	408	418	413	322	1,829	1,873	1,156	902	325	291	331	351	
V28	124	232	219	198	556	1,039	612	554	214	160	290	320	
V30	265	314	294	261	1,186	1,409	824	731	237	243	349	313	
V1	241.3	156.6	162.1	237.5	1,081.20	701.7	453.9	664.9	182	312.1	321.5	489.3	
V2	374.7	414.4	456.6	416.7	1,678.70	1,856.60	1,278.50	1,166.60	295	340.8	325.1	452.7	
V3	183.6	266.7	164.8	218.5	822.5	1,195.00	461.5	611.9	180.1	360.3	300.5	259.7	
V5	84.4	183.4	159.7	140.4	378.1	821.6	447.1	393.2	163.3	263.6	305.3	181.3	**Group #2**
V6	238.5	221.9	73.9	246.7	1,068.60	994.3	207	690.8	205	237.6	313.1	171.3	
V7	143.6	180.5	217.3	265.5	643.5	808.5	608.3	743.4	112.5	360.6	281.3	181.9	
V8	258.5	212.2	157.9	94.3	1,158.20	950.8	442.1	263.9	178.1	168.9	301.7	271.9	
V10	342.4	400	361.9	365.1	1,533.90	1,792.00	1,013.30	1,022.20	131.1	202.6	375.2	370.7	

At the end of the two months, the treatment installed on Group 1 for two months and data collected for both groups of vehicles in the experiment during the intervention period. Furthermore, the tracking system provided feedback to the supervisor and discussed on a daily basis to group 1 on aspects such as mileage, idle, and time used to complete the delivery. The data collected before and after the treatment from all participated vehicles used as inputs, and outputs to calculate vehicle's efficiencies using Data Envelopment Analysis (DEA). The model for efficiency evaluation specified with one output category (Effective vehicle's capacity) and two inputs (Mileage, Truck operational cost), which is set by modifying the model specification of Hjalmarsson and Odeck (1996) dealing with technical efficiency of trucks. In order to capture the variation in technical efficiency over time, this study adopted Boussofiane *et al*. (1991) method. According to them, if there are k units (Trucks) with data on their input/output measure, then a total of k*t need to be assessed simultaneously to capture the efficiency variations overt time. Then, this study will have 16 trucks (8*2) evaluated before and after treatment for each group. Data captured during the two months before and after the treatment presented in Table 1. Furthermore, as a measure for evaluation of appropriateness of model specification, dimensionality (= No. of Trucks / (No. of input factors + No. of output factors)) used. If it is > 5, the model specification looks good (Fernandez-Cornejo, 1994). Since the dimensionality of this research is 5.3 (16/3), which is greater than five, it is acceptable. Furthermore, here we are using a model with an output-oriented objective as contrasted with the input orientation.

3.1 Before-and-after without control design for proposed VRP solution

In the investigated retail distribution company, customers' orders are assigned to vehicles on a daily distribution schedule, and a driver needs to finish all the distribution assignments within the same day. Currently, the assignment schedules created manually with no pre-set criteria, but based on judgement and past experiences. This study will select eight vehicles (installed tracking system) after being assigned customers' orders and a sequencing schedule set by the dispatching department to participate in the analysis. Furthermore, data regarding load assigned and a routing details collected for two days, as is situation as presented in Tables 3 and 4. Accordingly, this study will adopt a VRP Spreadsheet Solver for representing, solving, and visualizing the results of Vehicle Routing Problems developed by Erdoğan (2015) to study the impact of the proposed vehicle routing IT solution on profit (Revenue – Transportation costs) and efficiency to test the second and third hypotheses respectively. The spreadsheet can be adapted to fulfil the real business situation under investigation. Therefore, the study considers a complete undirected graph G = (V, E), where V = 1….., n is the set of vertices and E is the set of edges. Vertex 1 is the depot, which is the starting and ending point of each tour, and has associated time window. Each vertex $\boldsymbol{i}$ = 2, . . . , n represents a potential customer. An edge ($\boldsymbol{i}$, $\boldsymbol{j}$) ∈ E represents the possibility to travel from vertex $\boldsymbol{i}$ to vertex $\boldsymbol{j}$. Each customer has a demand d_i, and time window. A nonnegative profit p_i is associated with each customer ($p_1 = 0$), and a service time. A symmetric travel time t_{ij} and a cost c_{ij} are associated with each edge ($\boldsymbol{i}$, $\boldsymbol{j}$) ∈ E. A set of m vehicles is available to visit the customers. Each vehicle has a capacity Q and can visit any subset of the potential customers without exceeding the capacity Q; the duration of the route of each vehicle does not exceed a working time limit T_{max}. Furthermore, the profit of each customer $\boldsymbol{i}$ can be collected by one vehicle at most. Therefore, the objective is to maximise the total collected profit (revenue minus total transportation cost).

