UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Faculty of Manufacturing Engineering

COST OPTIMIZATION BASED ON JOINT ECONOMIC LOT SIZE MODEL BY INCORPORATING TRANSPORTATION COSTS FOR SINGLE SUPPLIER-PURCHASER

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Master of Science in Manufacturing Engineering

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COST OPTIMIZATION BASED ON JOINT ECONOMIC LOT SIZE MODEL BY INCORPORATING TRANSPORTATION COSTS FOR SINGLE SUPPLIER-PURCHASER

RADEN ACHMAD CHAIRDINO LEUVEANO

A thesis submitted
in fulfillment of the requirements for the degree of Master of Science
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2014

DECLARATION

I declare that this thesis entitle ‘Cost Optimization Based on Joint Economic Lot Size Model by Incorporating Transportation Costs for Single Supplier-Purchaser’ is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not currently submitted in candidate of any other degree.

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APPROVAL

I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of Master of Science in Manufacturing Engineering.

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I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality as a partial fulfillment of Master of Science in Manufacturing Engineering.

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Date	:	

DEDICATION

"To my beloved parents"

"To my beloved wife"

"To my beloved brother and sister"

ABSTRACT

The increasing focus on supplier-purchaser coordination has become an essential issue to be managed efficiently in optimizing supply chain's performance. Procurement scenario indicates that most of supplier and purchaser have emphasized their effort in effective decision for inventory replenishment independently. Instead of independent decision, Joint Economic Lot Size (JELS) model has been proposed as the representation of coordinated decision between supplier-purchaser. The main objective is to minimize joint total cost of supplier and purchaser by jointly deciding the optimal order quantity, batch production lot, and number of deliveries. Determination of inventory replenishment need to consider transportation as the function of shipment weight and haulage distance that simultaneously emulate freight rate schedules and two modes of transportation namely Truckload (TL) and Less than Truckload (LTL) shipment. Hence, this study proposes to incorporate transportation or freight cost function into JELS model. There are three proposed models in this study, namely: (i) JELS-Inverse (JELS-I) for emulating TL shipment, (ii) JELS Adjusted-inverse (JELS-A) for emulating LTL shipment, and (iii) JELS Lot-splitting (JELS-L) for minimizing joint total cost if the transportation is limited based on TL and LTL shipment. JELS-I and JELS-A constitutes the analytical mathematical model that validated using sensitivity analysis to analyze the robustness of the model. JELS-L is a model based Heuristic optimization approach to search solution within the interval solution of JELS-I and JELS-A. The models are examined by the numerical example for analyzing its feasibility in deriving the solution. The result shows that JELS-I provides a large order quantity but a small number of deliveries, otherwise, JELS-A yields smaller order quantity but a higher number of deliveries. Both models only resulting minimum joint total cost in the case of TL and LTL shipment meanwhile JELS-L performs better result than other models in minimizing joint cost. The models tested by experimenting the wide range of model parameter in order to analyze the effectiveness of the model in yielding a best solution to minimize joint total cost. The experimental result shows that JELS-L provides a smaller deviation toward the best solution rather than another model. It can be indicated that JELS-L model successfully gives promising results in a coordinated decision of the supply chain.

ABSTRAK

Peningkatan tumpuan kepada penyelarasan pembekal dan pembeli telah menjadi satu isu penting yang perlu ditadbir dengan berkesan dalam mengoptimumkan prestasi rantaian bekalan. Senario pengadaan menunjukkan bahawa kebanyakan pembekal dan pembeli telah menekankan usaha mereka dalam membuat keputusan yang berkesan untuk menambahkan inventori secara bersaingan. Di sebalik keputusan yang berasingan, model Saiz Lot Ekonomi Bersama (JELS) telah dicadangkan sebagai mewakili keputusan yang selaras antara pembekal dan pembeli. Objektif utama adalah untuk meminimumkan jumlah kos bersama antara pembekal dan pembeli melalui kuantiti pesanan, lot produksi kumpulan, dan jumlah penghantaran optimum yang ditetapkan bersama. Penentuan penambahan persediaan perlu mempertimbangkan pengangkutan sebagai fungsi berat pengiriman dan jarak pengangkutan yang secara bersamaan mencontohi jadual tarif pengangkutan dan dua cara pengangkutan, iaitu Lori Penuh (TL) dan Kurang daripada Lori Penuh (LTL) pengiriman. Kajian ini mencadangkan untuk menggabungkan pengangkutan atau fungsi kos berat ke dalam model JELS. Terdapat tiga model yang dicadangkan dalam kajian ini, iaitu: (i) JELS-Terbalik (JELS-I) untuk mencontohi penghantaran TL, (ii) JELS-Penyelarasan-terbalik (JELS-A) untuk mencontohi penghantaran LTL, dan (iii) JELS Pemisahan lot (JELS-L) untuk mengurangkan jumlah kos bersama sekiranya pengangkutan adalah terhad berdasarkan penghantaran TL dan LTL. JELS-I dan JELS-A merupakan model analisis matematik yang disahkan dengan menggunakan analisis kepekaan untuk menganalisis ketahanan model. JELS-L ialah model berasaskan pendekatan pengoptimuman Heuristic untuk mencari penyelesaian dalam penyelesaian selang JELS-I dan JELS-A. Model diperiksa oleh contoh berangka untuk menganalisis kelayakan dalam memperoleh penyelesaian. Hasilnya menunjukkan bahawa JELS-I menyediakan kuantiti permintaan yang besar tetapi jumlah penghantaran yang lebih kecil, jika tidak, JELS-A menghasilkan kuantiti permintaan yang kecil tetapi bilangan penghantaran yang lebih tinggi. Kedua-dua model hanya menyebabkan kos minimum dalam kes penghantaran TL dan LTL sementara JELS-L melakukan keputusan yang lebih baik daripada model lain dalam mengurangkan kos bersama. Model diuji dengan melakukan percubaan pelbagai parameter model untuk menganalisis keberkesanan model dalam menghasilkan penyelesaian yang terbaik untuk mengurangkan kos bersama. Keputusan eksperimen menunjukkan bahawa JELS-L menyediakan sisihan yang lebih kecil ke arah penyelesaian terbaik berbanding dengan model yang lain. Hal ini menunjukkan bahawa model JELS-L berjaya memberikan hasil yang memberangsangkan dalam keputusan yang diselaraskan untuk rantaian bekalan.

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LIST OF ABBREVATIONS

DWP	**D**eliver **W**hat is **P**roduced
E	**E**qual-Size Shipment
EOQ	**E**conomic **O**rder **Q**uantity
EOQ-I	**E**conomic **O**rder **Q**uantity-**I**nverse
EOQ-A	**E**conomic **O**rder **Q**uantity-**A**djusted-inverse
EPQ	**E**conomic **P**roduction **Q**uantity
FTL	**F**ull **T**ruck**l**oad
IS	**I**nformation **S**haring
IDQ	**I**dentical **D**elivery **Q**uantity
JELS	**J**oint **E**conomic **L**ot **S**ize
JELS-I	**J**oint **E**conomic **L**ot **S**ize-**I**nverse
JELS-A	**J**oint **E**conomic **L**ot **S**ize-Adjusted-Inverse
JELS-L	**J**oint **E**conomic **L**ot **S**ize-**L**ot-Splitting
JIT	**J**ust **I**n **T**ime
LFL	**L**ot **F**or **L**ot
LTL	**L**ess-Than-**T**ruc**k**load
MSD	**M**ean **S**quare **D**ifferences
MSSP	**M**ulti **S**upplier **S**ingle **P**urchaser
SCM	**S**upply **C**hain **M**anagement
SP	**S**ingle **P**urchaser
SSP	**S**ingle **S**upplier **P**urchaser
SSMP	**S**ingle **S**upplier **M**ulti **P**urchaser
TL	**T**ruck**l**oad
U	**U**nequal-Size Shipment

LIST OF SYMBOLS

A	Ordering cost per order of the purchaser ($/order)
D	Demand rate of the purchaser (unit/period)
Df	Degree of freedom
d	Transportation distance (miles)
$F(D,\ q,\ d,\ w)$	Total freight cost
FTC	Total fix transportation cost
F_0	Fixed transportation costs per shipment for preparing and loading material ($/Shipments)
F_t	The freight rate in dollar per pound for the partial load ($/lbs)
F_x	The freight rate in dollar per pound per mile at (FTL) ($/lbs/mile)
F_y	The freight rate in dollar per pound per mile for the partial load ($/lbs/mile)
F_z	The freight rate in dollar per pound at full truck load (FTL) ($/lbs)
H_p	Holding costs per unit per period of the purchaser ($/unit/period)
H_s	Holding costs per unit per period of the supplier ($/unit/period)
JTC	Joint total cost
lb	Pound or a unit of mass
m	Number of deliveries
m_{adj}	Number of deliveries based on adjusted inverse function
m_{inv}	Number of deliveries based on inverse function
m_j	Joint number of deliveries
m_{jadj}	Joint number of deliveries based on JELS-A
m_{jinv}	Joint number of deliveries based on JELS-I
m_{jlot}	Joint number of deliveries based on JELS-L
MS	Mean of Squares
OC	Total ordering cost
P	Production rate of the supplier (unit/period)