Table 3: Summery for Day (I).

Day (I)						
Customer	**LA**	**LO**	**Order Capacity m3**	**Profit (J.D)**	**Design Capacity m3**	**Vehicle #**
C1	31.99632	36.01746	1.32	89	**28.8**	**V4**
C2	31.71922	35.79956	1.65	111		
C3	31.72673	35.7851	1.485	100		
C4	31.72676	35.7851	0.99	66		
C5	31.72383	35.7872	0.66	44		
C6	31.71602	35.77949	1.98	133		
C7	31.71637	35.77854	2.475	166		
C8	31.71827	35.77661	1.155	78		
C9	31.71669	35.78202	1.65	111		
C10	31.71626	35.77863	0.33	22		
C11	31.68085	35.72861	0.825	55		
C12	31.72397	35.78698	0.495	33		
C13	31.71904	35.79486	1.485	100		
C14	31.89948	35.85704	1.232	83	**24**	**V9**
C15	31.8996	35.85686	1.54	103		
C16	31.90329	35.85905	1.386	93		
C17	31.90539	35.86429	1.54	103		
C18	31.89957	35.85718	1.232	83		
C19	31.89286	35.84218	1.848	124		
C20	31.89227	35.84351	2.31	155		
C21	31.8939	35.84027	1.078	72		
C22	31.89446	35.83951	1.54	103		
C23	31.91383	35.82827	0.924	62		
C24	31.89787	35.83947	0.77	52		
C25	31.88049	35.85679	1.384	93	**24**	**V14**
C26	31.89301	35.85127	1.73	116		
C27	31.89963	35.85687	1.557	104		

C28	32.08641	36.20471	1.038	70		
C29	31.87031	36.76187	0.692	46		
C30	31.83602	36.81517	2.076	139		
C31	31.83257	36.81488	2.595	174		
C32	31.83228	36.81512	1.211	81		
C33	31.8344	36.81525	1.73	116		
C34	31.83236	36.81491	1.211	81		
C35	31.84086	36.80571	0.865	58		
C36	31.84203	36.80351	1.211	81		
C37	31.87028	36.76192	2.31	155		
C38	31.87274	36.75063	1.078	72		
C39	31.87285	36.74762	1.304	87		
C40	31.99701	36.03037	1.63	109		
C41	32.10547	35.72596	1.467	98		
C42	32.14402	35.6977	1.141	77		
C43	32.14952	35.69737	1.304	87		
C44	32.14768	35.70253	1.956	131	**24**	**V21**
C45	32.14724	35.70285	2.445	164		
C46	32.14673	35.70469	1.467	98		
C47	32.14597	35.70746	1.63	109		
C48	32.14298	35.70982	1.956	131		
C49	32.0227	35.71472	1.211	81		
C50	32.02366	35.71812	1.755	118		
C51	31.65937	35.78078	1.17	79		
C52	31.64419	35.77039	2.34	157		
C53	31.62134	35.76661	1.755	118		
C54	31.60699	35.76416	2.145	144		
C55	31.60414	35.76255	1.95	131	**24**	**V24**
C56	31.60369	35.75951	2.925	196		
C57	31.6041	35.75819	2.535	170		
C58	31.64482	35.77047	0.585	39		
C59	31.71079	35.79724	0.78	52		
C60	31.71151	35.80809	1.89	127	**24**	**V26**
C61	31.71709	35.80389	1.134	76		

C62	31.72081	35.80564	2.268	152		
C63	31.72004	35.80428	2.835	190		
C64	31.75653	35.87151	2.079	140		
C65	31.72459	35.80294	1.89	127		
C66	31.72782	35.7991	1.701	114		
C67	31.73017	35.79627	2.457	165		
C68	31.72372	35.79463	0.378	25		
C69	31.72249	35.80183	0.756	51		
C70	31.72471	35.803	1.512	101		
C71	31.72842	35.80471	2.535	170		
C72	31.72848	35.80478	1.809	121		
C73	31.74455	35.80331	1.407	94		
C74	31.75631	35.87165	2.412	162		
C75	31.97634	35.86287	1.608	108		
C76	31.97547	35.85613	2.211	148		
C77	31.9784	35.84455	2.01	135		
C78	31.97528	35.85333	2.412	162		
C79	31.97583	35.85359	2.613	175	**24**	**V28**
C80	31.97364	35.8684	2.01	135		
C81	31.96582	35.88348	1.608	108		
C82	31.97303	35.87254	0.78	52		
C83	31.97604	35.86318	1.89	127		
C84	31.97724	35.8634	1.134	76		
C85	31.71181	35.94999	2.268	152		
C86	31.70845	35.95099	1.608	108		
C87	31.70602	35.95181	1.809	121		
C88	31.76807	35.93666	1.206	81		
C89	31.7477	35.93832	2.412	162		
C90	31.73297	35.94349	1.608	108		
C91	31.7126	35.94978	2.211	148	**24**	**V30**
C92	31.69972	35.95722	2.01	135		
C93	31.71158	35.95019	1.206	81		
C94	31.64395	35.93725	2.613	175		
C95	31.79847	35.92974	1.608	108		

Table 4: Summery for Day (II).

Day (II)						
Customer	**LA**	**LO**	**Order Capacity m3**	**Profit (J.D)**	**Design Capacity m3**	**Vehicle #**
C1	31.78627	35.9008	1.386	93		
C2	31.75801	35.8740	1.54	103		
C3	31.75708	35.8730	1.232	83	**28.8**	**V4**
C4	31.72288	35.8032	1.848	124		
C5	31.74139	35.8137	2.31	155		
C6	31.74407	35.8010	1.078	72		
C7	32.04872	35.7692	1.54	103		
C8	32.06629	35.7219	0.924	111		
C9	32.02691	35.7184	0.77	112		
C10	32.02282	35.7147	1.384	114		
C11	32.02366	35.7202	1.038	115		
C12	32.13369	35.7005	0.692	117		
C13	32.14401	35.6977	2.076	118		
C14	32.14956	35.6974	2.595	120		
C15	32.14771	35.7025	1.211	121	**24**	**V9**
C16	32.1475	35.7033	1.73	123		
C17	32.14597	35.7074	1.211	124		
C18	32.1429	35.7098	0.865	125		

	9					
C19	32.13326	35.7324	1.211	127		
C20	32.14409	35.7084	2.31	128		
C21	32.13372	35.7006	1.078	130		
C22	32.02998	35.7134	1.485	131		
C23	32.02654	35.7151	0.99	133		
C24	32.04411	35.7068	0.66	134		
C25	31.72013	35.8044	1.98	136		
C26	31.71807	35.8015	2.475	137		
C27	31.71723	35.8003	1.155	139		
C28	31.71764	35.7995	1.65	140		
C29	31.71555	35.7980	0.33	142	**24**	**V14**
C30	31.71238	35.7958	0.825	143		
C31	31.70581	35.7919	0.495	145		
C32	31.70253	35.7921	1.485	146		
C33	31.71103	35.7947	1.232	148		
C34	31.72028	35.8048	1.89	149		
C35	31.71705	35.8039	1.134	151		
C36	31.72029	35.8049	2.268	152		
C37	31.72957	35.8191	2.835	154		
C38	31.97815	36.0133	2.079	155	**24**	**V21**
C39	31.95512	35.8560	1.89	156		
C40	31.91961	35.8588	1.701	158		

C41	31.91592	35.9107	2.457	159		
C42	31.90847	35.9309	0.378	161		
C43	31.90982	35.9228	0.756	162		
C44	31.79935	35.9425	1.512	164		
C45	31.76716	35.9395	2.535	165		
C46	31.76173	35.9400	1.809	167		
C47	31.73278	35.9435	1.407	168		
C48	31.71232	35.9498	1.512	170		
C49	31.71045	35.9505	2.535	171		
C50	31.70601	35.9518	1.809	173		
C51	31.70434	35.9510	1.407	174	**24**	**V24**
C52	31.70365	35.9497	2.412	176		
C53	31.70259	35.9479	1.608	177		
C54	31.70559	35.9468	2.211	179		
C55	31.7067	35.9463	2.01	180		
C56	31.705	35.9442	2.412	182		
C57	31.87514	35.9262	2.613	183		
C58	31.86586	35.8910	2.01	185		
C59	31.70834	35.9511	1.608	186		
C60	31.73284	35.9436	0.78	187		
C61	31.78267	35.9222	1.89	189		
C62	31.76615	35.9379	1.134	190		
C63	32.08647	36.2047	1.32	192	**24**	**V26**