PHC	Total holding cost of purchaser
q	Order quantity/delivery quantity (unit)
q_{adj}	Order quantity (unit) based on adjusted inverse function
q_{inv}	Order quantity (unit) based on inverse function
q_j	Joint order quantity (unit)
q_{jadj}	Joint order quantity (unit) based on JELS-A
q_{jinv}	Joint order quantity (unit) based on JELS-I
q_{jlot}	Joint order quantity (unit) based on JELS-L
Q	Batch production lot (unit), $Q = q\, m$
Q_{adj}	Batch production lot (unit) based on adjusted inverse function, $Q_{adj} = q_{adj}\, m_{adj}$
Q_{inv}	Batch production lot (unit) based on inverse function, $Q_{inv} = q_{inv}\, m_{inv}$
Q_j	Joint batch production lot (unit), $Q_j = q_j\, m_j$
Q_{jadj}	Joint batch production lot (unit) based on JELS-A, $Q_{jadj} = q_{jadj}\, m_{jadj}$
Q_{jinv}	Joint batch production lot (unit) based on JELS-I, $Q_{jinv} = q_{jinv}\, m_{jinv}$
Q_{jlot}	Joint batch production lot (unit) based on JELS-L, $Q_{jlot} = q_{jlot}\, m_{jlot}$
S	Setup cost per setup of the supplier ($/setup)
SC	Total setup cost
SHC	Total holding cost of supplier
SS	Sum of Squares
w	Weight of a unit part (lbs)
W_x	Full truckload (FTL) shipping weight (lbs)
W_y	Actual shipping weight (lbs)
α	Discount factor
$	The name of the united states currency

LIST OF PUBLICATIONS

The following publications are resulted during master study:

Journal

Saleh, C., Leuveano, A. C., Lagaida, R., and Razali, M., 2012. Retailers Ordering and Discounting Policies Under Advance Sales Discount and Trade Credit Based on Sharia. *Jurnal Teknologi*, Vol. 59 (2), pp. 115–121.

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Leuveano, A. C., Jafar, F. A., Saleh, C., and Razali, M., 2014. Incorporating Transportation Cost into Joint Economic Lot Size for Single Vendor-Buyer. *Journal of Software* (JSW, ISSN 1796-217X).

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Saleh, C., Leuveano, A. C., Lagaida, R., and Razali, M., 2011. Retailers Ordering and Discounting Policies under Advance Sales Discount and Trade Credit Based on Syariah. *5th Powder Metallurgy Symposium and Exhibition, Advances Processes and System in Manufacturing*, Kuala Lumpur, Malaysia, 14-15 Dec 2011. APSIM.

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CHAPTER I

INTRODUCTION

1.1 Background

In the global business practice today, competitions among companies have given a great deal attention in order to meet customer's requirements. Much product innovation with short life cycles have encouraged companies to strengthen their position in global competition via cost reduction, high quality, product customization and speed to market (Heizer and Render, 2010). Lower operation cost usually becomes important purpose to be gained through utilizing the internal function of organizations. On the one hand, coordination and collaboration with an external organization such as supplier and customer also provide much benefits in total cost reduction (Ben-Daya et al., 2008). In order to increase coordination with supplier, Supply Chain Management (SCM) has been widely used in sourcing strategies.

SCM has been studied extensively in recent years which encompass the management raw material and information flows refer to supply activities in and between organizations, such as suppliers, manufacturing, assembly plants and distribution center (Thomas and Griffin, 1996). The current issues in supply chain activities are to regulate local optimization in which the members of the supply chain are greatly focused on maximizing profit or minimizing costs. The important stages of the supply chain include procurement, production, and distribution (Gumus et al., 2008). Those stages are commonly buffered by large inventories in order to meet customer's requirements. Meanwhile, the impact of holding larger inventories will have costly consequences. Its costs were around 20-36 percent of total manufacturing cost (Chen and Liu, 2008).

Procurement has been thought as one of the key elements in inbound logistics, which is regarded with sourcing and qualifying strategy to acquire the goods. It commonly leads to lot sizing, pricing, discount, and delivery, for inventory replenishment (Banerjee, 1986). Emphasizing on the lot sizing problem, individual entities within the supply chain has long been treated separately in determining inventory replenishment decision (Lu, 1995; Yang et al., 2007). Poor decision resulted from a negotiation will affect to imbalance lot sizing which also directly affect the cost incur to inventory, ordering, production, and delivery.

Rather than working independently, coordination and collaboration among individual companies within the supply chain are fully providing an economical advantage. There has been increasing focus on managing inventory across the supply chain to synchronize the production flow from upstream to downstream by determining optimal decision which leads to cost reduction and increase the profit (Stadtler, 2005; and Govindan et al., 2012). As the members of the supply chain, cooperative policy is needed to solve the problem together. If no such coordination occurs, then each party will act individually to reduce their cost, certainly, it could not be optimal if SCM is not considered as a whole (Jalbar et al., 2007).

Supplier and *purchaser* relationship have long been studied in recent years in order to increase the performance of the supply chain. The number of researches has emerged, pointing at supply chain integration which is associated with coordination of inventory replenishment decisions (Goyal, 1977; Thomas and Griffin, 1996; Kelle et al., 2007; Ben-Daya et al., 2008; Chaharsooghi and Heydari, 2010; Glock, 2012b; and Kaya et al., 2013). Instead of determining inventory replenishment decision independently, Goyal (1977) was the first who introduced a coordination model that is well-known as Joint Economic Lot Size (JELS). It is aiming to embody the supply chain coordination in the form of central decision between supplier and purchaser. This decision includes order quantity and batch production that focus on reducing joint total costs of the system. In addition, considerable saving