C64	32.08971	36.2137	1.65	193		
C65	32.08987	36.2145	1.485	195		
C66	32.09169	36.2389	0.99	196		
C67	32.08989	36.2372	0.66	198		
C68	32.09572	36.2124	1.98	199		
C69	32.08997	36.2137	2.475	201		
C70	31.997	36.0303	1.155	202		
C71	31.89937	35.8575	2.412	204		
C72	31.9029	35.8591	2.613	205		
C73	31.90331	35.8590	2.01	207		
C74	31.90839	35.8593	1.608	208		
C75	31.90835	35.8593	0.78	210		
C76	31.90529	35.8643	1.89	211		
C77	31.89923	35.8657	1.134	213		
C78	31.89228	35.8435	2.268	214		
C79	31.89277	35.8419	1.608	216		
C80	31.89486	35.8387	1.809	217		
C81	31.89615	35.8371	1.206	218		
C82	31.89349	35.8410	2.412	220	**24**	**V28**
C83	31.89264	35.8430	1.608	221		
C84	31.89262	35.8492	2.211	223		
C85	31.88886	35.8430	2.01	224		
C86	31.89388	35.8395	1.206	226		
C87	31.88904	35.8585	2.613	227		

C88	31.89154	35.8602	1.54	229		
C89	31.8961	35.8645	0.924	230		
C90	31.99635	36.0174	0.77	232		
C91	31.7205	35.7974	1.384	233	**24**	**V30**
C92	31.72061	35.7929	1.73	235		
C93	31.7183	35.7930	1.557	236		
C94	31.71159	35.7833	1.038	238		
C95	31.71379	35.7873	0.692	239		
C96	35.7886	2.076	1.56	105		
C97	31.71328	35.7908	2.595	242		
C98	31.71454	35.7907	1.211	244		
C99	31.7107	35.7890	1.73	245		
C100	31.71342	35.7919	1.211	247		
C101	31.71921	35.7918	0.865	248		
C102	31.78501	35.8998	1.211	249		
C103	31.97136	36.0938	2.31	251		
C104	31.99572	36.0155	0.78	252		

Table 5 presents the several parameters used to calculate the objective function. Furthermore, data collected over two days for each vehicle regarding the actual load assignment (customer orders, volume of each order, revenue of each order, and customer google location) and actual sequence of delivery.

Table 5: Vehicle routing parameters

Vehicle #	V4	V9	V14	V21	V26	V28	V30
Capacity(m^3)	21.6	18	18	18	18	18	18
Cost per distance (J.D./Kilometer)	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Work start time	08:00	08:00	08:00	08:00	08:00	08:00	08:00
Driving time limit	18:00	18:00	18:00	18:00	18:00	18:00	18:00
Working time limit	19:00	19:00	19:00	19:00	19:00	19:00	19:00
Return depot	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Depot Service Time Window	07:00 – 08:00	07:00 – 08:00	07:00 – 08:00	07:00 – 08:00	07:00 – 08:00	07:00 – 08:00	07:00 – 08:00
Customer Time Window	08:00 – 17:00	08:00 – 17:00	08:00 – 17:00	08:00 – 17:00	08:00 – 17:00	08:00 – 17:00	08:00 – 17:00
Customer Service Time (minutes)	≤ 15	≤ 15	≤ 15	≤ 15	≤ 15	≤ 15	≤ 15

4. Results and discussion

This section will address the research objectives. The first objective is to assess and measure the impact of installing a "Tracking System" on vehicles' efficiency. The second and third objectives are related to adopting a vehicle routing IT solution to maximise revenue and improve efficiency.

4.1 Results of Installing a Tracking System

The monthly vehicle's efficiency for the two groups are used to determine what effect, if any, the installation of a "Tracking system" had on improving vehicle's efficiency in the retail distribution function. A pre-intervention (first two month), vehicles efficiencies calculated using data collected for outputs and inputs on a daily basis to be summed for a month as shown in Table 2. Efficiencies of the two groups participated in this field experiment calculated using DEA methodology as shown in Tables 6 and 7.

Table 6: Group #2 vehicle average efficiency

Vehicle #	Efficiency	
	Pre- treatment	Post- treatment
V1	68.74%	47.74%
V2	40.28%	21.23%
V3	58.35%	35.56%
V5	84.39%	37.81%
V6	48.31%	58.20%
V7	69.61%	23.37%
V8	37.15%	56.61%
V10	22.26%	24.22%

Table 7: Group #1 vehicle average efficiency (treatment)

Vehicle #		Efficiency	
		Pre-treatment	Post-treatment
V4		41.80%	59.97%
V9		59.46%	74.86%
V14		67.34%	73.84%
V21		66.94%	81.27%
V24		40.21%	47.45%
V26		43.12%	51.59%
V28		72.45%	80.37%
V30		41.80%	65.08%

After pre- intervention period, the first group (treatment) was randomly assigned the installed "Tracking System", while the second group (controlled) did not receive this treatment. A post- intervention (the intervention period), vehicles efficiencies were calculated as shown in Tables 4 and 5 using data collected for outputs and inputs on a daily basis to be summed for a month as shown in Table 2. In order to substantiate or refute the first hypothesis (H1), a set of statistical tests are conducted as shown in Table 6 in order to confirm internal validity, but the external validity or generalizability of the study is limited by the possible effect of pre-testing. However, in this study, a pre-test is not exposed to participants, rather a performance measure before introducing the treatment is calculated. Accordingly, generalizability of the study is not limited, and field experiments have more external validity (i.e., the results are more generalizable to other similar organizational settings), but less internal validity (i.e., we cannot decide the dgree to which variable X alone causes variable Y). (Sekaran (2003) noted that there are seven major threats to internal validity such as the effects of history, maturation, testing, instrumentation, selection, statistical regression, and mortality. Accordingly, since both groups are randomised; we could expect that the history, maturation, testing, and instrumentation effects have been controlled. Furthermore, no vehicle pulled out, nor drivers were changed or dismissed from the retail distribution company, then mortality effect is controlled. However, in order to confirm such control of stated threats, several statistical tests are conducted as shown in Table 8.

Table 8: Statistical tests (before and after treatment)

Group	Hypothesis test	Results	Conclusion
Before (G2-G1)	H_0: $\mu_{G2} = \mu_{G1}$ (there is no difference) H_A: $\mu_{g2} \neq \mu_{AG1}$ (there is difference)	p-value = 0.884	We do not reject the null hypothesis (there is no difference)
After (G2-G1)	H0: $\mu_{G2} = \mu_{G1}$ (there is no difference) HA: $\mu_{G2} \neq \mu_{G1}$ (there is difference)	p-value = 0.000	We reject the null hypothesis (There is difference)
Control (G2)	H_0: $\mu_{Before} = \mu_{After}$ (there is no difference) H_A: $\mu_{Before} \neq \mu_{After}$ (there is difference)	p-value = 0.078	We do not reject the null hypothesis (there is no difference)
Treatment (G1)	H_0: $\mu_{Before} \geq \mu_{After}$ (there is no increase) H_A: $\mu_{Before} < \mu_{After}$ (there is increase)	p-value = 0.042	We reject the null hypothesis (there is improvement)

The results showed no statistical difference exists between the two groups based on premeasurement of efficiencies (p-value = 0.884). Therefore, the two groups considered are "equivalent" with respect to their vehicle efficiencies. Second, a statistical test conducted before and after for Group 2 to find out if a statistical difference exists based on efficiencies, the results showed no significant differences before and after treatment period at p-value = 0.078. Third, a statistical test is conducted to find out if a statistical difference exists between the two groups based on post- intervention of the efficiencies. The statistical test showed that there is a difference between the two groups p-value = 0.000. Finally, a statistical test was conducted before and after for Group 1 to find out if a there is an improvement in fleet efficiency, the results showed a significant statistical improvement in efficiency at p-value = 0.042. In conclusion and based on the results of

Table 8, and since the only difference between the two groups consisted of installing a "Tracking System", this factor can be attributed to the improved efficiency of the treatment group. Accordingly, the study can confidently claim that the first hypothesis (H1) was supported, and vehicles installing a tracking system will improve their efficiencies over time.

Consequently, as shown in Table 2, installing a tracking system for the eight vehicles over a period of two months have saved the retail distribution company an amount of 1526.6 Jordanian Dinars (7633 kilometre * 0.20 cost/ kilometre). Therefore, the organisation can use capital budgeting techniques to assess the feasibility of such an investment. This field experiment approved that installing tracking systems will improve vehicles' efficiency and, consequently, reduces vehicles' operational costs.

4.2 Results of Installing a Vehicle routing System

Two performance measures are used to assess the impact of proposed vehicle routing IT solution on vehicles' profit (Revenue – Transportation cost), and vehicles' efficiency among selected vehicles. This study has chosen vehicles with installed tracking systems to participate at this stage of analysis. Accordingly, data collected over two days for the eight selected vehicles as the current situation shown in Tables 3 and 4, in order to measure profits and efficiencies. Then, the adopted IT solution used to generate recommended assignments and routing for every vehicle over two days operations as shown in Table 9. Accordingly, a two-sample t-test is applied to compare whether the average difference regarding profit between two methodologies (proposed and actual) is significant or if it is due instead to random chance. This statistical test helps to answer the second hypothesis (H2) whether the average profit is higher after implementing the proposed vehicle routing IT solution than before. The results of the two-sample t-test presented in Table 10 show that the proposed vehicle routing IT solution did improve the total profit. Therefore, H2 is accepted. Furthermore, Table 9 shows that the organisation is able to increase its profit by an amount of 129 Jordanian Dinars during 2 days only. Consequently, the organisation can use capital budgeting techniques to assess the feasibility of such an IT system.

Table 9: Proposed vehicle routing IT solution versus actual assignment and sequencing

	Proposed IT Solution			Current Situation		
Vehicle #	Time Duration	Total Distance	Profit (J.D.)	Time Duration	Total Distance	Profit (J.D.)
First-Day						
V4	5:45	32	6,794	8:20	161	6,584
V9	5:50	42	5,992	7:30	56	5,769
V14	5:53	64	5,907	9:13	188	5,362
V21	6:13	62	7,148	8:50	118	5,656
V24	6:11	33	6,633	7:45	157	6,009
V26	6:17	125	5,815	8:10	136	6,453
V28	5:28	51	2,390	7:30	69	6,074
V30	8:43	247	6,751	8:15	155	5,689
Second-Day						
V4	8:00	114	7,377	8:30	150	5,770
V9	5:10	61	4,232	7:45	110	6,058
V14	7:48	104	6,459	8:35	130	6,214
V21	8:24	61	6,588	8:50	95	6,541
V24	5:33	98	4,180	7:30	120	5,416
V26	7:14	112	7,138	8:15	155	5,689
V28	8:00	101	6,900	8:40	140	5,532
V30	5:56	97	4,541	7:45	110	5,898
Total	106:24	1,404	94,843	131:30	2,050	94,714

Table 10: Two-sample t-test results of profit

	N	Mean	StDev	SE Mean
Proposed IT Solution	16	5961	1389	347
Current Situation	16	5920	382	95
	T-Value = 0.11	P-Value = 0.545	DF =	30

Tested Hypothesis:
H_0: $\mu_{Proposed} \geq \mu_{Current}$ (improvement in Profit (Revenue – transportation cost)
H_A: $\mu_{proposed} < \mu_{Current}$ (no improvement in Profit (Revenue – transportation cost)

Furthermore, this study has also tested if vehicles' efficiencies have improved after adopting the vehicle routing IT solution. The eight vehicles (installed Tracking system) used to assess improvement in efficiency between current situation and the proposed vehicle routing IT solution as presented in Table 11.

Table 11: Technical efficiency comparison

	Technical Efficiency	
Vehicle #	Current Situation	Proposed IT Solution
V4	52.76%	74.94%
V9	87.68%	97.07%
V14	49.12%	69.99%
V21	67.33%	71.60%
V24	65.25%	85.37%
V26	57.88%	57.76%
V28	75.71%	75.55%
V30	64.69%	43.23%

Table 11 shows the results of technical efficiency using Data envelopment Analysis (DEA) technique. Time duration and distance travelled used as inputs, and profit as output to the DEA methodology. Again, the two-sample t-test applied to compare whether the average efficiency difference between two states (proposed and actual) is significant or if it is due instead to random chance.

Table 12: Two-sample t-test results of technical efficiency

	N	Mean	StDev	SE Mean
Current Situation	16	0.548	0.197	0.049
Proposed Vehicle Routing IT Solution	16	0.668	0.181	0.045
	T-Value = 1.79	P-Value = 0.958	DF = 30	
Tested Hypothesis: H_0: $\mu_{Installed} \geq \mu_{not}$ (there is an improvement in Efficiency after proposing vehicle routing IT solution)				

H_A: $\mu_{Installedt} < \mu_{not}$ (there is no improvement in Efficiency after proposing vehicle routing IT solution)

This statistical test helps to answer the third hypothesis (H3) whether the average technical efficiency improved after implementing the proposed vehicle routing IT solution than before. The results of the two-sample t-test presented in Table 12, which shows that the adopted vehicle routing IT solution did improve the technical efficiency. Therefore, H3 is accepted.

5. Conclusion

This study assessed the impact of installing routing and tracking systems on vehicles' efficiency in retail distribution operations, and the impact of vehicle routing on vehicle' efficiency and profit. In order to investigate the impact of installing tracking system on vehicles, a field experiment was conducted in order to establish causality with statistical evidence. The statistical results have supported the first hypothesis (H1) of this study, which states "vehicles installing a fleet management system (tracking system) will improve their efficiency over time". The results also support the second and third hypotheses (H2 and H3) related to the impact of routing systems on vehicle's efficiency and profitability.

The findings from this study fills the shortcoming of previous research in claiming IT solution benefits in a retail distribution environment, specifically on assuming causality through different research methods (surveys, case studies, interviews, analytical models and simulations). Consequently, the theoretical contribution of this study manifested itself by adopting a field experiment as a research method to establish causality relationships of the benefit of installing IT solutions in a retail distribution environment. The paper also demonstrated the role of field experiment as a valid approach for improving the rigour of retail logistics research. Through employing manipulation and random assignment to investigate causality in naturally occurring contexts, our results showed statistical evidence for installing IT solutions would improve retail distribution operations specifically fleet efficiency and profitability. This study fills a gap in literature through the application of a field experiment approach to establish causality relationships in retail distribution operations. The study addresses recent calls by literature (Aguinis and Vandenberg, 2014; Baldassarri and Abascal, 2017) for rigorous research methods that would improve causal persuasiveness, not only in retail logistics research (Salhieh *et al*., 2018; Näslund *et al*., 2010), but also the wider aspects of organizational research.

The practical contribution of this study is manifested in the ability of retail distribution's managers to use a field experiment setup to investigate potential IT solution impact prior to purchase and full implementation of such solutions. Field experimentation carried out in this study can be also appropriate for evaluating the saving retail distributors can achieve from deploying IT systems in last-mile distribution, and for evaluating the payback period for such an investment. This field experimentation provided the retail distribution company under investigation with valuable evidence that installing a "Tracking System" to all of their fleet would improve vehicles' efficiency, and consequently reduces vehicle's operational costs. Thus, this study is different from previous studies on IT benefits in logistics and retail distribution (Auramo *et al*., 2005; Evangelista and Sweeney, 2006), in its ability to make actual financial benefits of such investments.

Retail distribution managers could also benefit from this study by developing an appropriate vehicle routing IT solutions to maximise revenue and improve efficiency. The study is also of importance to retail distributors and fleet operators in assessing the true financial benefits of investing in vehicle routing systems.

Testing causal hypotheses rigorously is crucial for scientific purposes and developing evidence-based tools into the hands of retail distribution managers (Rynes and Bartunek 2017). Lacking evidence for causality leaves major unfinished business, and field experiments function as proofs-of-concept, that is, they designed to test core aspects of a theory (Baldassarri and Abascal, 2017; Towers *et al*., 2020). Managers and decision makers can use the field experiment approach to justify IT investments in retail distribution operations.

6. Limitations and Future Research

This study investigated only certain IT solutions in retail distribution operations, which could be a limitation of this study. Therefore, future research could examine other IT solutions impact on transportation operations and logistics in general (warehousing, and purchasing). In other words, adopting field experiment as a methodology to isolate the impact or the benefits of IT solutions on the operation's efficiency of warehousing and purchasing could be a stream of research in other logistics functions. In addition, the study only considered the city of Amman and not the whole coverage area of the company. Therefore, future research could be conducted on a larger geographical area. Furthermore, there are many phenomena in business research assume causality based on field research methods rather than field experimentation. Thus, we suggested that these assumptions should be revisited in future research. Future researchers could also capitalise on this research through applying field experiment approaches to other functions within different retail logistics contexts. Field experiment could be therefore applied within the emerging topics on digital transformation and disruptive technologies in supply chain management such as investments in block chain and the internet of things.

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